Golden Fetters, Paper Fetters, and the Rationale for Eliminating the Effective Lower Bound on Nominal Interest Rates*

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Abstract

This paper considers the parallels between the gold standard ("*golden fetters*") and the effective lower bound (ELB) on nominal interest rates that arises from the fact that paper currency accrues no interest ("*paper fetters*"). We begin by identifying common themes in the historical debates about the gold standard and the contemporary debates about the ELB. Next, we formulate a DSGE model that combines features of bounded rationality and heterogenous agents, and we conduct simulations of this model to show how monetary policy strategies for mitigating the ELB have disparate effects on asset holders compared to credit-constrained workers. Finally, we discuss the rationale for introducing a central bank digital currency that would facilitate the elimination of the ELB without abolishing paper cash, undermining the banking system, or imposing any fees on ordinary households and small businesses.

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1 Introduction

Although the classical gold standard served as the bedrock of the monetary system in numerous countries during the late 19th and early 20th century, its shortcomings in delivering price stability were highlighted by luminaries such as Jevons (1875), Marshall (1877), Wicksell (1898), and Fisher (1913), who advocated the adoption of a more elastic monetary standard. Debates about the gold standard also became a heated political issue, with candidates emphasizing its inequitable consequences for farmers and small businesses compared to wealthy bankers and industrialists. Nonetheless, the gold standard largely prevailed until the onset of the Great Depression, at which point the continuation of the so-called "golden fetters"[1] became untenable, and no country has ever returned to it since then.

In this paper, we consider the parallels between golden fetters and paper fetters, that is, the extent to which monetary policy is constrained by the effective lower bound (ELB) on nominal interest rates, which in turn arises from the fact that paper currency accrues no interest. Our analysis begins by identifying common themes in the historical debate about the gold standard and the current debate about the ELB.[2] Next, we formulate a dynamic stochastic general equilibrium (DSGE) model that combines features of bounded rationality and heterogenous agents, and we conduct simulations of this model to show how current approaches for mitigating the ELB (often referred to as "lower-for-longer" or "make-up" strategies) have disparate effects on asset holders compared to credit-constrained workers. We then discuss the rationale for introducing a central bank digital currency (CBDC) that would facilitate the elimination of the ELB without any need to abolish paper cash, undermine the stability of the banking system, or impose taxes or fees on ordinary households and small businesses.

Our historical analysis identifies several key issues that are relevant for assessing golden fetters and paper fetters. Both of these constraints reflect idiosyncratic technological factors (i.e., the relative global scarcity of gold, and the impracticality of paying interest on low-denomination banknotes and coins) rather than intrinsically desirable features of the monetary system. Moreover, both types of fetters leave the central bank with a moderate degree of flexibility before the constraint becomes fully binding. However, an important aspect of the golden fetters was that the government could simply depart from the gold standard in case of a war or other national emergency. By contrast, the ELB has no such "contingency clause", raising the prospect that this

[1] Eichengreen (1992) first introduced the term "golden fetters".

[2] Debortoli, Gali and Gambetti (2019) use a representative agent New-Keynesian model to illustrate that the responses of macroeconomic variables were only marginally affected by the ELB. Under the benchmark calibration of the model, the ELB binds once every 140 quarters for a period of 3 quarter. Swanson (2018) finds that ELB did not constrain the Federal Reserve's ability to affect medium- and long-term interest rates during the 2008-15 period. In contrast, Kiley and Roberts (2017), Reifschneider and Williams (2000), and Williams (2009) consider scenarios in which the ELB binds for several quarters.

constraint could severely hinder the central bank's ability to carry out its mission in the midst of an economic or financial crisis.

To shed further light on the implications of paper fetters, we formulate a novel DSGE model that combines two distinct strands of the New Keynesian literature. Our analysis draws on several previous studies that have investigated these issues in models with rational expectations and complete risk sharing.[3] Previous research has shown that bounded rationality can resolve the "forward guidance puzzle"[4] that arises in models with fully rational expectations, thereby facilitating more realistic assessments of the consequences of the ELB and the efficacy of lower-for-longer monetary policy strategies.[5] Likewise, recent research has investigated macroeconomic dynamics and policy multipliers in heterogenous-agent New Keynesian (HANK) models compared to more conventional DSGE models with representative agents.[6] Our analysis combines those two strands by formulating a two-agent New Keynesian (TANK) model that embeds the same type of bounded rationality as in Gabaix (2020), and we conduct simulations of this model to analyze the disparate effects of monetary policy at the ELB.

In light of these results, we consider specific design features of CBDC that would facilitate the elimination of the ELB. In particular, digital cash could be provided to the public via digital wallets held by supervised financial institutions, which would hold those funds in reserve at the central bank; such a public-private partnership would foster competition among payment providers, prevent money laundering, and preserve consumer privacy. Ordinary households and small businesses would never incur any fees and would remain free to hold paper cash if desired. However, the central bank could eliminate arbitrage incentives by imposing fees on very large transfers between digital cash and paper cash, thereby eliminating the ELB. Moreover, during a financial crisis or severe economic downturn, the central bank could impose graduated fees on very large holdings of digital cash, thereby preventing bank runs and disincentivizing investors from shifting their portfolios into risk-free assets. Consequently, the central bank would be assured of having sufficient policy tools to foster price stability and economic recovery.

[3] A number of studies have analyzed optimal monetary policy at the ELB in NK models with rational expectations; see Jung, Teranishi, and Watanabe (2001, 2005), Eggertsson and Woodford (2003), Adam and Billi (2006), Nakov (2008), Levin, Lopez-Salido, Nelson, and Yun (2010), and Boneva, Harrison, and Waldron (2018).

[4] The seminal contribution of Del Negro, Giannoni and Patterson (2012) identified the forward guidance puzzle. See also Kiley (2016).

[5] In Levin and Sinha (2020), we consider the limitations imposed on forward guidance in a NK model which nests different approaches to bounded rationality. McKay, Nakamura and Steinsson (2016) use a model of incomplete credit markets to mitigate the forward guidance puzzle. Imperfect common knowledge and and bounded rationality are used by Angeletos and Lian (2018) and Gabaix (2020) respectively, and the finite planning horizon model is used by Woodford (2019). Other approaches to attenuate forward guidance include Kiley (2016), Gust, Herbst, and Lopez-Salido (2018), Campbell et al. (2019), Farhi and Werning (2019), Hagedorn et al. (2019), and Lepetit and Fuentes-Albero (2020)

[6] See Gornemann, Kuester and Nakajima (2016); Kaplan, Moll and Violante (2018); Bilbiie (2020); Auclert, Rognlie and Straub (2020); Luetticke (2021); Alves, Kaplan, Moll and Violante (2021).

The remainder of this paper is organized as follows. Section 2 presents the historical analysis. Section 3 formulates the DSGE model, and Section 4 evaluates this model at the ELB. Section 5 discusses design principles for digital cash that would eliminate the ELB. Section 6 concludes.

2 Historical Analysis

2.1 Origins of the Gold Standard

The origins of the classical gold standard are remarkably idiosyncratic, reflecting a complex mix of technical factors and historical coincidences.[7]

United Kingdom. From the late medieval period through the renaissance, England and most other European countries maintained a bimetallic standard in which silver coins served as the medium of exchange for most low-value transactions while gold coins were primarily used for high-value transactions, especially international trade. In 1717, however, the nominal price of gold was raised to £4.44 pounds per ounce by the U.K. Master of the Mint, Sir Isaac Newton, causing a rapid shift to gold as the de facto unit of account. The development of coin milling (i.e., minting each coin with well-defined and durable edges) was a significant technical innovation that mitigated counterfeiting and debasement.[8] The Bank of England suspended gold redemptions of its banknotes in 1797, at the onset of the Napoleanic wars, and that suspension continued until 1816, when Parliament enacted the gold standard into law. A century later, gold redemptions were suspended at the start of World War I (WWI), and convertibility did not resume until 1925. The gold standard was finally abandoned in 1931 during the Great Depression.

United States. The U.S. Constitution authorized the Congress "to coin money and regulate the value thereof." The Coinage Act of 1792 established a bimetallic system of high-denomination gold coins and lower-denomination silver coins, with a nominal value ratio of 15 grains of silver per grain of gold. That nominal ratio undervalued gold relative to market prices, and hence silver coins became the de facto monetary standard. However, three southern U.S. states (Georgia, North Carolina, and South Carolina) were major gold producers, and their influence eventually caused Congress to revise the nominal ratio to 16:1, resulting in an abrupt shift to a de facto gold standard.[9] The fixed legal price of $20.67 per ounce prevailed from 1837 until the onset of the Civil War. In 1862, the federal government began financing its expenditures by issuing paper Greenbacks as legal tender, forcing state banks to suspend convertibility between banknotes and gold; convertibility eventually resumed as of 1879. As discussed below, there were heated political

[7] For a comprehensive review, see section IV of Bordo and Kydland, 1995. Also see Bordo (1984), Bordo and Rockoff (1996) and Bordo, Dittmar, and Gavin (2007).

[8] See Redish, 1990.

[9] See O'Leary (1937) and Friedman (1990) for further discussion.

debates about "free silver" during the late nineteenth century, but the gold standard prevailed, and gold was legally designated as the sole unit of account in 1900. An embargo on gold exports was imposed when the United States entered WWI in 1917 and lifted shortly after the end of the war in 1919. Apart from that brief interlude, however, the gold standard remained in effect until President Roosevelt effectively abolished it on his first day of office in March 1933.

France and Germany. The French government maintained a bimetallic standard from the middle ages until the late nineteenth century, although its monetary system was frequently subjected to debasements and devaluations. The German states also followed a bimetallic standard during most of the nineteenth century, but the gold standard was adopted when Germany became unified in 1871 following its victory in the Franco-Prussian War.[10] In the wake of massive discoveries of silver in the United States as well as the demonetization of silver in Germany and elsewhere, the French government began limiting silver coinage in 1874 and adopted the gold standard in 1878.[11] France suspended convertibility at the onset of WWI, returned to the gold standard at a vastly depreciated level in 1928, and remained on that standard until 1936. Germany suspended the gold standard during WWI and experienced extreme monetary instability in subsequent years.[12]

2.2 Origins of the ELB

As with the classical gold standard, the existence of the ELB reflects a combination of technological and historical factors. Of course, the basic cause of the ELB is readily apparent: Paper cash pays zero nominal interest and is issued by the central bank in whatever quantity is demanded by the public. Consequently, the central bank faces intrinsic limits on the extent to which it can provide additional monetary stimulus by pushing nominal interest rates below zero.

In particular, negative interest rates generate arbitrage incentives for households and businesses to shift from commercial bank accounts and other private assets into paper cash. Until about a decade ago, this constraint was typically referred to as the zero lower bound (ZLB), but in recent years a number of major central banks have pushed nominal interest rates well below zero and hence the constraint is now referred to as the ELB. Empirical analysis has documented the existence of economy-specific thresholds at which further interest rate reductions are likely to be counterproductive.[13] Such thresholds presumably reflect structural and regulatory factors as well as the rate structure of the policy regime, e.g., alternative rates for various types of deposits.

Evidently, the ELB reflects a deeper technological issue, namely, the impracticality of paying interest on paper currency. That difficulty reflects several specific factors: (a) paper bills are issued

[10] See Wiegand (2019).
[11] See Flandreau (1996) regarding the pressures imposed on France to join the gold standard.
[12] See Sargent (1982).
[13] See Eggertsson et al. (2017, 2019).

in small denominations to facilitate day-to-day transactions of consumers and businesses; (b) a paper bill can be transferred from one holder to another without recording any ledger entry; and (c) paper bills may circulate for an extended period of time before returning to the central bank or supervised financial institutions. These characteristics clearly distinguish paper currency from public or private debt securities, which are issued in large denominations to minimize transaction costs and whose ownership is recorded in a centralized ledger.

This limitation of paper currency was not particularly problematic during the gold standard era, because banknotes were redeemable in gold and hence bore essentially the same expected rate of return as gold coins. Moreover, since major gold discoveries were relatively rare, and gold has alternative uses in jewelry and other decorative arts (e.g., gilded ceilings), the real rate of return on gold coins and banknotes was broadly aligned with the overall pace of real economic growth per capita.[14]

By contrast, the shortcomings of paper money became evident in the modern era of fiat money. The Great Inflation of the late 1960s and 1970s generated incentives for households and businesses to cut back on their usage of paper cash, especially once commercial banks began paying interest on checkable accounts. In the wake of successful disinflations, many central banks established an inflation target of 2 percent, reflecting the motive of establishing an "inflation buffer" to raise the average level of the nominal interest rate and thereby reduce the risk of hitting the ELB. Nonetheless, it became apparent that the equilibrium real rate of interest had declined substantially in response to various demographic and structural factors, and hence a number of major central banks kept their policy rates at or close to the ELB over the past decade.

2.3 Price Stability under the Gold Standard

The record of the classical gold standard was one of good macroeconomic performance with significant economic growth and long-run price stability (Bordo, 1981). Long-run price stability was ensured by the operation of the global classical commodity theory of money (Fisher, 1911; Barro, 1979). Declining price levels, by raising the real price of gold, would lead to exploration and eventually discoveries, and also substitution from non-monetary to monetary uses of gold. This would expand the world monetary gold stock and the world money supply raising prices. Rising price levels, by reducing the real price of gold would lead to the shutting down of unprofitable gold mines, and substitution from monetary to non-monetary uses of gold, reducing the world monetary gold stock and money supply and hence prices. Thus in the long-run, the world price level would be mean reverting (Bordo, Ditmar, and Gavin, 2007). In the short to medium run (1 to 20 years), price levels would rise or fall reflecting the shocks to the gold market (Dierks, Rawls,

[14] See Barro (1979).

and Sims, 2020).

The alternating waves of rising and falling price levels led to political discontent and dissatisfaction with the operation of the classical gold standard. Periods of inflation, to the extent it was unanticipated, produced redistribution of income from creditors to debtors. The opposite occurred in periods of deflation when creditors gained and debtors lost.

The leading economists of the late nineteenth century and early twentieth centuries, Jevons, Marshall, Wicksell and Fisher, all were critical of the price level instability of the gold standard. Irving Fisher's compensated dollar (1913) is the best known alternative. Fisher's idea was to have the monetary authorities (U.S. Treasury) periodically change the official price of gold to completely offset changes in a designated price index. This would ensure a stable real price level (Bordo, Ditmar, and Gavin, 2007; Cagan, 1987; Patinkin, 1993). In many ways Fisher's scheme was similar to modern day proposals for a price level target. Keynes (1930) referred to gold as a barbarous relic and later advocated a plan that underlay the Bretton Woods articles which would combine discretionary monetary and fiscal policy with an adjustable peg exchange rate with a golden nominal anchor.

The classical gold standard collapsed with World War I in 1914 as all of the belligerents suspended gold payments and ran massive fiscal deficits and monetary expansion leading to high inflation. After the war, once price stability was restored, many countries wanted to restore the gold standard. The Genoa conference of 1922 set the stage for the gold exchange standard. The key innovation at Genoa was for adherents to substitute foreign exchange (pounds or dollars) for gold in international reserves. This was predicated on the belief that there would be a gold shortage.

The gold exchange standard was short-lived, from 1924 to 1936. The gold standard instituted in the 20s was very different from the pre war variant. Central banks could no longer subsume domestic policy priorities to the dictates of external balance (gold convertibility), because the rise of organized labor and the expansion of the suffrage in many countries that came out of World War I meant that domestic employment and macro stability became a priority (Eichengreen, 1992). This meant that credibility, which was the bedrock of the classical gold standard, was greatly weakened. Hence in the face of a crisis or negative shock, capital flows would no longer be stabilizing as they were pre 1914, and a country could be forced to abandon its peg. It also meant that the ability to conduct lender of last resort policies which was made possible pre 1914 by credibility, was weakened because doing so would lead to an attack.

The gold exchange standard collapsed in the Great Depression when deflationary shocks from the US Great Contraction, transmitted by the fixed exchange rate gold standard (Friedman and Schwartz, 1963) led to economic collapse and banking panics in central Europe (Bernanke and James, 1991). Because of "golden fetters" – the gold standard constraint – central banks were unable to use expansionary monetary policy as lenders of last resort to protect their banking systems for fear of triggering a speculative attack on their international reserves. Their only option was departure from the gold standard, devaluation and expansionary monetary policy. Evidence by (Fisher, 1933; Choudhri and Kochin, 1980 and Eichengreen and Sachs, 1985) dramatically showed that countries which left the gold standard ended economic contraction and quickly recovered, while those that did not, lingered in the slump.

The case of Germany in the early years of the thirties is an excellent example of the political consequences of "golden fetters" and of deflation on political unrest and the distribution of income.

Germany went back to the gold standard in 1924 at a greatly devalued parity after stabilizing from a horrendous hyperinflation in 1922-23. Successive governments in the Weimar republic attached great importance to adhering to the gold peg. When the US Great Contraction shock was transmitted to Germany through the balance of payments it led to a serious decline in output and prices and a decline in tax revenues. The Bruning government (1930-1932) attached top priority to maintaining a balanced budget (as well as honoring its Versailles treaty reparations to the allies). It followed a policy of austerity (cutting expenditures and raising taxes) from 1930-32. This aggravated the depression and inflation triggering growing political unrest manifest in rising popularity of the Nazi party. Research by (Galofré-Vilà, Meissner, McKee and Stuckler, 2021) showed that the share of the vote by the Nazi party in 4 elections from 1930 to 1933 kept increasing as the unemployment rate and other macro indicators worsened. They also found that the increase in discontent was felt by both the lower and middle classes.

Another key part of the story was the banking crisis in June/July 1931. The monetary authorities could not conduct expansionary lender of last resort actions because of the gold standard constraint. The banking panic morphed into a currency crisis. The crisis was ended by a freeze on foreign deposits, the imposition of capital and exchange controls and the nationalization of key banks. Strauman (2019) sees the financial crisis of 1931, preceded by the reparations induced debt crisis, as the key element in the collapse of the Weimar republic and the rise of Hitler.

Thus "golden fetters" has considerable resonance for the ELB, because of the mentalite of the gold standard. Adherents were loath to leave their pegs even if it would save them (Eichengreen and Temin, 2000). In the end jettisoning the gold standard constraint was the only way to exit from the Great Depression. For the ELB, in the face of a serious downturn, an alternative regime such as paying negative rates on CBDC could be a viable and comparable exit strategy.

2.4 Price Stability under the ELB

Paper cash pays zero interest and hence limits the extent to which a central bank can provide conventional monetary accommodation by reducing nominal interest rates in the face of weak aggregate demand and persistently low inflation. In the wake of the global financial crisis, the Federal Reserve and other major central banks became constrained by this ELB and deployed two basic forms of unconventional monetary policy: quantitative easing (QE) in the form of large-scale asset purchases, and forward guidance about the likely trajectory of short-term nominal interest rates. Each of these policy tools is intended to provide monetary stimulus, thereby fostering the pace of economic recovery and bringing inflation back upwards to its stated objective; thus, these tools are intrinsically different from the emergency liquidity measures that a central bank may implement in serving as a lender of last resort during a financial crisis.

In deploying these unconventional policies, central bankers and other analysts were quite optimistic that implementing QE and forward guidance could substantially mitigate the severity of the ELB. However, those projections relied heavily on extrapolations from statistical patterns over preceding decades and on event studies of policy actions taken in the midst of the financial crisis. Consequently, such assessments were necessarily subject to a high degree of uncertainty. With the passing of time, however, it became increasingly evident that QE and forward guidance have muted benefits in providing monetary stimulus; see Borio (2018), Greenlaw et al. (2018), Hamilton (2018), Bordo and Levin (2019).

The FOMC began providing specific forward guidance in its August 2011 statement, which indicated that the target federal funds rate was likely to remain unchanged "at least until mid-2013." That announcement was associated with a decline of about 10 basis points in the 2-year Treasury yield —roughly similar to a small surprise in conventional monetary policy during the precrisis period; see Williams (2013). By contrast, subsequent revisions in the Federal Open Market Committee's forward guidance in January 2012 ("at least through mid-2014") and in September 2012 ("at least through mid-2015") were associated with very small reductions in the 2-year Treasury yield of about 4 basis points and 1 basis point, respectively. Finally, in December 2012, the Federal Open Market Committee (FOMC) reframed its forward guidance in terms of specific quantitative thresholds for unemployment and inflation. According to the Federal Reserve Bank of New York's survey of primary dealers, that reframing came as a surprise to financial market participants but had negligible effects on their expectations regarding the likely timing of liftoff from the ELB.

The Federal Reserve initiated its first round of large-scale asset purchases (QE1) during the most intense phase of the financial crisis. In particular, at the tail end of 2008 and the first half of 2009, the Fed purchased $1.35 trillion of agency debt and mortgage-backed securities, predominantly issued by Fannie Mae and Freddie Mac, with the specific aim of "providing support to the mortgage and housing markets" by reducing risk spreads on those securities. QE1 also included $300 billion in purchases of Treasury securities. In 2010–11, the FOMC initiated purchases of an additional $600 billion in Treasuries (QE2) and a program to expand the average maturity of its

Treasury holdings (often referred to as "Operation Twist"). Nonetheless, the recovery remained sluggish and inflation remained well below target. The FOMC's third major round of asset purchases, commonly known as QE3, was launched in autumn 2012 and concluded about two years later.

The QE3 program was clearly aimed at providing additional monetary stimulus. Indeed, the FOMC specifically stated that QE3 was intended to push down longer-term bond yields, thereby fostering a more rapid economic recovery and pushing inflation upwards to the FOMC's 2 percent goal. Nonetheless, the term premium on 10-year U.S. Treasury securities was broadly stable during the second half of 2012 and the first quarter of 2013, even as the FOMC initiated QE3. The surveys of primary dealers conducted by the Federal Reserve Bank of New York indicate that the launch of QE3 was largely unanticipated prior to September 2012 and that over subsequent months financial market participants made large upward revisions to their assessments of its likely duration and cumulative size.

Any near-term effects from launching QE3 were subsequently swamped by the so-called taper tantrum in spring 2013. At that time, Fed officials suggested that the tantrum was a transitory phenomenon and that bond yields would quickly subside. However, the New York Fed's June 2013 survey indicated that most primary dealers attributed the tantrum to market confusion about the FOMC's policy strategy. And the term premium remained elevated over the subsequent year, even as investors made further upward revisions about the likely size of the Fed's balance sheet, and did not fall significantly until after the end of QE3 in late 2014.

The launching of QE3 and the initiation of explicit forward guidance appear to have had only muted effects on the U.S. labor market. Growth in nonfarm payrolls during 2013–14 was practically identical to its average pace from 2011 to 2016, with no evident acceleration due to QE3 nor any apparent deceleration following the conclusion of QE3. Likewise, QE3 had no visible impact on the broader U.S. economy. Real GDP growth remained in a narrow range of about 1.50 to 2.75 percent from 2011 thru 2016; the only exception was a temporary pickup in the first half of 2015, well after the conclusion of the QE3 program. Likewise, core PCE inflation (the Fed's preferred measure of underlying inflation) averaged just over 1.5 percent during 2013–14, little different from its average pace over preceding and subsequent years.

Evidently, the transmission mechanism of QE is fundamentally different from that of conventional monetary policy. A long empirical literature has documented that an unanticipated shift in the target federal funds rate has a significant impact on output and employment within a few months and a peak effect within a few quarters. By contrast, the launch of QE3 in autumn 2012 (which was almost entirely unanticipated prior to late August) had no visible impact on nonfarm payrolls or real GDP growth in 2013–14.

Further evidence on the muted effectiveness of unconventional monetary stimulus can be obtained by considering the recent experiences of other major economies where conventional policy has been constrained by the ELB. For example, the Bank of Japan (BOJ) launched its quantitative and qualitative easing (QQE) program in April 2013 and augmented that program in September 2016 by initiating yield curve control (YCC). Under QQE the BOJ's securities holdings have expanded by about ¥400 trillion, equivalent to roughly 80 percent of Japanese GDP. However, Japanese core-core inflation (excluding food and energy prices and the direct effects of the 2014 VAT hike) remained far below the BOJ's 2 percent inflation target. Indeed, over the past year this indicator and other BOJ measures of underlying inflation in Japan remained mired close to zero.

The European Central Bank (ECB) announced its asset purchase program (APP) in late 2014 and initiated large-scale securities purchases—including government securities, corporate bonds, covered bonds, and asset-backed securities—in March 2015. The ECB's asset purchases totaled about 2.5 trillion euros, equivalent to about 15 percent of eurozone GDP. The ECB specifically stated that this program was intended to "address the risks of too prolonged a period of low inflation." Eurozone core inflation (i.e., the 12-month change in the harmonized index of consumer prices excluding food, energy, alcohol, and tobacco) crept upwards to around 1.1 percent in 2018 (an increment of 0.3 percent from its level about five years ago) but remained far below the ECB's objective of keeping inflation "below but close to 2 percent over the medium run."

2.5 Disparate Effects of the Gold Standard

Deflation was a key source of political turmoil in the U.S. in last four decades of the nineteenth century. During and after the Civil War creditor groups clashed with debtors in the controversy over the issue and retirement of the Greenbacks (Mitchell, 1908; Friedman and Schwartz, 1963; Bordo and Bayoumi, 1998).

The American Civil War began in April 1861. The Federal government originally intended to finance its operations solely through borrowing and taxation but by the end of 1861 found it difficult to sell its bonds at favorable rates. Beginning in early 1862, it began issuing paper money—the greenbacks (non-interest bearing notes denominated in dollars and declared to be legal tender). Under the Legal Tender acts, the dates and provisions for convertibility of greenbacks were not specified. In January 1862 the commercial banks suspended specie convertibility and the dollar began a rapid depreciation against sterling, peaking in 1865 at slightly over double the prewar parity and the price level almost doubled.

Shortly after the war, the government made clear its intentions to resume payments at the prewar parity in the Contraction Act of April 12, 1866, which provided for the limited withdrawal of greenbacks. Declining prices from 1866 to 1868 led to a public outcry and to repeal of the Act in

February 1868. Over the next seven years a fierce debate raged between the hard-money factions - advocates of rapid resumption - and soft money factions - some of whom were opposed to restoring the gold standard, others favored resumption at a devalued parity, and yet others opposed undue deflation and favored allowing the economy to grow up to its money supply (Unger, 1964; Sharkey, 1959).

The soft money group included debtors and others (e.g. farmers, organized labor and western manufacturers who viewed the depreciated dollar as form of tariff protection). These forces coalesced into the Greenback party in 1875. The hard money forces were mainly creditors (bankers, land owners and the financial sector). The division between hard and soft money cut across party lines.

Triumphs of the conflicting factions were manifest in legislation: the Public Credit Act of 1869, contracting the greenback issue, the reissue of $26 million of retired greenbacks in 1873, expanding it, and in Supreme court decisions, initially declaring the Legal Tender Acts unconstitutional (Hepburn versus Griswold, February 1870), and then reversing the decision (Knox vs Lee, May 1871) and the elections of 1872,1874, 1876. Finally, the decision to resume convertibility on January 1, 1879, was made in the Resumption Act of January 1875, which the lame-duck Republican Congress passed by a majority of one. Restoration of convertibility was achieved on January 1, 1879.

Concern over deflation continued after the U.S. returned to the gold standard as world prices in terms of gold had been declining since the early 1870s. The concern was manifested in a vociferous debate over silver which dominated U.S. politics for the next three decades (Friedman and Schwartz, 1963; Silber 2019). The issue led to the Free Silver movement.

The agitation over silver began with the 'Crime of 1873', the name given by the free silver forces to the Coinage Act of February 1873 which demonetized the standard silver dollar coin. Although the U.S. at the time was on a paper money standard, officially it was on a bimetallic standard at the bimetallic ratio of 16:1. The market ratio had been well below that ratio since 1834 and the U.S. was on a de facto gold standard until the suspension in 1862. The coin was deleted by a Treasury official to standardize the coinage . In the 1870s , massive silver discoveries in Colorado and other western states, as well as Germany, France and other European countries switching from silver and bimetallic standards to the gold standard, increased the world supply of silver relative to gold and pushed down the silver gold ratio to the point where the U.S. would, under the bimetallic system, shift to a de facto silver standard.

The agitation over silver began when western silver producers realized that the market price of silver had fallen below the official $1.29 an ounce price, which if silver coins had not been demonetized, would have allowed them to sell all of their output to the U.S. mint rather than accept the lower prices that prevailed in the market. It also would have increased the U.S. monetary base and money supply and hence offset the deflation.

The silver producers regarded the Act of 1873 as a crime. They were joined in their agitation by the Greenbackers and all of the advocates of soft money. These forces succeeded in passing the Bland Allison Act of 1878 under which the standard silver dollar became legal tender again but its coinage was limited to between $2 million and $4 million per month. The Free silver forces viewed this legislation as inadequate because it did not allow for the unlimited coinage of silver at $1.29. This led to the formation of the Alliances in the 1880s as a successor to the Greenback party.

The Free silver forces succeeded in passing legislation which was more effective—The Sherman Silver Purchase Act of July 1890 –which doubled the amount of silver the Treasury could purchase relative to the Bland Allison Act. Agitation continued despite the increase in supply of silver currency. The Populist party was founded in 1892 with its basic mandate the free and unlimited coinage of silver. Fear of the inflationary consequences of the silver currency issue and of a perceived threat to maintenance of the gold standard, viewed as a cause of the Panic of 1893 led President Grover Cleveland to repeal the silver purchase clause of the Sherman Silver Purchase Act in November 1893. This inflamed the free silver forces leading to the formation of the American Bimetallic League and the National Silver Committee. The silver forces succeeded in nominating William Jennings Bryan as the Democratic party candidate for President in the election of 1896. Bryan gave his famous Cross of Gold speech at the Democratic Convention in Chicago in July 1896. At the same time the hard money forces formed the National Sound Money League.

Bryan lost the election to the Republican McKinley. He ran again in 1900 and also lost. By then the world price level had turned to inflation and the issue became moot. The debate ended with the passage of the Gold Standard Act of 1900 which made it official.

2.6 Disparate Effects of the ELB

(TO BE ADDED)

3 Model

Our model framework incorporates the dual issues of household heterogeneity in savings behavior, and bounded rationality in the formation of expectations by these households. Both of these elements are essential to capture the relevant model dynamics, and to our knowledge, this is the first model to combine these issues in a single framework.

We introduce household heterogeneity in the following way: there are two types of households in the economy, the savers (of proportion Υ) and the hand-to-mouth (of proportion $1-\Upsilon$). This formulation follows that of Bilbiie, Känzig and Surico (2021). Both types of households have identical utilities, separable over consumption and labor. The savers have access to risk-free government bonds, stocks of firms, and they also rent out the physical capital in the economy. The hand-to-mouth households only have access to their labor income, and government transfers.

In order to attenuate the effects of any forward guidance in our economy, we introduce myopia in the formation of expectations by the savers. Gabaix (2020) provides the micro-foundations for myopic expectations by optimizing households. In the benchmark formulation below, we only incorporate myopia on the consumption side of the economy.

The other aspects of the model framework are: investment in physical capital leads to the law of motion for capital; the intermediate goods producers hire labor from the labor supplier, which is a competitive firm. The labor supplier aggregates the differentiated labor supply by various households. Households set their wages using a Calvo setting. On the production side, there is a single final good, produced using intermediate goods. The perfectly competitive final goods producers take the intermediate and final good prices as given. The intermediate goods producers first minimize costs, taking the wages and rental prices as given. Then, they choose prices to maximize discounted real profits. The central bank is assumed to set the nominal interest rate following simple policy rules described below. This model setup follows the framework of Fernández-Villaverde and Rubio-Ramírez (2006). Finally, the government is assumed to run a balanced budget. It imposes a fixed, steady-state, constant redistributive transfer that equalizes steady-state consumption across the two types of households.

3.1 Households

The continuum of j households in the economy maximize the following lifetime utility function:

$$E_t \sum_{i=0}^{\infty} \beta^{t+i} d_{t+i} \left[\log C_{jt+i}^{Type} - \varphi_{t+i} \psi \frac{\left(L_{jt+i}\right)^{1+\gamma}}{1+\gamma} \right], \tag{1}$$

where β is the discount factor, γ is the inverse of Frisch labor supply elasticity, d_t is an intertemporal preference shock, ψ is the labor disutility parameter, and φ_t is the labor supply shock. The expectations operator E_t refers to the individual agent's expectations, which may incorporate myopia or other forms of bounded rationality. Consumption for the different types is indicated using C_{jt}^{Type}; for the savers, $C_{jt}^{Type} = C_{jt}^{S}$, and for the hand-to-mouth consumers, $C_{jt}^{Type} = C_{jt}^{H}$.[15] For the benchmark model, we assume that there is a centralized labor supplier. This supplier combines labor inputs and sets wages on behalf of both households, and there is a uniform allocation of hours: $L_{jt}^{S} = L_{jt}^{H} = L_{jt}$.

[15] Unlike the BKS (2021) model, we do not allow the savers to switch to the HTM state.

The budget constraint of the continuum of savers j is given by:

$$\begin{aligned} & C_{jt}^{S} + I_{jt} + \frac{B_{jt+1}}{P_t} + \int q_{jt+1,t} a_{jt+1} d\omega_{t+1,t} \\ = \;& W_{jt} L_{jt} + \left(r_t u_{jt} - \mu_t^{-1} a\left[u_{jt} \right] \right) K_{jt-1} + R_{t-1} \frac{B_{jt}}{P_t} + a_{jt} + T_t + \mathcal{F}_t. \end{aligned} \tag{2}$$

The savers undertake investment I_{jt}, and hold government bonds B_{jt}; a_{jt+1} denotes securities that pay one unit of consumption in event $\omega_{t+1,t}$, purchased by the savers at time t, at the real price of $q_{jt+1,t}$. W_t denotes the real wage rate, r_t is the real rental rate, and u_{jt} is the intensity of capital use. The physical cost of the use of resources is given by $\mu_t^{-1} a\left[u_{jt}\right]$, where μ_t is the investment-specific technological shock. The lump-sum transfer is given by T_t, and the profits of the firms are given by $\mathcal{F}_t$. Following Fernández-Villaverde and Rubio-Ramírez (2006), we assume $a\left[u\right] = \gamma_1 \left(u-1\right) + \frac{\gamma_2}{2}\left(u-1\right)^2$. γ_1 and γ_2 will be linear and quadratic terms in the capital utilization functions, and will be specified in the parameter values below.

The law of motion for capital is:

$$K_{jt} = \left(1-\delta\right) K_{jt-1} + \mu_t \left(1 - S\left[\frac{I_{jt}}{I_{jt-1}}\right]\right) I_{jt}. \tag{3}$$

The depreciation rate is δ, and the form of the adjustment cost function $S\left[\cdot\right]$ is given by $S\left(\frac{I_{jt}}{I_{jt-1}}\right) = \frac{\kappa}{2}\left(\frac{I_{jt}}{I_{jt-1}} - \Lambda_x\right)^2$.[16] Here, κ is the capital adjustment costs parameter, and Λ_x denotes the steady state growth rate of investment-specific technology, noted in the appendix below.

The savers set $C_{jt}^{S}, B_{jt}, u_{jt}, k_{jt}, I_{jt}, L_{jt}$, and a_{jt+1} to maximize the uility function in (1) subject to the budget constraint in (2) and (3). The Lagrangians with respect to (2) and (3) are denoted with λ_{jt} and Q_{jt} respectively. Furthermore, $q_{jt} = \frac{Q_{jt}}{\lambda_{jt}}$ is the Tobin's Q, and the resulting first-order

[16] This adjustment cost function will satisfy the following conditions: $S\left[\Lambda_x\right] = 0, S'\left[\Lambda_x\right] = 0$ and $S"\left[\cdot\right] > 0$.

conditions are:

$$
\begin{aligned}
d_t \frac{1}{C_{jt}^S} &= \lambda_{jt} && (4)\\
\lambda_{jt} &= \beta E_t \left[\lambda_{jt+1} \frac{R_t}{\Pi_{t+1}} \right] && (5)\\
r_t &= \mu_t^{-1} a' \left[u_{jt} \right] && (6)\\
q_{jt} &= \beta E_t \left[\frac{\lambda_{jt+1}}{\lambda_{jt}} \left\{ (1-\delta) q_{jt+1} + r_{t+1} u_{jt+1} - \mu_{t+1}^{-1} a \left[u_{jt+1} \right] \right\} \right] && (7)\\
1 &= q_{jt} \mu_t \left[1 - S\left(\frac{I_{jt}}{I_{jt-1}} \right) - S'\left(\frac{I_{jt}}{I_{jt-1}} \right) \left(\frac{I_{jt}}{I_{jt-1}} \right) \right] && (8)\\
&\quad + \beta E_t q_{jt+1} \mu_{t+1} \frac{\lambda_{jt+1}}{\lambda_{jt}} S'\left(\frac{I_{jt+1}}{I_{jt}} \right) \left(\frac{I_{jt+1}}{I_{jt}} \right)^2
\end{aligned}
$$

Under rational expectations, the Euler equation for the savers will be given by the (5) equation above. Under the case of myopic expectations, the corresponding Euler equation is:

$$
\frac{\lambda_{jt}}{\lambda} = \beta E_t \left[\left(\frac{\lambda_{jt+1}}{\lambda} \right)^{\vartheta} \frac{R_t}{\left(\frac{\Pi_{t+1}}{\Pi} \right)^{\vartheta}} M \right], \tag{9}
$$

where $\vartheta \in (0,1]$ is the myopia parameter. Here, M is a function of the steady state values of λ_{jt} and Π. As Gabaix (2020) notes, the myopic expectations apply to deviations from the steady state. Under rational expectations, $\vartheta = 1$, and (9) will revert to the rational expectations Euler equation in (5).[17] In our benchmark formulation, we only consider myopic expectations for the savers' consumption decision.

For the hand-to-mouth consumers, the budget constraint is given by:

$$
C_{jt}^H = W_{jt} L_{jt} + T_t. \tag{10}
$$

In term of labor, there exists a representative competitive firm with hires the labor supplied by the different households. This labor supplier combines the differentiated labor from households in the following way:

$$
L_t^d = \left(\int L_{jt}^{\frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}}. \tag{11}
$$

Here, $0 \leq \eta < \infty$ is the elasticity of substitution among different labor types, and L_t^d is the aggregate labor demand. The labor supplier's maximization problem, taking as given the differentiated labor wages W_{jt} and the aggrgate wage W_t is described in the appendix. The implied

[17] $M = \frac{1}{\lambda^{1-\vartheta} \Pi^{\vartheta}}$.

input demand function is:

$$L_{jt} = \left(\frac{W_{jt}}{W_t}\right)^{-\eta} L_t^d, \tag{12}$$

and the aggregate wage is:

$$W_t = \left(\int_0^1 W_{jt}^{1-\eta} dj\right)^{\frac{1}{1-\eta}}. \tag{13}$$

Also, households follow the Calvo setting for setting wages. Each period, $(1-\theta_w)$ of households can change their wages. The remaining households partially index their wages to past inflation. Indexation is determined by $\chi_w \in [0,1]$. Following Erceg, Henderson and Levin (2000), we consider the symmetric equilibrium in which $C_{jt}^S = C_t^S, C_{jt}^H = C_t^H, u_{jt} = u_t, K_{jt-1} = K_t, I_{jt} = I_t, \lambda_{jt} = \lambda_t, q_{jt} = q_t$ and $W_{jt}^* = W_t^*$ (optimal wages). The wage equations are:

$$f_t = \frac{\eta-1}{\eta} \left(W_t^*\right)^{1-\eta} \lambda_t W_t^{\eta} L_t^d + \beta\theta_w E_t \left(\frac{\Pi_t^{\chi_w}}{\Pi_{t+1}}\right) \left(\frac{W_{t+1}^*}{W_t^*}\right)^{\eta(1+\gamma)} f_{t+1} \tag{14}$$

$$f_t = \psi d_t \varphi_t \left(\frac{W_t}{W_t^*}\right)^{\eta(1+\gamma)} L_t^d + \beta\theta_w E_t \left(\frac{\Pi_t^{\chi_w}}{\Pi_{t+1}}\right)^{-\eta(1+\gamma)} \left(\frac{W_{t+1}^*}{W_t^*}\right)^{\eta(1+\gamma)} f_{t+1} \tag{15}$$

The real wage then evolves as:

$$W_t^{1-\eta} = \theta_w \left(\frac{\Pi_{t-1}^{\chi_w}}{\Pi_t}\right)^{1-\eta} W_{t-1}^{1-\eta} + (1-\theta_w) W_t^{*1-\eta}. \tag{16}$$

3.2 Firms

The final goods producers are perfectly competitive, and combine intermediate goods using the following production function:

$$Y_t^d = \left(\int_0^1 Y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{17}$$

where ε is the elasticity of substitution. The profit maximization of these firms, and the associated input demand functions are shown in the appendix.

A continuum of intermediate goods producers, indexed by i, use the following production function:

$$Y_{it} = A_t K_{it-1}^{\alpha} \left(L_{it}^d\right)^{1-\alpha} - \Phi Z_t. \tag{18}$$

Here, K_{it-1} is the capital rented by the firm, and L_{it}^d is the packed labor input rented by the firm. A_t is the technology parameter, and Φ is the fixed cost of production. Also, $Z_t = A_t^{\frac{1}{1-\alpha}} \mu_t^{\frac{\alpha}{1-\alpha}}$. Entry and exit of intermediate producers is ruled out. The two-stage problem of the intermediate firms is described in the appendix. The firms are assumed to follow Calvo pricing: in each period, a fraction $1-\theta_p$ of the firms change their prices.

3.3 Government

The government runs a balanced budget every period. In the benchmark model, we assume that the government imposes steady-state constant redistributive transfers which equalize steady state consumption across the two types of households. As in the Bilbiie, Känzig and Surico (2021) framework, this allows us to consider the symmetric steady state, with $C^S = C^H$. Deviations from this will be considered in future work. We note here that Bilbiie, Känzig and Surico (2021) find this to be an inconsequential assumption for their quantitative exercises.

3.4 Central Bank

In the benchmark model, we model the central bank as following a simple policy rule. We consider the Taylor (1993, 1999) rule, and the Kiley-Roberts (2017). Taylor and Williams (2011) discuss the robustness of simply policy rules, and their application in the real world. In ongoing work, we also solve for the Ramsey optimal monetary rule of the central bank, and consider the welfare implications for the two types of the households in the economy.

We begin by considering a Taylor rule of the following form by the central bank:

$$\frac{R_t^{Tay}}{R} = \left(\frac{R_t^{Tay}}{R}\right)^{\gamma_R} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\gamma_\Pi} \left(\frac{\frac{Y_t^d}{Y_{t-1}^d}}{\Lambda_{y^d}}\right)^{\gamma_y}\right]^{1-\gamma_R} \varepsilon_m. \tag{19}$$

This relates the level of the nominal interest rate to the deviations of inflation from target, and the output gap.

The Kiley-Roberts (2017) rule relates the change in the nominal interest rate to the deviations in inflation from its target and the output gap:

$$\frac{R_t^{KR}}{R} = \left(\frac{R_{t-1}^{KR}}{R}\right) \left[\left(\frac{\Pi_t}{\Pi}\right) \left(\frac{\frac{Y_t^d}{Y_{t-1}^d}}{\Lambda_{y^d}}\right)\right]^{\alpha_{KR}} \varepsilon_m. \tag{20}$$

This implementation of the Kiley-Roberts rule implies a commitment by the central bank to remain accommodative following a period in which the ELB binds. The policy keeps a track of the “shadow” rate of interest - that is, the interest rate that would have prevailed had the ELB not realized - and not raise interest rates until the shadow rate rises above the ELB. Also, as Kiley and Roberts (2017) discuss, the policy in (20) better captures the New-Keynesian literature’s emphasis on commitments to maintain policy accommodation for a longer period, and the rule may be nearly optimal.

The policy rate of the central bank is set as follow:

$$R_t = \max[0, Ind^{KR} R_t^{KR} + (1 - Ind^{KR}) R_t^{Tay}], \tag{21}$$

where Ind^{KR} is an indicator variable. It takes a value of 1 if the Kiley-Roberts rule is followed, and 0 if the Taylor rule is followed.

3.5 Aggregation and Equilibrium

In this model framework, the equilibrium is defined by the first order conditions of the household (equations (4), (5), (6), (7), (8), (14) and (15)), firms, laws of motion for prices and wages, the monetary policy rule (21) and market clearing:

$$Y_t^d = \frac{A_t \left(u_t K_{t-1}\right)^{\alpha} \left(L_t^d\right)^{1-\alpha} - \phi z_t}{v_t^p} \tag{22}$$

$$Y_t^d = C_t + I_t + \mu_t^{-1} a \left[u_t\right] K_{t-1} \tag{23}$$

and

$$L_t = v_t^w L_t^d \tag{24}$$

$$v_t^p = \theta_p \left(\frac{\Pi_{t-1}^{\varkappa}}{\Pi_t}\right)^{-\varepsilon} v_{t-1}^p + \left(1 - \theta_p\right) \Pi_t^{*-\varepsilon} \tag{25}$$

$$v_t^w = \theta_w \left(\frac{W_{t-1}}{W_t} \frac{\Pi_{t-1}^{\varkappa_w}}{\Pi_t}\right)^{-\eta} v_{t-1}^w + \left(1 - \theta_w\right) \left(\Pi_t^{*^w}\right)^{-\eta} \tag{26}$$

$$C_t = \left(1 - \Upsilon\right) C_t^H + \Upsilon C_t^S \tag{27}$$

$$K_t = \left(1 - \delta\right) K_{t-1} + \mu_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t \tag{28}$$

As noted above, there is technological growth in this model. In the appendix, we present the corresponding equilibrium equations with the stationary variables.

3.6 Steady State

In the benchmark model, we solve for the steady state in which the consumption of the two types of households is equalized. In this case, $C_{ss} = C_{ss}^H = C_{ss}^S$, where the steady state values are denoted by the ss subscript. This is acheived using the redistributive transfers T_{ss}. To compute this value of the steady state transfers, we first compute the level of L_{ss}^d. We use this to find the value of C_{ss} (from the market clearing conditions). Finally, $T_{ss} = C_{ss} - W_{ss} L_{ss}$, using the constraint of the hand-to-mouth consumers. We solve the model using the perfect foresight solver in Dynare.

3.7 Model Calibration

The full set of model parameters are presented in table 1 below. The rational expectations, representative agent version of the modely will correspond to setting the myopia parameter $\vartheta = 1$, and the percentage of saver households in the economy, $\Upsilon = 1$. The steady state inflation rate in the model is 2%.

Table 1: Model Parameters

Name	*Param*	*Value*	*Name*	*Param*	*Value*
Myopia	ϑ	0.8	Percentage of savers	Υ	0.75
IES	σ	1	Wage indexation	χ_ω	1
Capital adj cost	κ	9.51	Price indexation	χ_p	1
Discount factor	β	0.998	Calvo for prices	θ_p	0.875
Elast of subs b/w labor varieties	η	10	Calvo for wages	θ_w	0.875
Elast of subs b/w good varieties	ε	10	Capital share	α	0.21
Labor disutility	ψ	8.92	Taylor rule smoothing	γ_R	0
Firm fixed costs	Φ	0	Taylor rule infl coeff	γ_Π	1.29
Inverse Frisch elasticity	γ	1.17	Taylor rule output coeff	γ_y	0.19
Pref. shock autocorr	ρ_d	0.9	Kiley-Roberts sensitivity	α_{KR}	0.4
Lab. disutility shock autocorr.	ρ_ψ	0.93	Std dev of pref. shock	σ_d	-1.51
Depreciation rate	δ	0.025	Std. dev of lab disut. shock	σ_ψ	-2.36
Cap. utilization quad. term	γ_2	0.001	Std. dev. mon. policy shock	σ_m	-5.85

4 Model Dynamics

We analyze the dynamics of the model formulated in the previous section. We consider the performance of the model in response to a preference shock, d_t, that is determined as follows:

$$\log d_t = \rho_d \log d_{t-1} + \sigma_d \varepsilon_{d,t}, \ \varepsilon_{d,t} \sim N(0,1). \tag{29}$$

We consider two alternative simple rules in equations (19) and (20). We start by considering the dynamics under the conventional assumptions of representative agents and rational expectations, and then examine the effects of heterogeneous households. Next, we examine the dynamics at the ELB for aggregate variables, and highlight the differences that arise with the introduction of heterogeneity and bounded rationality.

4.1 Small Preference Shock

We begin by considering a small preference shock. The aggregate dynamics are shown for the Taylor and Kiley-Roberts rules in figures 1A and 1B respectively. We first consider the model with rational expectations, and no household heterogeneity. As the figures illustrate, the aggregate dynamics are in line with the standard implications of the New-Keynesian framework: following the shock, policy rule in (21) responds with a decline in the nominal interest rate. The response of aggregate consumption is shown in deviations from steady state, and the initial decline in consumption is smaller under the Kiley-Roberts rule.

Next, we consider the effects of adding heterogeneity of households. The percentage of savers is assumed to be 75% of the households. These responses are shown in figures 2A and 2B for the two policy rules. Away from the ELB, the differences in the consumption dynamics of the hand-to-mouth and saver households are small. After five years, the savers are back at the steady state consumptions, and the hand-to-mouth consumers are approximately 0.2% away from it. Thus, aggregate consumption dynamics are a close approximation of the consumption dynamics of these two groups of households.

Figure 1A: Taylor rule

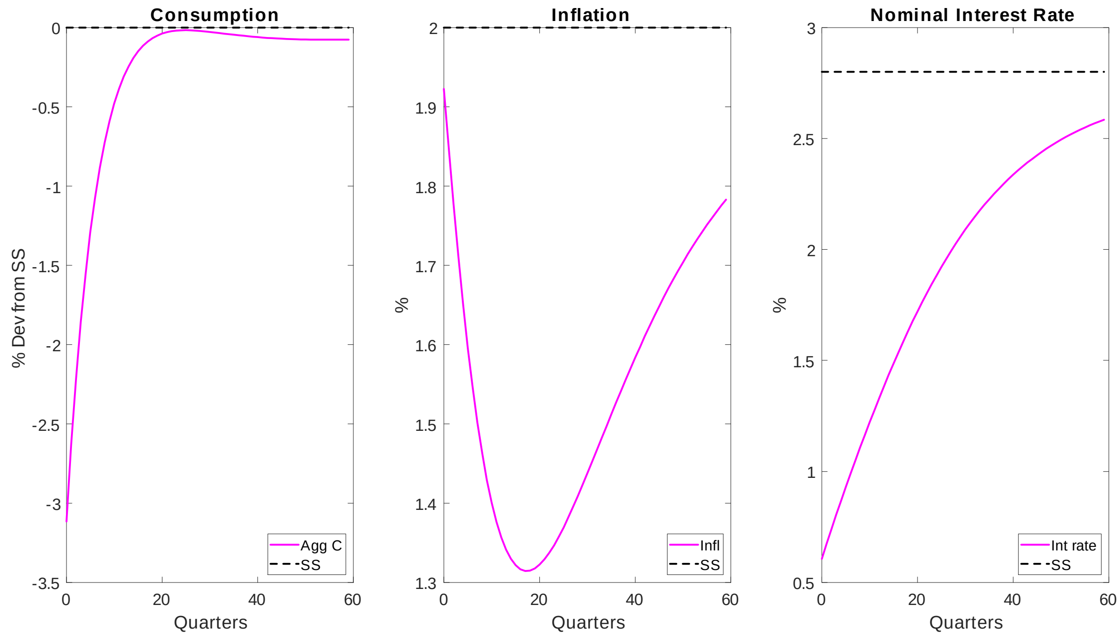
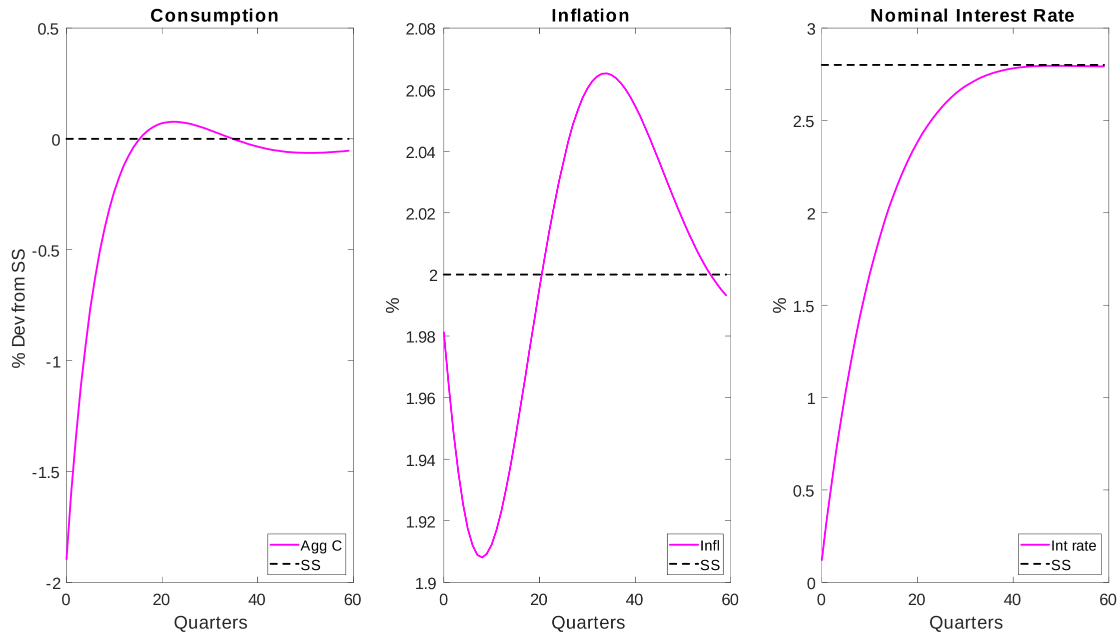


Figure 1B: Kiley-Roberts Rule



Note: These figures show the responses of the aggregate consumption, inflation and nominal interest rate in response to the preference shock. Rational expectations and no heterogeneity are imposed: $\vartheta = 1, \Upsilon = 1$. Pref. shock size is -0.009.

Figure 2A: Taylor rule

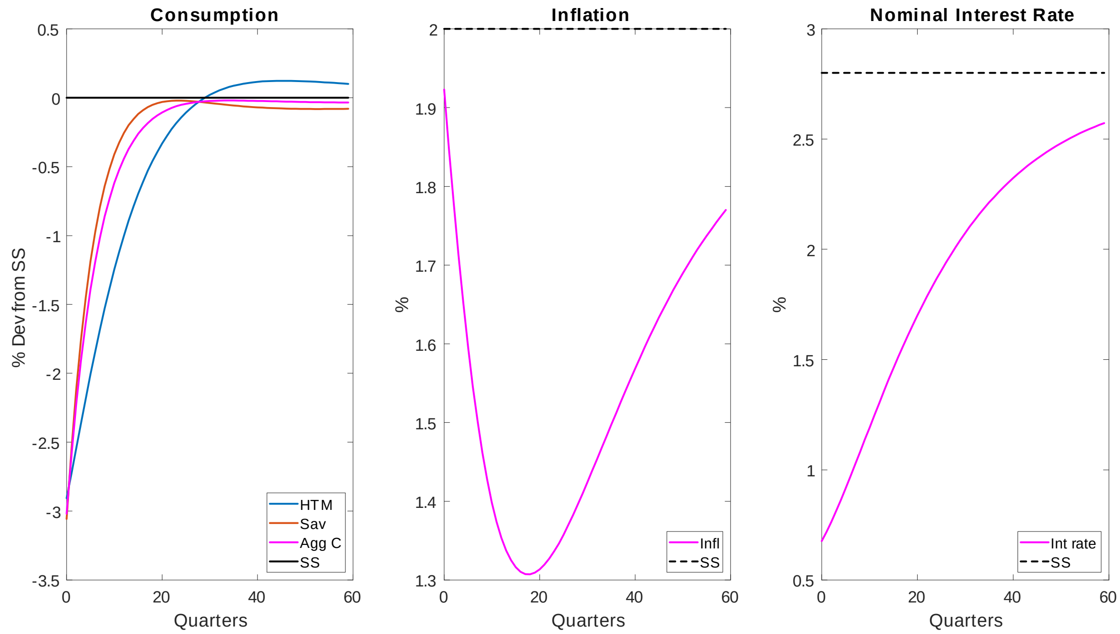
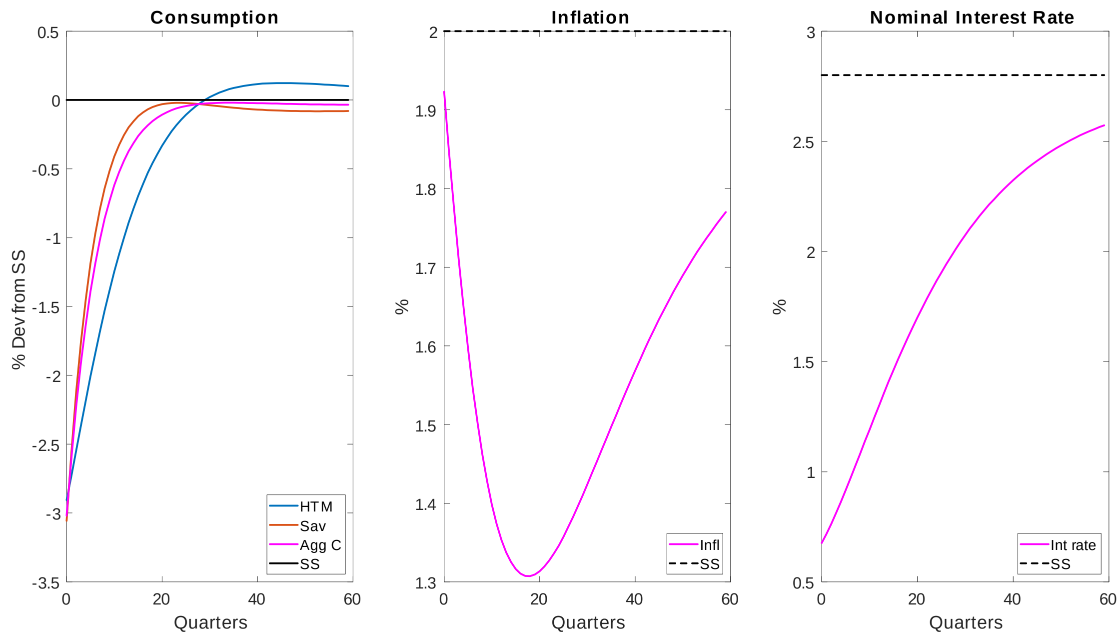


Figure 2B: Kiley-Roberts Rule



Note: Aggregate cons. (Agg C), cons. of hand-to-mouth (HTM) and saver (Sav) households are in % deviations from steady state in response to the preference shock. Inflation and nominal interest rate are in %. Rational exp., and heterogeneity are assumed: $\vartheta = 1$, $\Upsilon = 0.75$. Pref. shock size is -0.009.

4.2 Large Preference Shock

Next, we consider the effects of a preference shock that pushes the economy to the ELB. The dynamics of the model for the representative household model are shown in figures 3A and 3B. In figure 3A, the economy is at the ELB for one quarter, and under the Kiley-Roberts rule, the ELB accommodation is present for three quarters. In figures 4A and 4B, we consider the same shock as in figure 3, now allowing for both saver and hand-to-mouth households. The figures illustrate that the recovery of the hand-to-mouth consumers is more protracted under both policy rules. For example, under the Taylor rule in figure 4A, after ten quarters, the savers are approximately 0.4% below their steady state levels, while the hand-to-mouth consumers are 1% below the steady state consumption. We also note that in the benchmark simulations, we have assumed that the steady of the hand-to-mouth and saver households is the same. This is achieved using redistributive transfers in steady state. While this is assumed for analytical tractability, the steady state consumptions of the hand-to-mouth households would be smaller without the transfer, and the welfare implications could be worse than those implied by figure 4. In ongoing work, we allow for different steady state consumption levels of the two types of households.

Figure 3A: Taylor rule

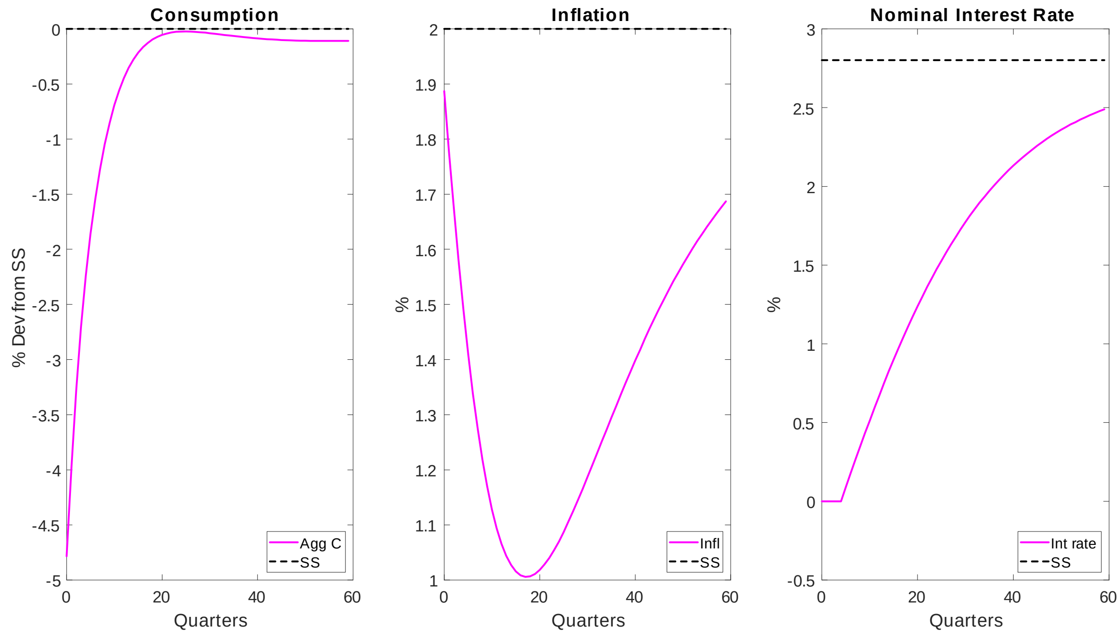
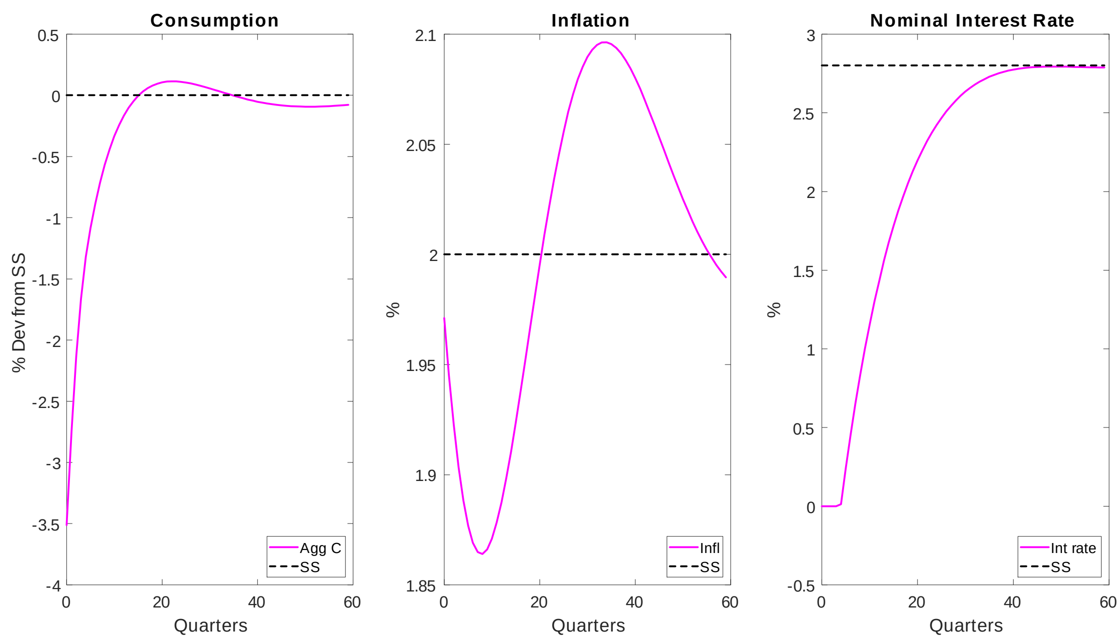


Figure 3B: Kiley-Roberts Rule



Note: These figures show the responses of the aggregate consumption (in percentage deviations from steady state), inflation and nominal interest rate in response to the preference shock. Rational expectations and no heterogeneity are imposed: $\vartheta = 1, \Upsilon = 1$. Pref. shock size is -0.013.

Figure 4A: Taylor Rule

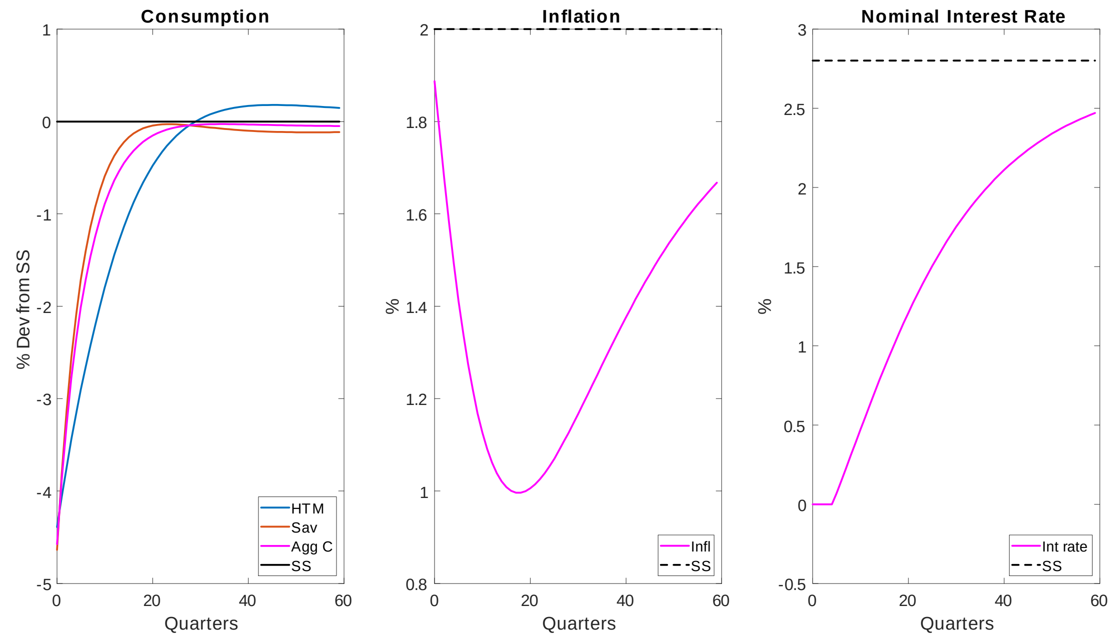
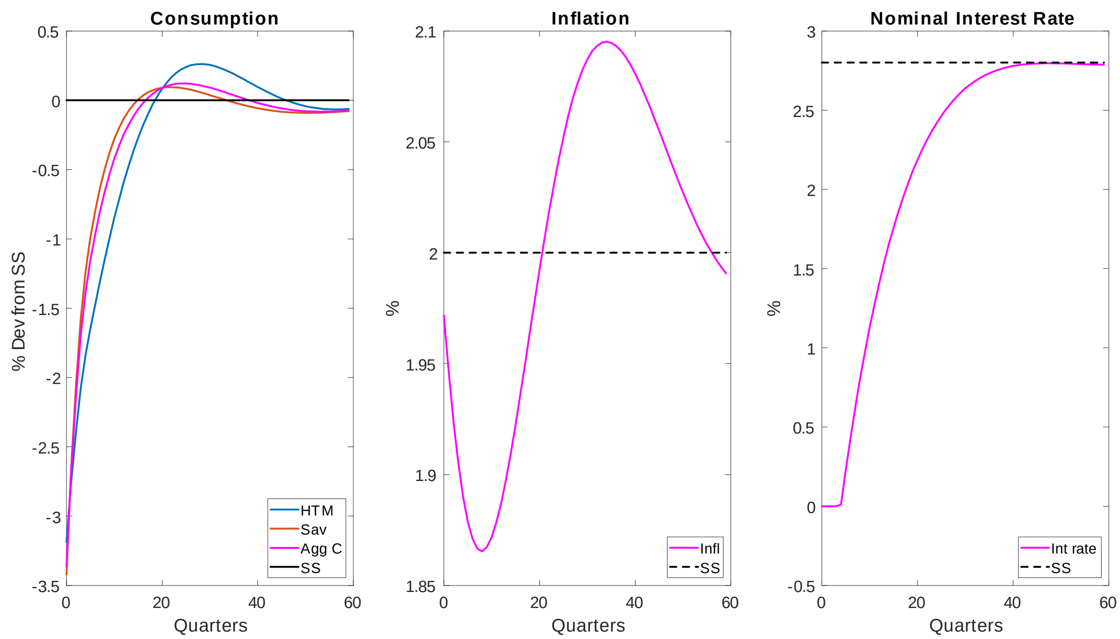


Figure 4B: Kiley-Roberts Rule



Note: Aggregate consumption (Agg C), consumption of hand-to-mouth (HTM) and saver (Sav) households are in % deviations from steady state in response to the preference shock. The responses of inflation and nominal interest rate are in %. Heterogeneity is assumed: $\Upsilon = 0.75$. Pref. shock size is -0.013.

The performance of the model in response to a shock that pushes the economy to the ELB for a longer duration is shown in figure 5. In this case, we also allow for myopia in the expectations formation for the saver households. Figures 5A and 5B illustrate the model dynamics under the Taylor and Kiley-Roberts rules. Here the ELB operates for almost 4 years under the different policy rules. The responses of the consumption dynamics of the hand-to-mouth and saver households in the economy illustrate the disparate effects of the policy intervention on the households. Under this policy shock simulation, both types of households are hit with a large shock to consumption, and it takes the hand-to-mouth consumers almost seven years to reach steady state levels. At ten quarters, the savers are 1.5% below their steady state consumption levels, and the hand-to-mouth are much worse, at 3% below the steady state.

In order to investigate the effects of removing the ELB, we consider the same policy shock in figures 6A and 6B under the two policy rules. Both types of households are better off. Without the ELB, after ten quarters, the hand-to-mouth consumers are approximately 2.4% below the steady state consumption levels. The performance under the Kiley-Roberts rule is even better, as the nominal interest rate is allowed to be even more negative than under the Taylor rule.

Our model simulations suggest that the constraint of the ELB has disparate effects on the savers and hand-to-mouth households. The latter fare even worse in case of shocks that push the economy to the ELB for an extended period. Removing the ELB constraint improves the economic performance of the aggregate economy, while also allowing the hand-to-mouth consumers to recover faster. Central Bank Digital Currency (CBDC) is a way to eliminate the ELB.

Figure 5A: Taylor Rule

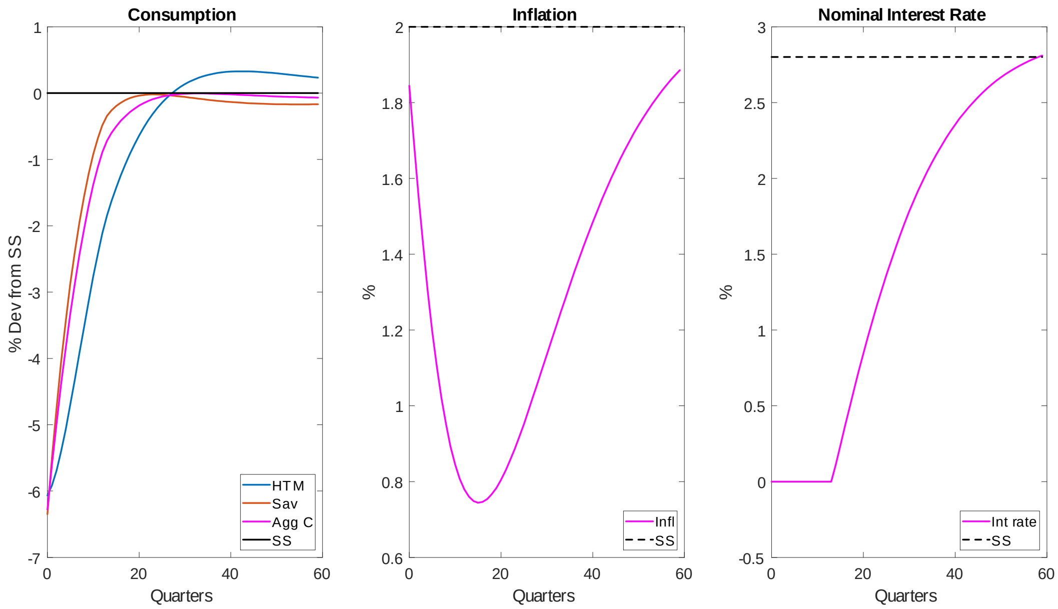
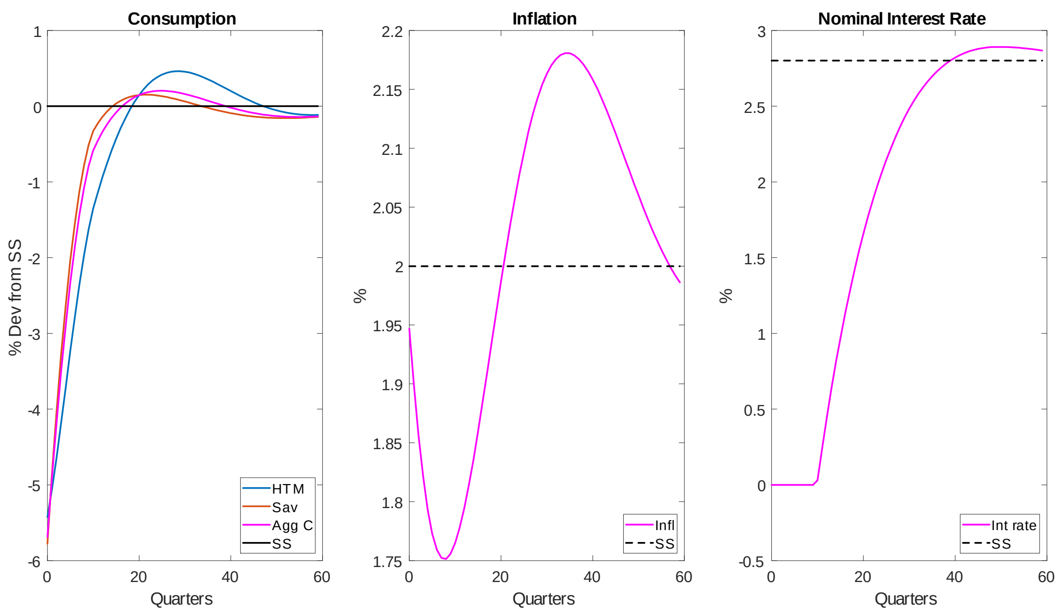


Figure 5B: Kiley-Roberts Rule



Note: Aggregate consumption (Agg C), consumption of hand-to-mouth (HTM) and saver (Sav) households are in % deviations from steady state in response to the preference shock. The responses of inflation and nominal interest rate are in %. Myopia, and heterogeneity are assumed: $\vartheta = 0.8, \Upsilon = 0.75$. Pref. shock size is -0.022.

Figure 6A: Taylor Rule

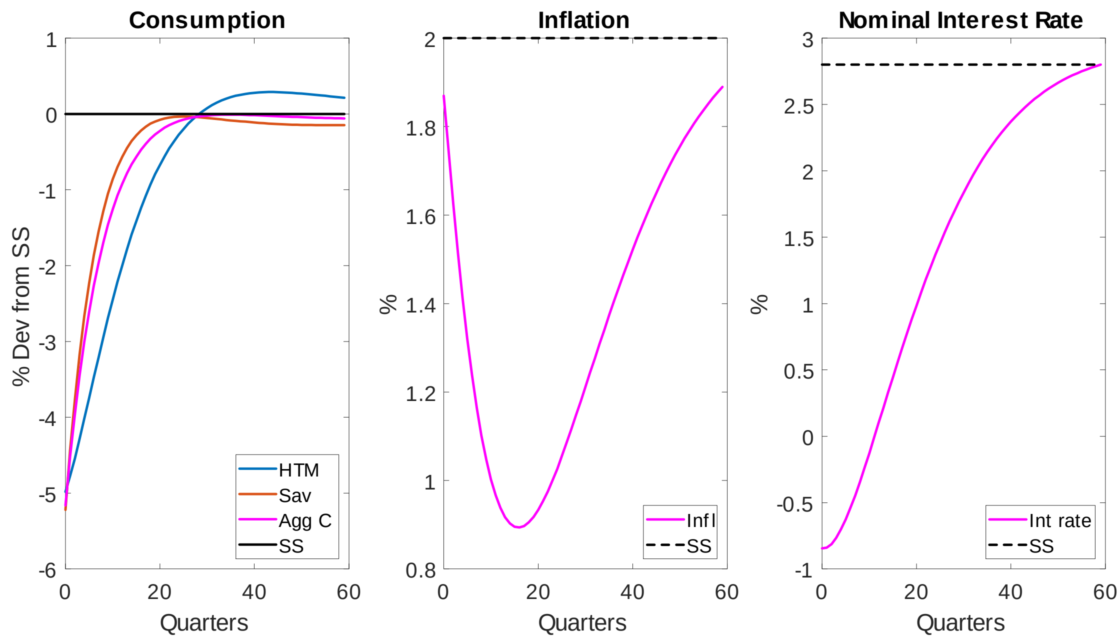
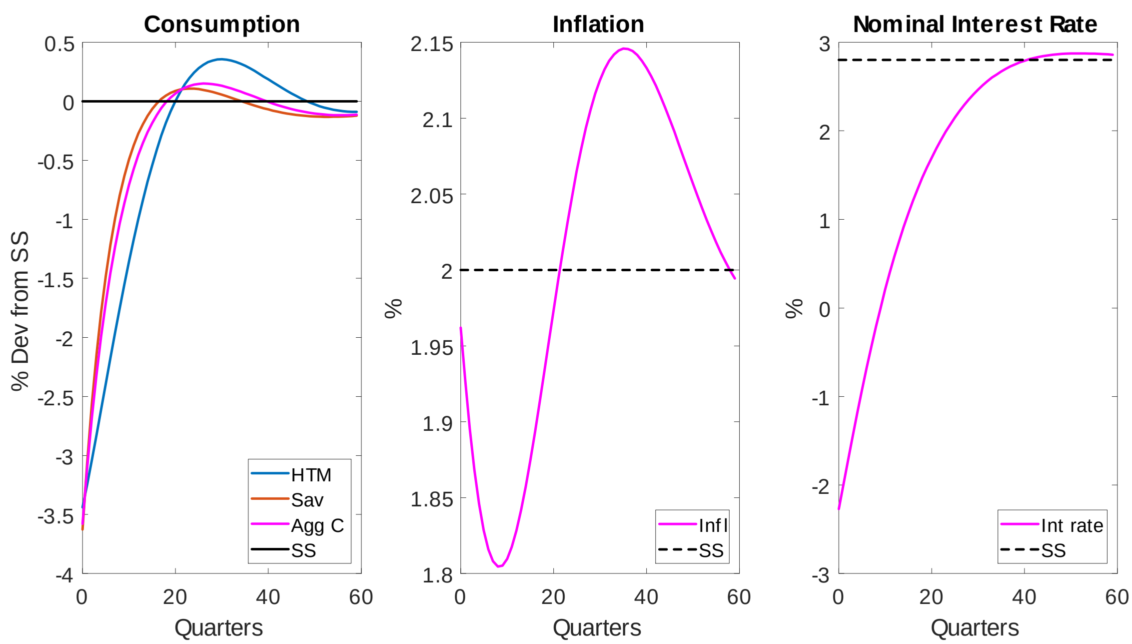


Figure 6B: Kiley-Roberts Rule



Note: Aggregate consumption (Agg C), consumption of hand-to-mouth (HTM) and saver (Sav) households are in % deviations from steady state in response to the preference shock. The responses of inflation and nominal interest rate are in %. Myopia, and heterogeneity are assumed: $\vartheta = 0.8, \Upsilon = 0.75$. Pref. shock size is -0.022.

5 Design Principles for CBDC

In this section, we describe the broad design principles for CBDC, and the role it would play in the operation of monetary policy. Bordo and Levin (2017, 2019) have emphasized that CBDC can fulfill the three basic functions of money, serving as a practically costless medium of exchange, a secure store of value, and a stable unit of account. While private forms of money can fulfill some aspects of these functions, there are intrinsic reasons why households and nonfinancial firms should also have access to a fiduciary form of money issued by the central bank. In particular, the central bank's money serves as a unit of measure that facilitates the economic decisions and financial plans of all households and firms. Moreover, in an efficient monetary system, the medium of exchange should serve as a secure store of value that bears the same rate of return as other risk-free assets.[18] By contrast, any purely private form of money is intrinsically subject to default risk and hence cannot serve as a reliable medium of exchange nor as a stable unit of account. In light of these broad principles, we have formulated the following set of basic design principles for establishing CBDC:

- Public-Private Partnerships: CBDC should be provided through designated accounts held at supervised financial institutions, which would hold part or all of those funds in segregated reserve accounts at the central bank.[19] In effect, the central bank will be responsible for managing the centralized ledger, while supervised financial institutions provide CBDC "wallets" for their customers. This approach would foster competition among financial institutions and protect the privacy of individual transactions while facilitating appropriate law enforcement. In effect, the provision of digital cash would be similar to that of many other aspects of our public infrastructure.

- Security and Efficiency: With a centralized ledger, each payment transaction can be transmitted instantaneously and securely at practically zero cost, simply debiting the payer's digital cash account and crediting the payee's digital cash account. Moreover, the scope and scale of fraudulent transactions can be mitigated by standard and efficient security methods such as two-step identity verification.

- Legal Tender: The digital cash should serve as legal tender, usable for all public and private payment transactions. In addition, consumers and firms should remain free to make transactions using any other legal form of payment, such as credit cards, debit cards, or online services. Moreover, some individuals and small businesses may still prefer to use paper cash

[18] Friedman (1960).
[19] See Tobin (1987).

for some of their transactions. However, once digital cash becomes convenient and ubiquitous, the demand for paper cash and coins will rapidly diminish. Indeed, it may not be very long before paper currency is merely a collector's item, similar to typewriters and audio cassette tapes.

- Store of Value: Digital cash accounts should serve as a secure store of value that bears the same rate of return as other risk-free assets such as treasury securities, thereby eliminating the opportunity cost of holding money.[20] While interest-bearing digital cash might seem like a dramatic new development, in fact the Federal Reserve has already implemented similar measures whose benefits accrue mainly to large financial institutions and "high net worth" individuals:

  - A wide array of financial institutions (such as money market funds and pension funds) can engage in repo market transactions in which they "lend" funds to the Federal Reserve and earn interest on those funds. As of mid-October 2021, the Federal Reserve's reverse repo facility held about \$1.8 trillion in funds from such institutions, nearly the same as the amount of currency in circulation (\$2.2 trillion).
  - Customer deposits at institutions designated as systemically important financial market utilities (FMUs) are held in special accounts at the Federal Reserve so that the clients of those institutions may rest assured that their funds are secure, liquid, and interest-bearing. For example, the margin accounts of traders at the Chicago Mercantile Exchange and the customers of ICE Clear Credit are held in segregated deposits at the Federal Reserve Bank of Chicago.
  - The Federal Reserve pays interest on the reserves that commercial banks hold at the Federal Reserve. The interest rate on reserves (IOR) is currently very low, but as of two years ago it stood at 2.35%. At that time, commercial banks paid similar rates on the funds that they borrowed and lent in wholesale markets, whereas they paid no interest at all on the checking accounts of ordinary households and small businesses. With the establishment of digital cash, all consumers and small businesses would be able to receive a competitive interest rate on their payment accounts.

- Eliminating Arbitrage Incentives: Given that funds held in digital cash wallets will be fully secure, safeguards will be needed to ensure that "high net worth" individuals and financial institutions do not seek to transfer large amounts of assets into digital cash accounts at times when the financial system is under stress. Placing fixed upper limits on the size of

[20] See Friedman (1960).

such accounts might prove impractical or exacerbate systemic stress. Therefore, our analysis involves a two-pronged approach:

- The central bank should impose fees on very large holdings of digital cash. For example, digital cash accounts above a specific threshold could be subject to a holding fee of 2% that would be sufficient to discourage asset holders from liquidating private assets and moving those funds into digital cash. In effect, this arrangement would be reminiscent of the fees that banks charge for maintaining safe deposit boxes, except that such fees would only pertain to very large holdings of digital cash and would only be imposed under extraordinary circumstances.
- The central bank should impose fees on very large transfers between digital cash and paper cash. For example, transfers exceeding a specified threshold in a single day might be subject to a transfer fee of 2 percent. Such fees would curtail incentives for arbitrage between paper cash and digital cash, while ordinary consumers and small businesses would remain free to use paper cash without incurring any fees at all.

- Price Stability: The interest rate on digital cash should become the central bank's primary tool for conducting monetary policy.[21] During normal times, this interest rate would be positive. In the face of a severe adverse shock, the central bank could push market interest rates below zero by imposing fees on large holdings of digital cash.[22] However, the interest rate on digital cash held by ordinary households and small businesses would never drop below zero. Consequently, the establishment of CBDC would strengthen the central bank's ability to carry out its mandate of fostering price stability and economic recovery.

6 Conclusion

Our analysis illustrates the parallels between golden fetters and paper fetters. Since paper currency accrues no interest, it constrains the operation of monetary policy. The model analysis accounts for the disparate nature of households in terms of their savings behavior, and suggests that long-lasting ELB episodes have severe implications for hand-to-mouth consumers, relative to the asset holders. Finally, we discuss the rationale for introducing a CBDC that would facilitate the elimination of the ELB without any need to abolish paper cash, undermine the stability of the banking system, or impose taxes or fees on ordinary households and small businesses.

[21] See Rogoff (2016).

[22] See Aggarwal and Kimball (2015), Buiter (2009), Goodfriend (2000, 2016).

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