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LIQUIDITY TRAPS:
A UNIFIED THEORY OF THE GREAT DEPRESSION AND GREAT RECESSION

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Liquidity Traps: A Unified Theory of the Great Depression and Great Recession
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ABSTRACT

This paper presents a unified framework to explain three major economic downturns: the U.S. Great Depression, the U.S. Great Recession, and Japan's Long Recession. Temporary economic disruptions, such as banking crises and excessive debt accumulation, can drive natural interest rates into negative territory in the short term. At the same time, structural factors, including demographic decline and rising inequality, can depress natural interest rates over short and long horizons. A negative natural interest rate and the zero lower bound (ZLB) are necessary conditions for a liquidity trap. Credible monetary policy can counteract the adverse effects of short-run liquidity traps. Diminished monetary policy credibility or persistent negative natural rates may necessitate fiscal interventions. The framework sheds light on the macroeconomic challenges of low-interest-rate environments and underscores the central importance of *policy regimes*. We close by reflecting on the great macroeconomic question of our time: Will short-term interest rates collapse back to zero once the inflation surge of the 2020s moves to the back mirror and the political landscape in the US has dramatically changed?

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1 Introduction

"To understand the Great Depression is the Holy Grail of Macroeconomics" Ben Bernanke, former Chair of the Federal Reserve, 1995[1]

This paper reviews the modern literature on the liquidity trap: the awkward situation where the central bank has cut its policy rate to zero and cannot cut it further due to the zero lower bound (ZLB). With the most potent tool constrained to react to falling inflation and rising unemployment, the government seeks alternative options.

Two cases of a liquidity trap changed the course of history: the Great Depression and the Great Recession. These historical turning points had far-reaching consequences; arguably, the Great Depression played a central role in explaining the rise of Hitler and World War II. More generally, recent research has found that the increase of populism, both left and right, is highly correlated with macroeconomic crises. Looking over the past 120 years, for example, Funke, Schularick and Trebesch (2023) find that the rise in populism has two peaks: the years following the start of these two major economic crises, triggering in some cases dictatorships, the collapse of democratic institutions, and war.

The U.S. experience during the Great Depression and the Great Recession is the central empirical counterpart to the theoretical analysis in this review. We also comment on the Long Recession in Japan, which started the modern general equilibrium literature on liquidity traps with Krugman (1998*a*), and comment briefly on the experience of several other industrial countries.

The assumed fiscal and monetary policy regime is a fundamental driver of all the main results. It is at the core, for example, of Temin and Wigmore (1990) explanation for the end of the Great Depression, which they attribute to a regime change in the spirit of Sargent (1982). As we explain below, the idea of a policy regime will be one of two organizing principles of this review.

We define the liquidity trap as follows: a liquidity trap is a general equilibrium in which the nominal interest rate has collapsed to zero *and* the fiscal-monetary policy regime implies a further decline in the nominal rate — if not for the ZLB.

This definition does not imply that a central bank "can do nothing" or that expansionary monetary policy is like "pushing on a string."[2] It only suggests that the central bank has reached the ZLB and would choose lower policy rates if not for the ZLB for a given monetary and fiscal policy regime. Even with short-term rates at zero, the central bank can increase aggregate spending by changing expectations about future interest rates, inflation, and output once the ZLB is no longer binding. The power of central banks to manage expectations suggests a less pessimistic view of monetary

[1] See Bernanke (1995).

[2] The idea that monetary policy loses its power when *long-term* interest rates are sufficiently low is central in Keynes (1936). See Eggertsson and Petracchi (2021) for a discussion of the relationship between the original and modern definitions of the liquidity trap. The term "liquidity trap" is attributed to Robertson (1940). The metaphor comparing monetary policy at the ZLB to pushing on a string originated from Democratic Congressman Thomas A. Goldsborough during a Congressional hearing on the Banking Act of 1935. See Wood (2006) and Sandilands (2001).

policy's effectiveness in a liquidity trap relative to the early literature on the liquidity trap inspired by Keynes (1936). Yet, changing expectations can be challenging if the central bank lacks credibility or the underlying shocks are permanent. In this case, Keynes' policy prescriptions of using discretionary government spending to maintain sufficient aggregate demand in downturns still resonate today.

Our review has two central organizational principles, as illustrated in figure 1. The first organizational principle is the *nature of the underlying shocks* that led to the Great Depression, Great Recession, and Long Recession. The left column of Figure 1 shows sections where the ZLB is binding due to temporary shocks, while the right column shows where the ZLB may be binding due to permanent shocks. We ask: What are their driving forces? Do these forces respond to policy? Can these forces be characterized in a parsimonious way?

The assumed *monetary and fiscal policy regime* is the second organization principle. Figure 1 shows how each section is organized from top to bottom, based on assumptions about the policy regimes. A monetary and fiscal policy regime specifies how policy is determined not only today but no less importantly in the future. Accordingly, the policy regime shapes expectations today, which have a first-order impact on today's aggregate demand and supply.

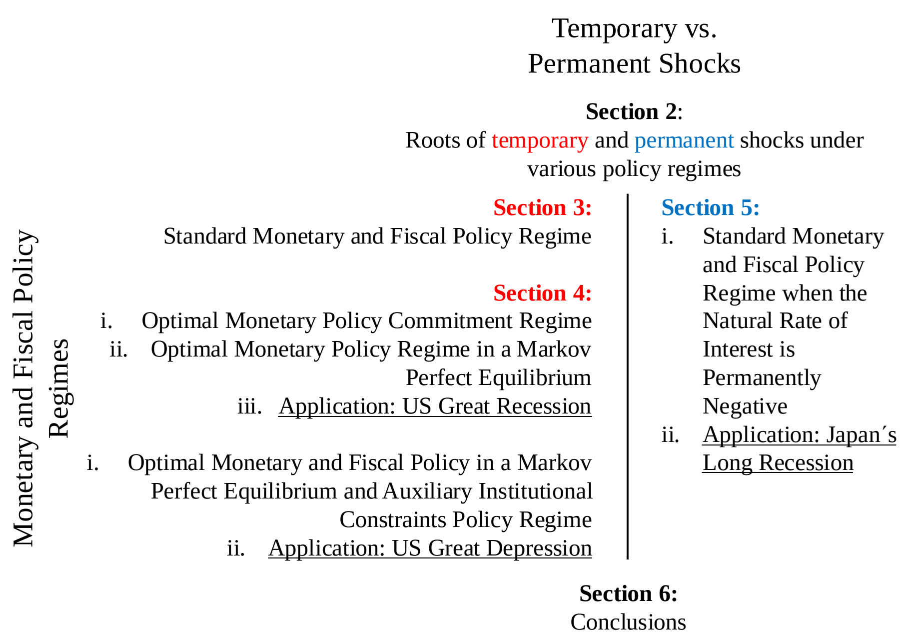


Figure 1: Two Organizational Principles of the Paper

To see why these organizational principles are central, consider the classic question of macroeconomics in depression: What is the multiplier of government spending? This statistic answers the following question, cast in its simplest form: If the government increases its spending by one dollar, by how many dollars does aggregate GDP increase? We cannot address the question unless we specify the monetary and fiscal policy regime and determine whether the shock is short-lived or permanent.

Consider a shock that makes the ZLB temporarily binding, and suppose monetary policy fixes the interest rate at the ZLB throughout the shock's duration. Then, a central result is that the multiplier can be very large. Meanwhile, faced with a temporary shock, if monetary policy is flexible and can compensate for its inability to cut rates today with promises of future interest rate reductions, then the spending multiplier is smaller since monetary policy will endogenously reduce its expansionary stance in response to the fiscal expansion. Yet the ability of the monetary authority to compensate for current rate cuts with commitment to future ones depends crucially on two assumptions. First, the shock is only temporary. Second, the central bank has the credibility to manipulate expectations about future interest rates.

Researchers have formulated numerous policy regimes and stochastic shock processes to generate the ZLB. When posing a particular policy regime and the underlying shock process, we have a specific objective in mind: to illuminate public policy choices made during the Great Depression, the Great Recession, and the Long Recession. We argue that what emerges are elements of a unified theory of these episodes, from which we can draw some tentative but broad lessons.

This review is divided into four main sections, each addressing a broad theme aligned with the two central principles discussed above. To maintain perspective on the overall structure, we encourage readers to refer to the road map in Figure 1 as we outline the remainder of this paper.

Section 2 reviews the two building blocks of a liquidity trap: The first is the shocks, i.e., forces that generate a negative natural *real* interest rate. It is the equilibrium real interest rate under the assumption that wages and prices are fully flexible.[3] We distinguish between fast-moving and slow-moving forces. Examples of fast-moving forces are firm/household debt overhang, banking crises, and asset bubbles that can generate negative natural rates in the short run. Slow-moving forces include demographics (slowdown in population growth or increased life expectancy), permanent rise in inequality, and falling productivity. These forces can generate a negative natural interest rate in the short and long run.

The second building block of the liquidity trap is the ZLB. You do not want to lend anybody 1 dollar unless you receive at least 1 dollar in return (abstracting from storage costs), for then you are better off sitting on it. The ZLB arises from the existence of paper currency. We briefly review how it can be relaxed, a topic we return to later in the paper. Section 2 focuses on the two building blocks and offers only crude specifications of the monetary and fiscal policy regimes, which are the primary focus of the following two sections. Yet, even with only the two building blocks and a very stylistic policy regime, section 2.3 allows us to make a critical empirical prediction that was very controversial when first stipulated by Krugman (1998*a*). Krugman (1998*a*) was the first to formulate this prediction in a modern microfounded general equilibrium model. Krugman showed that under certain conditions, printing money has no effect on prices. Previously, this prediction had largely been discounted as an old Keynesian fairy tale. Indeed, Krugman (2022) has described how his original motivation for

[3] We only consider exogenous shocks in this review as a reason for the ZLB being binding. We do not consider the possibility of self-fulfilling beliefs generating a liquidity trap, a separate branch of the literature. The seminal paper in that literature is Benhabib, Schmitt-Grohé and Uribe (2001). This important branch of the literature merits a separate review.

the paper he presented in 1998 paper was to expose that the prediction was indeed, only a fairy tale. Once subjected to the rigor of micro-foundations, however, to his surprise the fairy tale came true!

The review next analyzes the consequences of different policy regimes under various assumptions of the underlying shocks. We start by focusing on the temporary negative natural rate of interest.

Section 3 introduces the textbook New Keynesian Model. In line with our two main organization principles, we limit our attention first to (i) the *Standard monetary and fiscal policy regime* under (ii) the assumption that the ZLB is only temporarily binding. In brief, a simple way of describing this policy regime is that monetary policy follows the classic Taylor rule regime unless constrained by the ZLB. At the same time, we consider a family of fiscal policy specifications given this monetary policy regime.[4]

The Standard monetary and fiscal policy regime has been the focus of much of the existing literature. We impose the necessary conditions for a liquidity trap, as reviewed in section 2, and explore the following questions. Suppose the monetary policy regime remains fixed. How effectively substitute to interest rate cuts are alternative policies, ranging from classic aggregate demand or supply policies to "unconventional" monetary policy that directly intervenes in the financial markets? Can the underlying shocks be directly addressed? Are there policies that may circumvent the ZLB itself?

The Standard monetary and fiscal policy regime forces policymakers to confront a topsy-turvy world in which many traditional economic laws are stood on their head. As we will see later, but worth highlighting at the start, these properties derived in section 3 depend at a fundamental level on the assumed policy regime. In response to shocks, the nominal rates collapse to zero. It only turns positive once the shock subsides.

The first major result is that a fiscal stimuls, that is in direct response to the shocks, can be very large, and in general larger than on at the ZLB assuming the Standard fonetary and fiscal policy regime.

Next, we review the paradox of price flexibility, suggesting that increasing price flexibility generates more significant recessions so that traditional market price mechanisms cannot be relied upon to bring about stability. The paradox of toil poses another challenge, stipulating that while positive supply reform improves the economy's production capacity, those policies might contract demand when the economy does not fully utilize its production capacities. This happens by generating deflationary expectations which imply more restrictive monetary policy whose power is driven by the real interest rate $r = i - \pi^e$.

We also consider an extension that connects the modern theory to the older Keynesian literature, which first introduced the notion of fiscal multiplier (whose foundation was that one's spending becomes other people's income who will increase their spending, generating higher income of a "third round" of people who will also spend a fraction of their income and so on). This multiplier effect is

[4] An alternative way of describing the monetary regime, which we show is identical for many applications, is via a strict inflation target, according to which the central bank sets its interest rate to achieve the target unless the ZLB prevents it from doing so. In this case, the central bank sets the interest rate at zero.

absent in the canonical New Keynesian model. We show a simple extension in which some agents are debt-constrained while others are not. Introducing debt-constrained agents allows us to connect directly with the older Keynesian literature. Now, the multipliers are even more significant and paradoxes get exaggerated even further. Section 3 closes by reviewing tax proposals designed to eliminate the problem of the ZLB and discusses possible practical limitations,

Section 4 analyzes the same model as in section 3 but relaxes one of the central assumptions from section 3 – one of the two organizational principles of this review: The policy regime. Instead of the Standard monetary and fiscal policy regime, we ask: what is the optimal policy regime? How is the design affected by the ability of the central bank and fiscal authorities to commit to future policy and set their policies to maximize a joint objective? This part of the review is not simply a theoretical characterization of abstract policy regimes. Instead, we focus the analysis on a subset of possible policy regimes that we believe are most useful in understanding actual policy-making in the Great Recession, the Great Depression, and the Long Recession in Japan.

We first consider two opposite extremes focusing on the monetary policy regime. The *Optimal monetary policy commitment regime* is at one end of the spectrum: The central bank maximizes welfare and can fully commit to future short-term interest rate policy. The *Optimal monetary policy in a Markov Perfect Equilibrium* is at the other end of the spectrum. In a Markov Perfect Equilibrium, the central bank shares the same objective as under commitment but can only formulate strategies that are functions of the current values of state variables of the policy game, precluding policies like forward guidance about future interest rates due to credibility problems, absent further adjustment to the game. We show that the equilibrium predicted by the Optimal monetary policy regime in a Markov Perfect Equilibrium is identical to that of the Standard monetary and fiscal policy regime.[5]

While neither the Optimal monetary policy regime in a Markov Perfect Equilibrium nor the Optimal monetary policy commitment regime fully captures reality, we review evidence suggesting both provide valuable insights into the policy challenges policymakers confronted during the Great Recession based on narrative evidence from declassified Federal Reserve Open Market Committee Minutes and speeches from policymakers during this period.

One lesson from section 3, assuming a credible optimal monetary policy regime, is that the ability of the monetary policy authorities to commit to future interest rate policy has a fundamental effect on the effect of other policy interventions. Consider the fiscal multiplier. Suppose the central bank is able to adopt the Optimal monetary policy commitment regime, allowing it to commit to low future interest rates. In that case, an expansionary fiscal policy leads to a tighter monetary policy, simply less monetary easing is needed, resulting in fiscal policy having a more modest impact and resembling results derived at positive interest rates. If monetary authorities successfully adopt this regime at the

[5]The Optimal monetary policy in a Markov Perfect Equilibrium is often referred to as optimal policy under discretion. We prefer using Markov Perfect Equilibrium language because it becomes more natural to consider alternative policy regimes differentiated by additional institutional constraints, such as the gold standard or other well-defined "commitment technologies." One such technology is the government's ability to pay back debt in nominal value: No country that can print currency has chosen outright default over indirect default via inflation. Markov Perfect Equilibrium language also allows for the introduction of well-defined verbal "commitment technologies" that may fall short of the central bank's ability to commit fully but provide a valuable perspective of what can be achieved short of that.

ZLB, they will largely avoid a ZLB recession. Not only are multipliers orthodox in the Optimal monetary policy regime, in addition regular economic logic applies, and most of the paradoxes assuming the Standard monetary and fiscal policy regime no longer apply.

The empirical evidence we review suggests that neither an Optimal monetary policy regime in a Markov Perfect Equilibrium nor an Optimal monetary policy commitment regime can describe in a satisfactory way the actual policy regime in the United States during the Great Recession. Instead, a more general specification is needed to account for the data, which the literature has not yet reached a consensus on. We offer some comments on possible avenues for future research that may capture a more general monetary policy regime consistent with observations from the Great Recession. Based on the latest empirical evidence we review, our assessment is that an emerically realistic policy regime should generally demonstrate properties that align with large spending multipliers and the paradox of toil while simultaneously highlighting a non-trivial role of forward guidance.

Next, we consider Optimal monetary *and* fiscal policy regime in a Markov Perfect Equilibrium, and take into account institutional constraints. Three institutional constraints are of primary importance during the U.S. Great Depression: The gold standard, a commitment to a balanced budget, and a limit on the size of the government. Optimal monetary and fiscal policy regime in a Markov Perfect Equilibrium assumes that the government can credibly pay back its debt's nominal value as in Calvo (1978) and Lucas and Stokey (1983).

We define regime change as a major change in some institutional constraints. The model we review formalizes Temin and Wigmore (1990) hypothesis that the regime change implemented by Franklin Delano Roosevelt in 1933 ended the Great Depression, which we model as elimination of these institutional constraints, and sheds light on the second phase of the Great Depression, characterized by the "Mistake of 1937" and the recovery that had begun before WWII spending started. We show that a simple New Keynesian model can replicate in broad brush the evolution of key variables during this time period.

Section 5 relies on the two vital organizational principles of the review. In contrast to 3 and section 4, we now consider the possibility that the natural interest rate is negative in both the short and the long run while policy follows the Standard monetary and fiscal policy Regime. This analysis builds on the secular stagnation hypothesis, which Summers (2014) recently resurrected based on Hansen (1939). Formalizing the secular stagnation hypothesis in a modern general equilibrium model requires a fundamental reformulation of the New Keynesian model's aggregate demand and supply side - an approach first attempted in Eggertsson and Mehrotra (2014) with an extensive literature following. Building on these developments, we show that while some of the policy implications of section 3 and section 4 still apply, others need to be modified. This section focuses on analyzing policy under the Standard monetary and fiscal policy regime; however, studying optimal policy in secular stagnation should be a high priority for future research.

We summarize the policy implications at a broad level as follows:

1. A sufficiently credible and flexible monetary policy can largely offset a temporary drop in the natural interest rate by adapting the Optimal Monetary Policy Commitment Regime. The force of credible monetary policy in the face of temporary shocks represents one of the critical policy implications of this review.

2. Carefully designed fiscal support becomes critical if the monetary policy regime lacks credibility to support a robust recovery. In this case fiscal policy is one of the central lines of defense that is robust across different models.

3. Credit easing, or Quantitative Easing (QE), can directly affect the natural interest rate. This policy proved particularly effective when financial markets experienced severe disruption, as seen in the immediate aftermath of the Great Financial Crisis of 2008. Even in periods without financial disruption, QE, through the purchase of long-term securities, can influence interest rates, though studies demonstrate varying degrees of effectiveness across different market conditions and implementation approaches.

4. Monetary policy can lose much of its power if the natural interest rate remains negative in the short and long run. In this case, carefully designed fiscal support becomes *essential*. As of writing, this raises a fundamental question: Has the natural rate declined permanently, as many believed before the inflation spike of the 2020s, or will it return to pre-Great Recession levels now that some indications show inflation is stabilizing?

The long-run evolution of the natural interest rate represents one of the central macroeconomic unknowns of our time.

2 The Root Causes of the Liquidity Trap

Section 2 reviews the two building blocks of a liquidity trap. Subsection 2.1 defines the natural interest rate and reviews the forces that can cause it to become negative, forming the first building block. The second building block, reviewed in subsection 2.2, is the existence of paper currency, which gives rise to the zero lower bound (ZLB). If the natural rate is negative, the central bank must set negative policy rates to maintain price stability, which is impossible due to the ZLB. Subsection 2.3 concludes by reviewing an important empirical prediction derived from these two building blocks, which states that increasing money supply is irrelevant if expectations of future monetary policy are entrenched.

2.1 The First Building Block of a Liquidity Trap: A Negative Natural Rate of Interest

We distinguish between fast-moving and slow-moving forces that can generate negative natural interest rates. Fast-moving forces, such as banking crises and the overaccumulation of debt by households or firms, lead to temporary negative rates. Slow-moving forces, including declining birth rates, increasing life expectancy, and rising inequality, may trigger permanently negative rates.

2.1.1 The Natural Rate of Interest and the Liquidity Trap

The natural interest rate plays a fundamental role in this review as the first building block of the liquidity trap. A negative natural rate is a necessary condition for the liquidity trap under plausible restrictions on the monetary policy regime.

To understand why a negative natural rate is a necessary condition for a liquidity trap, we find it helpful to review the origin and modern formulation of the concept. Knut Wicksell, a Swedish economist, first proposed the idea in 1898, defining it as the interest rate if prices are stable (Wicksell (1898)). According to the modern definition proposed by Michael Woodford, it is the real interest rate (r) if all prices are flexible in the New Keynesian model. Since prices are sticky in the New Keynesian model, it is purely a fictional construct that cannot be directly observed (Woodford (1999)). Woodford demonstrates that a central bank achieves complete price stability, i.e., a constant price level, if it sets the policy rate (i) equal to the natural rate of interest, as will be evident in section 3 when we introduce the New Keynesian model. With constant prices, a negative natural rate implies a negative nominal interest rate, violating the ZLB. A negative natural rate is a *necessary condition* for a liquidity trap, assuming the central bank has a weakly positive inflation target ($\pi \geq 0$) but not a *sufficient* condition. For example, a central bank targeting a 2% inflation target can accommodate the negative natural rate as low as -2% since at the ZLB, $r = i - \pi = -2\%$.

The definition of the natural rate of interest as the real interest rate when all prices are flexible suggests a straightforward way of proceeding. We can focus on simple environments that help us address the following question: what are plausible conditions in which the real interest rate under flexible prices/wages turns temporarily or permanently negative? To answer this, we can abstract from price level determination and, in large part, simplify the analysis by treating output as exogenous. This abstraction is made with the understanding that output can be made endogenous. Importantly, the real rate derived here then corresponds to the natural interest rate in the more general setting. This extension is the topic of sections 3 to 5. For this reason we will often refer to the real rate below as the natural rate. Our objective is to develop simple models that illustrate the origins of three major economic crises: the Great Depression, the Great Recession, and the Long Recession.

First, we provide a broad overview of critical patterns in the data from the three historical episodes that motivate the model we consider.

2.1.2 Setting the stage: Some Data from U.S./ Great Depression and Great Recession and Japan's Long Recession

The onsets of the Great Depression, the Great Recession in the U.S., and the Long Recession in Japan left the same footprints in the data.

In the U.S., the Great Depression and the Great Recession began with asset price collapses followed by banking crises. The Dow Jones Industrial Average lost 89% of its nominal value from its peak in

September 1929 to its lowest point in July 1932, and 56% from its peak in October 2007 to its lowest point in March 2009. The short-term nominal interest rate collapsed close to zero in 1932 during the Great Depression and December 2008 during the Great Recession.

The Long Recession in Japan left the same footprints. It started with a spectacular asset price bubble collapse. Malkiel (2010) estimates that at the bubble's apex in 1990, the Imperial Palace grounds in Tokyo were worth more than all the real estate in California. The bubble burst in early 1992, leading to a banking crisis. The Nikkei lost 80% of its value from its 1989 peak to its 2003 bottom. The Bank of Japan's policy rate dropped below 1% in 1995. In 1999, the Bank of Japan officially implemented a zero-interest-rate policy, see subsection 2.3.

2.1.3 Fast Moving Forces and a Negative Natural Rate in the Short-Run

Fast-moving forces that trigger a liquidity trap are the stuff of newspaper headlines: bank runs with panicked customers lining up outside banks, spectacular asset price collapses, large numbers of home foreclosures, firms filing for bankruptcy, mass layoffs, and so on.

2.1.3.1 Modeling a Minsky Moment as a Result of Unsustainable Household Debt

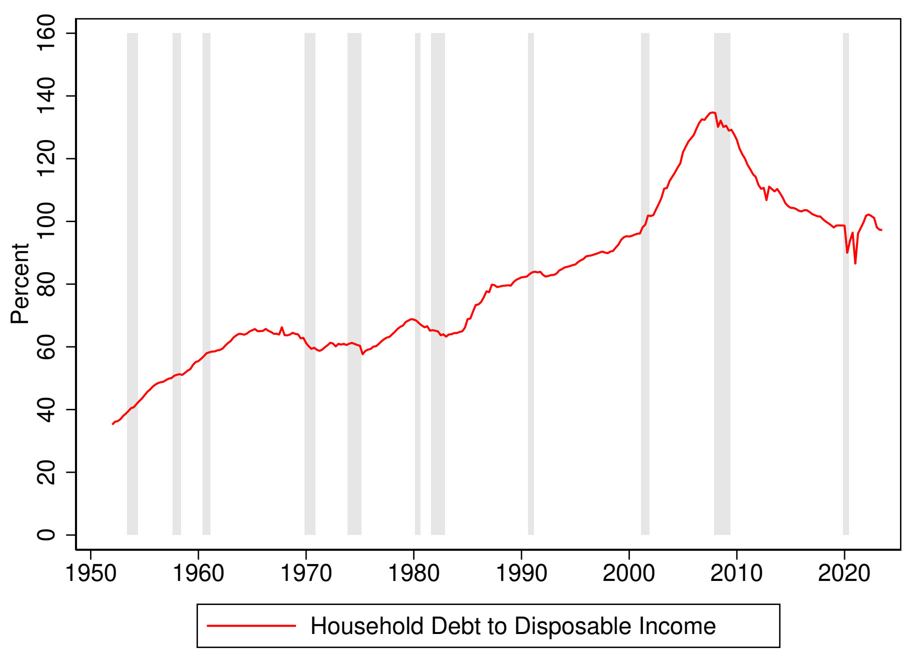


Figure 2: Ratio of Household Debt to Disposable Income

Figure 2 shows household debt rising from under 100% of disposable income in 2000 to over 130%

by 2008.[6] We model the sudden reduction in household borrowing capacity, a Minsky moment. This idea is built on the work of Minsky (1986), who argued there existed a recurrent cycle of instability in which calm periods led to complacency about debt, and hence rising leverage, which in turn set the stage for a crisis leading to rapid deleveraging. The natural interest rate turns negative if the deleveraging event is large enough. Since one person's debt is someone else's asset, we need a model with borrowers and savers to capture this idea. Below, we use the simple example of a borrower-saver model in Eggertsson and Krugman (2012).[7]

This simple model is helpful to think about a crisis as a debt-driven phenomenon generating a temporarily negative natural rate of interest. Imagine a world with two types of agents, savers (s) and borrowers (b), who differ only in their time preference, with $\beta^s > \beta^b$ and for simplicity, there is an equal number of the two types. Their decision problem is:

$$\max_{C_t(i), D_t(i)} E_t \sum_{t=0}^{\infty} \beta^{(i)t} \ln C_t\left(i\right), \tag{1}$$

s.t.:

$$D_t(i) = (1 + r_{t-1})D_{t-1}(i) - Y + C_t(i) - T_t(i), \tag{2}$$

where E_t is the expectation operator, $C_t(i)$ is consumption, $i = \{b, s\}$, $D_t(i)$ is one-period real debt, r_t is the real interest rate at time t, Y is the per-period exogenous output endowment corresponding to output per capita.[8] We assume the borrower's taxes $T_t^b(i)$ remain constant at T^b, while only the saver's taxes vary. This assumption simplifies the model, ensuring Ricardian equivalence where the timing of the saver's tax changes and government debt levels become indeterminate. Agents face an exogenous debt capacity D^{high}:

$$(1 + r_t)D_t(i) \leq D^{high}, \tag{3}$$

the impatient agent will exhaust his debt capacity for a sufficiently low D^{high}.[9] Constraint 3 is often stated instead in terms of a debt limit, i.e., $D_t < D^{\lim}$. We find this to be a slightly less natural way of stipulating the limit borrowers face, which presumably depends on the borrower's ability to repay in the next period and should thus include the interest payment at that time.

While the borrower is at the corner solution, borrowing as much as the limit permits, the saver satisfies an interior optimality condition, pinning down the short-term real interest rate:

$$\frac{1}{C_t^s} = \left(1 + r_t\right) \beta^s E_t \frac{1}{C_{t+1}^s}. \tag{4}$$

[6] The rapid accumulation of private debt has been carefully documented by several authors, notably in important work by Mian and Sufi (2009).

[7] Independently, Guerrieri and Lorenzoni (2017) developed a similar idea with idiosyncratic income risk (Bewley (1977)). After the Great Recession, a large literature has emerged emphasizing household spending heterogeneity with nominal frictions, following a seminal contribution by Kaplan, Moll and Violante (2018), which matches wealth distribution, marginal propensity to consume due to uninsurable shocks, and assets with varying liquidity and returns.

[8] So the borrower and saver receive the same income.

[9] The D^{high} is strictly lower than the present discounted value of the output of each agent.

In solving the model, the first step is to find its steady state. It follows immediately from the consumption Euler equation of the saver that in a steady state:

$$\bar{r} = \frac{1-\beta^s}{\beta^s}, \tag{5}$$

where $\bar{r}$ is the steady state real interest rate. We can now solve for the steady state consumption of the borrower, who is up against his borrowing constraint:

$$C^b = Y - \frac{\bar{r}}{1+\bar{r}} D^{high}, \tag{6}$$

consuming his income net of interest rate payment; conversely, the saver consumes his endowment plus the interest the debtor pays on his debt:

$$C^s = Y + \frac{\bar{r}}{1+\bar{r}} D^{high}. \tag{7}$$

We do not try to model the sources of the debt capacity, but we review literature that explores that direction below. We think of its reduction as a proxy for a more general view about the perceived "safe" level of borrowers' debt capacity, considering, for example, default risk, moral hazard, and, for now, limiting ourselves to households. Debt-driven crisis theories typically propose that this safe level can change abruptly. We model this as an unanticipated reduction in the household debt capacity: $D^{high} \to D^{low}$. The reduction in debt capacity could, for example, reflect a sudden realization that default risk or moral hazard proves more severe than previously understood, but we consider other narratives too.

The model adjusts to the new steady state in one period, identical to the old one but with D^{low} instead of D^{high}, and the same steady-state real interest rate. Call the adjustment period short run (S) and the new steady state the long run (L). The key assumption is that the debtor must cut spending, i.e., deleverage, to satisfy the new debt capacity in a single period. Since aggregate output is constant, the saver must make up for this drop in spending. Manipulating each agent's budget constraints 2 in the short run yields an expression for the saver's consumption in the short and long run.[10]Substituting this into (4) gives an expression of the real rate, or more generally, the natural rate of interest:

$$1 + r_S = \frac{1}{\beta^s} \frac{Y + D^{low}}{Y + D^{high}}. \tag{8}$$

As can be seen by this formula, the natural rate of interest, r_S, can be negative if D^{low} is sufficiently small relative to D^{high}.

[10]We assumed there is the same number of savers and borrowers, and for simplicity, normalize the number of agents to 1. Then at any time t we have $Y = \frac{1}{2}C_t^b + \frac{1}{2}C_t^s$. In the long run, the saver satisfies $C_L^s = Y + (1-\beta^s)D^{\text{low}}$. The short-run saver consumption is the part of output not consumed by the borrower: $C_S^s = 2Y - C_t^b$. The borrower must cut spending to satisfy the new debt capacity, given by $D_S = \frac{D^{\text{low}}}{1+r_S}$. The borrower's budget constraint implies $C_S^b = Y + \frac{D^{\text{low}}}{1+r_S} - D^{\text{high}}$, so the resource constraint yields $C_S^s = Y - \frac{D^{\text{low}}}{1+r_S} + D^{\text{high}}$.

We can summarize why the deleveraging shock triggers a drop in the natural interest rate as follows: Debt deleveraging causes borrowers to reduce their spending. Since aggregate output remains fixed and all production is consumed, savers must increase their spending by an equivalent amount to compensate. Only a lower real interest rate can induce savers to spend more. The required interest rate drop may push the real rate into negative territory if the shock is large enough.

Eggertsson and Krugman (2012) demonstrate an amplification effect due to redistribution between debtors and creditors when debt is denominated in nominal terms. An increase in demand raises prices, which reduces the real value of the debt, redistributing wealth from creditors to debtors. Debtors spend more out of their income, thus amplifying the increase in demand. We discuss the empirical importance of this mechanism in section 4.4.2 during the U.S. Great Depression based on Hausman, Rhode and Wieland (2021). Our model assumes a permanent drop in borrowing capacity. Despite this, the real interest rate eventually returns to its steady-state value. Consequently, our model predicts only a *temporary* drop in the natural rate.

2.1.3.2 Minsky Moment as a Shock to Firms Balance Sheets

A second candidate for a fast-moving force is firms' overaccumulation of debt. A modest extension of the model can capture this idea.

The literature has a long tradition of tracing business cycle fluctuations to variations in firms' ability to borrow from the banking sector.[11] Two classic papers that integrate this perspective into general equilibrium business cycle models are Bernanke and Gertler (1989) (B.G.) and Kiyotaki and Moore (1997) (K.M.), which gave rise to a large literature. B.G. emphasizes the role of firms' net worth in mitigating the cost of external financing due to moral hazard. In contrast, K.M. emphasizes the role of firms' collateral in securing bank lending.[12] Consider how the model can capture some key elements of B.G. and K.M., even if not the rich dynamics. Imagine that the borrower represents entrepreneurs who invest in productive capital while savers deposit money in banks that lend it to the entrepreneurs.[13] The shock, $D^{high} \rightarrow D^{low}$, then captures a decline in firms' borrowing capacity, a reduced form way of capturing lower collateral values of the assets firms can pledge to secure loans, for example, due to a fall in asset prices (K.M.) or a reduction in firms' net worth, which limits their ability to borrow from banks due to moral hazard as the firm has less skin in the game (B.G.). The net result is a temporary reduction in the real interest rate.

2.1.3.3 Minsky Moment as a Reduction in Bank Lending Capacity

A third candidate for a fast-moving force is an abrupt reduction in banks' ability to extend credit. Again, a modest extension of the model can capture this idea.

[11] Bernanke (1983) is a classic reference which builds on Friedman and Schwartz (1963).

[12] For a recent review of this literature and how it evolved following the Great Depression, see Gertler and Gilchrist (2018). Two other influential papers in this literature, which also review some of its origins, are Bernanke, Gertler and Gilchrist (1999) and Gertler and Kiyotaki (2010).

[13] This extension is worked out in detail in appendix 2.2 in Eggertsson and Krugman (2012).

In the wake of the Great Recession, a second generation of models in the tradition of B.G. and K.M. emerged, focusing on distress in the banking sector as a key source of instability.[14] The shock, $D^{high} \to D^{low}$, can alternatively be interpreted as a reduction in the bank's capacity for lending rather than a decrease in households' or firms' debt capacity. We show an example of a model capturing this in the next subsection.

Although not strictly necessary, it is helpful to introduce the notion of spread, i.e., the difference between bonds that carry risk and those that are considered safe. To do so, we introduce a spread function that allows us to consider all three forces simultaneously: shocks to households' or firms' debt capacity and shocks to the banking sector that limit their ability to extend loans.

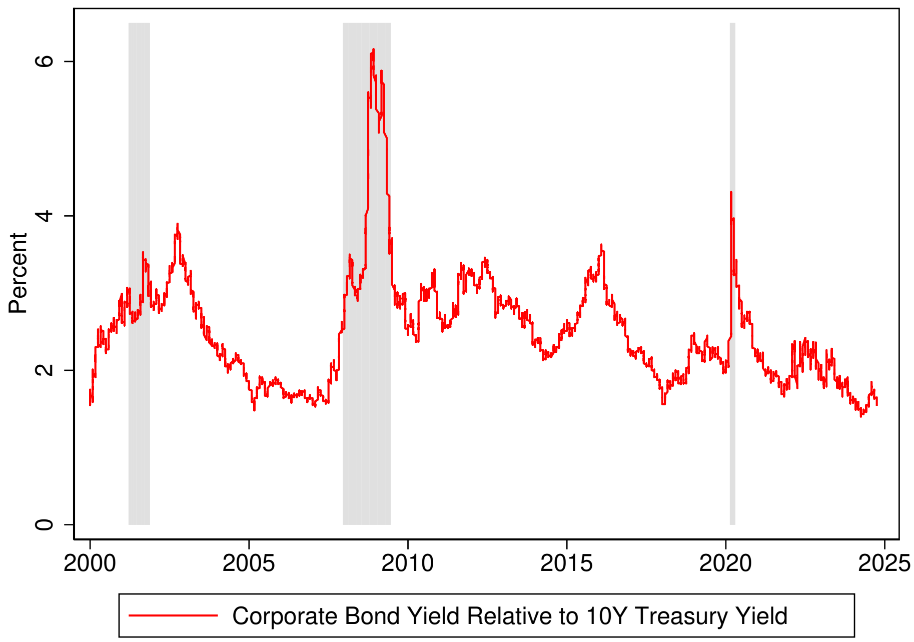


Figure 3: Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury of Constant Maturity

2.1.3.4 Minsky Moment and the Spread Between Risky and Risk-free Assets

The literature on financial frictions prominently features the spread between risky and risk-free bonds. Figure 3 illustrates the spread between Moody's Baa corporate bonds and 10-year Treasuries, which spiked sharply during the early part of the Great Recession. As we will see in this section, we can view the spread increase as a proxy for a drop in the natural interest rate from any of the three sources we have reviewed: over-leveraged households, firms, or distress in the banking sector.[15]

[14] Prominent examples include Curdia and Woodford (2010), Gertler and Kiyotaki (2010), and Brunnermeier and Sannikov (2014). See Gertler and Gilchrist (2018) for a survey of this and related literature.

[15] The evolution of these spreads raises a central question about the nature of the Great Recession liquidity trap: whether it is temporary or permanent. We discuss this question at the end of this subsection.

Let us imagine that borrowers and savers now face different interest rates (indexed by b and s). The savers' interest rate is risk-free from bank deposits, while the borrowing rate reflects idiosyncratic and aggregate risk. The function $\phi(.)$ relates these two rates. Benigno, Eggertsson and Romei (2019) derive this function from a micro-founded banking model:[16]

$$1 + i_t^b\,(j) = (1 + i_t^s)\,\phi\left(\frac{D_t^b(j)}{\bar{D}_t{}^b(j)}, \frac{D_t}{\bar{D}_t}, \varsigma_t\right), \tag{9}$$

where the borrower no longer faces a strict debt capacity. Instead, if borrowing, $D_t^b(j)$, is above the risk-free borrowing capacity $\bar{D}_t^b(j)$, the borrowing rate increases. The spread is due to the part of $\phi(.)$ capturing idiosyncratic default risk. D_t refers to aggregate lending of the banking system, capturing risk associated with bank lending that is independent of individual borrowers' risk and cannot be diversified. The term ς_t captures other features of the underlying banking model, that is, banks' leverage ratios and cost of raising equity, which also influences the spread.[17] Benigno, Eggertsson and Romei (2019) show that the natural rate of interest can be expressed analytically as a function of the arguments in the spread function, i.e., the higher the spread, the lower the natural rate of interest.

A Minsky moment, leading to an increase in spreads and a drop in the natural rate of interest is triggered by changes in either the debt capacity of households or firms ($\bar{D}_t^b(j)$) or a banking crisis ($\bar{D}_t, \varsigma_t$) and its duration is endogenous and depends upon policy. We share the assessment of Gertler and Gilchrist (2018) that all three played an essential role in the Great Recession, but also the Great Depression and the Long Recession.

A few years after the onset of the financial crisis of 2008, around 2013, most spreads had normalized, and the run-up in household debt had essentially reversed (figures 2 and 3). Other metrics capturing lending standards, such as the Survey of Senior Loan Officers (figure 4), were consistent with this pattern. Federal Reserve stress tests indicated that banks' balance sheets had recovered from 2011 onward.[18] The debt-deleveraging hypothesis predicts that this should imply the natural interest rate normalizes at a positive level, generating inflation or an output boom if the Federal Reserve did not raise rates. However, in late 2013, rates remained at zero with no signs of inflationary pressures or a boom. Instead, concerns grew about the anemic recovery, leading researchers to explore alternative forces driving low interest rates beyond the financial crisis that triggered the Great Recession.

2.1.4 Slow Moving Forces and a Negative Natural Rate of Interest in the Long Run: The Secular Stagnation Hypothesis

Several plausible slow-moving forces can trigger a permanent decline in the natural rate of interest, posing a more fundamental policy challenge, a theme we will return to in section 5. Figure 5 shows

[16] Curdia and Woodford (2010) develop a banking model that gives rise to a spread function, focusing on shocks representing shock to banks intermediation costs

[17] This is shown in Benigno, Eggertsson and Romei (2019), building on Justiniano, Primiceri and Tambalotti (2015) and Jermann and Quadrini (2012).

[18] See for example of Governors of the Federal Reserve System (2011) capital analysis and review and similar reports issued in the following years.

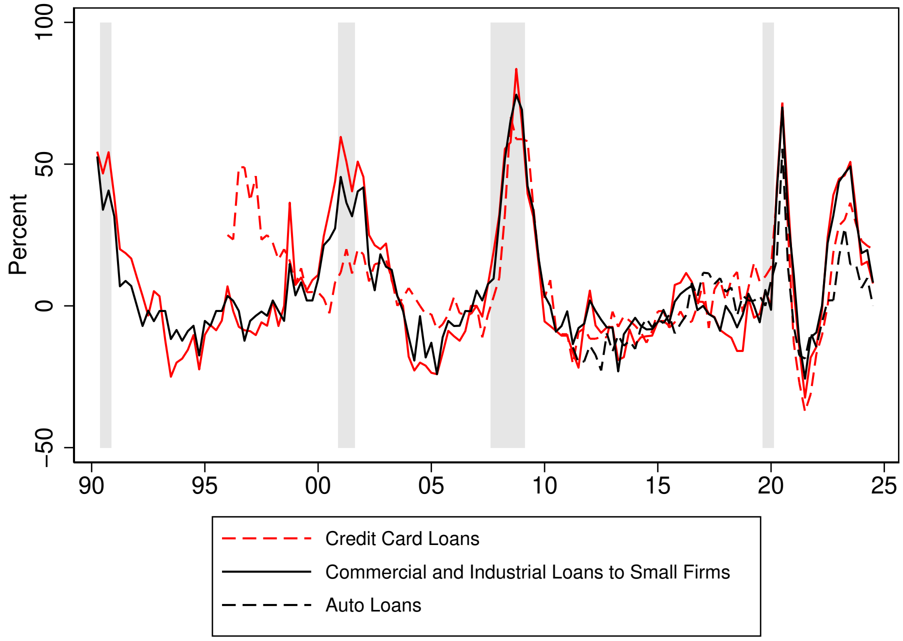


Figure 4: Loan Officer Survey of Lending Standards: Net Percentage of Domestic Banks Tightening Standards by Group

that while short-term rates collapsed to zero following the Great Recession, the general fall in rates has been continuous over several decades if one considers measures of long-term interest rates. A plausible hypothesis is that slower-moving forces were also at work, masked by temporary swings in the short-term rate. The possibility of a permanently negative natural rate is often termed the secular-stagnation hypothesis, based upon an interpretation suggested by Summers (2014) of Hansen (1939). A steady state of a representative-agent or saver-borrower model implies a positive steady-state interest rate, $\bar{r} = \frac{1-\beta^s}{\beta^s}$. However, these models do not derive this from any deep insight. Instead, it stems from the assumption that households live forever.

Below, we review an example from Eggertsson and Mehrotra (2014) and Eggertsson, Mehrotra and Robbins (2019) in which the natural rate of interest is permanently negative, representing the first formal attempt to model the secular stagnation hypothesis in a general equilibrium framework. Like our model of the first building block of the liquidity trap we have covered so far, which studies a temporary reduction in the natural interest rate, we consider a model where output is exogenous. We then study endogenous output and inflation dynamics in section 5.

Let us consider an overlapping-generations model with three generations: young (y), middle-aged (m), and old (o), inspired by Samuelson (1958). We augment Samuelson's model with a constraint on the borrowing capacity of the young. Moreover, we assume that only the middle-aged receive

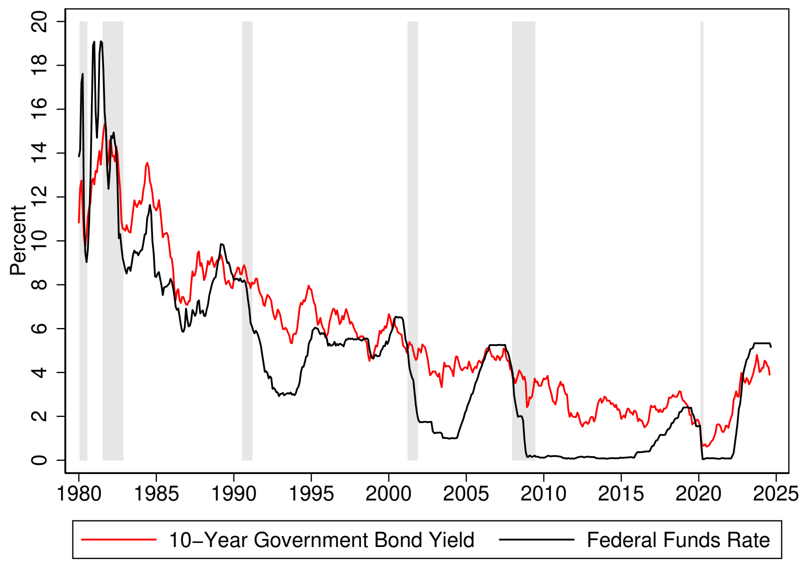


Figure 5: Short and Long-Run Interest Rates

income, Y. A representative household born at a time (t) solves:

$$\max_{C_t^y, C_{t+1}^m, C_{t+2}^o} \mathbb{E}_t \left\{ \ln\left(C_t^y\right) + \beta \ln\left(C_{t+1}^m\right) + \beta^2 \ln\left(C_{t+2}^o\right) \right\}, \tag{10}$$

subject to:

$$C_t^y = D_t, \tag{11}$$
$$C_{t+1}^m = Y - (1 + r_t)\, D_t^y + D_{t+1}, \tag{12}$$
$$C_{t+2}^o = -\,(1 + r_{t+1})\, D_{t+1}^m, \tag{13}$$
$$(1 + r_t) D_t \leq D^{\text{capacity}}. \tag{14}$$

The optimality conditions are then:

$$C_t^y = \frac{D_t}{1 + r_t}, \qquad \frac{1}{C_t^m} = \beta E_t \left(\frac{1 + r_t}{C_{t+1}^o} \right), \qquad C_t^o = -(1 + r_{t-1}) D_{t-1}. \tag{15}$$

In the formulation above, D_t represents how much debt the young can contract in period t. In contrast, $D_t = C_t^y(1 + r_t)$ represents the borrowing capacity of the young, which is determined by the repayment value of their debt in the next period and can vary exogenously with time. Suppose the size of each generation is given by N_t, and we define population growth as $1 + g_t = \frac{N_t}{N_{t-1}}$. Equilibrium in the bond market requires that borrowing by the young equals the savings of the middle-aged so that $N_t D_t^y = -N_{t-1} D_t^m$ or:

$$(1 + g_t) D_t^y = -D_t^m. \tag{16}$$

The left-hand side is the demand for savings, L_t^d, while the right-hand side is the supply, L_t^s. The expression for loan demand is given by the first equation in (15). Loan supply is derived by combining the middle equation of 15 with the household budget constraint, assuming perfect foresight, yielding:

$$L_t^d = \frac{1 + g_t}{1 + r_t} D_t, \quad L_t^s = \frac{\beta}{1 + \beta}(Y_t - D_{t-1}). \tag{17}$$

Equating the demand and supply for loans yields:

$$1 + r_t = \frac{1 + \beta}{\beta} \frac{(1 + g_t)}{Y - D_{t-1}}. \tag{18}$$

This formula fundamentally differs from the predictions of representative agent models or the borrower-saver model: the steady interest rate is not constrained to be positive, a permanent debt-deleveraging shock has a permanent effect on the interest rate, so does a slowdown in population growth or an increase in lifetime expectancy (Eggertsson, Mehrotra and Robbins (2019)).

This formulation can be used to highlight a more general principle: any force affecting the supply of savings relative to the demand for loans can affect the natural rate of interest, even in a steady state. Eggertsson and Mehrotra (2014) and Eggertsson, Mehrotra and Robbins (2019) show that apart from population slowdown then, i) increased life expectancy, ii) rise in inequality, iii) fall in the relative price of investment, or iv) overall productivity can lower the natural rate. Meanwhile, increased government debt or pay-as-you-go social security puts upward pressure on it.[19]

Following Eggertsson and Mehrotra (2014) and Eggertsson, Mehrotra and Robbins (2019) several attempts have been made to quantify various contributors to lower real interest rates, such as demographics Carvalho, Ferrero and Nechio (2016); Gagnon, Johannsen and Lopez-Salido (2016), inequality Auclert and Rognlie (2018), Straub (2019), Mian, Straub and Sufi (2021), or multiple factors at once including Farhi and Gourio (2018), Del Negro et al. (2017*a*), Summers and Rachel (2019) and Platzer and Peruffo (2022). Caballero and Farhi (2018) offer a complementary perspective to the one offered here, allowing for the possibility of a permanently negative real interest rate but instead tracing them to a shortage of safe assets. This literature can account reasonably well for the observed decline in interest rates, suggesting no strong a priori reason to expect re-normalization to positive levels, yet, our assessment is that, at this stage, the literature has not yet reached a consensus estimate about a reasonable forecast about the natural interest rate nor how it is impacted by policy.

[19] While mainly analytical, they do a quantitative exercise, focusing on demographic and technological factors, finding that these alone can account for a natural rate between -1.5 and -2 percent.

2.2 The second building block of a Liquidity Trap: Paper Currency

Paper currency gives rise to the ZLB and is, therefore, a root cause for a liquidity trap, along with a negative natural rate of interest. We now introduce paper money, the second building block of the liquidity trap. We then show how the price level is determined when prices are flexible. Price level determination leads to a significant empirical prediction, which is extended and empirically validated in the following subsection: increasing the money supply at the ZLB is irrelevant if expectations about future policy are entrenched.

2.2.1 Paper Currency, the Zero Lower Bound, the Monetary Base, and the Effective Lower Bound

We now show how the existence of paper money leads to the ZLB, the second building block of the liquidity trap. We return to the borrower and spender model (even if many other models can be used to derive it). For simplicity, we keep the borrower's problem the same but allow the saver household to trade in nominal bonds, B_t, and paper currency, M_t. The price level, P_t, is the cost of consumption units in dollars. The nominal bonds are defined as follows: one dollar's worth of B_t at time t gives the household $1 + i_t$ dollars for sure in the next period $(t + 1)$.

The saver's budget constraint is now:[20]

$$B_t + M_t - P_t D_t^s = B_t + M_t - P_t(1 + r_{t-1}) D_{t-1}^s + P_t Y - P_t C_t^s - T_t^s. \tag{19}$$

Recall that the tax on the borrowing household is constant, while the tax on the savers, T_t^s, may vary. We extend the model to include the benefit of holding real money balances in the household's utility function. Real money balances are given by $m_t \equiv \frac{M_t}{P_t}$, where M_t is cash and P_t is the price level at time t. This part of utility is added separately through the function $\varphi\left(\frac{M_t}{P_t}\right)$. The function $\varphi(m)$ shows the utility from holding real money balances, with $\varphi_m(m) > 0$, so increasing money balances increases utility up to a certain point m^* because it makes transactions easier. Above this point, having more real money balances does not increase utility, so $\varphi_m(m) = 0$ for all $m \geq m^*$ which is called the satiation point in real money balances. The satiation point captures the idea that once people have enough cash, additional money does nothing to help with transactions and is equivalent to any nominal asset with zero nominal return. To be more concrete:

$$\varphi\left(\frac{M_t}{P_t}\right) = \begin{cases} > 0 & \text{if } \frac{M_t}{P_t} < m^* \\ 0 & \text{if } \frac{M_t}{P_t} \geq m^* \end{cases}$$

For $m_t \leq m^*$, we can then back out the money demand at $i_t > 0$, while at $i_t = 0$, money demand becomes indeterminate.

If the interest rate is zero, the saver is indifferent between holding a risk-free one-period nominal bond and money because they represent the same thing: an asset denominated in cash with the

[20] Since the borrower holds neither money nor nominal bonds, we only include the superscript s for C and D.

same monetary value the next period. Neither serves any purpose aside from storing wealth when $m_t \geq m^*$.

Negative nominal interest rates are impossible because if the short-term nominal interest rate is negative, the saver is better off holding money than the risk-free bond. You will not lend someone one dollar unless you get at least one in return. This basic non-arbitrage argument implies that in equilibrium:

$$i_t \geq 0. \tag{20}$$

Even if people trade paper currency, they can deviate from the ZLB, but only to a limited extent. The storage costs of holding paper cash can reduce the bond, as people may pay banks to keep their money safe. Including bank reserves at the central bank in the definition of money allows for slightly negative nominal rates on reserve balances since commercial use reserves to settle interbank transactions, a service they are willing to pay for. Yet, since banks can exchange their reserves for paper cash, the central banks' ability to charge negative rates is limited.[21] Despite the possibility of slightly negative policy rates, we prefer the term ZLB instead of the effective lower bound (ELB), which some authors have adopted in response to experiments with negative interest rates on bank reserves. Policy rate cuts below zero are theoretically and empirically different from regular policy rate cuts, as discussed in subsection 3.2.7.1.

2.2.2 Price Level Determination when the Natural Rate of Interest is Negative in the Short-Run

This subsection shows how the nominal price level is determined when the natural interest rate is negative in the short term. To do so, we rely upon the simplest possible monetary and fiscal policy regime and the most basic structure for the underlying shock.

Suppose the natural interest rate is unexpectedly negative at first (the short run, S) and then becomes positive and stays forever in the long run (the long run, L). Then, we can obtain the equilibrium price level without almost any algebra. Key are two simplifying assumptions suggested by Krugman (1998*a*).

The first is a simpler version of the money demand derived in the last section via a cash constraint:[22]

$$M_t \geq \iota P_t Y, \tag{21}$$

where $\iota > 0$ is a coefficient, showing that a portion (ι) of output is bought with cash. The inequality may not be strict because, as we learned in the last subsection, households are indifferent between holding money or bonds at the ZLB. The second simplifying assumption fixes the long-run money supply at $(M_L = M^*)$, which defines the monetary policy regime.[23]

[21] See Eggertsson et al. (2024) for discussion.

[22] Krugman's money cash constraint can be micro-founded, for example, using the money demand from the last subsection and using a parametric form taking a limit in which money demand is interest rate inelastic at positive interest rate.

[23] For simplicity, we suppose that the borrower's contract is in real debt as in the previous section; see Eggertsson and Krugman (2012) for an extension to nominal debt and discussion in 4.4.2.

Consider first the long run. The LM equation (21) shows that the price level is proportional to the money supply, $P_L = \frac{M^*}{\iota Y} = P^*$, so the real and nominal interest rates are at their steady state, $\bar{\imath} = \bar{r} = \frac{1-\beta^s}{\beta^s} > 0$.

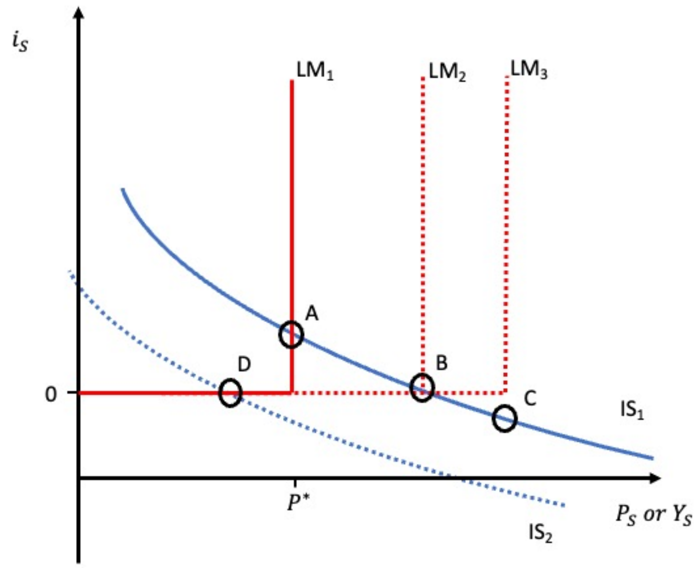


Figure 6: Liquidity Trap

Now, consider the short run. The LM equation (21) determines the price level $P_S = \frac{M_S}{\iota Y}$ if the constraint binds as shown in figure 6. The saver's optimization problem implies that the nominal interest rate satisfies:

$$\frac{1}{C_t^s} = (1+i_t)\beta^s E_t \frac{1}{C_{t+1}^s}\frac{P_t}{P_{t+1}}. \tag{22}$$

Combining equations (4) and (22) yields the Fisher equation:

$$1 + i_S = (1 + r_S)\frac{P^*}{P_S}. \tag{23}$$

We write this equation assuming perfect foresight and that all policy interventions and shocks are one time and unanticipated. The assumption of perfect foresight has no substantive effect on the result but simplifies the exposition; we will abandon it in the coming sections. The central bank lowers the nominal interest rate via open market operation, exchanging interest-free money with risk-free government bonds.[24] By lowering the interest rate i_S via open market operations, the price level P_S rises.

Krugman (1998*a*) argues that the simplest way to understand this relationship is to recognize that the

[24]In section 2.3, we discuss the case when the central bank pays interest on bank reserves to control the policy rate.

equilibrium real interest rate is purely exogenous (see equation (8) where it is given as a function of exogenous variables). In our setting, the real rate also satisfies equation (23). If an equilibrium exists, the economy will deliver the real interest rate given by (8) interest rate regardless of the behavior of nominal prices and money supply.

In the IS curve, $\frac{P^*}{P_S}$ is expected gross inflation. As the central bank cuts the nominal interest rate by expanding money via open market operations, then P_S increases while expected inflation falls since the future price level P^* is fixed by M^*. This change in inflation expectations is necessary to keep the exogenous real interest rate unchanged.

The central bank's open market operations determine the interest rate by intersecting the money supply (LM curve, 21) and the IS curve (23) at point A in figure 6. Suppose the previous period, the price level was the same as in the long run, i.e., $P_- = P^*$. Point A represents the central bank's definition of price stability, of no inflation. If the government increases the money supply through open market operations, the LM curve shifts from LM_1 to LM_2. This increase reduces the nominal interest rate and increases inflation (point B). However, a further increase to LM_3 implies a negative nominal interest rate at point C, which cannot be an equilibrium. The household will always choose to hold money instead of a one-period risk-free nominal bond with negative returns, making the cash constraint slack, so equilibrium remains at point B. No further interest rate cuts are possible, so the LM curve kinks at the ZLB. Any further increases beyond LM_2, such as to LM_3, have no effect on the price level.

An interesting case arises if there is a debt-deleveraging shock, causing $r_S < 0$ (shown by the dashed IS_2 curve). In this situation, the equilibrium is at point D, where the price level is below the price stability point A. This results in deflation ($\frac{P_S}{P^*} < 1$).

Deflation occurs at point D because, with the future price level fixed at P^* and the nominal interest rate already at zero, the only way to achieve a negative *real interest rate* is by creating expected inflation. For this, the short-run price level needs to fall. An increase in $\frac{P^*}{P_S}$ generates the negative real rate implied by the debt-deleveraging shock. Since the curves intersect at the ZLB, increasing the money supply has no effect since spending is no longer constrained by it. Thus, the central bank loses control over the price level and cannot raise it. The LM curve loses relevance, and the economy stays at point D regardless of how much money the central bank prints in the short run. The key is that agents expect any increase in M_S to be temporary. The public anticipates that the central bank will reduce the money supply back to its long-run value M^* once the shock is over.

Thus, two fundamental properties of the model cause prices to fall in the short run. First, a shock triggers the need for a negative real interest rate. With the expected long-run price level constant, the ZLB implies that the real rate can only be negative if short-run prices, P_S, fall enough to generate expected inflation that matches the exogenously given natural interest rate. Second, the assumed policy regime plays a crucial role. M^* defines the policy regime, which implies that in the long run, $P_L = P^*$. Supposing the $P_- = P^*$, the short-term prices, P_S, must fall for expected inflation to be high enough to make the real interest rate negative sufficiently negative to match the exogenously given natural interest rate given by equation 8.

The need for the current price level to fall in response to the debt-deleveraging shock hints at potential problems in more general settings, which we confirm when prices do not adjust instantaneously. The simple model shows signs of the problem once we consider a limiting case with fixed prices. This limiting case leads to an IS-LM graph as in figure 6 but with output, Y_S, on the x-axis instead of the price level. Now, output is dropping instead of inflation, and the central bank cannot increase aggregate demand. Monetary policy cannot cut the nominal interest rate to turn the tide, while printing money has no effect on output.[25]

The conclusion that a sufficiently negative natural rate of interest results in a combination of deflation and output drop, if expectation about the future money supply are fixed, extends to much more general classes of policy regimes and richer models and is easiest by illustrating the Fisher equation in perfect foresight:

$$1 + i_t = (1 + r_t)\Pi_{t+1}. \tag{24}$$

where $\pi_t \equiv \frac{P_t}{P_{t+1}}$. Take logs of both sides, evaluate in steady state, and then subtract from the original equation (in logs) to obtain:

$$\hat{\imath}_t = \hat{r}_t + \pi_{t+1}, \tag{25}$$

where $\hat{\imath}_t \equiv \ln(1 + i_t) - \ln(1 + \bar{\imath})$ is the gross short-term nominal interest rate in log deviation from steady state, $\hat{\pi}_t \equiv \ln \Pi_t - \ln \bar{\Pi}$, while $\hat{r}_t \equiv \ln(1 + r_t) - \ln(1 + \bar{r})$. In our notation, the ZLB is now written as:

$$\hat{\imath}_t \geq i^{zlb}. \tag{26}$$

Because the variables are expressed in deviation from the steady state, the ZLB implies that the short-term nominal interest rate, in log deviation from the steady state, must be greater than $i^{zlb} \equiv -(1 + \bar{\imath})$. This notation has some useful properties, as we will discuss once we move to the log-linearized New Keynesian model.

An immediate implication of this derivation is that the inflation target, $\bar{\pi}$ cannot be reached if:

$$-\ln(1 + r_S) > \bar{\pi}, \tag{27}$$

[25] The formula for output with fixed prices is:

$$Y_S = Y_S^n - D^{low} \frac{i_S - r_S^n}{(1 + i_s)(1 + r_s^n)},$$

where r_S^n is the natural rate of interest given by equation (8) and Y_S^n is the natural rate of output. We do not dwell on this case, as fixed prices are a special case of the standard New Keynesian model in the next subsection, this is a useful modeling device introduced in Werning (2011*a*).

where $\bar{\pi} \equiv \ln(\bar{\Pi})$ approximates the net inflating target and $\ln(1+r_s)$ the net real interest rate to a first order. For example, suppose the natural interest rate is -2%. In that case, the central bank can, both in this example and more generally, only achieve its inflation target if the target is 2% or higher. [26]

We conclude by observing that Krugman (1998*b*) identified a clear solution to falling prices. When the government credibly "commits to being irresponsible" and convinces the public that it will permanently increase the money supply, this action shifts the IS curve upward in Figure 6. A large enough increase in the money supply allows the central bank to return to point A, though this causes a one-time price increase in the next period. Similarly, a corresponding monetary expansion can prevent output from declining. We will explore this idea in much greater depth in later sections when considering alternative policy regimes.

2.2.3 Price Level Determination if the Natural Rate of Interest is Negative in the Short and Long-Run

The ZLB imposes even tighter restrictions on inflation dynamics when we consider a permanent reduction in the natural interest rate.

Let us revisit the overlapping generations model from subsection 2.1.4 but introduce the price level as in the last subsection. Gross inflation is $\frac{P_t}{P_{t-1}}$, or $\bar{\Pi}$ in steady state. The steady-state Fisher equation is:[27]

$$1+\bar{\imath} = (1+\bar{r})\bar{\Pi}. \tag{28}$$

The ZLB then implies a lower bound on inflation:

$$\bar{\Pi} \geq \frac{1}{1+r}. \tag{29}$$

This inequality shows that the ZLB sets a floor for steady-state inflation based on the natural interest rate. For example, if the natural interest rate permanently drops to -5%, inflation must rise above 5% when prices are flexible. Even if the central bank uses all its tools in the model to keep inflation below 5%, no equilibrium exists. This suggests major problems when the natural interest rate becomes negative, especially in settings where prices or wages are rigid. In Section 5, we examine what happens when the central bank targets an inflation rate that violates inequality 29. This leads to secular stagnation — a permanent recession where inflation stays below the central bank's target and output remains below its potential for an arbitrary duration.

[26] There is a subtle issue related to the existence of an equilibrium once the central bank targets positive inflation, which Krugman (1998*a*) cleverly avoids by fixing the long-run price level as in the example above. This theoretical subtlety is discussed in subsection 3.1.5, as it provides the resolution of the paradox of price flexibility (see footnote 52, which proves non-existence).

[27] As in the last subsection, we adjust the household's budget constraint to allow trade in one-period risk-free nominal bonds, assuming they are traded in zero supply so that actual borrowing is denominated in the real bond. The middle-aged household now also satisfies an Euler equation for the risk-free nominal bonds, which determines the nominal interest rate given by $\frac{1}{C_t^m} = \beta E_t \left(\frac{1+i_t}{C_{t+1}^o} \frac{P_t}{P_{t+1}} \right)$. Combining that equation with the middle equation in (15) and evaluating in steady state yields the Fisher equation stated in the text.

2.3 An Empirical Prediction Based on the Two Building Blocks: Irrelevance Results for Monetary Expansion in a Liquidity Trap if Expectations of the Future Policy Reaction Function are Fixed

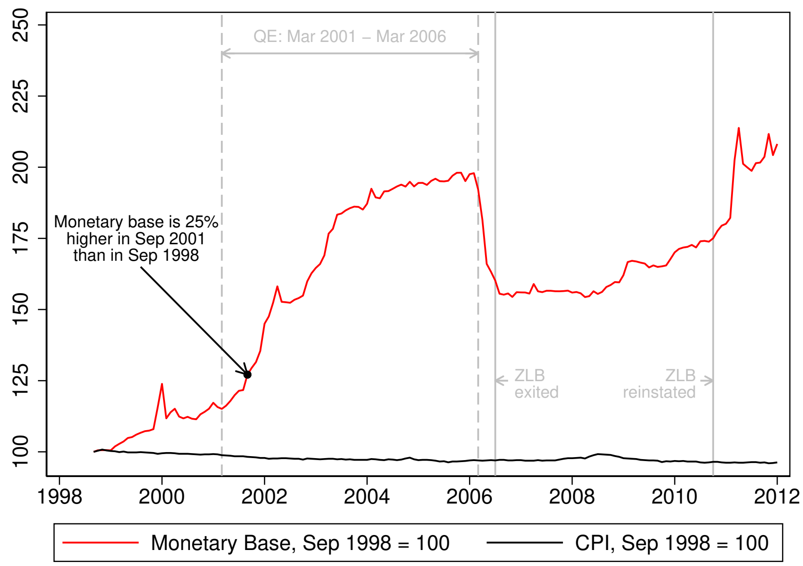


Figure 7: The Monetary Base and Price Level in Japan

Krugman (1998*a*) highlighted a fundamental empirical prediction derived from the framework developed thus far. This prediction is a remarkable example of model-based reasoning without any direct empirical or historical counterpart. The academic community initially met this prediction with great skepticism, perhaps due to a lack of a historical counterpart.This prediction is particularly striking because, despite being out of consensus, it proved correct.

At the core of Krugman (1998*a*)'s paper is an irrelevance result illustrated in figure 6: an increase in the money supply has *no effect* on prices and output as long as expectations regarding the future money supply remain fixed.

Eggertsson and Woodford (2003) extend this irrelevance result. Instead of assuming a fixed future money supply, they propose a generic interest rate rule, encompassesing interest rate rules typical in applied work where the central bank increases the interest rate if inflation exceeds the target. Moreover, while Krugman (1998*a*) assumes the government increases the money supply via purchases of short-term government bonds, Eggertsson and Woodford (2003) goes one step further and suggests the method of increasing the money supply is irrelevant, allowing for purchases of any financial asset with arbitrary state-contingent payoffs. Krugman's irrelevance result remains unchanged: any increase in the money supply has no effect, regardless of what the government purchases.[28]

[28] Eggertsson and Woodford (2003) present their irrelevance result as a generalization of the irrelevance result of Wallace

As we already alluded to, professional economists greeted Krugman (1998*a*)'s prediction, as well as that of Eggertsson and Woodford (2003), with a great deal of skepticism. Given the radical nature of these predictions, and how directly they contradicted monetarism, the skepticism was not very surprising. Indeed, as we mentioned in the introduction, Krugman (1998*a*) himself set out to disprove what has become his famous prediction. His initial goal was to show that the liquidity trap represented an old Keynesian fairytale - one that could not withstand the scrutiny of general equilibrium analysis.

Kenneth Rogoff, commenting on Krugman's paper, motivated by Japan's liquidity trap, nicely summarized the shared view in the profession at the time:[29]

> No one should seriously believe that the Bank of Japan would face any significant technical problems in inflating if it puts its mind to the matter, liquidity trap or no. For example, one can feel quite confident that if the Bank of Japan were to issue a 25 percent increase in the current money supply and use it to buy back 4 percent of government nominal debt, inflationary expectations would rise.

This comment reflected the consensus that the Japanese liquidity trap was mainly due to the Bank of Japan's unwillingness to do what was necessary to bring about inflation. The consensus was that the Bank of Japan had plenty of room to expand aggregate demand and that the problem was mainly due to bureaucratic constraints or incorrect analysis. In retrospect, many observers may have been overly optimistic about the ability of a central bank to stimulate demand with simple policies such as open market operations in short-term government bonds. Figure 7 shows Japan's monetary base's evolution since September 1998. Despite the Bank of Japan's quantitative easing (QE) policy starting in March 2001, which more than doubled the money supply by March 2006, the price level continued to fall, and inflation expectations remained unchanged.[30]

The irrelevance results of Krugman (1998*a*) and Eggertsson and Woodford (2003) can explain the Bank of Japan's experience. The Bank of Japan ended QE in 2006 because it gained confidence that the economy was recovering and inflation was rising. As Krugman (1998*a*) anticipated, without "credibly committing to being irresponsible," even doubling the money supply did not affect inflation expectations. Market participants correctly predicted that the Band of Japan would contract the money supply at the first sign of inflation – which it did in 2006 Figure 7 vividly displays this contraction.

Moreover, looking over a more extended period, from September 1998 to April 2021, the Bank of Japan increased the money supply by *1,103%*, while the CPI dropped about 3% over these 23 years.

(1981) to an environment with sticky prices, monetary frictions, and the ZLB, but Wallace (1981) was sometimes considered of little practical interest since it implied typical open market operations where irrelevant. In Eggertsson and Woodford (2003), this is only the case at the ZLB. Eggertsson and Woodford (2003) discuss in detail the logic of the irrelevance result and possible caveats.

[29] See the commentary in Krugman (1998*a*).

[30] For data on inflation expectations, see Eggertsson and Ostry (2005), who measure them with data from Surveys of Professional Forecasters.

As we have discussed, Krugman (1998*a*) suggests that increases in the money supply have no effect if the public expects the government to reverse them in the future.Eggertsson and Woodford (2003) pose their irrelevance result in terms of an interest rate reaction function and show that the optimal interest rate commitment, discussed in section 4 need not require much inflation, but instead a commitment to an output boom and prolonged period of zero interest rates (in their numerical example inflation only rises by about 0.3% under the optimal commitment, discussed in detail later in the paper).[31]

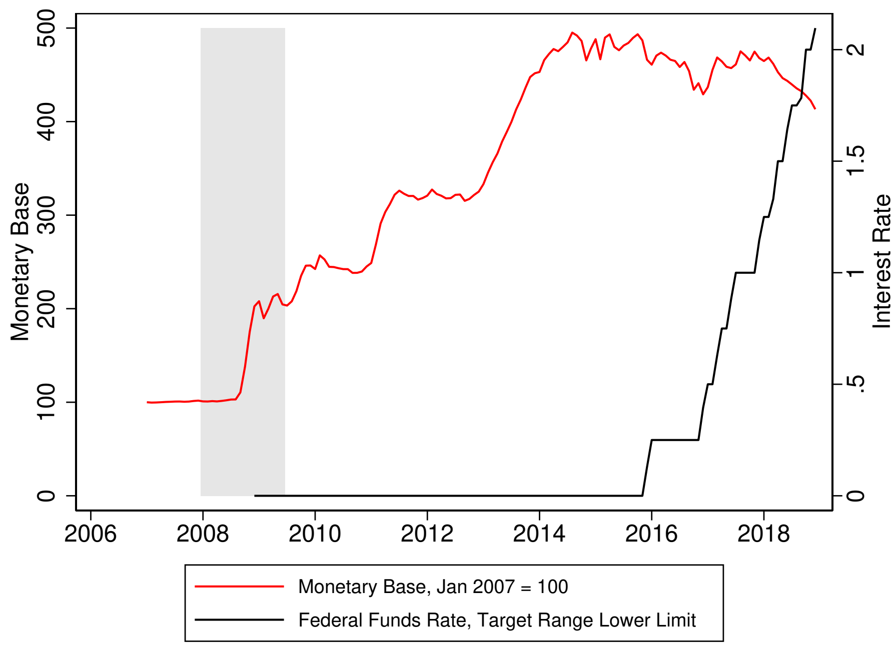


Figure 8: The Monetary Base in the US

In retrospect the lack of results should not have been very surprising, since the policy makers of Bank of Japan communicated the increase in money supply was only temporary. Below are two examples of senior policymakers statements, one at the beginning of QE, the other at the end,

> The Bank will continue to provide ample liquidity until deflationary concerns subside, but we remain vigilant and will adjust our policy stance if signs of inflation emerge.
>
> *– Bank of Japan Governor Masaru Hayami, March 21, 2000*

> The Bank has adopted "the year-on-year rate of change in the CPI of zero percent or higher" as the criterion providing the least permissible constraint on the flexibility in its monetary policy.
>
> *– Bank of Japan Governor Toshihiko Fukui, March 9, 2006*

[31] The limiting case of fixed prices, first shown in Werning (2011*b*), makes the point especially transparent since then no inflation is involved.

A caveat to Krugman's 1998 prediction makes the irrelevance result starker. Since 2008, several central banks have been able to pay *interest on reserves*. This new power implies that increasing the monetary base is not only irrelevant at the ZLB but also when it is no longer binding. Figure 8 shows that since the Federal Reserve cut its interest rate to zero in December 2008, the base increased by a factor of five when it raised the federal funds rate seven years later in 2015, without the need to contract the money supply. The Federal Reserve increased the interest rate of reserves of commercial banks deposited. Under this new regime, the bottom line became even more self-evident: What matters is not some measure of the money supply but the current and expected short-term nominal interest rate determined by the Federal Reserve.

The irrelevance results of Krugman (1998*a*) and Eggertsson and Woodford (2003) may seem inconsistent with several other results in the literature. For example, Auerbach and Obstfeld (2005) in their paper "The Case for Open-Market Purchases in a Liquidity Trap" argue that open market operations in government bonds will increase aggregate demand, which may appear to contradict both papers. However, this argument does not contradict the irrelevance results we have reviewed because Auerbach and Obstfeld (2005) assume that the open market operations result in a permanent increase in the money supply, in contrast to what Bank of Japan implemented. As Krugman (1998*a*) first showed a permanent increase in the supply of money, will indeed increase aggregate demand via "committing to being irresponsible," so the two results align. Yet, the result of Auerbach and Obstfeld (2005) has nothing to do with the open market operations conducted at the time of the ZLB, as figure 7 vividly illustrates, along with the narrative surrounding it. All that matters are expectations about the money supply once economic conditions normalize. Open market operations before that date do not need to have any bearing on the central bank's actions in the future, as indeed turned out to be the case for the Bank of Japan.

Eggertsson and Woodford (2003) base their irrelevance result on the presumption that open market operations do not affect the central bank's interest rate reaction function. As they discuss in their paper, this assumption implies that the central bank will contract the money supply as soon as deflationary pressures subside. In contrast, if the central bank commits to low future nominal interest rates (as under Optimal monetary policy commitment regime, see section 4), which one can equivalently formulate as a higher future money supply, it will affect aggregate demand, just as in Auerbach and Obstfeld (2005). Again, however, open market operations during the ZLB remain irrelevant to implementing this commitment.

Buiter (2003) suggests "helicopter drops" of money, and Svensson (2000) proposes foreign exchange interventions to stimulate demand. Galí (2020) argues for a fiscal expansion financed by an increase in the money supply and contrasts it with bond finance issuance. The irrelevance results implies that the composition of aggregate government liabilities (i.e., whether they consist of money or bonds) does not matter at the ZLB. To reconcile these papers with the irrelevance results (and a large number of policy proposals and papers in this vein), we must recognize that all these papers assume the policy under consideration is associated with a *permanent increase in the money supply* or a change in the interest rate reaction function. In Krugman's terms, such proposals are associated with central banks "committing to being irresponsible." In the absence of some market imperfections or liquidity constraints (see subsection 3.4), increasing the money supply remains irrelevant at the ZLB *unless* it changes expectations about future money supply or the way in which policy rates are set as a function of endogenous variables in the model. The exception to this is if there are specific asset market imperfections that the central bank can exploit to uncouple prices from their fundamentals. Yet, even if successful in doing so, it is not obvious what effect such decoupling would have on aggregate conditions, and it would need to be evaluated on a case-by-case basis. We will explore some examples below.

3 A Standard Monetary and Fiscal Policy Regime and a Negative Natural Rate of Interest in the Short-Run

Section 3 analyzes inflation, output, and interest rates in a liquidity trap. Following the organizational principles discussed in the introduction, we first consider i) a temporarily negative natural rate and ii) the *Standard monetary and fiscal policy regime*. The essential principle of this regime requires the nominal interest rate to remain at the ZLB while the natural interest rate is negative. The combination of this policy regime and a temporary negative natural interest rate lands us in a topsy-turvy world where several accepted economic wisdoms are turned on their head with strong policy implications. These implications include significant fiscal policy impacts and counterintuitive effects of supply shocks. This section presents two important extensions. In section 3.2.5, we analyze a simple model with heterogeneous agents where a fraction faces liquidity constraints. We demonstrate that the multiplier's size at the ZLB increases substantially due to income effects connecting closely to Kahn (1931)'s original work. While our baseline model employs a simple two state Markov Process to express solutions in closed form, subsection 64 examines a common alternative: an autoregressive process of order 1. This examination proves our results are not artifacts of a specific stochastic process.

3.1 The Canonical New Keynesian Model and the Liquidity Trap

In the canonical New Keynesian model, a temporary reduction in the efficient interest rate, defined below, can generate a liquidity trap with a sharp drop in output and a decline in inflation, replicating the depth of the Great Recession and Great Depression for calibrated parameters.

3.1.1 Setting the Stage: Data from the US Great Depression and Great Recession

Figure 9 shows the evolution of output, inflation, and short-term nominal interest rates in red. During the Great Depression, US output dropped by approximately 30%, with a clear turning point in mid-1933 when the economy started recovering. In comparison, output fell by less than a third of that (7.5%) in the Great Recession. There is less evidence of a drastic turning point during the Great

Recession. The reaction of inflation differs across the two episodes. While deflation reached 10% per year in 1932 during the Great Depression, inflation dropped more modestly below the Federal Reserve's 2% target in the Great Recession. The solid black line shows the simulated path based on a calibration of the New Keynesian model, which we will explain below.

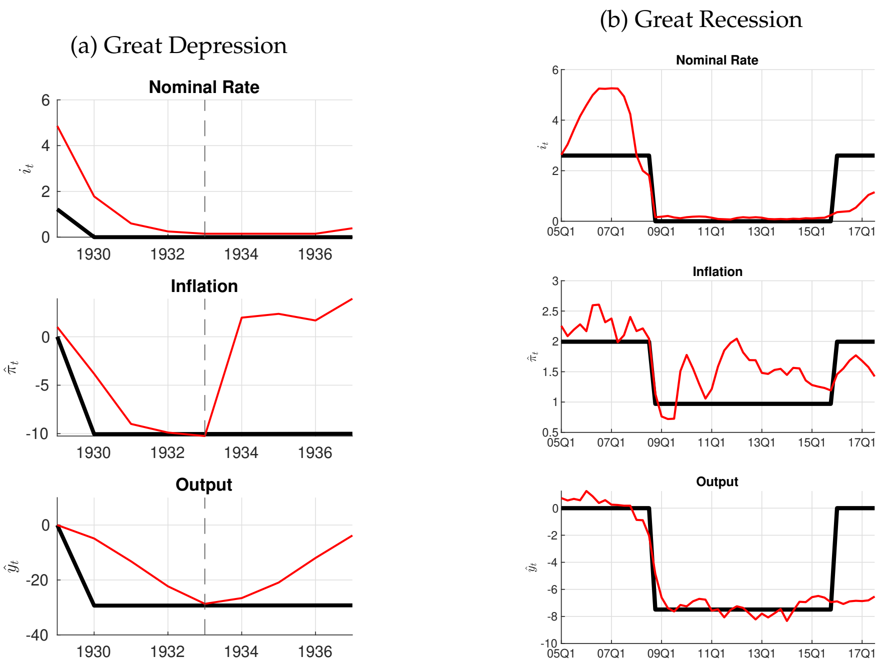


Figure 9: The Great Depression and the Great Recession in the model (solid black line) and the data (thin red line).

3.1.2 The Model

Section 2 explains short-term drops in the natural interest rate endogenously as a function of fast-moving forces while output is exogenous. In section 3, we flip the script and analyze the liquidity trap in the New Keynesian model, where output is endogenous, and the natural rate is an exogenous stochastic process.

The New Keynesian model has two fundamental equations: the Investment-Savings (IS) equation and the New Keynesian Phillips Curve (AS); we report them here in their approximated form, as their derivation is available from several sources.[32] The maximization problems of households and firms are all standard; thus, we state the key equations in a log-linear form instead. We relegate to

[32] The exact characterization we use to illustrate fiscal instruments is from Denes, Eggertsson and Gilbukh (2013). The canonical New Keynesian model consists of IS and AS equations that express the real interest rate in deviation from the natural interest rate and output as deviations from its natural level. Equivalently, one can decompose the natural rate into efficient and inefficient components, as we have done in the paper. It also includes a social welfare criterion derived from a second-order approximation of household utility. This first depiction of the New Keynesian model stated in this way is found in Woodford (1996) and Woodford (1999), see also Clarida, Gali and Gertler (1999) for an influential review in this journal that traces the historical origins of the model in more detail. For textbook treatments see Woodford (2003) and Galí (2015).

footnote the exact formulation of the utility function, demand structure, and production function to help the reader understand the notation we use.[33]

Unless otherwise stated, we express all variables in natural log deviation from their steady state. The IS equation, derived from the household maximization problem:[34]

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(\hat{\imath}_t - E_t \hat{\pi}_{t+1} - \hat{r}^e_t) + \mathcal{F}^{IS}_t, \tag{30}$$

where $\hat{Y}_t \equiv \ln Y_t - \bar{Y}$ is output in log deviation from steady state denoted by bar, $\hat{\imath}_t \equiv \ln(1 + i_t) - \ln(1 + \bar{\imath})$ is the gross short-term nominal interest rate in log deviation from steady state, while $\hat{\pi}_t \equiv \ln \Pi_t - \ln \bar{\Pi}$ is inflation in log-deviation from the central bank's inflation target. The parameter $\sigma > 0$ measures spending sensitivity to real interest rates, and $\mathcal{F}^{IS}_t$ is a composite of fiscal variables defined later when we analyze fiscal policy.

The efficient rate of interest $\hat{r}^e_t$ summarizes the exogenous shocks to the IS curve. This rate represents the natural interest rate, assuming fiscal instruments are at their efficient levels.[35] We use the definition of the efficient rate instead of the natural rate, as it is independent of fiscal policy, simplifying the exposition.

We interpret a drop in the efficient interest rate as a reduced form representation of the drop in the natural interest rate we modeled in section 2. Occasionally, when no danger of confusion (e.g. when fiscal policy remains unchanged), we use the terms "natural rate of interest" and "efficient rate of interest" interchangeably.

The IS equation says that an increase in expected future income or a reduction in the real interest rate relative to the efficient interest rate causes an increase in aggregate demand.

[33]Households derive utility from a consumption aggregate derived from a continuum of goods of measure one:

$$C_t \equiv \left[\int_0^1 c_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$ measures the elasticity of substitution between goods. In addition, the household derives disutility of working given by supplying a continuum of labor to different types of industries of measure one:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma_c}}{1-\sigma_c} - \int_0^1 \frac{N_t(i)^{1+\omega}}{1+\omega} di\right] \xi_t$$

, where $N_t(i)$ is labor of each type, and ω is the inverse of the Frisch elasticity of labor supply. σ_C is the intertemporal elasticity of substitution of consumption. We define the parameter $\sigma = \sigma_c \frac{C}{Y}$ Given the specification of aggregate consumption, demand given by

$$y_t(i) = (\frac{c_t(i)}{C_t}) - \theta,$$

where θ is the elasticity of goods of type i. Each firm retains its price with probability α but re-optimizes with probability $1 - \alpha$. For simplicity, production is linear in labor, so $y_t(i) = N_t(i)$. See Woodford (2003) Chapter 3.1.

[34]A large part of the modern literature presumes that only the real interest rate matters and that economic agents form expectations rationally. Accordingly, it matters little from the perspective of demand if the central bank cuts the nominal rate or raises expected inflation; other things are constant. Recent literature has started empirically and theoretically questioning this assumption; see, e.g., survey papers by Weber et al. (2022) and Eusepi and Preston (2018).

[35]The efficient levels of output and government spending are assumed to be constant, and the shocks are restricted so that the efficient values of all fiscal instruments are constant.

The nominal interest rate is subject to the ZLB:[36]

$$\hat{\imath}_t \geq i^{zlb}. \tag{31}$$

Because we express the variables as deviations from steady state, the ZLB implies that the short-term nominal interest rate, in log-deviation from steady state, must exceed $i^{zlb} \equiv -\ln(1+\bar{\imath}) = -\ln((1+\bar{r})\bar{\Pi})$. This notation possesses some useful properties, which we will discuss shortly.

The New Keynesian Phillips Curve (AS), derived from firms' optimal price setting, is:

$$\hat{\pi}_t = \kappa \hat{Y}_t + \beta E_t \hat{\pi}_{t+1} + \mathcal{F}_t^{AS}, \tag{32}$$

where $\kappa > 0$ measures inflation sensitivity to output. The variable β is the time discount factor typically calibrated close to 1, satisfying the restriction $0 < \beta < 1$. The composite variable $\mathcal{F}_t^{AS}$ represents the effect of fiscal policy instruments (and, possibly, other exogenous shocks).

The New Keynesian Phillips curve says that inflation depends on the deviation of aggregate output from the steady state and expectations of future inflation. Firms set prices today anticipating that prices will remain in place for some time and thus taking future conditions into account.

The most critical assumption in section 3 is the assumed policy regime and the assumption of the shock being temporary. We define the Taylor rule as representing the Standard monetary and fiscal policy regime while incorporating the ZLB constraint.

Assumption 1a (A1a): A *Standard monetary and fiscal policy regime* is a ZLB-constrained Taylor rule of the form:

$$\hat{\imath}_t = \max(i^{zlb}, \hat{r}_t^e + \phi_\pi \hat{\pi}_t + \phi_y \hat{Y}_t), \tag{33}$$

where ϕ_π and ϕ_y determine the central bank's reaction to output and inflation in deviations from steady state while non-distortionary lump sum taxes offset the fiscal interventions.

Policy rule (33) is a family of policy rules which differ in the implicit inflation target $\bar{\pi}$.

[36] A higher inflation target reduces i^{zlb}, giving the central bank more room to cut rates.

We consider various fiscal policies in this review. Initially, we abstract from fiscal policy but keep track of $\{\mathcal{F}_t^{IS}, \mathcal{F}_t^{AS}\}$ for results shown later. For now, it is sufficient to assume that for any realization of $\{\hat{r}_t^e, \mathcal{F}_t^{IS}, \mathcal{F}_t^{AS}\}$ and the evolution of the endogenous variables, lump-sum taxes adjust so that the real value of government debt is stable, an assumption we maintain unless otherwise specified.[37]

Equilibrium is a collection of stochastic processes $\{\hat{Y}_t, \hat{\imath}_t, \hat{\pi}_t\}$ solving (30), (31, (32), and (33), given $\{\hat{r}_t^e\}$ and $\{\mathcal{F}_t^{IS}), \mathcal{F}_t^{AS}\}$.[38]

We can state the Standard monetary and fiscal policy regime in an alternative form, which proves helpful for some applications but results in a less intuitive AS-AD representation. Unless we state otherwise, the equilibrium results presented in section 3 remain identical whether we assume the policy regime defined by A1a or A1b below. Eggertsson and Woodford (2003) proposed this alternative specification:

Assumption 1b (A1b): A *Standard monetary and fiscal policy regime* is a ZLB-constrained strict inflation target: The central bank commits to adjusting the nominal interest rate so that:

$$\begin{aligned} \hat{\pi}_t &= 0, && \text{for } \forall t \text{ if possible} \\ \hat{\imath}_t &= i^{zlb}, && \text{otherwise.} \end{aligned} \tag{34}$$

Using the IS and AS equations, if the central bank satisfies the inflation target then $\hat{\imath}_t = \hat{r}_t^e$.[39] This is not feasible if $\hat{r}_t^e < i^{zlb}$, hence the qualification in the second line of A1a. It says that if the central bank cannot achieve its inflation target due to the ZLB, it will keep the interest rate at the ZLB.[40]

In older Keynesian models, aggregate demand is a function of interest rate, fiscal policy, and exogenous shocks. The main new element of New Keynesian aggregate demand is that expectations play a central role and are determined endogenously *as a function of the policy regime*.[41] Forward iteration of IS equation (30) yields:

$$\hat{Y}_t = -\sigma E_t \sum_{j=0}^{\infty} \left[(\hat{\imath}_{t+j} - \hat{\pi}_{t+1+j} - \hat{r}_{t+j}^e - \sigma^{-1} \mathcal{F}_{t+j}^{IS}) \right], \tag{35}$$

[37] To be more specific, we assume that fiscal policy is sustainable in the sense that lump-sum taxes will adjust for any path of prices, output, and interest rate to ensure that the household's transversality condition is satisfied. Our analysis relies on local approximation, so our equilibrium selection criterion only considers bounded equilibria. An alternative equilibrium selection device is the Markov Perfect Equilibrium considered in section 4, which is unique local to the steady state and yields the same result in equilibrium as the Standard monetary and fiscal policy regime imposed here.

[38] Relative to common Taylor rules, we include the efficient interest rate as a time-varying coefficient. For the results we present, this does not affect equilibrium outcomes due to the stochastic process we assume, but it does simplify the exposition significantly.

[39] Imposing for simplicity that $\mathcal{F}_t^{IS} = \mathcal{F}_t^{AS} = 0$, the condition is adjusted accordingly if these variables take non-zero value.

[40] As we will see in section 4, the equilibrium implied by the Standard monetary and fiscal policy regime can be microfounded naturally by assuming that the central bank maximizes social welfare but imposing a Markov Perfect Equilibrium, which limits a central bank's policy strategy to only react to current economic conditions as expressed by economic constraints it faces.

[41] In developing the IS-LM model Hicks (1937) highlights that treating expectation as exogenous is the main weakness of the model.

which says that output demand depends not only on the policy rate today but also on expected inflation and shocks. It depends on the entire expected path of these variables over the infinite horizon.

3.1.3 An Analytic Example

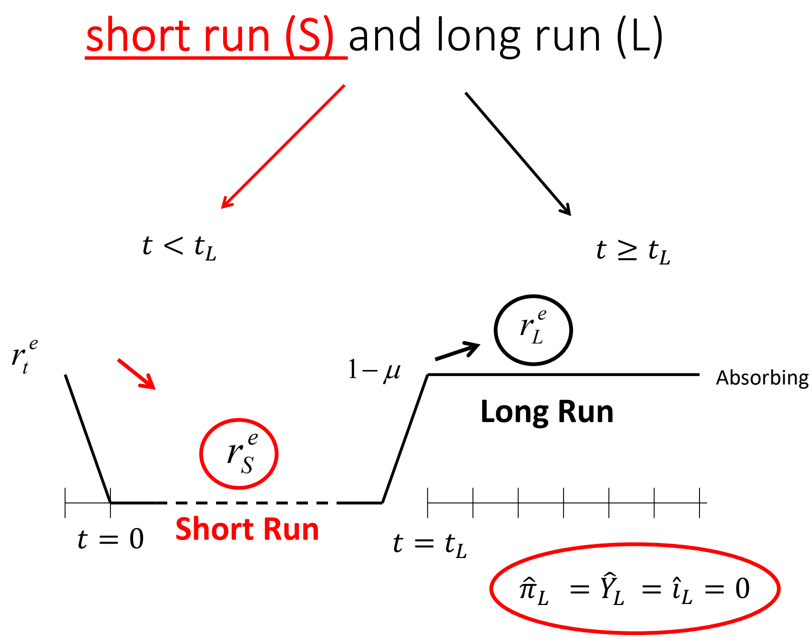


Figure 10: Assumption 2 (A2)

We can reduce the model to two equations in two unknowns, which we can use to sketch an AD-AS diagram similar to those in intermediate macro classes. To generate this useful result, we must impose the following assumption on the stochastic process for the natural rate of interest, which figure 10 illustrates and we summarize below:

Assumption 2 (A2): The Efficient Rate of Interest and the Efficient Output. The efficient interest rate, $\hat{r}_t^e$, is the real interest rate when fiscal policy instruments are at their efficient steady state, and prices are flexible. An unexpected shock at time zero results in $\hat{r}_0^e = \hat{r}_S^e < 0$, which persists with probability μ. Conditional on $\hat{r}_t^e = \hat{r}_S^e < 0$ at time t, the efficient interest rate reverts to the steady state, $\hat{r}_L^e = 0$, with probability $1 - \mu$ at period $t + 1$, which is also the absorbing state. The implied shock duration is $1/(1 - \mu)$, and the stochastic date of reversion to a steady state is denoted t_L. The efficient output level is constant at its steady state so that $\hat{Y}_t^e = 0$ at all times.

A2 is made for the sake of theoretical clarity, section 64 shows the key results that remain robust to assuming AR(1) stochastic process. We next impose an assumption on the fiscal stance which is not innocuous and relaxed later on:

Assumption 3 (A3): The fiscal stance, summarized by $\mathcal{F}_t^{IS}$ and $\mathcal{F}_t^{AS}$, follows the same process as $\hat{r}_t^e$ and is perfectly correlated with it, i.e. it takes some constant value $\mathcal{F}_S^{IS}$ and $\mathcal{F}_S^{AS}$ at $t < t_L$ and $\mathcal{F}_t^{AS} = \mathcal{F}_t^{IS} = 0$ for $t \geq t_L$.

Assumptions 1-3 allow us to solve the model for the long run once the shock is in a steady state (i.e., $t \geq t_L$) and then use this as input for the solution for $t < t_L$. For $t \geq t_L$, using the method of Blanchard and Kahn (1980) allows us to solve equations (30), (32), and (33) (or alternatively 34) to yield a unique bounded solution at positive interest rates:

$$\hat{\pi}_t = \hat{\pi}_L = 0, \hat{Y}_t = \hat{Y}_L = 0, \hat{\imath}_t = \hat{\imath}_L = \hat{r}_L^e = 0, \tag{36}$$

if $\phi_\pi + \frac{1-\beta}{\kappa}\phi_y > 1$.[42] The Taylor principle, $\phi_\pi > 1$ and $\phi_y \geq 0$, is a sufficient condition for this condition to always be satisfied. We state it as Assumption 4 (A4):

Assumption 4 (A4) $\qquad \phi_\pi > 1, \qquad$ and $\qquad \phi_y \geq 0. \qquad (37)$

If we use the alternative definition of the Standard monetary and fiscal policy regime, **A1b**, the variables in A4 are no longer needed to describe monetary policy and A4 is irrelevant.

Using Assumption 1a to Assumption 4 we can now verify then as as long as $r_t^e > i^{zlb}$ the central bank can always implement the inflation target by setting $\hat{\imath}_S = \hat{r}_S^e$. The derivation of this result follows exactly the same steps as when we showed the unique bounded solution in the long run.

Things become interesting once $\hat{r}_S^e < i^{zlb}$. Then the ZLB is binding, and we set $\hat{\imath}_S^e = i^{zlb}$. We obtain a solution for $t \leq t_L$ by solving the model backwards and computing the expectations of each variable using the solution from the long run as input. The resulting system can be solved using the method of Blanchard and Kahn (1980) to show that the model has a unique bounded solution if:[43]

Assumption 5 (A5) $\qquad \vartheta(\mu) \equiv (1-\mu)(1-\beta\mu) - \kappa\sigma\mu > 0, \qquad (38)$

where we make the function ϑ depend on μ to emphasize the importance of shock persistence on the

[42]See Proposition 4.3 in Woodford (2003), p. 254.

[43]To obtain the solution, use the expression for the long run to obtain expectations in the short run:

$$E_{t,S}\hat{\pi}_{t+1} = \mu E_{t,S}\hat{\pi}_{t+1,S} + (1-\mu)E_{t,S}\hat{\pi}_{t+1,L} = \mu E_{t,S}\hat{\pi}_{t+1,S},$$

where $E_{t,S}$ is the expectation formed at time t conditional on $t < t_L$, so the shock is in the low state, and $\hat{\pi}_{t+1,S}$ denotes inflation at time $t+1$ conditional on the shock remaining in its low state. We can similarly express expectations about output as $E_{t,S}\hat{Y}_{t+1,S}$. Substituting $\hat{\imath}_t = i^{zlb}$, equations (30) and (32) at time $t < t_L$ are expressed as:

$$\hat{Y}_{t,S} = \mu E_{t,S}\hat{Y}_{t+1,S} - \sigma(\hat{\imath}_t - \hat{r}_S^e) + \sigma\mu E_{t,S}\hat{\pi}_{t+1,S} + \mathcal{F}_S^{IS},$$

$$\hat{\pi}_{t,S} = \kappa\hat{Y}_{t,S} + \beta\mu E_{t,S}\hat{\pi}_{t+1,S} + \mathcal{F}_S^{AS}.$$

Using the method of Blanchard and Kahn (1980), we obtain a unique bounded solution for $\hat{Y}_S$ and $\hat{\pi}_S$ as a function of $\mathcal{F}_S^{IS}, \mathcal{F}_S^{AS}, \hat{r}_S^e$ if A4 is satisfied as proved in Proposition 2 in Eggertsson (2011).

value of the function. Under Assumptions 1-5, we obtain constant short-run solutions $\hat{\pi}_S$ and $\hat{Y}_S$ as a function of $\hat{r}^e_S$.

The model has an analytic solution. If a unique bounded solution exists, output, inflation, and the interest rate are all constant in the short run and indexed by S. Given Assumption 1-5, we can combine equations (30) and (33) to obtain Aggregate Demand:

Aggregate Demand
$$\hat{Y}_S = \begin{cases} -\frac{\sigma(\phi_\pi - \mu)}{1-\mu+\sigma\phi_y}\hat{\pi}_S + \frac{1}{1-\mu+\sigma\phi_y}\mathcal{F}^{IS}_S, & \text{if } \hat{\imath}_S \geq i^{zlb} \\ \\ \frac{\sigma\mu}{1-\mu}\hat{\pi}_S + \frac{\sigma}{1-\mu}(\hat{r}^e_S - i^{zlb}) + \frac{1}{1-\mu}\mathcal{F}^{IS}_S, & \text{if } \hat{\imath}_S = i^{zlb}. \end{cases} \tag{39}$$

Similarly, we can write the New Keynesian Phillips Curve (32), or the Aggregate Supply equation, as follows under assumption A2:

Aggregate Supply
$$\hat{\pi}_S = \frac{1}{1-\beta\mu}\left(\kappa\hat{Y}_S + \mathcal{F}^{AS}_S\right) \quad . \tag{40}$$

One aspect of assumption A2 is worth commenting on. In solving the model, the transition probability μ represents beliefs about the duration of the shock. While we interpret it as representing the true underlying stochastic process, in principle, nothing prevents us from interpreting it as a deviation from the "true" underlying stochastic process. This interpretation connects the model to the recent literature that emphasizes deviations from rational expectations, even if in reduced form.[44]

The AD and AS curves are plotted together in figure 11, using the numerical examples for the Great Depression and Great Recession explained in the following subsection, but the general shape does not depend on the parameters. The AS curve is always upward-sloping. The AD curve is downward-sloping if the ZLB is not binding but upward-sloping if it binds.[45] When the ZLB is not binding, the central bank cuts the nominal interest rate in response to a drop in inflation, reducing the real rate and stimulating demand. However, the central bank cannot cut the nominal rate below zero, which generates a kink at $\hat{\imath}_S = i^{zlb}$. In this case, lower inflation *increases* the real interest rate, reducing demand instead of increasing it because with a fixed interest rate, the real interest rate depends on expected inflation, which is $E_S\hat{\pi}_{S+1} = \mu\hat{\pi}_S$ in the short run.

[44]See recent survey of this literature by Eusepi and Preston (2018).

[45]This is where the policy regime A1a is better for exposition that A1b, since under the latter the AD curve would be a horizontal line at the inflation target, while under A1a it is downward-sloping at a positive interest rate which corresponds to the traditional exposition of AD.

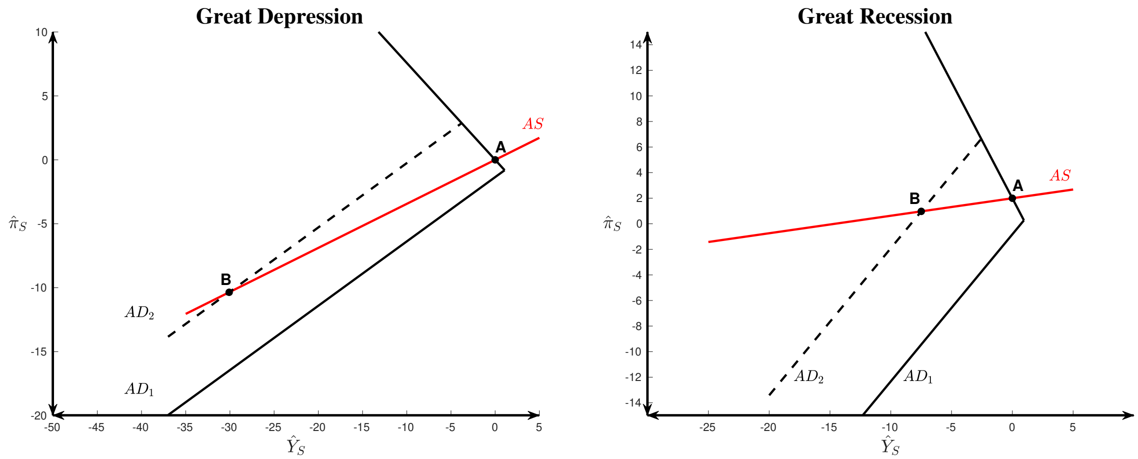


Figure 11: AS-AD diagram for Great Depression and Great Recession

The AD and AS curves have two possible intersections, depending on the exogenous shock $\hat{r}^e_S$ (and the fiscal instruments, which we keep at zero for now). If $\hat{r}^e_S \geq i^{zlb}$, there is a regular equilibrium at point A in figure 11, with inflation and output at steady state in the Great Depression example (left) and the Great Recession example (right). If $\hat{r}^e_S < i^{zlb}$, the shock is large enough for the ZLB to bind, as illustrated at point B. Recall that this section focuses on the shock that makes the natural rate of interest temporarily negative. We considered several possible sources of fast-moving forces that can explain this drop, including overaccumulation of debt by households, firms, or banks triggering a Minsky moment, a collapse in asset prices, or other shocks triggering the shock to banks' net worth and so on. We can solve the model analytically using the AD and AS equations to yield (assuming $\mathcal{F}^{IS}_S = \mathcal{F}^{AS}_S = 0$ if the ZLB is not binding):

$$\hat{Y}_S = \begin{cases} 0 & \text{if } \hat{r}^e_S \geq i^{zlb} \\ \frac{\sigma(1-\beta\mu)}{\vartheta}\left(\hat{r}^e_S - i^{zlb}\right) + \frac{\sigma(1-\mu\beta)}{\vartheta}\mathcal{F}^{IS}_S + \frac{\sigma\mu}{\vartheta}\mathcal{F}^{AS}_S & \text{if } \hat{r}^e_S < i^{zlb}, \end{cases} \tag{41}$$

$$\hat{\pi}_S = \begin{cases} 0 & \text{if } \hat{r}^e_S \geq i^{zlb} \\ \frac{\sigma\kappa}{\vartheta}\left(\hat{r}^e_S - i^{zlb}\right) + \frac{\kappa}{\vartheta}\mathcal{F}^{IS}_S + \frac{1-\mu}{\vartheta}\mathcal{F}^{AS}_S & \text{if } \hat{r}^e_S < i^{zlb}. \end{cases} \tag{42}$$

We will later explore the effect of policies that change $\mathcal{F}^{IS}_S$ and $\mathcal{F}^{AS}_S$ at the ZLB, but for now restrict them to zero, in which case the expression above implies that $\hat{Y}_S < 0$ and $\hat{\pi}_S < 0$. Yet this more general formation will be helpful for later purposes.

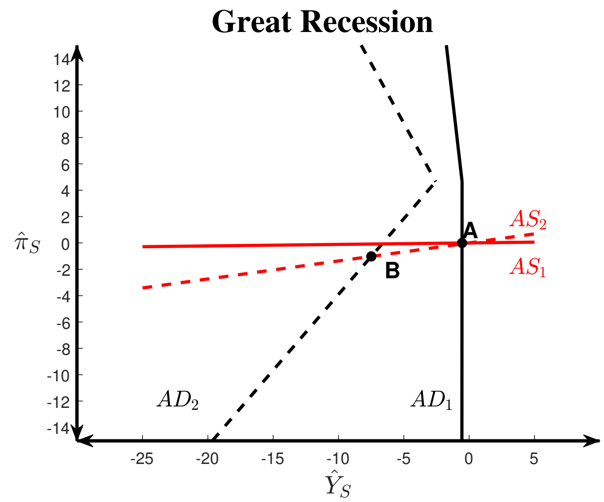


Figure 12: The consequence of increasing the expected duration of the shock at the ZLB on AD and AS illustrated using the Great Recession numerical example

The model restricts how persistent the shock can be, i.e., the expected duration of the shock $\frac{1}{1-\mu}$ cannot be too large. This is captured by A4 which stipulates that $\vartheta(\mu) = (1-\mu)(1-\beta\mu) - \kappa\sigma\mu > 0$. Define $\bar{\mu}$ as the critical value at which point this condition is violated, i.e., $\vartheta(\bar{\mu}) = 0$. As μ approaches $\bar{\mu}$, then ϑ approaches zero, and the model generates arbitrarily large contractions and "explodes."

Why it explodes is clarified in figure 12, which shows, via solid lines, the case in which $\mu = 0$. The equilibrium is at the intersection point A. Here, the output is completely demand-determined by the vertical AD curve once the ZLB is binding. It is pinned down by the shock $\hat{r}^e_S$. For a given output, inflation is determined by the intersection of the vertical part of the AD curve at the ZLB (39) and AS, curve at point A.[46]

Increasing μ provides insights into how the model can create sharp contractions of the order of the Great Recession or Great Depression and highlights the importance of the persistence of the shock, μ, in A5. The dashed lines in figure 12 show the effect of increasing μ. A higher μ implies that the contraction is expected to last longer than one period. The expectation of a possible future contraction shifts both the AD and AS curves. The AS curve is steeper: Lower *inflation expectations* $\mu\hat{\pi}_S$ now reduces output. This is because, with the interest rate at the ZLB, any drop in inflation increases the real interest rate, contracting demand. Moreover, the expectation of a future contraction, $\mu\hat{Y}_S$, appears on the right-hand side of the equation (30), amplifying the effect of both the shock and the expected drop in inflation, as seen in equation (39). Similarly, the AS curve is steeper. Firms expecting lower future inflation will set relatively lower prices for a given aggregate demand. The net effect of the shifts in both curves is a more severe contraction and deflation, shown by the intersection of the dashed curves at point B in figure 12, representing the Great Recession. Increasing μ further leads to

[46]Observe that at the positive interest rate, the AD curve is not vertical, but close to it. Since π_S is is premultiplied by the term $\frac{\sigma(\phi_\pi - \mu)}{1-\mu+\sigma\phi_y}$ it becomes smaller as μ closes to ϕ_π.

an even greater drop in output so that in the limit as $\mu \to \bar{\mu}$, the curves become parallel. At this point, – and beyond – no equilibrium exists.[47]

This discussion clarifies that a first-order approximation of the model can generate an arbitrarily large drop with a sufficiently persistent shock, helping to account for the Great Recession and Great Depression if we calibrate the model accordingly.[48]

3.1.4 Calibrating the Great Recession and the Great Depression and the Role of the Inflation Target as a Buffer

The model is calibrated to replicate the depth of the drop in output and inflation during the Great Depression and Great Recession in the US, as shown in figure 9.

The calibration applies Bayesian methods,[49] assuming each period corresponds to a quarter, resulting in the parameters in Table 1.[50] For the Great Depression, the parameters and shocks match a 30% drop in output and a 10% deflation. The model results are plotted with data from 1929-1937, assuming the efficient rate of interest remains negative. For the Great Recession, parameters and shocks match a 7.5% deviation of output from the trend and a drop in inflation from 2% to 1%. The model results are plotted with data from 2005-2017, assuming the shock reverts to a steady state in Q4 2015 when the Federal Reserve raised rates. The return date is not crucial; what matters instead is the expected duration of the shock which is what is important for demand at time t.

There are two critical differences between the Great Depression and Great Recession calibration. First, prices were more flexible during the Great Depression relative to the Great Recession; the implications of this are discussed in the following subsection. Second, the inflation target is 2% for the Great Recession and 0% for the Great Depression. The inflation target is crucial for the central bank's ability to respond to a short-term negative efficient rate. It determines the available *policy space* the central bank has before hitting the ZLB. Understanding the role of inflation target in the Standard monetary and fiscal policy regime clarifies the notation we adopt and helps the reader interpret the results.

Before the Long Recession in Japan and the literature that emerged in response to it, building on Krugman (1998*a*), there was a growing awareness that the drop in inflation following the Great Inflation of the 1970s might come at a cost. Summers (1991) noted in an insightful commentary on monetary policy challenges that real interest rates had been negative for one-third of the time from World War

[47] Based on the linearized equations alone, one might suspect that instead, this result says that an equilibrium exists but is indeterminate, i.e., that there are infinitely many possible solutions to the model. As shown by Eggertsson and Singh (2019), by solving the fully nonlinear model, this interpretation is incorrect. They show that once μ reaches a critical value $\bar{\mu}$, there is a finite contraction in output and that moving beyond it results in non-existence.

[48] once the collapse becomes unbounded, the approximation breaks down. As shown by Eggertsson and Singh (2019), however. At the same time, the fully nonlinear version of this model does not lead to an unbounded contraction; it generates contractions of the same order as the Great Recession and Great Depression if the same Bayesian methods are used for calibration. It also leads to quantitatively similar findings for key outcomes such as the government spending multiplier.

[49] For details, see Denes and Eggertsson (2009).

[50] $\psi \equiv \frac{1}{\sigma^{-1}+\omega}$ where ω is the inverse of the Frisch elasticity of labor supply.

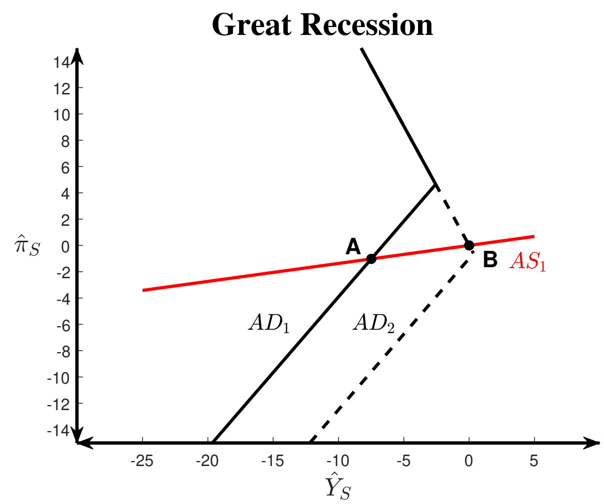


Figure 13: The effect of increasing the inflation target

II to 1991, suggesting that central banks' abilities to accommodate negative rates would be lost with a zero inflation target.[51]

The Standard monetary and fiscal policy regime encompasses a family of policy regimes that differ only in their inflation targets. The variable $\hat{\imath}_t$ measures the central bank's nominal interest rate reduction in basis points relative to its steady-state value $(1+\bar{r})\Pi$, while the inflation target determines steady state gross iterest rate. The variable $i^{zlb} < 0$ measures in basis points the distance the central bank can lower rates from steady state before hitting the ZLB, thus defining its maneuvering room. A higher inflation target reduces $i^{zlb} < 0$, expanding this maneuvering room.

To see this, recall that $\hat{\imath}_t$ is defined in the log-deviation from the steady state so that:

$$i^{zlb} = -\ln \bar{\Pi} - \ln (1+\bar{r}) \approx -\bar{\pi} - \bar{r}, \tag{43}$$

where $\bar{\pi} \equiv \ln \bar{\Pi}$ is the inflation target of the central bank and $\bar{r}$ is the steady-state real interest rate. A policy regime with a higher inflation target gives the central bank more room to cut rates without facing the ZLB constraint. During the Great Recession, for example, countries that entered the financial crisis with a history of high inflation were typically not constrained by the ZLB, see e.g. Eggertsson, Lancastre and Summers (2019).

[51] Summers proposed an optimal long-term inflation rate of 2-3 percent. Fuhrer and Madigan (1997) confirm Summers' insight by studying output volatility in a small forward-looking model, showing that a zero inflation target would frequently constrain policy and increase output volatility compared to a 4% target. While primarily known for launching the extensive literature on estimated DSGE models, Rotemberg and Woodford (1997) addresses the ZLB constraint by penalizing nominal interest rate volatility. They conclude that if the central bank moves the interest rate slowly in reaction to shocks (policy inertia, later studied in Woodford (1999)), output and inflation stabilize close to their targets without violating the ZLB or increasing average inflation, qualifying the findings of Fuhrer and Madigan (1997). Woodford (1999) conclusion is corroborated by Coibion, Gorodnichenko and Wieland (2012), who extend the welfare analysis to allow for steady-state inflation and also consider policy commitments where interest rates exhibit strong inertia, which substantially reduces the cost of occasionally binding ZLB. Woodford (1999) an important precursor to the analysis of the Optimal policy commitment regime, which takes the ZLB explicitly into account in section 4.

The way a higher inflation target gives the central bank more room is illustrated in figure 13 using our notation. The problem of the ZLB is created by the kink point in aggregate demand, indicating the point at which the central bank runs out of room to cut rates. The kink point of the AD curve is derived by equating the two branches of the AD curve in (39) to obtain:

$$\hat{\pi}^{kink} = i^{zlb} - \hat{r}^e_L \approx -\bar{\pi} - r^e_S, \tag{44}$$

where r^e_S is *the level* of the efficient interest rate in the short run. As shown in figure 13, increasing the inflation target from 2% to 10% pushes the kink point below point B (where inflation is on target so that $\hat{\pi}_S = 0$). At the kink-point, then $\hat{\pi}^{kink} < 0$ so the central bank can cut the policy rate to accommodate the drop in the efficient rate of interest while keeping inflation on target — with some room to spare. Figure 13 is drawn using the Great Recession example, where the efficient rate of interest drops by approximately 9%; the drop is of similar orders of magnitude in the Great Depression recalibration. It follows from 44 that a necessary condition for the central bank to achieve its inflation target in response to a shock is that:

$$\bar{\pi} \geq -r^e_S, \tag{45}$$

while a credible inflation target is part of how we define the Standard monetary and fiscal policy regime, increasing this target once the ZLB is reached is far from trivial for at least two reasons. First, we need a reliable estimate of how much the inflation target needs to be raised. If the efficient interest rate is -9 percent, then the inflation target needs to be 9 percent points or higher. Since the efficient interest rate is not directly observed, this poses a challenge. In section 4, we discuss how the Federal Reserve attempted to address this problem. Second, there is an inherent credibility problem associated with raising the inflation target once at the ZLB. In section 4, we document narrative evidence that policymakers considered this as a significant constraint during the Great Recession. We then address how policymakers confronted it during the inflationary regime change in 1933 once policymakers were confronted with the exact same problem. For the rest of section 3, we take the inflation target as a given constant in the Standard monetary and fiscal policy regime. Instead, we explore the implications of other policy options.

3.1.5 Is Market Self-Equilibrating at the ZLB? The Paradox of Price Flexibility

This subsection shows that if firms adjust prices more frequently at the ZLB, then the output contraction intensifies, suggesting that the market is not self-equilibrating. The last subsection showed that the combination of three elements, (i) a temporary negative efficient rate of interest, (ii) the ZLB, and (iii) price rigidities, generates a contraction in output and a fall in inflation. One might conjecture that market forces should lead firms to adjust prices more frequently during episodes like the Great Depression and the Great Recession, undoing one of the three elements creating the problem and thus

Parameterization based on Denes and Eggertsson (2009)			
Parameter	Great Recession	Great Depression	Description
α	0.8932	0.7746	Calvo parameter (price stickiness)
β	0.9985	0.9970	Discount factor
μ	0.9184	0.9016	Markov transition probability
ω	6.8569	1.5302	Inverse of the Frisch elasticity of labor supply
σ^{-1}	3.2338	1.1529	Risk aversion
θ	6.5571	12.6956	Elasticity of substitution between different goods
$\hat{r}^e_S$	-0.0239	-0.0138	Efficient rate in the low state of Markov process

Composite and calibrated parameters			
Parameter	Great Recession	Great Depression	Comment
κ	0.0028	0.0087	$\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}\frac{\sigma^{-1}+\omega}{1+\omega\theta}$
ψ	0.0991	0.3727	$\psi = \frac{1}{\sigma^{-1}+\omega}$
$\bar{\pi}$	0.0050	0.0000	Target inflation rate
$\bar{\imath}$	0.0065	0.0030	$\bar{\imath} = \frac{1+\bar{\pi}}{\beta} - 1$
$\imath^{zlb}$	-0.0065	-0.0030	$\imath^{zlb} = -\ln(1+\bar{\imath})$
$\bar{\tau}_S$	0.1000	0.1000	Steady-state consumption tax
$\bar{\tau}_I$	0.3000	0.3000	Steady-state income tax
ϕ_π	1.5000	1.5000	Response of policy rate to inflation
ϕ_Y	0.5000	0.5000	Response of policy rate to output gap

Table 1: Parameter Values for Numerical Examples

a natural mechanism, if loosened up, for pulling the economy towards recovery. Alas, this conjecture is incorrect. The result is known as the paradox of price flexibility.

The paradox of flexibility Suppose the natural rate of interest is negative and the ZLB is binding. Policy is set according to the Standard monetary and fiscal policy regime, and output is below its natural level. Then, as prices become more and more flexible, output deviates from its natural level further and further. This is a paradox because the natural level of output is defined as the output produced when all prices are flexible.

The main force that reduces output at the ZLB when prices are more flexible is that greater flexibility generates lower inflation expectations, thus increasing the real interest rate and lowering demand. This is illustrated in figure 14. Consider first equilibrium A, corresponding to the Great Recession example. If prices become more flexible, this results in a steeper AS curve which rotates around steady-state inflation and output, generating lower expected inflation ($\mu\hat{\pi}_S$) at the ZLB, raising real rates and thus contracting demand, as shown in point B.

The resolution of the puzzle is that the equilibrium under full price flexibility, where output equals the natural rate, is a mirage. It does not exist. Figure 14 illustrates this: as price flexibility increases, the AS curve steepens, intensifying the output contraction at point B. In the limit, with fully flexible

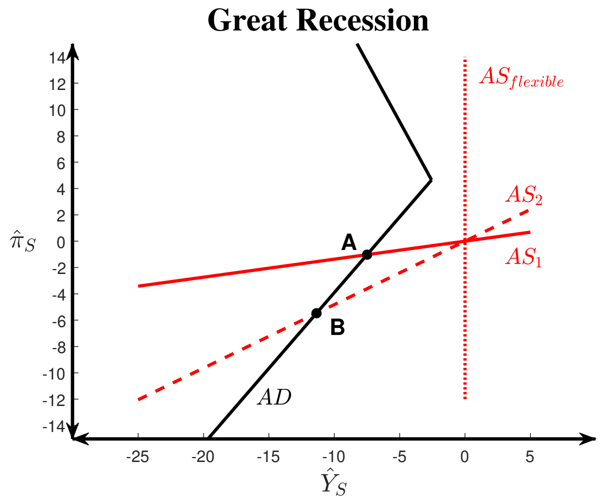


Figure 14: The Price Flexibility Paradox, increasing Price Flexibility in the Great Recession calibration (point A) by replacing the slope of the Phillips curve, κ, with the one from the Great Depression calibration (point B).

prices, the AS curve becomes vertical (the dotted line) and never intersects the AD curve at the ZLB, implying that no equilibrium exists. This is not an artifact of the approximated model but a natural feature of the Standard monetary and fiscal policy regime, which can be shown under minimalistic assumption, e.g. with fully flexible prices and treating output as exogenous.[52]

The paradox offers insight into why the Great Recession was less severe than the Great Depression. While figure 14 is qualitative, it also conveys an interesting quantitative point. While point A is the Great Recession calibration, point B is generated by replacing the slope of the Phillips curve in the Great Recession, κ, with the higher value in the Great Depression calibration. This results in an additional 4% drop in output and an additional 4.5% drop in inflation. Thus, if prices during the Great Recession had been as flexible as during the Great Recession, it would have been more severe.

The paradox of price flexibility was originally coined by Eggertsson and Krugman (2012). They demonstrated this paradox in the context of a spender-saver model like the one analyzed in section 2, augmented by price rigidities and the assumption of nominal debt. In this model, an unanticipated fall in inflation redistributes wealth from borrowers (who have a high marginal propensity to consume, MPC) to savers with a low MPC, reducing demand. This effect strengthens as prices

52. To see this, we use a proof by contradiction. Consider a nonlinear flexible-price economy under perfect foresight with real and nominal bonds but an exogenous output. We introduce the cash constraint as in section 2 to simplify the discussion of price determination. The equilibrium conditions are summarized by (i) Fisher equation: $1 + r_t = (1 + i_t)\frac{P_{t+1}}{P_t}$; (ii) ZLB: $i_t \geq 0$; (iii) Cash constraint: $M_t \geq \chi P_t Y$. The real interest rate is exogenous, like in section 2. The central bank can control the price level at time t by choosing M_t if the ZLB is not binding. $\frac{P_t}{P_{t-1}}$ is gross inflation. Consider an unexpected exogenous shock to the real interest rate in period 0 such that it is negative, i.e., $r_0 < 0$, reverting in the next period so that $r_t = \beta^{-1} - 1 > 0$ for all $t > 0$. Solve the model backwards by first considering any period $t \geq 1$. The central bank inherits P_{t-1} from the previous period. It is easy to confirm that the solution $\frac{P_t}{P_{t-1}} = 1$ satisfies (i)-(iii) for all $t \geq 1$, including period 1. Accordingly, the central bank sets the money supply so that $P_1 = P_0$ in period 1. And here we run into an immediate contradiction. Consider period 0. The implication from the solution just described is that in period 0, $\frac{P_1}{P_0} = 1$, so by (i), $i_t = r_t < 0$, violating (ii), i.e., the ZLB. Hence, there is no equilibrium consistent with this policy regime.

become more flexible. However, the source of the paradox in the New Keynesian model differs. It arises because the shock is expected to last for multiple periods, and increased price flexibility reduces expected inflation at the ZLB, increasing the real interest rate and reducing aggregate demand. Eggertsson (2012) first demonstrated this paradox in the New Keynesian model, although several previous authors, including Fisher (1923), Tobin (1975), and De Long and Summers (1986), noted the potential detrimental effects of higher price flexibility at or above the ZLB. Bhattarai, Eggertsson and Schoenle (2018) show the conditions under which the paradox applies generally in the New Keynesian model and estimate a medium-scale general New Keynesian model in the spirit of Smets and Wouters (2007). They find that more flexible prices during their estimation window, sample from 1966:I -2004:IV, would have created greater inflation and output volatility.

3.2 What Can Fiscal Policy Do Under the Standard Monetary and Fiscal Policy Regime?

Under the Standard monetary and fiscal policy regime, fiscal policy offers a powerful alternative to monetary policy. We review theoretical and empirical work suggesting that government spending multipliers grow substantially larger at the ZLB than when interest rates are positive. Large fiscal multipliers imply that fiscal austerity through spending cuts reduces the tax base, potentially increasing deficits, while changes in government debt may alter aggregate demand by shifting long-run expectations about future policy. This "confidence" effect disappears when interest rates are positive (due to monetary policy offsetting it). We also examine the effect of deploying multiple fiscal instruments simultaneously: such a strategy promises to eliminate the ZLB, but policymakers face challenges in implementing it. It is worth highlighting the roadmap from the introduction again that the results presented on fiscal multipliers in this section are specific to the Standard monetary and fiscal policy regime and highly contingent on it. The impact of fiscal policy under alternative monetary policy regimes will be substantially different depending on the underlying policy regime.

In this section, we also consider two important extensions to the baseline framework. The first is a simple illustration of a New Keynesian model with different agents that amplify the policy effect due to income effects. The second is that we show that the particular stochastic process we have used—a two-state Markov Process—is chosen for analytic convenience; we obtain the same central conclusion assuming an AR(1) process but also obtain a few new insights.

3.2.1 Fiscal Multipliers: The Theoretical Prediction of the New Keynesian Model under the Standard Monetary and Fiscal Policy Regime

This subsection shows the impact of increasing government spending on output in the short run by computing fiscal multipliers. The assumption of the Standard monetary and fiscal policy regime A1 (A1a or A1b) is critical in deriving these results. The fundamental property the combination of these two assumption generate is that the duration is the ZLB, the natural rate of interests and the fiscal expansion all coincide (A1 and A2). The size of the multiplier is different, assuming an alternative policy regime. The major takeaway is that the fiscal multiplier is significantly larger at the ZLB than at positive interest rates under A1 and A2.

In 2009 UK Conservative Party leader David Cameron declared that the "age of austerity" arrived, meaning it was time to curb government spending and/or raise taxes to balance the budget. After becoming prime minister in 2010, he implemented austerity measures. Several other governments, including Greece, Spain and Italy, followed a similar strategy. The US never fully embraced austerity, but after an initial spending burst in 2009 the US administration faced political pressures to contain deficits, thereby limiting stronger fiscal actions.

Blanchard and Leigh (2013) document a striking cross-country correlation in European countries. Figure 15 plots the forecast error of real GDP growth for 2010 and 2011 relative to spring 2010 forecasts, when several European countries implemented fiscal consolidation packages. The chart suggests austerity triggered a larger recession than expected. Countries that planned (and then implemented) significant austerity experienced a larger drop in growth than anticipated when these plans were designed relative to countries that did not implement austerity measures.

While we will show that fiscal multipliers at the ZLB assuming A1 are larger than under normal circumstances, this result was overlooked by many analysts and government officials in 2010, especially in the Eurozone, who based their outlook on the estimated effect of austerity measures using empirical evidence accumulated at positive short-term interest rates. US policymakers were less taken by this argument; see, e.g., Romer and Bernstein (2009), a note written by two key policymakers. The effects of fiscal policy reported in that note, 1.6, are not too far from those reported in this review, especially those in section 3.2.5. To understand the effect of fiscal spending, we need to define the composite terms that shift the IS equation (30) and the AS equation (32):

$$\mathcal{F}_t^{IS} \equiv (\hat{F}_t - E_t\hat{F}_{t+1}) + \sigma\chi^s Et(\hat{\tau}_{t+1}^s - \hat{\tau}_t^s), \tag{46}$$

$$\mathcal{F}_t^{AS} \equiv \kappa\psi(\chi^I\hat{\tau}_t^I + \chi^s\hat{\tau}_t^s - \sigma^{-1}\hat{F}_t). \tag{47}$$

Here, $\chi^s > 0$, $\chi^I > 0$, and $\psi > 0$ are coefficients[53] $\hat{F}_t$ is the deviation of real government spending on goods and services from steady state, expressed as a fraction of steady-state output. $\hat{\tau}_t^s$ is a sales tax levied on top of the firm's sticky price relative to the rate in steady state, and $\hat{\tau}_t^I$ represents taxes on all household income (labor income and income from firms' profits). A temporary increase in government spending increases aggregate demand in the short run, according to the IS equation, by directly increasing government consumption. A temporary cut in sales tax also increases demand by giving consumers more incentive to spend.

In the standard New Keynesian model, a cut in income taxes[54] has no effect on the IS equation but

[53] Defined as $\chi^s \equiv \frac{1}{1-\bar{\tau}^s}$, $\chi^I \equiv \frac{1}{1+\bar{\tau}^s}$.

[54] Here, our definition of income includes both labor income and firms' profits.

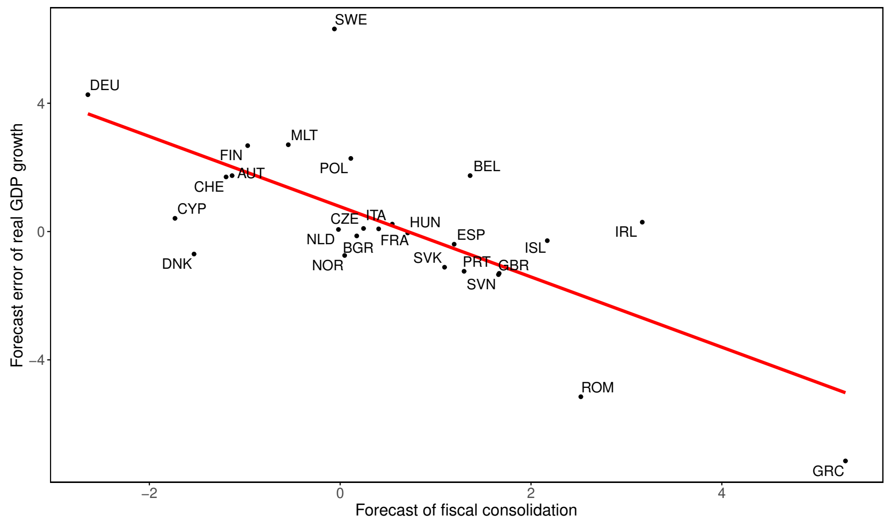


Figure 15: The Negative Effect of Austerity Measures Was Larger Than Expected
Note: This figure plots the forecast error for real GDP growth in 2010 and 2011 relative to forecasts made in the spring of 2010, which incorporated austerity measures for 2010 and 2011 that were designed in the spring of 2010, based on Blanchard and Leigh (2013). The Ordinary Least Squares regression is depicted by a red line.

increases the incentive to work (see AS equation). This is not a general result but a useful one.[55] Income taxes play a constructive role when analyzing the effect of a reduction in government spending on the deficit because they are kept constant at their steady-state value, capturing the fact that tax revenues drop in proportion to the drop in the tax base, i.e., output/income. Moreover, when analyzing the effect of supply shocks, they are a convenient reduced-form representation of general supply shocks, or what Chari, Kehoe and McGrattan (2007) call a *labor wedge*, a shorthand label for a number of distortions and shocks.

Sales taxes and government spending affect not only the IS equation but also the AS equation because they change incentives to work. For example, high government spending in the short run absorbs more aggregate output at the expense of private consumption, thus increasing the marginal utility of income and increasing people's eagerness to work. A cut in sales taxes works the same way. Neither of these supply effects is quantitatively important in the Great Recession and Great Depression calibrated examples.

We assume that all fiscal instruments, with the exception of lump-sum taxes, which adjust in the background, are at steady state *in the long run*:

$$\hat{\tau}_t^s = \hat{\tau}_t^I = \hat{F}_t = 0 \text{ for } t \geq t_L, \tag{48}$$

[55] It hinges on two assumptions. First, the New Keynesian agents are not borrowing-constrained. In a model with constrained agents, income tax cuts will directly increase the spending of those constrained by a debt limit. Second, wages are assumed to be perfectly flexible, so variations in income taxes have a stronger effect on inflation than in the case of rigid wages.

however, they may be adjusted in reaction to the shock *in the short run*:

$$\hat{\tau}_S^s \geq 0, \hat{\tau}_S^I \geq 0, \hat{F}_S \geq 0 \text{ for } t < t_L. \tag{49}$$

Assumptions A1 and A2 imply that we can write the composite fiscal terms in the short run as:

$$\mathcal{F}_S^{IS} = (1-\mu)\left(\hat{F}_S - \sigma\chi^s\hat{\tau}_S^s\right), \tag{50}$$

and:

$$\mathcal{F}_S^{AS} = \kappa\psi(\chi^I\hat{\tau}_S^I + \chi^s\hat{\tau}_S^s - \sigma^{-1}\hat{F}_S). \tag{51}$$

We define the fiscal multiplier under any policy regime with the first equality and the second two equalities are specific to the Standard monetary and fiscal policy regime:

$$M_F = \frac{E_0\sum\limits_{t=0}\beta^t\Delta\hat{Y}_t}{E_0\sum\limits_{t=0}\beta^t\Delta\hat{F}_t} = \frac{\frac{1}{1-\mu\beta}\Delta\hat{Y}_S}{\frac{1}{1-\mu\beta}\Delta\hat{F}_S} = \frac{\Delta\hat{Y}_S}{\Delta\hat{F}_S}. \tag{52}$$

Here, the second and third equalities follow from the simple stochastic structure of the efficient interest rate and the perfect correlation of the increase in government spending with the efficient interest rate under the Standard monetary and fiscal policy regime (A1a and A1b). A useful property of this shock structure is that what the literature defines as the *dynamic multiplier* – that is, the discounted sum in (52) – is identical to the *impact multiplier*, under A1a and A2b which is the last part of (52) and describes how much output increases today in response to government spending today. Setting all the fiscal instruments to zero except for $\hat{F}_S$, we can substitute (50) and (51) into equations (39) and (40) to show explicitly that while the fiscal multiplier assuming A1 is always below one at positive interest rates, it is always above one when the ZLB is binding:

$$\frac{\Delta\hat{Y}_S}{\Delta\hat{F}_S} = \begin{cases} \text{if } \hat{\imath}_S \geq i^{zlb}: & \\ \quad \textbf{A1a} & \frac{(1-\mu\beta)(1-\mu)+\kappa\psi(\phi\pi-\mu)}{(1-\mu+\sigma\phi_y)(1-\mu\beta)+\sigma\kappa(\phi_\pi-\mu)} < 1 \\ \quad \textbf{A1b} & \sigma^{-1}\psi < 1 \\ \text{if } \hat{\imath}_S = i^{zlb}: & \\ \quad \textbf{A1a} \text{ or } \textbf{A1b} & \frac{\vartheta+\sigma\mu(\sigma-\psi)}{\vartheta} > 0. \end{cases} \tag{53}$$

Where recall that $\psi \equiv \frac{1}{\sigma^{-1}+w} < \sigma$. The quantitative effect of fiscal policy at positive interest rates depends on whether we specify the Standard monetary and fiscal policy regime via a ZLB-constrained Taylor rule or a strict inflation target. The two are approximately equivalent if, in the Taylor specification, we assume $\phi_\pi = 1.5$ and $\phi_y = 0.5$, as reported in Table 2. As the value of the multiplier at positive interest rates is not the focus of this review, we refer readers to Woodford (2011) for an overview.

Multiplier	Great Recession		Great Depression	
	$\hat{\imath}_t = i^{zlb}$	$\hat{\imath}_t > i^{zlb}$	$\hat{\imath}_t = i^{zlb}$	$\hat{\imath}_t > i^{zlb}$
$\frac{\Delta \hat{Y}}{\Delta \hat{F}_S}$	1.1	0.3	2.2	0.2

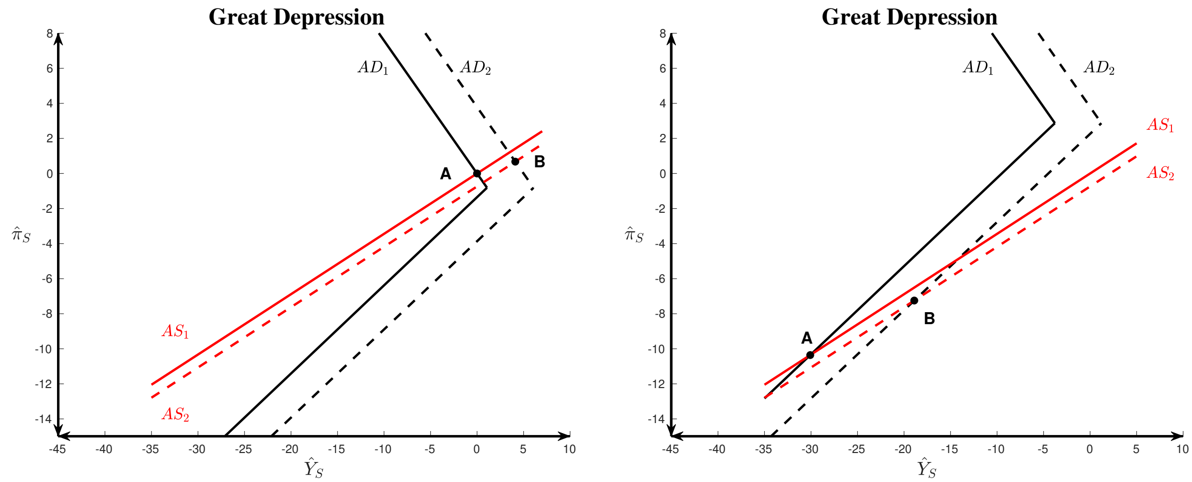
Table 2: Government-Spending Multipliers

Figure 16 shows why the government-spending multiplier under A1 is larger at the ZLB assuming the Standard monetary and fiscal policy than at positive interest rates and clarifies several interesting properties. Consider the two initial equilibria depicted by point A, on the left for positive interest rates and on the right for the ZLB (parameters are set as in the Great Depression numerical example). The figure shows the effect of an increase in government spending by 5 percent relative to output (which is similar in magnitude to the peak of the New Deal government spending). Both **AD** and **AS** shift rightward, resulting in a new pair of equilibria, B. The figure shows that the expansionary effect of fiscal spending at the ZLB is larger than the same effect at positive interest rates, with output increasing by more than 10 percent in response at the ZLB and by about 0.3 percent at positive interest rates. At positive rates, the central bank increases the interest rate in response to the increase in government spending. In contrast, at the ZLB, the central bank does not raise the interest rate.

The two numerical examples illustrate a more general principle. As the recession becomes more severe (compare the Great Depression to the Great Recession in Table 2), the multiplier increases. This "divine coincidence" is emphasized by Christiano, Eichenbaum and Rebelo (2011). It can be seen analytically by observing that the denominator in the expression for the multiplier, ϑ, is the same as in the expression for output (41). Accordingly, the closer the denominator is to zero, the larger the drop in output and, simultaneously, the higher the spending multiplier.

It is straightforward to understand why government spending in the Standard monetary and fiscal policy regime increases aggregate demand. This follows directly from the IS equation 30. More government spending simply increases aggregate spending as long as it is not offset by a reduction in private consumption. Private consumption will only offset the increase if the real interest rate rises. At the ZLB, however, the opposite occurs. Government spending increases not only current output and inflation but also *expected* output and inflation. The increase in inflation, with the interest rate fixed at the ZLB, reduces the real interest rate, stimulating demand via intertemporal substitution. The higher expectation of future output also stimulates spending through the permanent-income hypothesis.

An increase in $\hat{F}_S$ not only increases aggregate demand but also shifts out aggregate supply (figure 16). This is because an increase in government spending diverts resources from private consumption. The marginal utility of private consumption increases, and labor supply shifts out. This reduces wages and shifts the **AS** curve out, as firms are willing to produce more at a given price level. The effect of the increase in aggregate supply is subtle at the ZLB: it is contractionary. We return to this somewhat paradoxical property of the model in subsection 3.3.1. As can be seen in the definitions of $\mathcal{F}_t^{IS}$ and $\mathcal{F}_t^{AS}$, sales tax cuts have the same effect as the increase in government spending once



(a) ZLB is not binding (b) ZLB binding

Figure 16: The Effect of an Increase in Fiscal Spending using the Great Depression Calibration

scaled by $\sigma\chi_s$ assuming A1. Thus, the discussion above remains largely unchanged. However, the initial economic impulse created by the policy change differs. Sales tax cuts do not increase spending directly through government consumption of goods and services. Instead, they increase private consumption by incentivizing consumers to spend more.

3.2.2 Fiscal Multipliers: Brief Summary of Recent Evidence

In this subsection, we briefly discuss some recent empirical studies on how government spending multipliers at the ZLB compare with those at positive interest rates. Examining the large literature on government spending multipliers is beyond the scope of this paper; recent overview articles include Ramey (2016), Nakamura and Steinsson (2018), and Ramey (2019).

Some care is needed in interpreting this evidence. The empirical evidence does not explicitly condition on the Standard monetary and fiscal policy regime as we have done in our theoretical analysis. If monetary policy were to tighten at the ZLB in response to fiscal shocks, as it happens under the Optimal monetary commitment policy regime discussed below, one should expect a lower multiplier, generally below one, than we derived in our previous theoretical analysis. Based on our analysis in the previous section, we interpret the large fiscal effects and negative supply shocks, such as oil shocks, as evidence supporting a more general policy regime that shares important elements with the Standard monetary and fiscal policy regime. This is topic we come back to in section 4.3.

Empirical research, considering the ZLB, generally finds multipliers around 1.5, significantly higher than the 0.3 to 0.8 range observed at positive interest rates. Studies such as Klein and Winkler (2021), which analyzes data from 17 countries between 1917 and 2016, Miyamoto, Nguyen and Sergeyev (2018) with Japanese data from 1980 to 2014, and Ramey and Zubairy (2018) focusing on the US from

1889 to 2015, all report a ZLB multiplier in the vicinity of 1.5.[56] Nakamura and Steinsson (2014) discuss an open-economy multiplier also around 1.5, aligning with these findings under certain conditions. Chodorow-Reich (2019) finds that cross-sectional evidence points to a national multiplier of 1.7 or above, assuming that monetary policy does not offset the fiscal expansion, consistent with the Standard monetary policy regime (what he terms "no monetary response"). Observe that the no-monetary response leads to exactly the same equilibrium as the Standard monetary and fiscal policy we have assumed.

These studies report slightly higher multipliers than those suggested by models calibrated to the Great Recession shown in Table 2. Gordon and Krenn (2014) estimates the fiscal multipliers during 1940-41, leading up to World War II, to be around 2.5, modestly surpassing the multiplier implied by the Great Depression calibration reported in Table 2. We will provide a natural explanation for this in section 3.2.5. The standard New Keynesian model assumes that no agents are borrowing constrained and, therefore, satisfy Ricardian Equivalence. As we will see, once this assumption is relaxed, it is natural to arrive at a somewhat higher multiplier effect via income effects.

3.2.3 Fiscal Austerity and Deficits

Large spending multipliers at the ZLB imply that austerity policies — cutting fiscal spending to balance the budget — may backfire.

Large deficits following the Great Recession created political forces that drove David Cameron to declare the "age of austerity" in 2009. This happened not only in the UK but in most other industrial countries in the wake of the Great Recession. The deficits were driven by government stimulus packages and the costs of the banking crisis. Consequently, numerous economists and politicians prioritized controlling public finances to "restore confidence" and facilitate a rapid recovery.

Since the government-spending multiplier is higher at the ZLB than under normal circumstances, the effect of fiscal austerity on the deficit is not obvious. For concreteness, we define austerity as cutting government spending and/or increasing sales taxes, both of which lead to a reduction in output and the tax base (the UK, implemented both).

To understand the effect of austerity on the deficit, we need to be explicit about the government budget constraint. Consider a government that issues all its debt B_t in short-term nominal bonds. B_t is the dollar value of the debt at time t, which is repaid with interest in the next period $(1+i_t)\,B_t$. It is convenient to write the government budget constraint in terms of its real value in period t inclusive of the interest rate as $w_t \equiv \frac{B_t}{P_t}(1+i_t)$. A first-order approximation of the government budget constraint written in terms of w_t around some value $\bar{w}$ for the debt yields the following equation:

$$\beta\hat{w}_t = \hat{w}_{t-1} + \beta w_y \hat{\imath}_t - w_y \hat{\pi}_t + (1+\bar{\tau}^s)\,\hat{F}_t - \left(\bar{\tau}^I + \bar{\tau}^s\right)\hat{Y}_t - \hat{T}_t^L - c_y \hat{\tau}_t^s - \hat{\tau}_t^I, \tag{54}$$

[56] Ramey and Zubairy (2018) stress that this estimate excludes World War II rationing periods.

where both $\hat{w}_t$ and $\hat{T}_t^L$ are defined relative to steady state as a fraction of output, $\stackrel{c_y}{\equiv} \bar{C} bar Y, recall that in the steady state we appr$
$\frac{1}{1+\bar{r}}$.[57]

Up to this point, we have assumed that lump-sum taxes are adjusting in response to a particular fiscal policy. Due to Ricardian equivalence, the timing of lump-sum taxes is irrelevant, rendering the deficit indeterminate. We now assume lump-sum taxes in the short run are unchanged at the steady state[58] so that:

$$\hat{T}_t^L = 0 \text{ for } t < t_L, \tag{55}$$

but in the long run, adjust to stabilize public debt — that is, $\hat{T}_t^L$ adjusts so that:

$$\hat{w}_t = \hat{w}_{t_L-1} = \hat{w}_L \ \text{ for } t \geq t_L. \tag{56}$$

As before, provided other fiscal instruments remain constant and only lump-sum taxes adjust, the paths for inflation and output are determined independently of fiscal policy. The short-run deficit is then:[59]

$$\widehat{BD}_S = \beta w_y \hat{\imath}_S - w_y \hat{\pi}_S - (\bar{\tau}^I + \bar{\tau}^s)\hat{Y}_S + (1 + \bar{\tau}^S)\hat{F}_S - c_y \hat{\tau}_S^I - \hat{\tau}_S^I, \tag{57}$$

yielding the following expression for the deficit (given output and inflation, as determined by (41) and (42)) under the assumption that other fiscal variables are kept at a steady state:

$$\widehat{BD}_S = \begin{cases} 0 & \text{if } \hat{r}_S^e \geq i^{zlb} \\ \underbrace{\beta w_y i^{zlb} - w_y \hat{\pi}_S}_{\text{interest cost}} - \underbrace{(\bar{\tau}^I + \bar{\tau}^s)\hat{Y}_S}_{\text{reduction in tax base}} & \text{if } \hat{r}_S^e > i^{zlb}. \end{cases} \tag{58}$$

Figure 17 shows the increase in the deficit for the Great Depression and Great Recession numerical examples for the two cases of $w_y = 0$ and $w_y = 0.75 * 4$.[60]

At zero debt, the budget deficit increases proportionally to the output drop. In the Great Recession case, a 7.5% output drop leads to a 3% GDP deficit. Positive debt levels introduce two factors: lower interest rates reducing debt costs (first term in (58)) and falling inflation increasing real debt value (second term in (58)). In the Great Recession calibration, reduced interest costs decrease the deficit (dashed line in figure 17). In contrast, in the Great Depression example, outstanding debt tends to increase the deficit due to debt deflation.

Despite implementing austerity measures, several countries, such as Greece, Spain, and Portugal, initially experienced increased deficits, largely explained by the collapse of their tax bases. This is

[57] That is, $\hat{T}_t{}^L = \frac{T_t^L - \bar{T}^L}{\bar{Y}}$ and $\hat{w}_t = \frac{w_t - \bar{w}}{\bar{Y}}$.

[58] For technical reasons, we assume that lump-sum taxes are set so that public debt cannot exceed a debt limit $\bar{w} > 0$ that can be arbitrarily high and is never reached in the simulation considered. By imposing this limit, we guarantee that lump-sum taxes are set so that the transversality condition of the representative household is always satisfied. The simplest way of ensuring this is to make the assumption that the stochastic process governing the shock has some terminal date T$\geq t_L$ at which the shock reverts back to a steady state with probability 1.

[59] Given (36) and (56), the government budget constraint implies that $\hat{T}_L = (1 - \beta)\hat{w}_L = (1 - \beta)\hat{w}_{t_L-1}$.

[60] This corresponds to 75% of annual output.

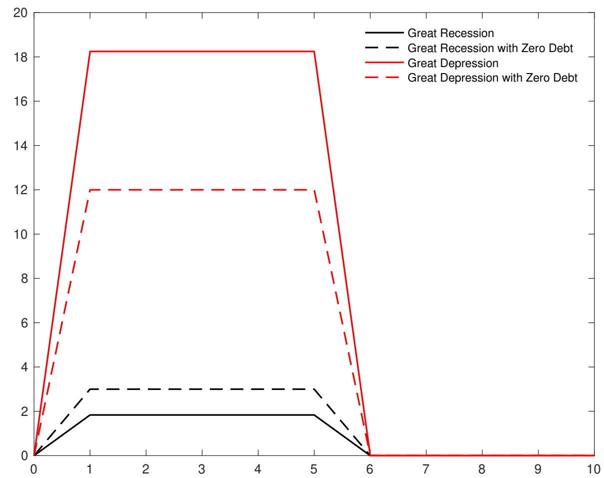


Figure 17: Deficits under the Standard monetary and fiscal policy regime

Table 3: Short-Run Deficit Multipliers of Government Spending

	Great Recession		Great Depression	
Multiplier	$\hat{\imath}_t = i^{zlb}$	$\hat{\imath}_t > i^{zlb}$	$\hat{\imath}_t = i^{zlb}$	$\hat{\imath}_t > i^{zlb}$
$\frac{\Delta \hat{D}_S}{\Delta \hat{F}_S}$	0.6	1.5	-0.3	1.1

consistent with the Great Depression numerical example shown in Table 3. In contrast, the UK's fiscal austerity slowed growth but also reduced the deficit, aligning more closely with the Great Recession numerical example in Table 3.

3.2.4 Deficits and confidence

Debt accumulation resulting from short-run fiscal policy can change expectations about long-run fiscal policy. Assessing the impact of a short-run fiscal stimulus requires considering its influence on future expectations, or "confidence," which emerges as a consideration special to the ZLB.

If the ZLB is not binding, expectations about long-run variables have no effect on demand and inflation assuming A1b since they will be offset by monetary policy. Conditional on the ZLB being binding, we now consider deviations of fiscal instruments from a steady state in the long run. In addition, we allow for long-run inflation to deviate from its original target. Following the same steps in deriving the short-run AD as in 39, while keeping track of long-run expectations, we obtain:

$$\hat{Y}_S = \underbrace{\frac{\sigma}{1-\mu}(i^{zlb} - \mu\hat{\pi}_S - \hat{r}^e_S) + \hat{F}_S - \sigma\chi s\hat{\tau}^s_S}_{\text{Short-Run Demand Effects}} + \underbrace{(\sigma + \frac{1-\mu\beta}{\kappa})\hat{\pi}_L - \psi\chi^I\hat{\tau}^I_L - \omega\psi\chi^s\sigma\hat{\tau}^s_L + \omega\psi\hat{F}_L}_{\text{Long-Run Demand Effects}}. \quad (59)$$

Assuming long-run debt is above steady state, Table 4 summarizes the effect of deficits on short-run demand under different assumptions about which variables are adjusted to pay interest on the debt. Denes, Eggertsson and Gilbukh (2013) show some numerical examples.

Adjusting variable	$\hat{\tau}_L^I \uparrow$	$\hat{\tau}_L^s \uparrow$	$\hat{F}_L \downarrow$	$\hat{\pi}_L \uparrow$
$\frac{\Delta \hat{Y}_S}{\Delta \hat{w}_L}$	-	+	+	+

Table 4: Effect of Deficit in the Short Run on Aggregate Demand under Different Assumptions of What Variables are Used to Pay Interest on the Debt in Steady State

A reduction in public debt can improve confidence primarily by creating expectations of lower future income taxes. Meanwhile, if higher public debt generates expectations of higher long-run sales taxes, demand increases to take advantage of lower sales taxes in the short run. Similarly, if higher debt triggers expectations of lower long-run government spending, this increases demand today, as it increases people's expectations of future private consumption. Finally, if higher debt triggers an increase in inflation expectations, this also increases demand in the short run.

The overall message is that the effect of a short-run policy intervention needs to be complemented with a clear vision of its long-run impact. To develop a positive theory of a policy regime encompassing both short- and long-run policy instruments, a more comprehensive model of government behavior is needed, the topic of section 4.

3.2.5 New and Old Fiscal Multiplier: Introducing Heterogeneous Agents

This subsection demonstrates how introducing borrowing-constrained consumers causes the fiscal policy multiplier to resemble the classic Keynesian multiplier of undergraduate textbooks. We present special conditions under which the fraction of borrowing-constrained consumers has an interpretation identical to the marginal propensity to consume in Keynesian literature, which determines the multiplier's value. Generally, this extension increases the previously derived multiplier value.

If some households are borrowing-constrained, tax cuts have a direct demand effect, as these households increase their spending by an amount equal to the tax cut. This triggers the traditional Keynesian multiplier: one person's spending becomes another's income. Since a fraction of the population spends any additional income in its entirety, this generates further spending, income, and so forth. This multiplier effect, first illustrated by Keynes's student Kahn (1931), forms the basis of the traditional fiscal multiplier.

Kahn's exposition, which persists in current undergraduate textbooks, assumes people spend a fraction c of their income (the marginal propensity to consume) while saving a fraction $1 - c$.[61] Assuming

[61] Kahn (1931) allows for different marginal propensities to consume from profits and labor income, but we follow later Keynesian literature in equating these.

rigid prices and a constant interest rate, the government spending multiplier is then:[62]

$$\frac{\Delta \hat{Y}_t}{\Delta \hat{F}_t} = \frac{1}{1-c}. \tag{60}$$

At the core of this is the Keynesian consumption function, which makes consumption a fraction of income net of taxes. The Keynesian consumption function also implies that households will spend part of tax cuts:

$$\frac{\Delta \hat{Y}_t}{\Delta \hat{T}_t} = \frac{c}{1-c}. \tag{61}$$

This logic is absent in the standard New Keynesian model, which has a representable household that is Ricardian: consumption behavior isn't a mechanical function of disposable income. The modern approach is rooted in Friedman's permanent income hypothesis instead (Friedman (1957)). However, the multiplier shown above emerges naturally if we reconsider the New Keynesian model with agents differing in their degree of impatience and borrowing constraints as in the model of Eggertsson and Krugman (2012) presented in section 3.[63]

Consider a model with a fraction χ of households that are more impatient than the remaining $1-\chi$ fraction. Werning (2015) proposes elegant abstractions to simplify the algebra. A useful special case is the zero liquidity limit, where the debt limit from section 3, D, tends to zero: $D \to 0$. In addition, suppose for simplicity that each agent receives the same share of income and profits, i.e., $Y_t = Y_t^b = Y_t^s$.[64] The impatient households spend as much as they can but are unable to borrow. Defining each variable in deviation from the steady state but as a ratio of the steady state output, their spending is:

$$\hat{C}_t^b = \hat{Y}_t^b - \hat{T}_t^b, \tag{62}$$

while the saver satisfies the standard consumption Euler equation:

$$\hat{C}_t^s = E_t \hat{C}_{t+1}^s - \sigma(\hat{\imath}_t - E_t \hat{\pi}_{t+1} - \hat{r}_t^e) + \mathcal{F}_t^{IS}. \tag{63}$$

Aggregate spending is

$$\hat{Y}_t = (1-\chi)\hat{C}_t^s + \chi \hat{C}_t^b + \hat{F}_t. \tag{64}$$

We assume that the AS equation remains unchanged, along with the term $\mathcal{F}_t^{AS}$.[65] Following Werning (2011*a*), we first consider the limiting case where $\kappa \to 0$, resulting in $\hat{\pi}_S = \mathcal{F}_S^{AS} = 0$.

[62]Let consumption be $\hat{C}_t = c(\hat{Y}_t - \hat{T}_t)$ with a resource constraint $\hat{Y}_t = \hat{C}_t + \hat{F}_t$. Substituting for $\hat{C}_t$ yields $\hat{Y}_t = \frac{1}{1-c}\hat{F}_t - \frac{c}{1-c}\hat{T}_t$, expressed in deviation from steady state relative to steady state output.

[63]Early examples of this approach in the New Keynesian literature include Galí, López-Salido and Vallés (2007) and Bilbiie (2008), which build on Campbell and Mankiw (1989).

[64]An example of microfoundations delivering this result is found in Benigno, Eggertsson and Romei (2019).

[65]See Benigno, Eggertsson and Romei (2019) for an example of micro-foundations consistent with this assumption.

The key change occurs in the IS equation. Combining the consumption behavior and aggregate resource constraint equations yields once again the IS equation (30) but with a critical difference: the term summarizing fiscal spending is now given by:

$$\mathcal{F}_t^{IS} = \frac{1}{1-\chi}\left(\hat{F}_t - E_t\hat{F}_{t+1}\right) - \frac{\chi}{1-\chi}\left(\hat{T}_t^b - E_t\hat{T}_{t+1}^b\right). \tag{65}$$

Here, assuming A2, it is helpful to consider AD to yield:

$$\hat{Y}_s = \sigma(i_s - E_t\pi t + 1 - r_s^e) - \frac{\chi}{1-\chi}\hat{T}_t^b + \frac{1}{1-\chi}\hat{F}_t. \tag{66}$$

The variable $\hat{T}_t^b$ represents the tax on borrowing-constrained households. If fiscal interventions (i.e., variations in $\mathcal{F}_t^{IS}$) are financed by taxes on saving households, the model satisfies Ricardian Equivalence. Consequently, the time pattern of taxation on saving households, and thus government debt, is indeterminate and need not be accounted for.

The definition of this composite disturbance differs only in that fiscal spending is now multiplied by $\frac{1}{1-\chi}$, and taxes are proportional to $\frac{\chi}{1-\chi}$. As $\chi \to 0$, the model reduces to the standard New Keynesian model. Assuming the same stochastic process as before, we derive the government spending multiplier below. The multiplier for cutting taxes of the borrowing constrained, T_t^b, is the same except for that it multiplied by χ (recall we have simplified by assuming $\kappa \to 0$):

$$\frac{\Delta\hat{Y}_S}{\Delta\hat{F}_S} = \begin{cases} if\ \hat{\imath}_S \geq i^{zlb}: & \\ \quad A1a & \frac{1}{1-\chi}\frac{(1-\mu)(1-\beta\mu)}{(1-\mu+\sigma\phi_y)(1-\beta\mu)} \\ \quad A1b & \sigma^{-1}\psi \\ \text{if } \hat{\imath}_S = i^{zlb}: & \\ \quad \textbf{A1} \text{ or } \textbf{A2} & \frac{1}{1-\chi}. \end{cases} \tag{67}$$

We see that the ZLB multiplier closely resembles the classic Keynesian, assuming the Standard fiscal and monetary policy regime. There is a key difference: the fraction of constrained agents, χ, takes the place of the parameter c, which represents the marginal propensity to consume. This parallel is particularly interesting given that traditional Keynesian models typically assume fixed interest rates. The direct mapping of the fraction of constrained agents to the marginal propensity to consume reveals a useful link between these two approaches. At a positive interest rate, this link breaks down assuming A1b. Under A1b, inflation is on target, and the multiplier can be directly gauged from the AS curve.

Comparing the multiplier in equation 67 to that in the New Keynesian model (equation 53) at $\kappa \to 0$, we find they are identical except that equation 67 is pre-multiplied by $\frac{1}{1-\chi}$, resulting in a higher value (except in case A1b at positive interest rates). Furthermore, while lump-sum tax cuts (e.g., COVID-19 stimulus checks) have no multiplier effect in the New Keynesian model, in this model their multiplier equals $\frac{\chi}{1-\chi}$, making it smaller but far from trivial.

Table 5 shows the value of spending and tax multipliers using the parameter values from Table 1 while relaxing the assumption that $\kappa \to 0$.[66] The model's calibration in Table 1 exhibits an interesting feature: its independence from χ. The Survey of Consumer Finances suggests a reasonable χ value ranges between 0.25 and 0.4. Table 5 presents multiplier values across various χ values. The range of 0.25 to 0.3 yields calibrated values closely matching empirical estimates and aligns with Romer and Bernstein (2009)'s proposed values, which fall within the range of other empirical studies where the ZLB binds throughout the fiscal intervention. This alignment is encouraging, as our model's calibration did not target specific multiplier values. Formula 64 demonstrates this independence, where only the first term affects calibration and remains independent of χ.

This illustration demonstrates the potential amplification of income effects in Heterogeneous Agent New Keynesian (HANK) models, despite our simplifying assumption that all households have the same income.[67] The overall takeaway is that accounting for multiplier effects — where one agent's spending becomes another's income, and some agents spend more of their income than others— can lead to substantial amplification of the multiplier, aligning with recent findings in the HANK literature.

Great Recession

		$\chi = 0$	$\chi = 0.25$	$\chi = 0.5$
$\frac{\Delta \hat{Y}_S}{\Delta \hat{F}_S}$	$\hat{\imath} = i^{zlb}$	1.1	1.5	2.2
	$\hat{\imath} > i^{zlb}$	0.3	0.5	0.7
$\frac{\Delta \hat{Y}_S}{\Delta \hat{T}_S}$	$\hat{\imath} = i^{zlb}$	0	-0.4	-1.1
	$\hat{\imath} > i^{zlb}$	0	-0.1	-0.3

Great Depression

		$\chi = 0$	$\chi = 0.25$	$\chi = 0.5$
$\frac{\Delta \hat{Y}_S}{\Delta \hat{F}_S}$	$\hat{\imath} = i^{zlb}$	2.2337	3.2882	5.397
	$\hat{\imath} > i^{zlb}$	0.20388	0.26076	0.3745
$\frac{\Delta \hat{Y}_S}{\Delta \hat{T}_S}$	$\hat{\imath} = i^{zlb}$	0	-1.0544	-3.1633
	$\hat{\imath} > i^{zlb}$	0	-0.05687	-0.17061

Table 5: Multiplier with different fractions of borrowing constrained agents using calibration from Table 1

Our discussion of a multiplier with credit-constrained agents is short and designed to highlight how it connects the new and old multipliers and its role in amplifying the multiplier. Our focus in this review

[66] At the ZLB, the general solution is:

$$\begin{aligned}\hat{Y}_S = & \frac{\sigma(1-\beta\mu)}{\vartheta}(\hat{r}^e_S - i^{zlb}) \\ & + \frac{1}{1-\chi}\frac{(1-\mu)(1-\beta\mu) - \sigma\mu\delta\kappa(1-\chi)}{\vartheta}\hat{F}_S \\ & - \frac{\chi}{1-\chi}\frac{(1-\mu)(1-\beta\mu)}{\vartheta}\hat{T}^b_S.\end{aligned}$$

Above the ZLB, the solution is:

$$\begin{aligned}\hat{Y}_s = & \frac{1}{1-\chi}\frac{(1-\mu)(1-\beta\mu) + \sigma\delta\kappa(\phi_\pi - \mu)(1-\chi)}{(1-\mu+\sigma\phi_y)(1-\beta\mu) + \sigma\kappa(\phi_\pi-\mu)}\hat{F}_S \\ & - \frac{\chi}{1-\chi}\frac{(1-\mu)(1-\beta\mu)}{(1-\mu+\sigma\phi_y)(1-\beta\mu)+\sigma\kappa(\phi_\pi-\mu)}\hat{T}_S.\end{aligned}$$

[67] The clever acronym HANK originates from an influential paper by Kaplan, Moll and Violante (2018).

is mainly on the canonical New Keynesian model, Farhi and Werning (2016) for a comprehensive review of the fiscal multiplier, which includes credit-constrained agents and also the open economy dimension, which we abstract from.

3.2.6 Alternative Stochastic Process for Exogenous Shock and the Fiscal Intervention

The multipliers obtained under the two-state Markov process may seem special, raising the natural question if the results are driven by the stochastic process assumed. Here, we show that assuming the common Autoregressive Progress of order 1 (AR(1)) leads to the same general conclusion but with some useful additional insight, first highlighted by Erceg and Lindé (2014). Our goal is not to do a systematic qualitative comparison but to illustrate the key results and robustness using an alternative shock structure.

We examine the multipliers under the canonical New Keynesian model (thus abstracting from borrowing constraints introduced in the last subsection) assuming the Standard monetary and fiscal policy regime but assuming an AR(1) for $\hat{r}^e_t$.[68] The efficient rate follows:

$$\hat{r}^e_t = \rho \hat{r}^e_{t-1} + \varepsilon^r_t, \tag{68}$$

while the process for the fiscal shock has the same persistence:

$$\hat{F}_t = \rho \hat{F}_{t-1} + \epsilon^F_t. \tag{69}$$

Having a fiscal policy with the same persistence as the efficient rate inherits the key assumption we maintained when considering the two-state Markov process under the Standard monetary and fiscal policy regime: fiscal expansion is in direct response to the exogenous shocks.

The policy regime remains unchanged. Yet, we now explicitly account for the fact that it is the natural rate of interest and output entering the Taylor rule, which was an unnecessary complication earlier. The Taylor rule takes the form:

$$\hat{\imath}_t = \max\left(\hat{\imath}^{zlb}, \hat{r}^n_t + \phi_\pi \hat{\pi}_t + \phi_y \left(\hat{Y}_t - \hat{Y}^n_t\right)\right), \tag{70}$$

where the natural rate of interest and output are given by:

$$\hat{r}^n_t = \hat{r}^e_t + \frac{\sigma^{-1}\omega}{\sigma^{-1}+\omega}\left(\hat{F}_t - \hat{F}_{t+1}\right) \quad \text{and} \quad \hat{Y}^n_t = \frac{\sigma^{-1}}{\sigma^{-1}+\omega}\hat{F}_t. \tag{71}$$

Observe that the ZLB stops being binding as soon as $\hat{r}^n_t > i^{zlb}$.

[68] We set $\sigma = 2.35$, $\kappa = 0.05$, $\rho = 0.9$. We leave for future research comparison between the two stochastic processes using a unified estimation approach.

The model is simulated in figure 18. As the lower panel indicates, the timing of lift-off from the ZLB under the Standard policy regime is now endogenous and depends on the path of the fiscal policy. This has nothing to do with the forward guidance. Instead, it is a mechanical consequence of the policy rule. Since the fiscal policy directly increases the natural rate of interest, this means that the lift-off occurs earlier.

Yet, this does not dramatically change the value of the multiplier. Figure 18 presents the results under the Standard policy regime, assuming an AR(1). The top panel displays the size of the multiplier across a range of fiscal spending paths, indexed by the initial fiscal shock size, $\hat{F}_1$, going from $\epsilon > 0$ to 20 percent of GDP. In this illustrative example the fiscal package of $\hat{F}_1 = 1\%$ of GDP at time 0 yields a multiplier of 2.2. This is not by coincidence. Our numerical example is parameterized so the multiplier correspond to the multiplier during the Great Depression. However, as the size of the fiscal package increases, the multiplier declines, even if this decline is relatively modest. This indicates a diminishing return — a point first highlighted by Erceg and Lindé (2014). Additional impact per dollar of fiscal stimulus decreases as the package grows. The decline is slow, with multipliers above 1 for realistic sizes of the fiscal stimulus.

The bottom panel further illustrates this result by displaying the nominal interest rate paths under the standard policy regime, each corresponding to a fiscal package shown in the top panel. The duration of the ZLB shortens with larger fiscal packages. This outcome is intuitive: as the fiscal shock increases, the gap between the lower bound on the policy rate and the natural rate of interest increases thus inching closer to i^{zlb} where the bound is no longer binding; see equation 71. As the fiscal shock grows, the time spent at the ZLB decreases, and as the constraint loosens, the effectiveness of additional fiscal stimulus diminishes. For a sufficiently large fiscal package, the model exits the ZLB.

The large multipliers under the Standard policy regime persist beyond the 2-state Markov shock structure. These multipliers remain consistent with both alternative shock structures and endogenous lift-off timing conditional on specific fiscal spending paths. All paradoxes and findings reported in our analysis apply to these alternative frameworks. Our results confirm Christiano, Eichenbaum and Rebelo (2011)'s findings in our simple setting. They examine a medium-scale DSGE model where exogenous shocks follows AR(1) processes, while the model incorporates several featurs typical of quantiative DSGE model such as capital, adjustment costs adn so forth. Their findings align directly with our results.

3.2.7 Fiscal Policies That Circumvent the ZLB

Theoretically, the government can use fiscal policy, and othe policies, to eliminate the ZLB problem. Yet, most tax instruments face institutional constraints, and the effects of tax proposals are model-dependent.

3.2.7.1 Gesell's Tax on Money and Negative Central Bank Policy Rates

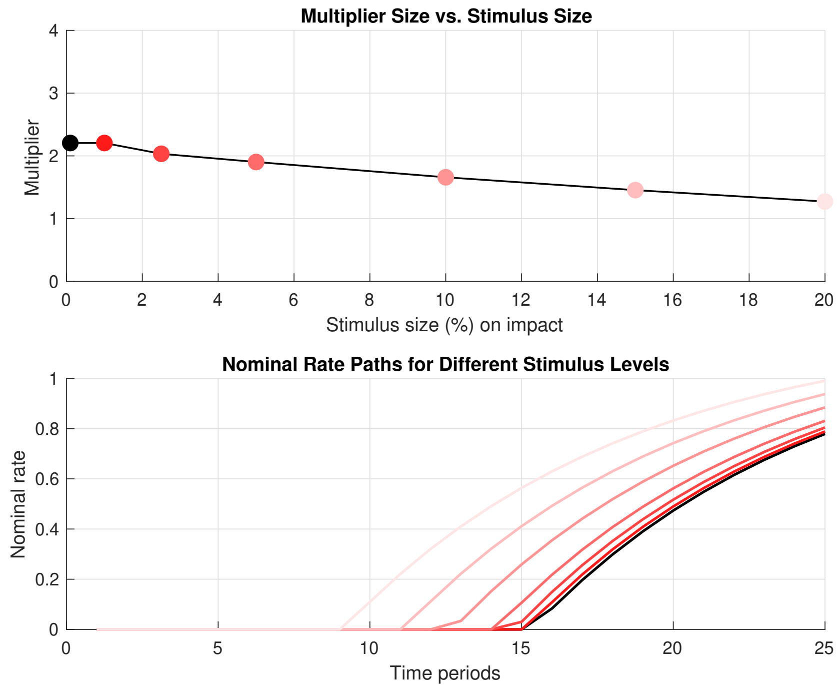


Figure 18: Multipliers and Nominal Rate Paths for Different Sizes of Fiscal Spending

Gesell (1916) proposed a tax on currency to circumvent the ZLB, but it was never implemented. Instead, several central banks experimented with negative policy rates during the Great Recession, with mixed results.

The lower bound on interest rates exists since people can hold zero-return paper currency. Gesell proposed an explicit carrying cost for holding money by suggesting the periodic stamping of currency notes at a cost.

Gessel's idea was revived by Goodfriend (2000) and Buiter and Panigirtzoglou (2003). Both authors note that while taxing reserves is feasible, taxing currency would involve significant administrative costs. Rogoff (2017) advocates for the elimination of most paper currency, particularly high-denomination bills, to enable negative interest rates and allow banks to charge negative deposit rates. If all currencies were digital, this would effectively eliminate the zero lower bound. Agarwal and Kimball (2015) proposed establishing different values for physical cash and electronic money (held in commercial and the central bank), creating an exchange rate between the two. While this approach is theoretically feasible, communication and operational challenges have so far prevented central banks from seriously experimenting with it.

Several central banks (Switzerland, Japan, Eurozone, Denmark, Sweden) experimented with negative policy rates after the Great Recession. Policy rates in this context refer to rates paid on the reserves of commercial banks, which they hold at central bank to settle interbank transactions and other services. Banks are willing to pay for these services via negative interest rates. However, central banks' ability to lower interest on reserves is limited because banks can exchange reserves for cash. For sufficiently negative interest rates, banks may opt to settle interbank transactions outside of the central bank, imposing a bound on the policy rate, as shown in Eggertsson et al. (2024). Typically, central bank rate cuts lower commercial banks' financing rates, but this relationship may brake down with negative rates as commercial banks appear unwilling to impose negative rates on their costumers,feareding customers would withdraw balances and hold cash. In Sweden, Eggertsson et al. (2024) found that negative policy rates did not lower mortgage rates (unlike typical policy rate cuts) but modestly *increased* them.

Abadi, Brunnermeier and Koby (2023) identify a *reversal rate* below which rate cuts are no longer expansionary due to the effect they have on banks' balance sheets, estimated at -0.8%, while Eggertsson et al. (2024) model implies a 0% reversal rate. In summary, the literature suggests that in presence of paper currency, there is a lower bound at which policy rate cuts are no longer effective, even if there is no consensus on the exact value.

3.2.7.2 Using Multiple Tax Instruments Simultaneously

This subsection examines using a combination of tax instruments to circumvent the liquidity trap. While the proposals work in some models, they may backfire in others or face institutional limitations.

Feldstein (2002) is the first to suggest that Japan suspend its sales tax (τ_t^s) and gradually lift it to its previous level, making up revenue loss by raising income taxes (τ_t^I) Feldstein (2001). Eggertsson and Woodford (2004) model this as:

$$\hat{\tau}_S^s = \frac{(\chi^s)^{-1}}{1-\mu}\hat{r}_S^e < 0, \tag{72}$$

$$\hat{\tau}_S^I = -\frac{\chi^s}{\chi^I}\hat{\tau}_S^s > 0. \tag{73}$$

Adjusting the two tax instruments this way completely offsets the shock and prevents output contraction in the model we have considered. Intuitively, the commitment to raise consumption taxes works via exactly the same mechanism as raising inflation expectations at constant interest rates. Correia et al. (2013) extend this result in a more general setting. With a rich tax structure, negative natural rate shocks can typically be offset.

Eggertsson (2004) asks if fiscal policy can substitute for monetary policy in a monetary union with the simple rule of having fiscal spending follow each country's specific natural rate of interest. If the monetary policy does not replicate the country-specific natural rate due to an interest rate set by a common monetary authority (which may or may not be subject to the ZLB), the local fiscal authorities can raise the domestic natural rate of interest to match the common monetary union interest rate using fiscal policy instuments thus stabilizing domestic inflation and output.[69] This insight is corroborated

[69]See discussion in section 4 in Eggertsson (2004) that elaborates on this.

and shown to apply in a richer setting in Farhi, Gopinath and Itskhoki (2014) who term this fiscal devaluation.

Translating Feldsteins insight into concrete policy advice has caveats, such as potentially requiring negative sales taxes and complications due to the interaction of firms' price strategies and taxes (see the discussion in Eggertsson and Woodford (2004)).

Lancastre (2017) represents a more fundamental challenge to Feldstein's proposal by showing it is model-dependent and sensitive to the assumption of no liquidity-constrained agents. In an overlapping generations model with nominal frictions, and borrowing constraints, Lancastre (2017) shows that the suggested policy creates a sharper recession.

Nonetheless, reforming the tax system to adjust to ZLB-causing shocks could yield large gains. The practical limitations are institutional constraints and an incomplete understanding of impacts. Yet, in theory, tax policy can eliminate the ZLB problem.

3.2.8 Reconciling Contradictory Findings

Eggertsson (2001*b*) and Christiano (2004) were the first to analyze fiscal policy in the New Keynesian model at the ZLB, finding a significant role in real government spending. Subsection 3.2 analytical results have mainly built on Eggertsson (2011) and Denes, Eggertsson and Gilbukh (2013). Christiano, Eichenbaum and Rebelo (2011) shows large fiscal multipliers in medium-scale quantitative models, and Woodford (2011) provides a comprehensive overview that includes determinants of the multiplier at positive interest rates, which has not been the focus here. Farhi and Werning (2016) extend the analysis to open economies and non-Ricardian agents.

While some papers, such as Cogan et al. (2010) and Drautzburg and Uhlig (2015), suggest smaller multipliers, the main reason for the difference is assumptions about the timing of spending increases and future offsetting distortionary taxes. Accounting for these differences, the results are consistent and highlight the need for a clear long-run vision to complement short-run policy interventions, a point we emphasized in subsection 3.2.4, see Table 4.[70]

Boneva, Braun and Waki (2016) consider a variation of the New Keynesian model assuming a quadratic cost of price adjustment as in Rotemberg (1982) and argue large multipliers and related paradoxes are artifacts of log-linearization, but Eggertsson and Singh (2019) confirm the results do not depend on log-linearization using a closed-form nonlinear model with Calvo-pricing.[71] Kiley (2016) suggests that replacing sticky prices with sticky information overturns the results, but Eggertsson and Garga (2019)

[70] For example, a permanent spending increase violating A3 has no effect on the IS equation (30), it only affects AS equation. Coenen et al. (2012) consider several models, finding large multipliers for temporary interventions and small for permanent increases.

[71] Eggertsson and Singh (2019) also point out that the results in Boneva, Braun and Waki (2016) are driven by the implausibly large fraction of resources are being devoted to price changes in the nonlinear model due to the assumption of quadratic cost of price adjustment. Once these costs are stripped out of the aggregate resource constraint, the model of Boneva, Braun and Waki (2016) delivers almost identical results as the nonlinear Calvo model.

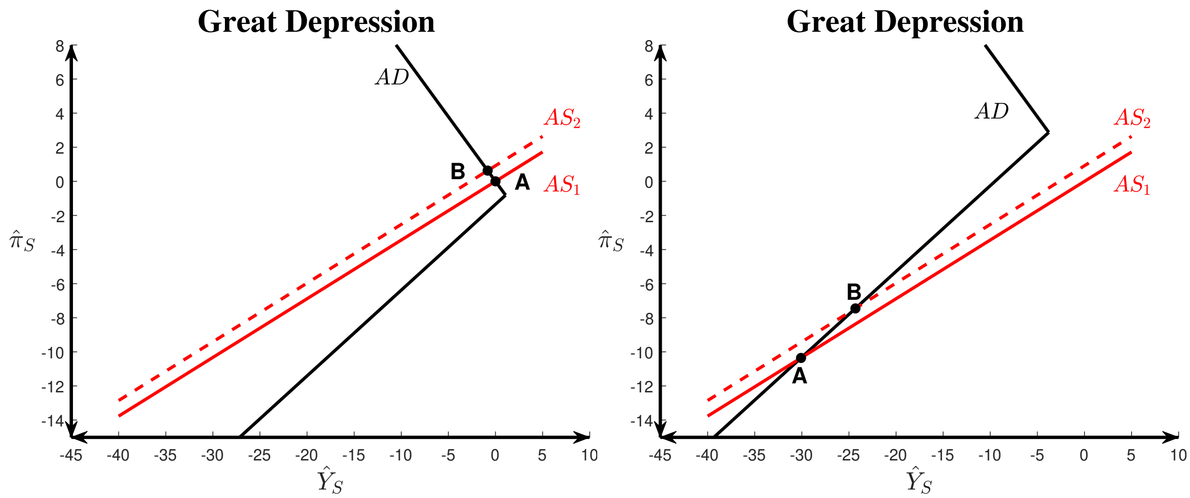


Figure 19: The effect of a negative supply shock at a positive interest rate (left) and the ZLB (right).

show that this is due to the fact that Kiley considers a different ZLB experiment than typical in the literature. Moreover, they show that assuming A1-A5 leads to even higher multipliers and stronger paradoxes with sticky information. Cochrane (2017) argues that large multipliers are an artifact of equilibrium selection, but as discussed in subsection 4.2, this is due to Cochrane (2017) implicitly assuming a monetary policy regime that closely approximates the Optimal monetary policy under commitment regime, studied in section 4, instead of the Standard monetary and fiscal policy regime considered here. We leave further discussion of this point to later.

3.3 Aggregate Supply Shocks, Supply side Policies, and the Paradox of Toil under the Standard Monetary and Fiscal Policy Regime

We now turn from aggregate demand to supply. The paradox of toil, a startling result of modern liquidity trap literature, suggests that *positive* supply shocks *contract* output at the ZLB. This implies that structural reforms proposed in Europe during the Great Recession might have been counterproductive at the ZLB, while the much-maligned National Industrial Recovery Act of 1933 implemented by President Roosevelt as part of the New Deal can be cast more positively, despite widespread condemnation from economists ranging from Friedman to Keynes. We also review empirical evidence testing the implications of the paradox.

3.3.1 The Paradox of Toil: An Analytic Result

We start by stating the paradox of toil:

The paradox of toil. Imagine you wake up one day and decide to work more. You start looking for extra jobs and, if lucky, find some in partial equilibrium. Now imagine everyone waking up with the same idea. At first, it may seem that everyone will work at least as much as before. However, the paradox of toil shows that at the ZLB, everyone wanting to work more may actually result in less work in general equilibrium.

This paradox is a classic fallacy of composition, just like Keynes's paradox of thrift. The fallacy of composition is the presumption that what is true for a single individual can be extrapolated to the population. For example, if one person stands up at a concert, he or she can see better, but if everyone stands up, nobody's view improves.[72]

The left part of figure 19 shows that normally in response to a negative supply shock (imagine, for example, an increase in oil prices) a central bank raises rate and reduces aggregate demand. At the ZLB, however, the right part of the figure shows the central bank will not raise the rate in response to inflationary pressures stemming from a negative supply shock. A negative supply shock at the ZLB triggers an increase in inflation and, more importantly, an increase in inflation expectations, which reduces the real interest rate and increases demand. With inflation below target, this is exactly what the central bank wants.

To characterize the paradox, we adopt the notation $\hat{\omega}_t \equiv \psi\chi^I\hat{\tau}^I_t$ to emphasize that we interpret $\hat{\tau}^I_t$ as a stand-in for a large range of supply disturbances, often referred to as labor wedge. It is straightforward to solve 39 and 40 together so that A1-A5 lead to:

$$\frac{\Delta\hat{Y}_S}{\Delta\hat{\omega}_S} = \begin{cases} -\frac{\sigma(\phi_\pi-\mu)}{\left(1-\mu+\sigma\phi_y\right)(1-\beta\mu)+\sigma\kappa(\phi_\pi-\mu)}1 < 0 & \text{if } \hat{\imath}_S > i^{ezlb} \\ \\ \frac{\sigma\mu\kappa}{(1-\mu)(1-\beta\mu)-\sigma\mu\kappa} > 0 & \text{if } \hat{\imath}_S = i^{ezlb} \end{cases} \tag{74}$$

If we assume the Standard monetary and fiscal policy regime is characterized by A1, the formula for positive interest rate is even simpler and can be directly read out of the AS equation, resulting in $\frac{\Delta\hat{Y}_S}{\Delta\hat{\omega}_S} = -1$.

3.3.2 The Paradox of Toil: Empirical Evidence

Recent empirical evidence suggests that the effects of oil price changes on key aggregate variables switch signs once the ZLB is binding, as predicted by the paradox of toil.

Datta et al. (2021) show that the correlation between daily oil and equity prices flips from negative to positive at the ZLB, as shown in figure 20. They also find that oil and equity returns become

[72]We do not state the paradox of thrift here, which is well known, as it involves introducing capital, which we abstract from here; see Eggertsson (2011) for this extension.

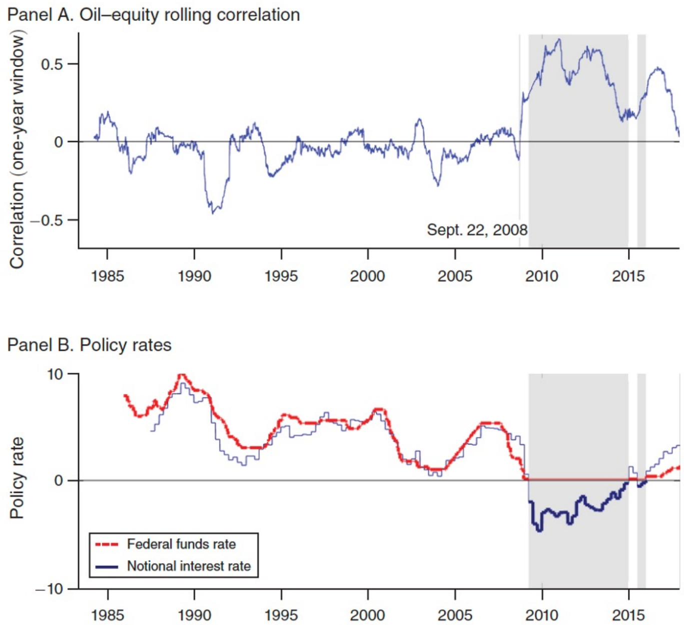


Figure 20: Daily Oil-Equity Correlation and Policy Rates from Datta et al. (2021)

more responsive to macroeconomic news surprises at the ZLB, in contrast to historical experience, consistent with the idea that the ZLB prevents the central bank from offsetting the shock.

Miyamoto, Nguyen and Sergeyev (2024) use high-frequency data to identify the effect of oil prices on industrial production and unemployment. Following Känzig (2021), they identify the shocks using the change in oil futures prices in a tight window around OPEC production announcements. The series of future oil price changes then becomes an external instrument in a VAR, allowing the authors to tightly estimate the impact of structural oil shocks on industrial production and unemployment. As shown in figure 21, the result of this analysis suggests that in response to oil shocks, the change in unemployment and industrial production change sign in both the US and Japan. Moreover, this change is statistically significant.

These papers build on Wieland (2019), which first attempted to test the paradox empirically. While his results for the Great East Earthquake in Japan do not support the paradox, this event might not be well-suited for testing as it does not necessarily trigger expectations of future inflation. Although point estimates for oil shocks at the ZLB have the opposite sign of Miyamoto, Nguyen and Sergeyev (2024), the results are not inconsistent with each other: Wieland (2019) reports that the difference between the impulse responses estimated at the ZLB and positive interest rates is not statistically significant. A possible interpretation is that Miyamoto, Nguyen and Sergeyev (2024)'s high-frequency identification of oil shocks gives them more statistical power.

While the empirical evidence cited above gives a relatively consistent picture, even if tentative, it is fair to say that the literature is very far from having reached any consensus on the effect of the National Industrial Recovery Act during the Great Depression. FDR himself viewed it as a failure,

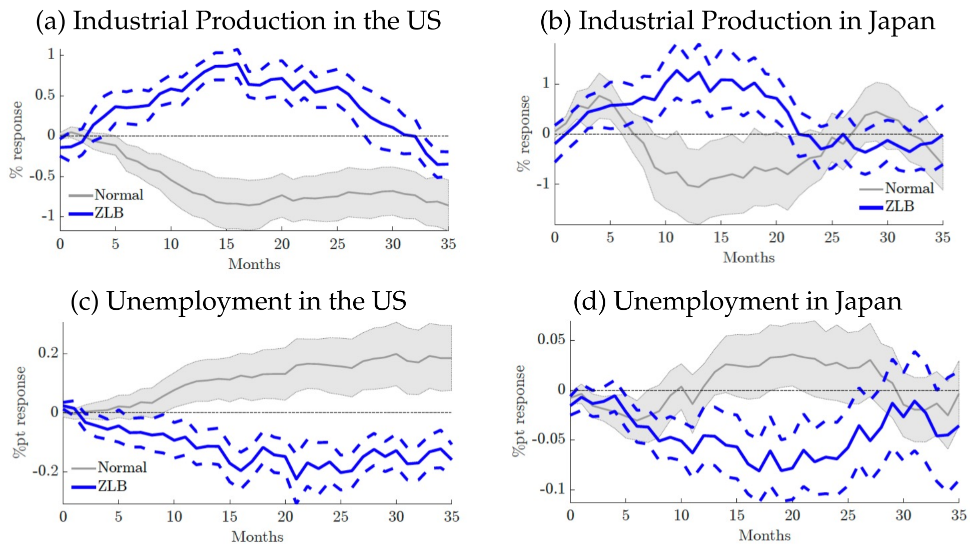


Figure 21: Estimated impulse response functions from Miyamoto, Nguyen and Sergeyev (2024) showing industrial production and unemployment in the US and Japan in response to positive oil price shocks, along with one standard deviation confidence bands, using high-frequency identification from.

and it was struck by the Supreme Court in 1935. Cohen-Setton, Hausman and Wieland (2017) provide evidence from France in the 1930s which was even more ambitious than NIRA. Overall, they find that these policies led output to stagnate. One challenge in interpreting this evidence in comparison to the US is that in contrast to NIRA, the policies in France promoted a permanent change, which we will show below (equation 75) is *always* contractionary. In contrast, NIRA was an "emergency" legislation that was installed to reinflate the price level. The NIRA legislation stated:

A national emergency productive of widespread unemployment and disorganization of industry [...] is hereby declared to exist.

It then went on to specify that when the emergency would cease to exist,

This title shall cease to be in effect, and any agencies established here- under shall cease to exist at the expiration of two years after the date of enactment of this Act, or sooner if the President shall by proclamation or the Congress shall by joint resolution declare that the emergency recognized by section 1 has ended.

As we see in next section in the context of the discussion of structural reform in Europe, whether the public expect the policy to be temporary or permanent has critical effects.

3.3.3 The Great Recession and the Debate on Structural Reforms in Europe

During the Great Recession, the European Central Bank, like the Federal Reserve, was constrained by the ZLB. The main policy advice for southern Eurozone countries lacking fiscal space to stimulate demand was structural reforms. However, the paradox of toil suggests that these policies could have resulted in counterproductive short-run effects.

With interest rates at zero and austerity measures failing in Europe following the Great Recession, structural reforms were the primary option put forward by the European Commission, especially for the southern periphery. These reforms aimed to increase competition in product and labor markets, as evidence suggests less competition in the service sector in the southern periphery than at the core Eggertsson, Ferrero and Raffo (2014).[73]

Structural reforms have positive long-term effects on growth and demand but also short-term deflationary effects. Consider a supply shock with effects in both the short and long run, i.e., $\hat{\omega}_S < 0$ and $\hat{\omega}_L < 0$. Assuming the ZLB is not binding and policy regime A1b holds, so that $\hat{\pi}_t = 0$, we have:

$$\hat{Y}_S = -\hat{\omega}_S \qquad \text{and} \qquad \hat{Y}_L = -\hat{\omega}_L. \tag{75}$$

At the ZLB, consider the long-run effect of structural reforms:

$$\text{AD:} \qquad \hat{Y}_S = \hat{Y}_L + \frac{\sigma^{-1}\mu}{1-\mu}\hat{\pi}_S + \frac{\sigma^{-1}}{1-\mu}\hat{r}^e_S, \tag{76}$$

$$\text{AS:} \qquad \hat{\pi}_S = \frac{\kappa}{1-\mu\beta}\hat{Y}_S + \frac{\kappa}{1-\mu\beta}\hat{\omega}_S. \tag{77}$$

In figure 22, the short-run equilibrium at the ZLB is shown in point A. Reforms may be contractionary or expansionary in the short run: it depends on the relative strength of the permanent income effect (AD shift) and the deflationary effect (AS shift). If there is no income effect, the equilibrium is at point B. More realistically, credible structural reforms will have an income effect, which, if strong enough, leads to an increase in output as illustrated in point C. Eggertsson, Ferrero and Raffo (2014) find that a 10% reduction in markups in the service sector of the periphery leads to a 5% increase in long-run output but a 1 percentage-point additional contraction at the ZLB, thus the equilibrium is between point A and C. Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2014) show that supply policies with limited short-run effects but positive long-run effects on income are expansionary in the short run, thus the equilibrium is between A and C.

3.3.4 The Great Depression and the National Industrial Recovery Act of 1933

The National Industrial Recovery Act (NIRA) of 1933, a key component of the New Deal, aimed to curb the deflationary spiral during the Great Depression by encouraging firms to increase prices, suspending anti-trust laws, and encouraging workers to unionize to prop up wages.

[73] For instance, in his closing remarks following the 2012 State of the Union, J. M. Barroso, the president of the European Commission at the time, stated, "The biggest problem we have for growth in Europe is the problem of lack of competitiveness that has been accumulated in some of our Member States, and we need to make the reforms for that competitiveness. ... to get out of this situation requires ... structural reforms, because there is an underlying problem of lack of competitiveness in some of our Member States" (Eggertsson, Ferrero and Raffo (2014)).

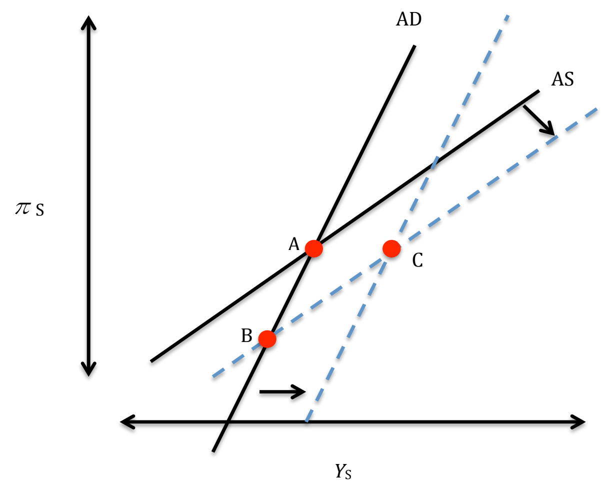


Figure 22: Short-Run Equilibrium at the ZLB under Permanent Structural Reforms

The paradox of toil provides a theoretical rationale for this legislation. An interesting aspect of NIRA was that it was designed to be *state-contingent*. The NIRA legislation stated: "A national emergency productive of widespread unemployment and disorganization of industry [...] is hereby declared to exist." It then went on to specify that "this title shall cease to be in effect and any agencies established hereunder shall cease to exist at the expiration of two years after the date of enactment of this Act, or sooner if the President shall by proclamation or the Congress shall by joint resolution declare that the emergency recognized by section 1 has ended." Hence, a reasonable assumption is that NIRA was expected to be an emergency measure and to last only as long as the natural rate of interest was negative (which creates the deflationary emergency in the model). It follows that we can use exactly the same **AD**-and-**AS** apparatus as in figure 19.

Interestingly, the economics profession universally condemned NIRA, with Keynes opposing it in an open letter to FDR published in the *New York Times*, Friedman offering a scathing criticism, and influential quantitative work by Cole and Ohanian (2004) which argues the New Deal slowed the recovery from the Great Depression. It was only later that modern theory caught up with policymakers' intentions, with De Long and Summers (1986) emphasizing NIRA's role in making wages and prices more rigid and Eggertsson (2012) highlighting it as a direct tool for propping up prices via the paradox of toil.[74] This curious history of thought flips a famous quote from Keynes's *General Theory* on its head.[75]

[74]The *overall* legacy of NIRA, on the other hand, is mixed at best, as it brought about a large bureaucracy with associated inefficiencies and was ultimately ruled to violate the Constitution by the Supreme Court in May 1935.

[75]"Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back."

3.4 Credit Policy and Central Bank Lending Facilities under a Standard Monetary and Fiscal Policy Regime

In section 3, we examined aggregate demand and aggregate supply policies in the absence of a monetary policy regime change. However, section 2 showed that financial market frictions are potentially a central cause of a temporary drop in the efficient interest rate. Can a policy of direct government intervention in such circumstances offset the shocks? Bhattarai and Neely (2022) comprehensively reviews these policies in this journal. Our treatment of QE will be more condensed that might merited if not for this recent review.

3.4.1 Quantitative Easing and the Feds Liquidity Facilities

During the Great Recession, the Federal Reserve extended credit directly to financial markets through various liquidity facilities. Influential literature rationalizes these policies as the government substituting bank lending with government liquidity and finds significant effects, especially at the beginning of the crisis. This is shown by the light blue area in figure 23.

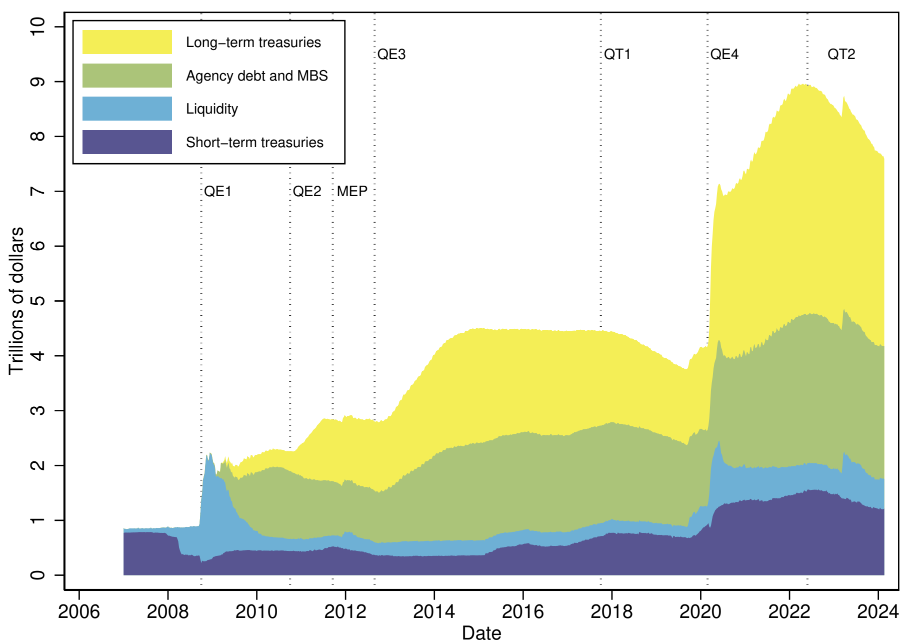


Figure 23: The Expansion of the Federal Reserve Balance Sheet

Financial distress is a plausible trigger for the Great Depression and Great Recession (section 2), and policies aimed at easing financial conditions likely affect $\hat{r}_t^e$. During the initial phase of the Great Recession, the Federal Reserve expanded its balance sheet by $3 trillion (20% of GDP) via quantitative easing (QE1), as further interest rate cuts were not feasible. This expansion escalated even further after COVID-19, with QE4 reaching nearly 40% of GDP. The empirical literature suggests QE has a significant effect, especially on targeted asset prices Swanson (2021).

Theoretically, QE can have an effect if we relax two assumptions from Eggertsson and Woodford (2003): (1) complete markets and no limits to arbitrage; (2) no effect on expectations about future interest rates.

Many economists, including the authors of this review, make a sharp distinction between QE1 and the subsequent quantitative intervention. QE1 was mostly aimed at providing direct liquidity to the private sector via various "liquidity facilities", while later QEs targeted government debt or debt of government-sponsored enterprises. As shown in figure 23, long-term treasuries were one of the largest parts of these purchases. Yet, quasi-government bonds such as Agency Mortgage-Backed Securities (MBS) were bought on a large scale. These corresponded to securities from government-sponsored entities like Fannie Mae, Freddie Mac, and Ginnie Mae. The Fed also bought, even if in smaller quantities, bonds directly issued by these institutions to fund their mortgage-related activities.

Generally, the literature finds large effects for QE1 but the results are more mixed for later QEs. Separating direct effects from signaling effects on future interest rates during those interventions is especially challenging.

Gertler and Karadi (2011) rationalize QE1 by relaxing assumption 1 of Eggertsson and Woodford (2003). In their model, there is a negative shock to banks' capital when they reduce lending. QE offsets this drop via direct credit extension. The Federal Reserve is less efficient than private intermediaries, creating a trade-off. Gertler and Karadi (2011) captures well the impact of QE1, as a response to to credit disruptions. It also captures the effect of mortgage-backed securities purchases, which we will treat in more detail in the next section, while this model is less suited for modeling purchases of long-dated government bonds (later QE phases).

One useful way of thinking about QE1 is to think of the Federal Reserve's liquidity facilities during that period as an extension of the Discount Window (limited to deposit-accepting banks).

The Discount Window is an important policy tool designed to prevent bank runs – an important financial market failure. Bank runs occur when customers simultaneously withdraw funds, forcing banks to liquidate long-term assets at a discount, potentially causing the collapse of fundamentally sound banks. This is socially inefficient. The problem of bank runs was well understood when the Federal Reserve was established in 1913. The Discount Window, established in 1914, allows eligible financial institutions, mostly serving small depositors, to borrow from the Federal Reserve at a discount rate, posting long-term assets as collateral. This reduces the need for fire sales and the incentive for bank runs. The Banking Act of 1933, passed during the Great Depression, established the Federal Deposit Insurance Corporation, providing additional guardrails for banks catering to small depositors and preventing banking panics.

Diamond and Dybvig (1983) formalizes the economics of bank runs, showing they occur even with rational agents. The only requirement is that bank assets are illiquid and that their long-term assets only be sold at a discount if everyone withdraws simultaneously. Often overlooked is that Diamond and Dybvig (1983) did not merely formalize what policymakers already knew when establishing the Discount Window in 1914 and the Federal Deposit Insurance Corporation in 1933. These policy innovations presumed small customers were irrational, sensitive to rumors, and prone to herd behavior, while little regulation was needed for large, sophisticated investors, presumably less prone to erratic behavior.

Yet, what Diamond and Dybvig (1983) clarify is that inefficient bank runs may occur even when large, sophisticated investors are involved. Bank runs don't require traditional banks; they only need firms engaging in bank-like behavior—borrowing short-term and investing in long-term illiquid assets, making them vulnerable to liquidity risk. Such institutions include hedge funds and investment banks.

The term *shadow banking*, introduced by Paul McCulley in 2007, captures the part of the financial system that is bank-like yet not subject to the same regulations, safeguards, and Discount Window access as commercial banks. It is, however, subject to the same vulnerability that policymakers believed was isolated to banks catering to small customers.

Del Negro et al. (2017*b*) propose a model of QE that naturally extends Discount Window services to the shadow banking system. The Federal Reserve did this via liquidity facilities targeting specific frozen markets. The main element of their model is that the Great Recession brought a sudden reduction in private asset liquidity, leading to a sharp drop in available credit, investment, and the natural interest rate. The reduced natural rate, together with the ZLB and nominal frictions, generates a full-scale macroeconomic crisis. Credit intervention is helpful, as liquidity facilities replace some illiquid assets — like the Discount Window does — with perfectly liquid government-issued paper. Gertler, Kiyotaki and Prestipino (2020) incorporate Diamond and Dybvig (1983) into a dynamic general equilibrium model. While not their focus, their framework is another natural setting that rationalizes the Fed's liquidity facilities.

3.4.2 Quantitative Easing 2, 3, 4, MEP and Beyond

We now examine the economic rationale for the bulk of quantitative easing policies, shown in yellow and green areas in Figure 23. The Fed executed large-scale purchases of Agency Mortgage-Backed Securities (MBS) from government-sponsored entities like Fannie Mae, Freddie Mac, and Ginnie Mae. Additionally, the Fed acquired smaller quantities of bonds directly issued by these institutions to fund their mortgage-related activities. These trillion-dollar purchases effectively provided government guarantees to these entities, reducing risk premia and enhancing the securities' liquidity. For additional transmission channels, see Vissing-Jorgensen and Krishnamurthy (2011) and Bhattarai and Neely (2022)'s comprehensive review. This intervention directly lowered mortgage costs for American homebuyers by reducing the risk premia associated with these bonds.

It is more challenging to explain QE's effects through risk-premium reduction in long-term treasury purchases, since these treasuries presumably carry the same risk as reserves. Chen et al. Chen, Cúrdia and Ferrero (2012) address this challenge by modeling long-term government bond purchases using preferred-habitat theory (Vayanos and Vila (2021)). Their analysis of QE2 and subsequent programs violates assumption 1 in Eggertsson and Woodford (2003) by incorporating segmented markets and transaction costs. Their main conclusion reveals that these mechanisms generate small effects unless the purchases alter expectations about future rates, thus requiring violation of assumption 2 in Eggertsson and Woodford (2003).

An alternative way QE can influence monetary policy is by altering expectations of future interest rates through changes in government debt maturity structure. Bhattarai et al. Bhattarai, Eggertsson and Gafarov (2023) formalize this mechanism in a model where QE violates assumption 2 in Eggertsson and Woodford (2003), i.e. QE changes expectations of future monetary stimulus. When the Federal Reserve purchases long-term government bonds with short-term bonds, it effectively shortens the maturity of government debt—analogous to a homeowner switching from a 30-year fixed mortgage to a floating rate. Eggertsson and Woodford (2003) demonstrate that in a Markov Perfect Equilibrium, this maturity shortening makes interest rate increases more costly for the government through higher fiscal costs, or from the central bank's perspective, through capital losses.

Empirical evidence shows that while government bond purchases affected long-term government bond prices, these effects do always consistently extend to other assets like corporate bonds. The effectiveness of this aspect of QE in easing financial conditions remains a topic of some controversy, beyond acknowledging that it distorts government bond prices and may reduce government financing costs Swanson (2011), Krishnamurthy and Vissing-Jorgensen (2013), Lucca and Wright (2022). Eggertsson and Woodford (2003) suggested that significant bond purchases could indeed decouple long-term government bond rates from the broader term structure of interest rates that influences economic activity. However, they question that if the rest of the term structure remains unchanged as a result of these operations, it is far from clear how effective they are in stimulating economic activity.

4 Policy Regime Changes: Optimal Monetary Policy Regimes and a Negative Natural Rate of Interest in the Short-Run

Section 3 assumed the Standard monetary and fiscal policy regime, precluding discussion of key strategies used in the Great Recession and Great Depression that emphasized changing expectations about future policy rates and inflation. Section 4 departs from this, reviewing two polar cases for optimal monetary policy. Both regimes maximize social welfare. At one extreme, the *Optimal monetary commitment regime* can fully commit to future policy. At the other extreme, it can only condition its policy strategy on the current state variables in the economy: this is the *Optimal Monetary Policy Regime in a Markov Perfect Equilibrium*.

These polar cases provide useful interpretations of US monetary policy during the Great Recession. We also review an Optimal joint monetary and fiscal policy regime in a Markov Perfect Equilibrium with additional institutional constraints such as the gold standard. These additional constraints can later be abandoned by future policymakers – triggering a regime change. We review work suggesting that a regime change captures the dramatic turnaround in inflation and output in 1933 we saw in the Great Depression panel of figure 9.

4.1 The Great Recession and the Deflation Bias: Contrast of the Optimal Commitment Monetary Policy Regime and the Optimal Monetary Policy Regime in a Markov Perfect Equilibrium

This subsection reviews the Optimal monetary policy commitment regime and the Optimal monetary policy regime in a Markov Perfect Equilibrium. The analysis sheds light on the Federal Reserve's use of forward guidance about future interest rates during the Great Recession. Forward guidance implies a regime change relative to the Standard monetary and fiscal policy regime assumed in section 3. We argue that US policy fell short of the Optimal monetary policy commitment regime, partially due to credibility issues, but we do review evidence suggesting forward guidance had statistically significant effects on markets. For now, we completely abstract from fiscal policy.

4.1.1 The Optimal monetary policy commitment regime with a Negative Natural Rate in the Short Run

This subsection derives the Optimal monetary policy commitment regime, showing it largely offsets a temporarily negative efficient interest rate despite the ZLB. The policy keeps the real interest rate below the efficient rate after the latter reverts to the steady state, contrasting with the Standard monetary and fiscal policy regime in section 3. The central bank's objective function is derived by a second-order expansion of the household utility function:

$$-\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\left(\hat{\pi}_t^2+\lambda_y\hat{Y}_t^2\right). \tag{78}$$

$$\begin{aligned}
\partial\hat{\pi}_t: &\quad \hat{\pi}_t+\sigma\beta^{-1}\phi_{1t-1}+\phi_{2t}-\phi_{2t-1}=0,\\
\partial\hat{Y}_t: &\quad \lambda_y\hat{Y}_t+\phi_{1t}-\beta^{-1}\phi_{1t-1}-\kappa\phi_{2t}=0,\\
\partial\hat{\imath}_t: &\quad -\sigma\phi_{1t}+\phi_{3t}=0,\\
CS: &\quad \hat{\imath}_t\geq i^{\text{zlb}},\phi_{3t}\geq 0,\phi_{3t}(\hat{\imath}_t-i^{\text{zlb}})=0.
\end{aligned} \tag{79}$$

The equilibrium is a set of stochastic processes for $\{\hat{\pi}_t,\hat{Y}_t,\hat{\imath}_t\}$ that solve (30), (32) and (79), given $\{\hat{r}_t^e\}$. The complementary-slackness condition complicates the solution since the duration of the ZLB is an endogenous stochastic variable. Eggertsson and Woodford (2003) suggest a guess-and-verify algorithm, which is automated for a more general setting in Eggertsson et al. (2019).

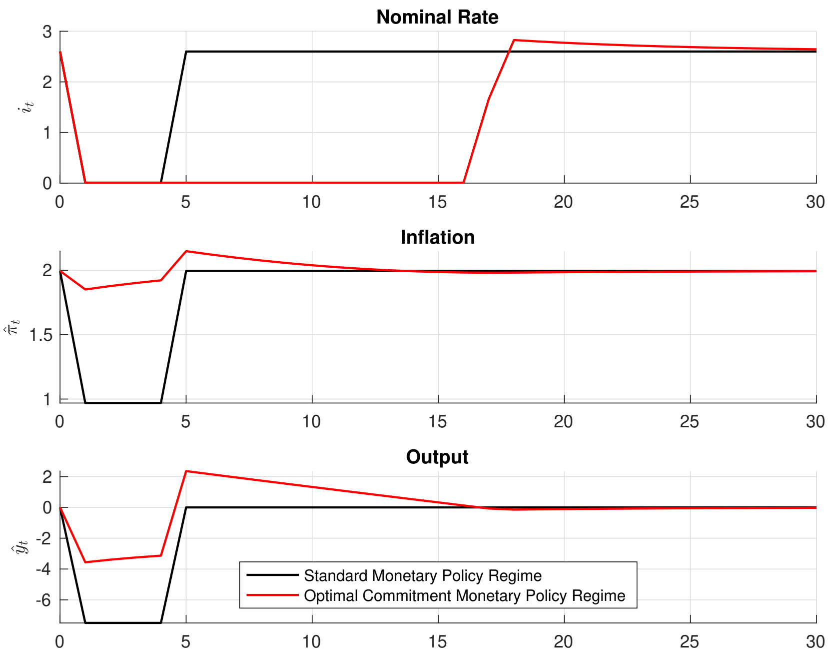


Figure 24: The Standard Monetary and Fiscal Policy Regime and the Optimal Monetary Policy Commitment Regime when the Shock Lasts Five Periods

The Optimal monetary policy commitment regime implies keeping the real interest rate low after the shock reverts to a steady state. Figure 24 shows the optimal policy for the Great Recession example, where the central bank maintains the policy rate at the ZLB beyond the shock's end, contrasting with the Standard policy regime. The figure shows a single realization of the shocks, corresponding to the contingency when it reverts back to the steady state in period 5.[76]

The Optimal monetary policy commitment regime mitigates the drop in output and inflation via several mechanisms. Relative to the Standard monetary and fiscal policy regime, the commitment to lower the future nominal interest rate, together with a commitment to higher inflation, reduces the real interest rate, which stimulates demand. Moreover, the Optimal monetary policy commitment regime generates expectations of higher future output relative to the Standard monetary and fiscal policy regime, which similarly increases spending via the permanent-income hypothesis.

How many additional periods the central bank maintains rates at the ZLB after the shock has reverted to a steady state under the Optimal monetary policy commitment regime depends on how long the efficient rate has been negative; with the additional duration, the longer the natural rate has been negative as illustrated in figure 25.

[76]While the earlier literature is cast in discrete time, Werning (2011*a*) is the first characterization of the optimal monetary policy problem in continuous time, a solution method that has found applicability in a number of papers that have followed. His findings are largely consistent with those reported below.

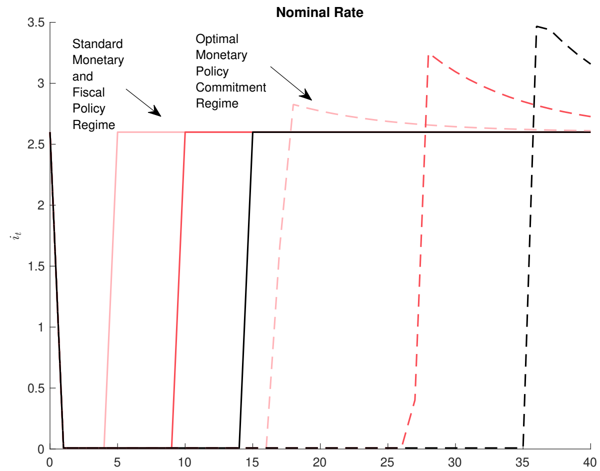


Figure 25: Interest Rate assuming the Standard Monetary and Fiscal Policy Regime and Optimal Monetary Policy Commitment Regime under Great Recession calibration.

Under the Standard monetary and fiscal policy regime and the Optimal monetary policy regime in a Markov Perfect Equilibrium, the duration of the zero-interest rate policy is exactly equal to the duration of the negative natural rate episode. It is the *expected* duration of the negative natural rate episode that is important for the size of the output and inflation deviations from the steady state in the short run. $\hat{Y}_S$ and $\hat{\pi}_S$ depend upon μ but not upon a particular realization of the shock duration. For example, a shock that is expected to be persistent will lead to a bigger decline in $\hat{Y}_S$ and $\hat{\pi}_S$ even if ex-post realized duration turns out to be short. Vice versa, a shock that is expected to subside soon will lead to a smaller decline in $\hat{Y}_S$ and $\hat{\pi}_S$ even if ex-post realized duration turns out to be long. The Optimal monetary policy commitment regime is different because the duration of the zero interest rate policy is not necessarily equal to the duration of the negative natural interest rate episode but is typically longer. For each realized duration of the episode, there's an appropriate policy response with an additional zero interest rate policy after the shock has already subsided, leading to the duration of the negative natural rate episode affecting output and inflation in the short-run.

The Optimal monetary policy commitment regime is derived independently by Eggertsson and Woodford (2003) and Jung, Teranishi and Watanabe (2005).[77] Two important papers predate these results. Rotemberg and Woodford (1997) accounts for the ZLB indirectly by penalizing interest rate variation in the central bank loss function, concluding that the problem implied by the ZLB can be substantially mitigated if interest rates move slowly in response to shocks.[78] Reifschneider and Williams (2000) simulate the FRB/US model assuming a Taylor rule augmented by the ZLB and find significant output losses associated with ZLB episodes. They suggest modifying the Taylor rule to keep track of when it is violated due to the ZLB. Their modified policy rule says that if the policy rate is constrained by the ZLB, future interest rates are kept low to substitute, capturing the key elements of the Optimal monetary policy commitment regime.[79]

[77]While the former considers a two-state Markov process for the natural rate, the latter considers a deterministic AR(1) process. Adam and Billi (2006) generalize Jung, Teranishi and Watanabe (2005) to a stochastic AR(1) process.

[78]See discussion in footnote 51.

[79]Specifically, Reifschneider and Williams (2000) consider the rule: $\hat{\imath}_t = max(\hat{\imath}_t^{Taylor} - \alpha Z_t, i^{zlb})$ where $\alpha \in (0,1]$, $\hat{\imath}_t^{Taylor}$ is the

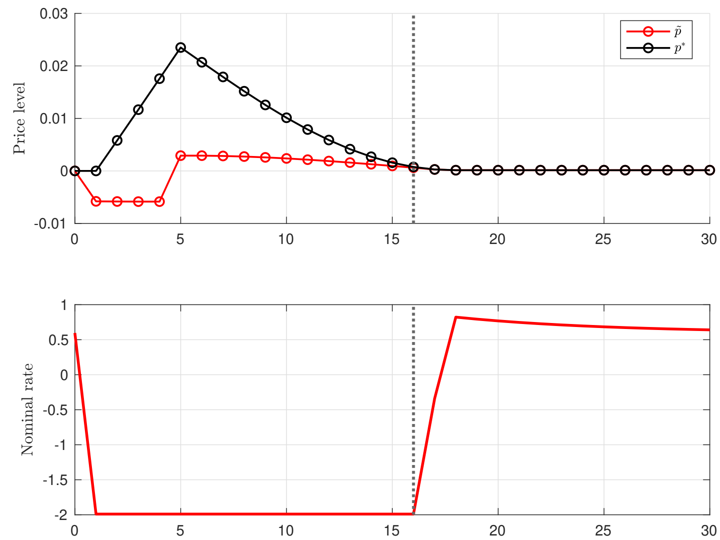


Figure 26: Price Level, Actual and Target, under the Commitment-policy-regime

4.1.2 How can the Optimal Monetary Policy Commitment Regime be Implemented?

This subsection shows that the Optimal monetary policy commitment regime analyzed in the previous subsection can be communicated in a surprisingly simple form: The central bank simply defines appropriate thresholds, which depend on a combination of the price level and output. Once these thresholds are met, a lift-off from the ZLB is signaled. This policy shares important commonalities with the so-called Evans rule adopted by the Federal Reserve in 2012.

Bernanke, Reinhart and Sack (2004) distinguish between unconditional (calendar-based) and conditional (economic-based) forward-guidance strategies at the ZLB. Most major central banks used both during the Great Recession but relied more on calendar-based commitment as illustrated in Table 6 for the case of the Federal Reserve (from Swanson (2021)).

Despite the complexities of stochastic shock duration, unobserved efficient rate, and shocks to the AS equation, which can be hard to measure, Eggertsson and Woodford (2003) show that the Optimal monetary policy commitment regime can be communicated in a simple way that is independent of the stochastic properties of the underlying shock.

They propose the central bank announce a threshold, formulated using the output gap and price level, to be met before raising rates. The output-gap-adjusted price-level target is:

$$\tilde{p}_t = p_t^*, \tag{80}$$

nominal rate implied by an unconstrained Taylor rule, $d_t = \hat{\imath}_t - \hat{\imath}_t^{Taylor}$ measures the difference between the policy rate and the Taylor rule rate, and Z_t is the sum of past d_t values. This rule implies that if policy is constrained by the ZLB, it will "make up" for it by remaining lower in future periods when the ZLB no longer binds, replicating key aspects of the Optimal monetary policy commitment regime. Eggertsson et al. (2019) show this remains true in the New Keynesian model simulations.

where $\tilde{p}_t \equiv p_t + \frac{\kappa}{\lambda}\hat{Y}_t$ and p_t^* is computed as:

$$p_{t+1}^* = p_t^* + \beta^{-1}(1+\kappa\sigma)\Delta_t - \beta^{-1}\Delta_{t-1}, \tag{81}$$

with $\Delta_t \equiv p_t^* - \tilde{p}_t$ measuring the ZLB-induced target miss.

Figure 26 illustrates this for a realization of the stochastic process that lasts for five periods, corresponding to the Optimal monetary policy commitment regime shown in figure 24. If the price-level target is missed, the central bank increases it further.[80]

Commitments of this form, which Bernanke, Reinhart and Sack (2004) term conditional, allow market expectations to adjust to new shocks, unlike unconditional commitments. Thus, if correctly specified, monetary policy will automatically become more accommodative in response to negative shocks, as markets anticipate the central bank is further away from reaching its threshold. Figure 25 compares the interest rate paths under the Optimal monetary policy commitment regime relative to the Standard monetary and fiscal policy regime for different realizations of the underlying shock process.

The Federal Reserve initially used unconditional announcements in the Great Recession (Table 6). The 2012 Evans rule, specifying conditions for rate increases, was closest to the conditional approach. While not fully implementing the New Keynesian model commitment solution, it featured a threshold rather than a deterministic time horizon.

4.1.3 The Deflation Bias: Optimal Monetary Policy Regime in a Markov Perfect Equilibrium with a Negative Natural Rate in the Short Run

This subsection reviews the Optimal monetary policy regime in a Markov Perfect Equilibrium. This means the central bank can only base its policy strategy on current conditions and cannot make binding commitments about its future policy choices. It is the polar opposite of the Optimal monetary policy commitment regime. If markets expect the central bank to follow this policy regime, forward guidance about future interest rates has no effect. We will show that the Optimal monetary policy regime in a Markov Perfect Equilibrium results in an identical equilibrium as the Standard monetary and fiscal policy regime in section 3.

The Optimal Monetary Policy Regime in a Markov Perfect Equilibrium suffers from a basic credibility problem, leading to what Eggertsson (2001*a*) (building on Krugman (1998*a*))) coins as the *Deflation Bias*.[81] In the Markov Perfect Equilibrium, actions and expectations depend only on observed state variables. The only state variables in the model are the exogenous shocks $\hat{r}_t^e$ and $\hat{F}_t$, but for now, we set

[80] The analysis of Eggertsson and Woodford (2003) is predated by Wolman (2005). He suggested replacing inflation in the Taylor rule with the price level and shows that this goes a long way to eliminating the cost of the ZLB in a model with rigid prices.

[81] Krugman recognized this credibility problem, stating that monetary policy can be effective in a liquidity trap if the central bank can credibly promise to be irresponsible and seek a higher future price level. Eggertsson (2001*a*) formalized this idea, terming it *deflation bias* using the statistical process in A2, while Adam and Billi (2007) show it using global methods for a general first-order autoregressive process.

$\hat{F}_t = 0$, which the central bank takes as exogenous; we abstract from other fiscal policy instruments. Expectations of inflation and output are replaced by $E_t\hat{\pi}_{t+1} = \pi^e(\hat{r}^e_t)$ and $E_t\hat{Y}_{t+1} = Y^e(\hat{r}^e_t)$, which the central bank takes as given.

The central bank's optimization problem becomes static and is solved by the Lagrangian method with multipliers ϕ_{1t}, ϕ_{2t}, and ϕ_{3t} for the IS equation (30), AS equation (32), and ZLB (31). The first-order conditions are:

$$\begin{aligned}
\partial\hat{\pi}_t : &\quad \hat{\pi}_t + \phi_{2t} = 0, \\
\partial\hat{Y}_t : &\quad \lambda_y\hat{Y}_t + \phi_{1t} - \kappa\phi_{2t} = 0, \\
\partial\hat{\imath}_t : &\quad -\sigma\phi_{1t} + \phi_{3t} = 0, \\
CS : &\quad \hat{\imath}_t \geq i^{zlb}, \phi_{3t} \geq 0, \phi_{3t}(\hat{\imath}_t - i^{zlb}) = 0.
\end{aligned} \tag{82}$$

The equilibrium is a set of stochastic processes for $\{\hat{\pi}_t, \hat{Y}_t, \hat{\imath}_t\}$ that solve (30), (32) and (82) given $\{\hat{r}^e_t\}$. In the long run ($t \geq t_L$), if the ZLB is not binding, $\phi_{3t} = \phi_{2t} = 0$. The unique bounded solution is $\hat{\pi}_L = \hat{Y}_t = 0$, equivalent to the Standard monetary and fiscal policy regime, requires $\hat{\imath}_t = \hat{r}^e_t = 0$. In the short run ($t < t_L$), this violates the ZLB, suggesting $\phi_{3t} > 0$. If the ZLB binds, the solution then satisfies exactly the same set of equations as the Standard monetary and fiscal policy regime, resulting in the same solution. Hence, the Markov Perfect Equilibrium is a natural game theoretic *foundation* for the Standard monetary and fiscal policy regime. Figure 24 shows that the Optimal monetary policy commitment regime delivers better results than the Optimal monetary policy regime in a Markov Perfect Equilibrium, with output and inflation falling less due to expectations of lower interest rates after the shock, and higher output.

To see why the Optimal monetary policy commitment regime is not credible in such setting and thus does not satisfy the requirement of Markov Perfect Equilibrium, consider the solution in isolation *only* from period five onward. From the perspective of period $t \geq 5$, the central bank is creating excess inflation and output above target when no shocks are hitting the economy. Clearly, from the perspective of period $t \geq 5$ onward, the central bank can achieve the best possible outcome e.g. both the inflation and the output targets: $\hat{\pi}_t = \hat{Y}_t = 0$. Indeed, independent observers of the central bank at time five would feel justified in asking a policy maker operating under an Optimal monetary policy commitment regime: Why are you generating inflation and output boom today when economic conditions we observe give you no justification for doing it? This is at the heart of the credibility problem at the ZLB.

One important implication of the Markov Perfect Equilibrium is that forward guidance by the central bank has no effect. Below, we briefly summarize empirical evidence from the US about the impact of forward guidance.

4.1.4 Empirical Evidence on the Effect of Forward Guidance

The empirical literature provides evidence that forward guidance by the Federal Reserve about future interest rates had a statistically significant impact on financial markets and output growth during the Great Recession.

This literature identifies the impact of forward guidance by considering market reactions within short event windows, e.g. 30 minutes, typically around Federal Open Market Committee (FOMC) meetings but more recently also speeches by FOMC members (see Swanson and Jayawickrema (2023)).[82]

Table 6: Some Major Unconventional Monetary Policy Announcements by the Federal Open Market Committee (FOMC), 2009–15, adapted from Swanson (2021)

Date	Announcement
March 18, 2009,	FOMC announces it expects to keep the federal funds rate between 0 and 25 basis points (bp) for "an extended period," and it will purchase $750B of mortgage-backed securities, $300B of longer-term Treasuries, and $100B of agency debt (a.k.a. QE1).
November 3, 2010	FOMC announces it will purchase an additional $600B of longer-term Treasuries (a.k.a. QE2).
August 9, 2011	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through mid-2013."
September 21, 2011	FOMC announces it will sell $400B of short-term Treasuries and use the proceeds to buy $400B of long-term Treasuries (a.k.a. Operation Twist).
January 25, 2012	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through late 2014."
September 13, 2012	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through mid-2015" and it will purchase $40B of mortgage-backed securities per month for the indefinite future.
December 12, 2012	FOMC announces it will purchase $45B of longer-term Treasuries per month for the indefinite future and it expects to keep the federal funds rate between 0 and 25 bp at least as long as unemployment remains above 6.5% and inflation expectations remain subdued.
December 18, 2013	FOMC announces it will start to taper its purchases of longer-term Treasuries and mortgage-backed securities to $40B and $35B per month, respectively.
December 17, 2014	FOMC announces that "it can be patient in beginning to normalize the stance of monetary policy."
March 18, 2015	FOMC announces that "an increase in the target range for the federal funds rate remains unlikely at the April FOMC meeting."

The broad conclusion of this empirical work is that forward guidance was an effective monetary policy tool at the ZLB during the Great Recession. Table 6 from Swanson (2021) shows examples of the

[82] Kuttner (2001) and Gürkaynak, Sack and Swanson (2005) are two influential papers that started this rapidly growing literature. See the "related literature" section in Swanson (2023) for an overview of its different branches.

forward guidance studied, such as the FOMC's January 25, 2012 announcement to keep the federal funds rate between 0 and 25 basis points "at least through late 2014." Multiple authors, including Swanson (2021), Campbell et al. (2012), Krishnamurthy and Vissing-Jorgensen (2011), Gertler and Karadi (2015), Jarociński (2024), find that forward guidance had significant effects on various asset markets in the US while Brand, Buncic and Turunen (2010) provides similar evidence for the Eurozone. Additionally, Gertler and Karadi (2015), Bauer and Swanson (2023), and Del Negro, Giannoni and Patterson (2023) show that forward guidance also impacted output.

Campbell et al. (2012) distinguish between "Delphic" and "Odyssean" forward guidance. If the market interprets forward guidance as implying that economic conditions are weaker than previously expected, it is classified as Delphic. Conversely, if the market interprets forward guidance as implying that the Federal Reserve is willing to keep interest rates lower for longer than previously anticipated, at the risk of higher inflation, it is classified as Odyssean. Odyssean forward guidance aligns with the Optimal monetary policy commitment regime, while the Optimal monetary policy regime in a Markov Perfect Equilibrium implies that Odyssean forward guidance is irrelevant as the central bank cannot make credible future promises.

Del Negro, Giannoni and Patterson (2023) contain an interesting case study of two FOMC statements. The August 9, 2011 statement, which is considered Delphic forward guidance, indicated that "economic conditions...are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013," which the market interpreted as reflecting a pessimistic outlook rather than a policy change. Conversely, the September 12, 2012 announcement, while acknowledging "moderate" growth and "subdued" inflation, stated that monetary policy would remain accommodative "for a considerable time after the economy strengthens," which the market interpreted as capturing the core feature of the Optimal monetary policy commitment regime: keeping rates at the ZLB even after the economy had recovered. They estimate that while the first announcement had no impact on inflation expectations, it lowered expected GDP growth, while the latter increased inflation expectations and increased expected growth.

Swanson and Williams (2014) estimate the effect on yields of Treasury bonds to macroeconomic news. The idea is that if the ZLB posed little to no constraint on monetary policy, e.g., if the Federal Reserve was able to implement the Optimal monetary commitment regime, then the effect of news on longer-term yields would be similar to when the ZLB was not binding. We summarize the three most essential points relevant to the review. First, they find that when looking at yields up to six months ahead, they responded differently than normally to news. This is intuitive since changes in the news would lead the markets to change their expectations about the interest rate in the near future under regular circumstances, while if the market expects the ZLB to bind at least for two quarters, there should be no change at all. Second, they find that within the period 2008-2010, the yield on one-to-two years to maturity was surprisingly (authors' words) responsive to the news. In late 2011, however, those yields also stopped being responsive to the news. We think the most plausible explanation for these findings, which is one of many offered by the authors, is that until about August 2011, market participants expected the zero bound to constrain policy only for a few quarters, which minimized the effect on medium and long term yields. Another explanation, which we find less compelling for the reason

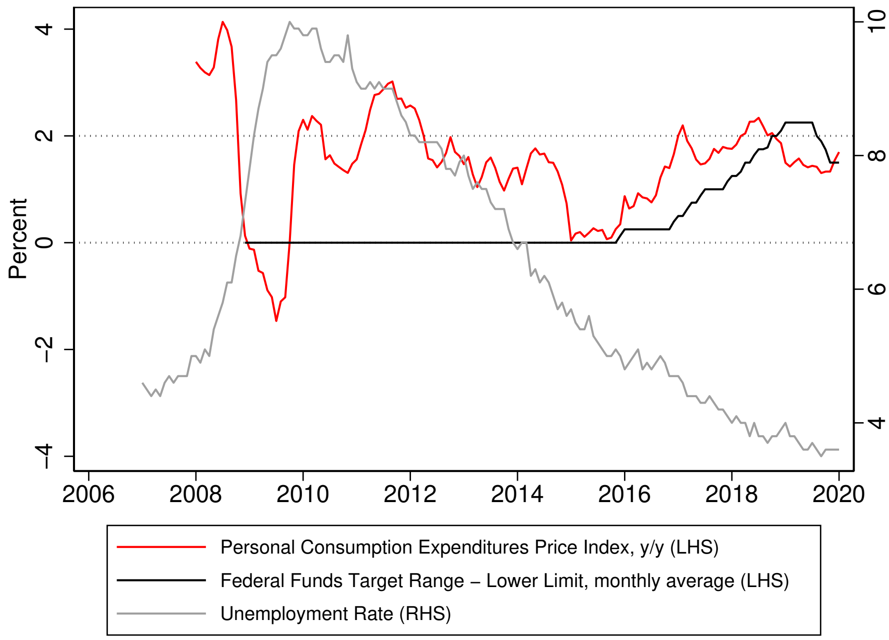


Figure 27: The Interest Rate Policy of the Federal Reserve, 2008–19, along with unemployment and inflation

we explain in next section, was that the Federal Reserve was in fact following the Optimal monetary policy commitment regime, and thus offsetting incoming shocks endogenously by extending or shortening the duration of its commitment to lower rates.

4.1.5 Did the Federal Reserve Follow the Optimal Monetary Policy Commitment Regime during the Great Recession?

While there is statistically significant empirical evidence that forward guidance impacted markets, contradicting the prediction of the Optimal monetary policy regime in a Markov Perfect Equilibrium, this subsection reviews data suggesting that Federal Reserve policy fell short of the Optimal monetary policy commitment regime. We also provide narrative evidence from policymakers, indicating that this shortfall is partially explained by the *Deflation Bias* of the Optimal monetary policy regime in a Markov Perfect Equilibrium.

The signature of the Optimal monetary policy commitment regime is that the Federal Reserve keeps interest rates low even after the economy has fully recovered and inflation is on target, overshooting both parts of its dual mandate. This, however, is not consistent with the Federal Reserve's behavior as it started projecting a full recovery. The record shows that the FOMC aimed to have inflation slowly approach its 2% target *from below* rather than replicating the key property of the Optimal monetary policy commitment regime. Table 7 reports the projections of the 19 FOMC members when they

Table 7: Summary of Economic Projections of Federal Reserve Board members and Federal Reserve Bank Presidents in December 2015

	Median					Central Tendency				
Variable	**2015**	**2016**	**2017**	**2018**	**Long-Run**	**2015**	**2016**	**2017**	**2018**	**Long-Run**
GDP growth	2.1	2.4	2.2	2.0	2.0	2.0 - 2.3	2.3 - 2.5	2.0 - 2.3	1.8 - 2.2	1.8 - 2.3
Unemployment	5.0	4.7	4.7	4.7	4.9	5.0 - 5.1	4.6 - 4.8	4.6 - 4.8	4.5 - 5.0	4.7 - 5.8
PCE inflation	0.4	1.6	1.9	2.0	2.0	0.3 - 0.5	1.2 - 1.7	1.8 - 2.0	1.9 - 2.0	2.0
Policy Rate	0.4	1.4	2.4	3.3	3.5	0.1 - 0.6	0.9 - 1.4	1.9 - 3.0	2.9 - 3.5	2.9 - 3.9

started raising rates in December 2015, with inflation at 0.4%. FOMC members projected inflation would reach its target only in 2018. The FOMC started tightening policy in 2015, despite inflation being below target, because they estimated the natural rate of unemployment to be 4.9% (Table 7, Long-Run). With unemployment at 5%, the FOMC projected it to go slightly below its natural rate, pushing inflation back to target slowly. The interest rate increase was a pre-emptive attempt to avoid inflation overshooting, consistent with the Optimal monetary policy regime in a Markov Perfect Equilibrium.

Why did the Federal Reserve fall short of implementing the Optimal monetary policy commitment regime? In a 2019 speech, Chair Jerome Powell (2019) reflected on this question, which includes allowing for excess inflation to make up for the fall in the price level during the ZLB episode (a makeup strategy), see figure 26):

> For makeup strategies to achieve their stabilizing benefits, households and businesses must be quite confident that the "makeup stimulus" is really coming. This confidence is what prompts them to raise spending and investment in the midst of a downturn. In models, confidence in the policy is merely an assumption. In practice, when policymakers considered these policies in the wake of the crisis, they had major questions about whether a central bank's promise of good times to come would have moved the hearts, minds, and pocketbooks of the public. Part of the problem is that when the time comes to deliver the inflationary stimulus, that policy is likely to be unpopular—what is known as the time consistency problem in economics.

Powell cites FOMC minutes suggesting that members shared similar concerns about the Optimal monetary policy commitment regime. John Williams, vice Chair of the FOMC and president of the Federal Reserve Bank of New York, noted in FOMC minutes from 2011: "In the jargon of academics, our commitment technology is very limited. It is simply impossible for us to set a predetermined course of policy that will bind future Committees." The dynamic inconsistency problem, the Deflation Bias, is, therefore, one of the reasons policymakers did not implement a policy consistent with the Optimal monetary policy commitment regime. Recognition of this bias and concerns about an increasing frequency of ZLB episodes led the Federal Reserve to change its monetary policy framework in 2020. It includes a reformulation of Fed's objectives in a way that makes implementation of

Multiplier	Great Recession		Great Depression	
	Standard monetary and fiscal policy regime	Optimal monetary policy commitment regime	Standard monetary and fiscal policy regime	Optimal monetary policy commitment regime
$M_F = \frac{E_0 \sum_{t=0} \beta^t \Delta \hat{Y}_t}{E_0 \sum_{t=0} \beta^t \Delta \hat{F}_t}$	1.1	0.4	2.2	0.5

Table 8: Government Spending Multipliers contrasting Standard monetary and fiscal policy regime (equivalent to Optimal monetary policy regime in a Markov Perfect Equilibrium) from section 3 to the Optimal monetary policy commitment regime.

makeup strategies more credible.[83]

During the Great Recession, the Federal Reserve faced the same credibility problem as policymakers did during the Great Depression. Subsection 4.4 examines how FDR's 1933 regime change credibly committed to reflating the economy, confronting similar issues as the Federal Reserve in the Great Recession.

Before getting to the Great Depression, the next subsection takes stock of what we have learned so far and considers how the results from section 3 relate to the analysis of Optimal monetary policy with commitment and in a Markov Perfect Equilibrium).

4.2 Empirical Implication of the Optimal Monetary Policy Commitment Regime

This subsection reviews empirical predictions of the Optimal monetary policy commitment regime: government spending multipliers are small, and the paradoxes reviewed in section 3 no longer apply. A reasonable policy regime that captures key features of the data remains an open research question. We summarize key properties of what a regime of this kind may look like and how it differs from the Optimal monetary policy commitment regime.

The government spending multiplier when monetary policy is set according to the Optimal monetary policy commitment regime can be analyzed in the same way as in section 3.[84]The result, shown in Table 8, reveals that the multiplier drops considerably and closely approximates the government spending multiplier at positive interest rates.

[83]See Eggertsson and Kohn (2023) for a discussion of the 2020 policy framework, its forward guidance implementation in Fall 2020, and its contribution to the 2020s inflation surge. This framework, a de facto "constitutional framework" for FOMC policy, is meant to be amended infrequently. The Federal Reserve first released the "Statement of Long-Run Goals and Monetary Policy Strategy" in 2012, announcing a 2% PCE inflation target. The 2020 revision was the first change to the framework. The Federal Reserve's 2020 policy framework had two key innovations. First, the committee stated that if inflation is persistently below its 2% target, as it was from 2008 to 2021, it would aim for inflation moderately above 2% for some time. Second, the Federal Reserve would put less weight on employment being above maximum employment than if it were below it. The first change was partly implemented to address the dynamic inconsistency problem associated with overshooting the target if inflation fell below it. The second change was motivated by the FOMC's retrospective judgment that their assessment

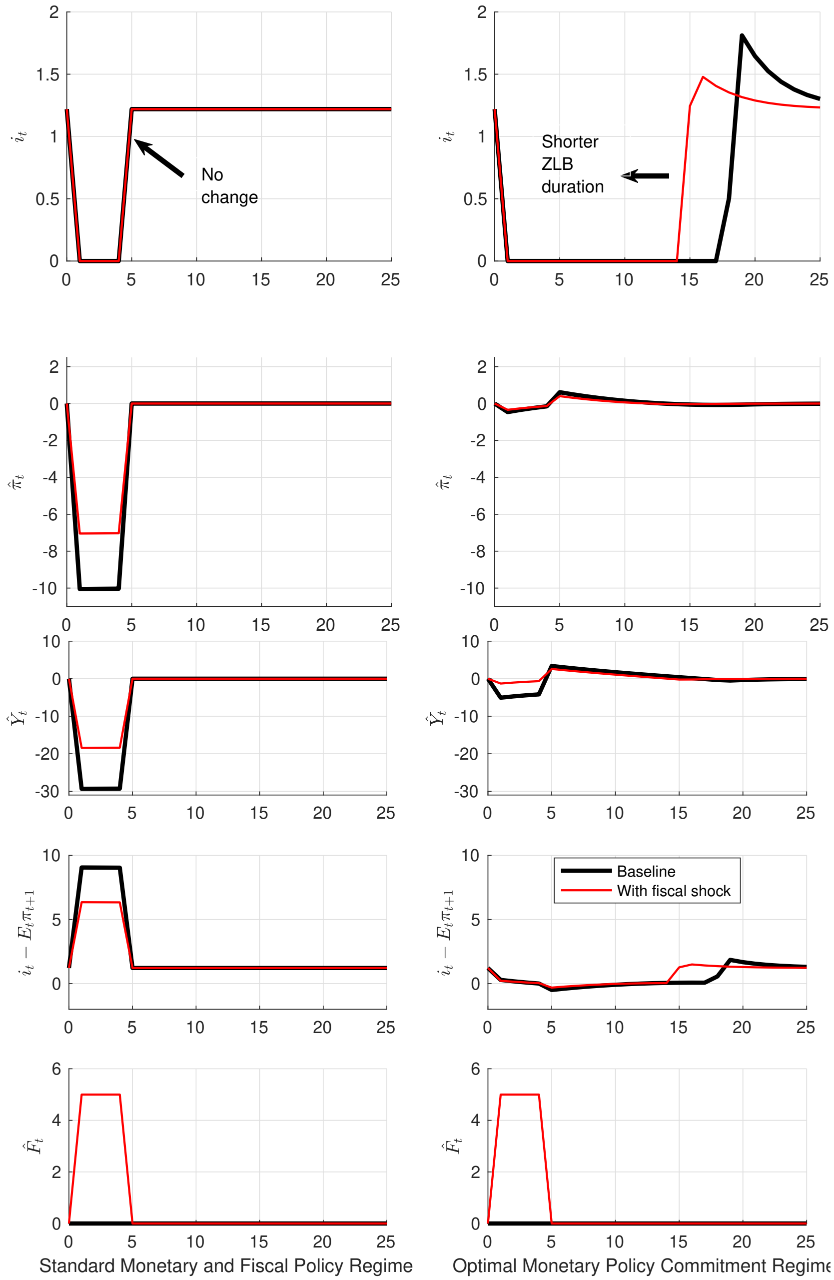


Figure 28: Effect of a 5 percent of GDP increase in government spending that lasts five periods using the Great Depression calibration: under the Standard monetary and fiscal policy regime from section 3 and the Optimal Monetary Policy Commitment Regime from section 4.

Figure 28 illustrates the large drop in the multiplier, paralleling earlier figures by showing the case where the efficient rate is negative for five periods. The left panel shows the results under the Standard monetary and fiscal policy regime (that are equivalent to the results under the Optimal monetary policy regime in a Markov Perfect Equilibrium). An increase in government spending equivalent to 5% of steady state output reduces the output collapse to 19% instead of 30% as suggested by the multiplier. In contrast, the right panel shows a modest increase in output under the Optimal monetary policy commitment regime, consistent with the multiplier being more than four times smaller, as shown in Table 8.

The top panel illustrates why the multiplier is much smaller under the Optimal monetary policy commitment regime. Under the Optimal monetary policy regime in a Markov Perfect Equilibrium, the policy rate does not change in response to the government spending shock. In contrast, under the Optimal monetary policy commitment regime, there is less reason for aggressive monetary policy if government spending is increased, so the ZLB binds for a shorter period. The effect of the fiscal expansion now looks more similar to what happens at positive interest rates, as the fiscal expansion is met by tightening monetary policy.

The paradox of toil and the paradox of flexibility no longer apply under the Optimal monetary policy commitment regime. These paradoxes arise when monetary policy cannot offset deflationary forces and will welcome inflationary shocks associated with fiscal spending or oil shocks since inflation is below its target. In such a setting the central bank welcomes some inflation to bring it closer to target. However, under the Optimal monetary policy commitment regime, the central bank regains control of the price level through its ability to commit to future interest rate policy.

The analysis in this subsection is based on Eggertsson, Egiev and Roulleau-Pasdeloup (2024), which studies the conjecture of Cochrane (2017) that the results reviewed in section 3 are "sensitive to equilibrium choice". Recall that those results can be derived assuming the Standard monetary and fiscal policy regime or the Optimal monetary policy regime in a Markov Perfect Equilibrium. As an alternative, Cochrane (2017) suggests "backward stable" and "no jump" equilibria. In both alternatives, the government spending multiplier is small, and these equilibria are free of paradoxes.

The alternative equilibria studied in Cochrane (2017) represent policy regimes. Both closely resemble the flexible price equilibrium. The Optimal monetary policy commitment regime is designed to replicate the flexible price allocation. The several properties of the equilibria considered in Cochrane (2017) are best understood as properties of regimes that are close variations on the Optimal monetary policy commitment policy regime.[85]

of maximum sustainable employment, defined as the non-inflationary unemployment level, was too pessimistic, given the 3.5% unemployment rate without inflation signs on the eve of the COVID-19 pandemic.

[84]This is because the monetary policy regime treats the path of government spending, $\hat{F}_t$, as exogenous.

[85]A subtle point is that the three policy regimes in Cochrane (2017) are associated with the same *path* of the policy rate. However, as shown by Sargent and Wallace (1975), a given path of nominal interest rates implies indeterminacy, meaning there is an infinite number of possible solutions to the model. Thus, a policy regime is not fully specified if it only prescribes an exogenous path for a nominal interest rate (local indeterminacy). Such incompletely specified regimes lead to indeterminacy absent some other restrictions which impede the usage of comparative statics.

4.3 Taking stock: What was the Nature of the Monetary Policy Regime during the Great Recession?

A central question that remains open is how to best describe the monetary policy regime during the Great Recession. Empirical evidence from high-frequency movements in oil prices and on government spending multipliers points towards the Standard monetary and fiscal policy regime, which suggests that deflationary pressures are not offset by a commitment to the future interest rate. In contrast, evidence suggesting that forward guidance had statistically significant effects is easier to explain by acknowledging that central banks have at least some power to make credible commitments about the future path of the policy instrument. This contradicts the two polar cases we have proposed.

One way to reconcile the evidence is to posit a generalization of the Optimal monetary policy regime in a Markov Perfect Equilibrium that still falls short of the Optimal monetary policy commitment regime. To identify the desirable properties of a more general regime, it is helpful to consider contributing factors, on the one hand, to the large fiscal multipliers at the ZLB and the positive effect of oil shocks and, on the other, factors that give power to the forward guidance.

Under an Optimal monetary policy regime in a Markov Perfect Equilibrium, a large multiplier and positive effect of a negative supply shock (paradox of toil) emerge because monetary policy does not offset the inflationary impact of these shocks by raising rates. Under the Optimal monetary policy commitment regime, forward guidance becomes effective because the monetary authority can influence expectations about the future path of the policy rate, thereby reducing long-term interest rates.

The empirical evidence points to both large multipliers and the paradox of toil which point to the Markov perfect equilibrium policy regime. To be fair, this empirical debate is still raging so the consensus can at best be called tentative. Yet at the same time the empirical literature has reached another tentative consensus. Forward guidance effectively reduces real interest rate. This points to the relevance of the commitment regime. This raises the obvious question if these two empirical pieces of evidence can be encompassed in a single and more general policy regime.

Several plausible policy regimes can account for the patterns documented by the empirical literature in a theoretically consistent way, but this topic remains largely unexplored by the theoretical literature. Here we sketch out one illustrative example. The key property of the Standard and Markov Perfect Equilibrium regimes that explains the model's properties under these regimes is that interest rates are fixed so they do not respond to e.g. fiscal shocks. It is easy to imagine a policy regime that maintains this property while at the same time giving forward guidance some power, without this power implying that monetary policy will always automatically adjust to any fiscal intervention at the ZLB.

Consider optimal monetary policy in a Markov Perfect Equilibrium augmented with a limited commitment technology of a simple form: the central bank can credibly announce a calendar date before which it commits not to raise the policy rate, even if the natural rate of interest recovers before that date arrives. If credible, this type of commitment changes the expected path of the policy rate when announced, explaining why forward guidance has a statistically significant impact in the data. Yet, this policy regime also retains the key property generating large spending multipliers and the paradoxical behavior we covered in Section 3: the interest rate does not endogenously respond to shocks, unlike under the commitment regime. If the natural rate reverts *before* the calendar date to which the central bank commits, the ZLB remains binding, explaining the power of forward guidance but doing nothing to reduce e.g., the fiscal multiplier, which relies on interest rates tightening in response to a fiscal expansion. Consider now the case in which the natural interest rate reverts to steady state *after* the binding forward calendar date. In this case, the forward guidance is not binding and policy follows the Optimal policy regime in a Markov Perfect Equilibrium, which is identical to the standard monetary and fiscal policy regime.

4.4 The Great Depression and Optimal Joint Monetary and Fiscal Policy Regime in a Markov Perfect Equilibrium with Additional Institutional Constraints

This subsection reviews optimal monetary and fiscal policy in a Markov Perfect Equilibrium subject to additional institutional commitments, such as the gold standard. We call this regime, which now includes fiscal instruments, the Optimal joint monetary and fiscal policy regime in a Markov Perfect Equilibrium. It interprets the 1933 turning point of the Great Depression, when FDR became president, as a regime change that triggered a sharp recovery. Institutional commitments and regime change are motivated by historical records, with regime change defined as the elimination of institutional commitments. The government's central objective in 1933 became inflating prices to pre-depression levels. The Optimal joint monetary and fiscal policy regime in a Markov Perfect Equilibrium rationalizes, within the model, *why* the inflation program credibly shifted expectations from deflationary to inflationary in the spring of 1933, triggering rapid recovery from 1933-1937. The theory also accounts for the 1937 recession (The Mistake of 1937) and the subsequent recovery resumption in 1938.

Sargent's (1982) seminal paper "The Ends of Four Big Inflations" demonstrates the importance of modeling regime changes when analyzing macroeconomic crises. Using a rational expectations model, Sargent studies four major post-World War I inflationary episodes, emphasizing that a policy regime change's effectiveness relies on its credibility and expectations, with fiscal policy playing a central role. Thus, the success of a policy regime change depends not only on the technical aspects of reform but also on the public belief in the government's commitment to it.

Temin and Wigmore (1990) apply Sargent's insight to analyze the Great Depression in their classic paper "The End of One Big Deflation." The interpretation of the US recovery from the Great Depression, reviewed in this subsection, formalizes Temin and Wigmore's idea,[86] which can be applied using the standard New Keynesian model.

[86] They use a narrative approach instead of providing an explicit model.

This subsection models policy regimes as the result of maximizing social welfare subject to the constraints of the New Keynesian model and potential institutional limits. Social welfare is captured by household utility. We use the same model as in section 3 where we studied fiscal policy, but with one key difference: we simplify the analysis by assuming a distortionary tax, $\hat{T}_t^d$, associated with deadweight loss as in Barro (1979*b*) instead of the multiple tax instruments introduced in section 3.

Imagine only part of government spending, G_t, contributes to social welfare. Taxation absorbs real resources via the increasing and convex function $f(T_t^d)$, representing tax-collection costs or "indirect misallocation costs" that create economic distortions, as proposed by Barro (1979*b*). Total government spending is then:

$$F_t = G_t + f(T_t^d). \tag{83}$$

We assume total taxes comprise two components:

$$T_t = T_t^d + T_t^L, \tag{84}$$

here, T_t^L is a lump-sum tax, which the government has limited access to but carries no distortions. Allowing some forms of lump-sum taxation simplifies the analysis and enables us to consider an economy local to the efficient steady state. Welfare is then approximated by:

$$-\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t(\underbrace{\hat{\pi}_t^2 + \lambda_x x_t^2}_{\substack{\text{Dual Mandate of}\\ \text{the Federal Reserve}}} + \underbrace{\lambda_F \hat{F}_t^2 + \lambda_T(\hat{T}_t^d)^2}_{\substack{\text{Fiscal Policy}\\ \text{Consideration}}}), \tag{85}$$

$x_t \equiv \hat{Y}_t - \sigma^{-1}\psi\hat{F}_t$ is the output gap, with each variable having the same interpretation as in the last subsection, except for $\hat{T}_t{}^d$ already defined.

The policymaker's problem is to maximize the social welfare function (78), which, in addition to the dual mandate, now includes a desire to keep government spending at a constant target level and taxation smoothing. In addition to the constraints or dogmas of the monetary policy problem we consider shortly, the policymaker takes into account the government budget constraint written as in section 3, but with the simplified taxation system:

$$\hat{w}_t = \beta^{-1}\hat{w}_{t-1} + w_y\hat{\imath}_t - \beta^{-1}w_y\hat{\pi}_t + \beta^{-1}\hat{F}_t - \beta^{-1}\hat{T}_t. \tag{86}$$

Consider three additional institutional commitments, termed dogmas, based on the historical record:[87]

$$\textit{No-Deficit Dogma:} \qquad \hat{w}_t = 0, \tag{87}$$

$$\textit{Small-Government Dogma:} \qquad F_t = \bar{F}, \tag{88}$$

$$\textit{Gold Standard Dogma:} \qquad M_t \leq \lambda_g p_g g_t^m. \tag{89}$$

The first two policy dogmas are self-explanatory: no-deficit dogma maintains the real value of gov-

[87] See Eggertsson (2008) for a detailed discussion.

ernment debt at steady state, while small-government dogma fixes government spending at the (low) steady-state level, $\hat{F}_t = 0$.

The gold standard dogma requires elaboration. M_t is the nominal money stock, g_t is the Federal Reserve's gold reserves, p_G is the dollar price of gold, and λ_g measures the required gold backing of the monetary base. In the 1920s US, the Federal Reserve needed to keep gold reserves at 40% of the monetary base.[88] For simplicity, g_t is exogenous.

The gold standard formulation follows Barro (1979*a*), except Barro (1979*a*) assumes equality. The inequality reflects the Federal Reserve's commitment to hold *at least* as much gold as required, not considering excess holdings problematic. This asymmetry was important: the Federal Reserve "sterilized" gold inflows throughout the 1920s and much of Hoover's term, hence not increasing the money supply in proportion to gold inflows.[89]

The gold standard's asymmetry was crucial for understanding US monetary policy, as it implied that it did not tie the hands of the Federal Reserve to expand the supply of money. The Fed held more gold than it needed to support the outstanding money supply adn could therefore expand it further. This point has been highlighted by several authors, including Friedman and Schwartz (1963), Temin (1991), Eichengreen (1992) and Meltzer (2010).[90]

The government's problem is to maximize (78) subject to constraints imposed by the New Keynesian model but with the additional institutional commitments implied by the No-Deficit Dogma, the Small-Government Dogma, and the Gold Standard Dogma, which enter as additional constraints.

The policy regime change when FDR took power in the spring of 1933 is modeled as:

$$\text{Hoover Regime} \rightarrow \text{Unexpected Elimination of the No-Deficit Dogma, the Small-Government Dogma, and the Gold Standard Dogma} \rightarrow \text{Roosevelt Regime}$$

This historical record provides compelling evidence that President Hoover's policy regime was constrained by the policy dogmas; see discussion in Temin and Wigmore (1990) and Eggertsson (2008) with a few illustrative quotes Table 9. What is equally clear from the record is that a central part of FDR's policy when he assumed the presidency was to eliminate these policy dogmas, which was largely unanticipated (as it violated his election platform). In response to the abrupt policy change, several senior administration officials resigned, with one, Douglas Lewis, the Director of the Budget, declaring: "This is the end of Western Civilization".[91]

Considering the equilibrium free of the institutional constraints imposed by the policy dogma, we observe that the real value of government debt, $\hat{w}_{t-1}$, is an endogenous state variable. In a Markov

[88] The price of gold was 20.67 per ounce, so g_t is measured in ounces.

[89] In case of outflows, if the constraint was close to being binding, the Federal Reserve lacked this flexibility and would need to contract the monetary base, a situation many other gold standard countries faced during the Great Depression.

[90] Meltzer notes that in February 1932, gold covered 71% of outstanding money supply, suggesting the constraint was far from binding.

[91] See Eggertsson (2008).

Perfect Equilibrium, agents' expectations depend only on the minimum set of state variables. We consider a solution where the expectation functions are:

$$\begin{aligned} E_{t,J}\hat{Y}_{t+1} &= Y_r^J \hat{r}_t^e + Y_w^J \hat{w}_t, \\ E_{t,J}\pi_{t+1} &= \pi_r^J \hat{r}_t^e + \pi_w^J \hat{w}_t, \\ E_{t,J}\hat{F}_{t+1} &= F_r^J \hat{r}_t^e + F_w^J \hat{w}_t, \end{aligned} \tag{90}$$

with unknown constants $Y_r^J, Y_w^J, F_r^J, F_w^J, \pi_r^J$, and π_w^J solved using the method of undetermined coefficients, and J being S for short-run and L for long-run. The government's problem is characterized by the Bellman equation:

$$V(\hat{w}_{t-1}, \hat{r}_t^e) = \max_{\hat{T}_t, \hat{F}_t, \hat{i}_t} -\{\pi_t^2 + \lambda_y(\hat{Y}_t - \delta\hat{F}_t)^2 + \lambda_F(\hat{F}_t)^2 + \lambda_T\hat{T}_t^2 + \beta E_t V(\hat{w}_t, \hat{r}_{t+1}^e)\}, \tag{91}$$

subject to the IS equation (30), AS equation (32), ZLB (31), and budget constraint (86) with expectations replaced by 90. In addition, the No-Deficit Dogma, the Small-Government Dogma, and the Gold Standard Dogma apply in the Hoover regime. However, the gold standard constraint is assumed not to be binding under President Hoover, even if its elimination is critical for the credibility of the FDR inflationary regime change since the inflation program implied it might be binding in the future.

Table 9: The Regime Change in the Spring of 1933

Small-Government Dogma (D1)	
President Hoover "Every additional expenditure placed upon our government in this emergency magnifies itself out of all proportion into intolerable pressures, whether it is by taxation or by loans. Either loans or taxes [...] will increase unemployment. [...] We can carry our present expenditures without jeopardy to national stability. We can carry no more without grave risks." September 21, 1931,	**President Roosevelt** "Our greatest primary task is to put people to work. This is no unsolvable problem if we face it wisely and courageously. It can be accomplished in part by direct recruiting by the government itself, treating the task as we would treat the emergency of a war, but at the same time, through this employment, accomplishing greatly needed projects to stimulate and reorganize the use of our natural resources." March 4, 1933,
No-Deficit Dogma (D2)	
President Hoover "For the Government to finance by bond issues deprives industry and agriculture of just that much capital for its own use and for employment. Prosperity cannot be restored by raids on the public Treasury." July 18, 1930,	**President Roosevelt** On debt: "In the first place, government credit and government currency are really one and the same thing." On the purpose of increasing debt: "That is why powers are being given to the Administration to provide, if necessary, for an enlargement of credit [...] These powers will be used when, as, and if it may be necessary to accomplish the purpose [i.e., increasing inflation]." April 19, 1933,
Gold Standard Dogma (D3)	
President Hoover As FDR during the presidential campaign in the fall of 1932, President Hoover was a strong supporter of the gold standard.	**President Roosevelt** FDR formally suspended the gold standard on April 20, 1933.

4.4.1 Hoover Regime and the Great Depression in 1929-1933

This subsection illustrates the Hoover Regime. It shows that the three policy dogmas lead to a trivial role for fiscal policy. This results in the equilibrium that is (as long as the gold standard constraint is not binding) which is identical to the equilibrium under the Optimal monetary policy regime in a Markov Perfect Equilibrium regime.[92]

Suppose government spending that contributes to utility is fixed at $G_t = \bar{G}$. Real debt is constant by the no deficit dogma, and we assume lump-sum taxes adjust to cover variations in interest rate

[92] See Eggertsson (2008) for a more detailed discussion of the role of this constraint under the Hoover Regime.

costs.[93] Consider now social welfare shown in (78), which includes the fiscal variable F_t and T_t^d. The no deficit says real debt is constant. The small government dogmas indicates constant spending. An implication is that the central bank's objective now boils down to the dual mandate. As long as the the gold standard constraint is not binding, which it was not in the US, the government's policy problem yields equations (82) once again.

The Hoover regime delivers the solution depicted in figures 9 and 24, which correspond to the equilibrium under the Standard monetary and fiscal policy regime and the Optimal monetary policy regime in a Markov Perfect Equilibrium.

4.4.2 FDR Regime Change and the Recovery 1933-1937

FDR's central policy objective upon taking office was a regime change aimed at reversing the 10 percent annual deflation and increasing the price level, using all available tools. "If we can't do it one way, we will do it another. But do it we will," he said in the fall of 1933 when the policy was suffering from lack of credibility. This subsection rationalizes FDR's inflation program as the Optimal monetary and fiscal policy in a Markov Perfect Equilibrium once the government is free from the additional institutional constraints. There are other fruitful interpretations of the complex nature of the regime change in 1933 and subsequent recovery, such as Jacobson, Leeper and Preston (2019).[94] We consider this to be a fertile area for future research. In the context of the Great Recession, in section 4.3, we suggested we expect future literature to combine elements of both the Optimal Commitment and Optimal Markov Perfect Equilibrium regimes when modeling the policy regimes during this period. We expect a similar development in the modeling of a policy regimes during the Great Depression.

Under this regime, the government uses both monetary and fiscal policy ($\hat{F}_t$ and $\hat{T}_t$) to achieve its goal, which determines the real value of debt ($\hat{w}_t$) which becomes the endogenous state variable. Expectations are a linear function of the state variable but with an undetermined coefficients, $\hat{Y}_w$,, π_w, and F_w, which can be found using methods of undetermined coefficients. The first-order conditions are computed by formulating a Lagrangian for the government's problem in period t, with Lagrange multipliers ϕ_{1t}, ϕ_{2t}, ϕ_{3t}, and ϕ_{4t} for the IS equation (30), AS equation (32), ZLB (31), and budget constraint (86), respectively. The first-order conditions are:[95]

[93]Taking account of how monetary policy affects these interest costs has trivial quantitative effects since our approximation is local to the efficient steady state. To be more concrete, we assume total government spending and the welfare-contributing part are fixed at $G_t = \bar{G}$. With real debt constant at $\bar{w}$, the budget constraint implies taxes are determined by:

$$\hat{T}_t = (1 + \bar{\imath})w_y \hat{\imath}_t - w_y \hat{\pi}_t.$$

Taxes must adjust to offset changes in real interest rate payments given fixed government spending, affecting the government's tax-smoothing incentive. We abstract from this by assuming general taxes T_t are:

$$T_t = s(\bar{T}^d) + T_t^L,$$

where $\bar{T}^d$ is distortionary taxation at steady state, and T_t^L is lump-sum taxation adjusting to offset variations in debt payment costs.

[94]Eggertsson and Pugsley (2006) for example, model it as a reduced form commitment to inflation.

[95]Here, we have substituted out the derivative of the value function $E_t V(\hat{w}_t, \hat{r}^e_{t+1})$ using the Lagrange multiplier ϕ_{3t} and an

$$\begin{aligned}
\partial\hat{\pi}_t : && \hat{\pi}_t + \phi_{2t} + \beta^{-1} w_y \phi_{4t} = 0, \\
\partial\hat{Y}_t : && \lambda_x(\hat{Y}_t - \sigma^{-1}\psi\hat{F}_t) + \phi_{1t} - \kappa\phi_{2t} = 0, \\
\partial\hat{F}_t : && \lambda_F\hat{F}_t - \phi_{1t} + \kappa\psi\sigma^{-1}\phi_{2t} = 0, \\
\partial\hat{T}_t : && \lambda_T\hat{T}_t + \phi_{4t} = 0, \\
\partial\hat{w}_t : && -E_t\phi_{4t+1} - \phi_{1t}(\hat{Y}_w + \sigma\pi_w - F_w) - \beta\pi_w\phi_{2t} + \phi_{4t} = 0, \\
\partial\hat{\imath}_t : && -\sigma\phi_{1t} + \phi_{3t} = 0, \\
CS : && \hat{\imath}_t \geq i^{zlb}, \phi_{3t} \geq 0, \phi_{3t}(\hat{\imath}_t - i^{zlb}) = 0.
\end{aligned} \tag{92}$$

Monetary and fiscal policy coordination improves the outcome through two mechanisms. First, free from the small government dogma, the government is able to increase spending. This increases aggregate demand by direct actions today, which is not subject to the credibility problem associated with a promise of some future policy.

Second, the key element of the regime change was that FDR promised to inflate the price level to pre-depression levels. Free from the No-Deficit Dogma, the government had a direct tool to back this up and make the inflation pledge credible: it could finance spending by running deficits. As illustrated in Table 9, this is how FDR himself rationalized how the goal of inflation could be reached, stating, "That is why powers are being given to the Administration to provide, if necessary, for an enlargement of credit [...] These powers will be used when, as, and if it may be necessary to accomplish the purpose."

By most measures, FDR backed up the rhetoric with action. The federal government's consumption and investment, for example, was 90 percent higher in 1934 (Roosevelt's first full calendar year in office) than in 1932 (Hoover's last). The deficit during Roosevelt's first fiscal year was one of the highest in US history outside of wartime and 2020 (during the COVID-19 epidemic), increasing by 66 percent in FDR's first fiscal year (from June 1933 to June 1934) and reaching 9 percent of GDP. Unlike Hoover, who tried and failed to balance the budget, FDR deliberately pursued deficit financing and explicitly said he would use it to bring up inflation.[96] This made a permanent monetary expansion credible, firming up inflation expectations and making the target of the price level of 1926 more credible. Fiscal expansion made the reflation objective a critical strategy for financing government debt payments.[97]

FDR recognized the problem that the Federal Reserve might not be pliable to his fiscal needs and fully on board with his inflation program. This was one reason for the "credibility crisis" in the fall of 1933, which historians have referred to as mini recession. To address this issue, he rewrote the

envelope condition, typically referred to as the Benveniste-Scheinkman condition in economics:

$$V_w(\hat{w}_{t-1}, \hat{r}_t^e) = -\beta^{-1}\phi_{3t}.$$

By forwarding this condition once and taking conditional expectations at time t, we can substitute the value function in the above first-order condition.

[96] See Eggertsson (2008) for more conservative estimates. Relative to government spending, the deficit was larger than in 2020 due to the smaller government spending and taxing capacity during this period.

[97] Table 9 shows a quote from FDR indicating that he considered increasing deficits as a way to generate inflation.

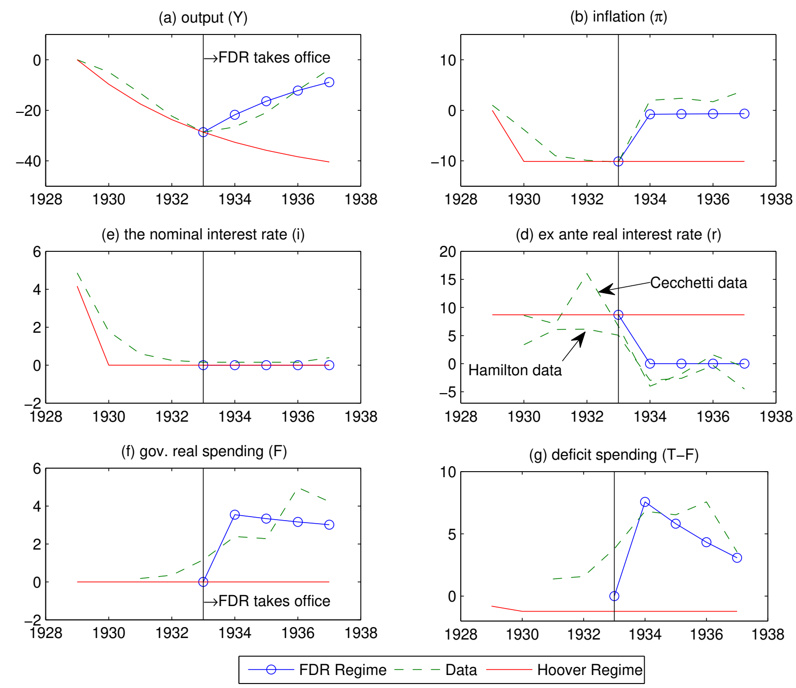


Figure 29: The FDR regime change implies a collapse in real interest rates and a robust recovery in prices and output. The regime change can account for 67% of the recovery in prices and 79% of the recovery in output in the period 1933 to 1937.

Federal Reserve Act to centralize power in Washington DC, and appointed Marriner Eccles as chair, who favored active and coordinated fiscal and monetary response, see Eggertsson and Schüle (2024).

Figure 29 compares the simulated model path to the data, using the calibration from Eggertsson (2008). The only difference is the assumption of external habits in consumption and labor, replacing output with the quasi-growth rate $\tilde{Y}_t = \hat{Y}_t - \rho\hat{Y}_{t-1}$.[98] The vertical line denotes the regime change when FDR takes power, and the dashed green line represents the data. Panel (a) shows that under the Hoover regime, the output would have continued collapsing, while the regime change generated the blue-circled line, closely matching the recovery in the data. The turning point was not driven by interest rate cuts (panel e) or money supply changes (Temin and Wigmore (1990)). Instead, the regime change can be explained by eliminating the three policy dogmas in the Optimal joint monetary and fiscal policy regime in a Markov Perfect Equilibrium. Panels (f) and (g) show substantial increases in real and deficit spending,[99] triggering a shift in inflation and inflation expectations.

Panel (b) shows the model-generated increase in inflation, matching the data. Panel (d) shows the drop in ex-ante real interest rates, driven by the change in expected inflation, based on measures from Cecchetti (1992) and Hamilton (1992). Although the gold standard was not binding, its elimination played a crucial role. Even with sufficient gold reserves in 1933 for monetary expansion, there was no

[98]This implies a more gradual fall in output.
[99]As a fraction of GDP.

guarantee the constraint would not become binding if the administration succeeded in restoring the 1926 price level. Eliminating the gold standard was central to coordinating expectations toward an inflationary regime, which is broadly consistent with the central role Eichengreen (1992) gives to the gold standard. As shown in Eggertsson and Krugman (2012), which models debtors and creditors in section 2.1.3.1, the redistribution aspect of inflation can have a significant effect since most debt contracts are nominal. Hausman, Rhode and Wieland (2021) provide interesting evidence that this mechanism may have played an important role in the recovery of 1933.

4.4.3 The Mistake of 1937 and the Recovery of 1938

While defense spending picked up following the fall of France in the Q2 of 1940 (Gordon and Krenn (2014)), the US economy had already made significant headway. It is a caricature to claim World War II ended the Great Depression, ignoring the impact of FDR's inflationary policies in 1933–37 and the recovery resumption in 1938 before the major boost in defense spending.

We consider our general account of the recovery from the Great Depression to be consistent with the broader literature. Bernanke (1983) and Friedman and Schwartz (1963) emphasize the role of disruption in financial intermediation as an important source of the Great Depression. As we saw in section 2, this narrative gives a natural interpretation for the reduction in the natural rate of interest triggering the Great Depression. Similarly, Romer (1992) stresses the role of monetary policy in generating the recovery from 1933, recognizing that with the interest rate at zero, "the main way that the monetary expansion could stimulate the economy was by generating expectations of inflation and thus causing a reduction in real interest rates," thus highlighting what became the central theme of the modern literature on the liquidity trap.

The analytic framework we outlined in the last subsection can be used to cast light on the second phase of the Great Depression. One interpretation is that it was caused by emerging doubts about FDR's inflationary commitment, with markets anticipating restoration of the previous regime. The 1938 recovery can be interpreted as the administration recommitting to its 1933 inflationary pledge, triggering a sharp rebound.

The widespread perception that World War II ended the Great Depression misses the critical 1933 turning point, driven by the regime change of inflating prices to pre-depression levels, resulting in the fastest GDP growth outside wartime in 1933-37. It also overlooks two other turning points consistent with the hypothesis, as shown in figure 30. One can argue that the fall of 1934 marks a fourth turning point, as discussed in Eggertsson and Schüle (2024), but in late 1933 the Federal Reserve started showing some signs of undermining the inflation program. The appointment of Marriner Eccles, played a major role in shifting expectations in the fall of 1934 as shown in Eggertsson and Schüle (2024).

Eggertsson and Pugsley (2006) term the first turning point "the Mistake of 1937" and the second "the Reversal of 1938." By 1937, the price level was far from the 1926 target despite industrial production

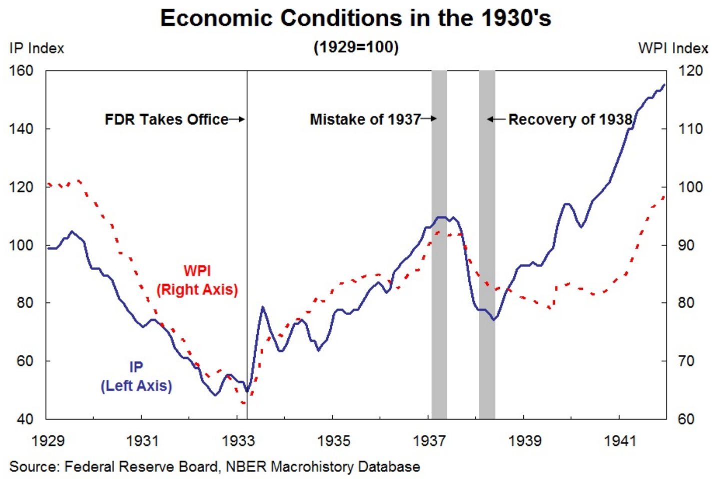


Figure 30: Both wholesale prices (WPI) and industrial production (IP) collapsed in 1929-1933 but abruptly started to recover in March 1933, when FDR took power and implemented a regime change along with New Deal policies. The second phase of the Great Depression occurred after the Mistake of 1937, when the Supreme Court struck down the New Deal, and the administration appeared to back away from its commitment to reflate the price level to pre-Depression levels.

reaching pre-depression levels (figure 30). The administration weakened its commitment to the price level target, as evidenced by the narrative examples in Table 10, and reinforced by the Federal Reserve raising reserve requirements and attempting to balance the budget. Market expectations shifted, believing the administration had reverted to the pre-Hoover regime. Eggertsson and Pugsley (2006) show that a small change in beliefs about inflationary regime can generate large output movements, as observed in the data. The drop in industrial production following the Mistake of 1937 was the sharpest contraction in US history. Recovery resumed in 1938 when the administration recommitted to re-inflating prices.

Table 10: The Regime Changes in 1937 and 1938

The Mistake of 1937	**The Reversal of 1938**
February 18, 1937. Marriner Eccles, Chair of the Board of Governors, speaks in Senate hearings: "The short-term rates are excessively low, and there may be a tendency for rates near the vanishing point to increase" *(Wall Street Journal, February 19, pg. 1)*. **March 15, 1937.** Marriner Eccles, Chair of the Board of Governors, gives a statement: "The upward spiral of wages and prices into inflationary levels can be as disastrous as the downwards spiral of deflation." *(Chicago Daily Tribune, March 16, pg. 1)*.	**February 15, 1938.** President Roosevelt holds a press conference: "At his press conference today, the President said that he believes now, as he did in 1933, that achievement of permanent prosperity depends on raising general price levels to those prevailing in 1926" *(Chicago Daily Tribune, February 16, 1938, pg. 1)*. **February 18, 1938.** President Roosevelt releases a written statement at a press conference that was prepared by Henry Morgenthau Jr., secretary of the Treasury; Henry A. Wallace, secretary of agriculture; Frances Perkins, secretary of labor; Marriner Eccles, Chair of the Board of Governors of the Federal Reserve System; and economists of various executive departments: "It is clear that in the present situation, a moderate rise in the general price level is desirable [...]. Our program seeks a balanced system of prices that will promote a balanced expansion in production. Our goal is a constantly increasing national income through increasing production and employment. This is the way to increase the real income of consumers."

Continuation of Table 10

The Mistake of 1937	**The Reversal of 1938**
March 17, 1937. Commerce Secretary Daniel C. Roper and Secretary of Agriculture Henry A. Wallace hold press conferences. Both secretaries warn against excessive inflation. *(Wall Street Journal, March 18, 1937, pg. 8)*. **March 24, 1937.** Marriner Eccles, Chair of the Board of Governors, outlines five steps to avert "dangerous inflation" in *Forbes* magazine: (i) reserve requirement "to eliminate excess reserves," (ii) fiscal policy that balances the budget, (iii) reduction in the gold price of the dollar, (iv) increase in the labor share of national income, (v) antitrust legislation. *(Christian Science Monitor, March 25, 1937)*. **April 2, 1937.** FDR holds a press conference: "I am concerned—we are all concerned—over the price rise in certain materials." **August 3, 1937.** FDR's views on price-level targeting are revealed. Senator Elmer Thomas publishes a letter from FDR to himself rejecting his proposal that the Federal Reserve formally target the 1926 price level. *(Wall Street Journal, August 4, 1937, pg. 6)*.	**April 14, 1938.** FDR addresses Congress, announcing that the reserve requirement will be abandoned: "The measures for expanding excess reserves which were announced on Thursday by President Roosevelt will re-create the bases for a great credit inflation [...]. Monetary management, after having been directed for some time towards guarding against a possible inflationary boom, has turned, under the pressure of the business depression, toward the other extreme" *(New York Times, April 17, 1938)*.

5 Long-Run Recessions and a Negative Natural Rate of Interest in the Short and the Long Run

During the closing phase of the Great Depression in 1938, the President of the American Economic Association, Alvin Hansen, delivered a disturbing message in his Presidential Address to the Association (Hansen (1939)). He suggested that the Great Depression might start a new era of ongoing unemployment and economic stagnation without any natural force toward full employment. This idea was termed the "secular stagnation" hypothesis. According to Hansen, one of the main driving forces of secular stagnation was a decline in the population birth rate, oversupply of savings, and lack of investment opportunities, suppressing aggregate demand. Soon after Hansen's address, the Second World War led to a massive increase in government spending, effectively ending any concern about insufficient demand. Moreover, the baby boom following World War II drastically changed the population dynamics in the US, thus effectively erasing the problem of excess savings of an aging population.

Alvin Hansen, often called the "American Keynes", based his analysis on Keynesian foundations. He implicitly presumed a classic Keynesian consumption function $C_t = C^a + c(Y_t - T_t)$ where $C_a > 0$ and $0 < c < 1$. His analysis is consistent with a typical early Keynesian investment function $I_t = I^a - bi_t$ where $I^a > 0$, $b > 0$. The variables C^a and I^a are autonomous consumption and investment spending, while r_t is the interest rate.[100] Combining this with the resource constraint $Y_t = C_t + I_t + F_t$ we obtain:

$$Y_t = \frac{C^a}{1-c} + \frac{F_t}{1-c} - \frac{c}{1-c}T_t + \frac{I^a}{1-c} - \frac{b}{1-c}i_t. \tag{93}$$

Hansen (1939) proposed that declining population growth was exerting downward pressure on autonomous Investment Spending, I^a, through various mechanisms. He doubted that future innovation would generate enough new investment opportunities to sustain the necessary investment and compensate for this reduced spending. Additionally, he suggested that introducing new production technology would lead to falling production costs over time, a concept modern economists refer to as a decrease in the relative price of investment, thus reducing investment demand over time without more technological innovation.

With short-term nominal interest rates near zero and a very limited understanding of price dynamics at the time, it was natural for Hansen, like John Maynard Keynes, to have little confidence in interest rate policy.

The situation in 2013 strongly resembled that of 1938 when Hansen delivered his speech. Although governments had largely contained a meltdown of the order of the Great Depression following the 2008 financial crisis, growth remained anemic, investment weak, population and productivity growth low, prompting people to seek alternative explanations. In this environment, Lawrence Summers gave an influential speech at the IMF in the Fall of 2013 (see Summers (2014)). He revived Hansen's secular stagnation hypothesis but proposed a novel and provocative reformulation that tied it directly to the modern ZLB literature we have reviewed in this paper. Summers posed the following question: How do policy prescriptions change if we assume a *permanently* negative natural interest rate instead of a *temporarily* negative one?

We already discussed in section 2.1.4 how to model this in an endowment economy alongside forces that temporarily reduce the natural rate. However, we did not explore its implications for output inflation and policy. In comparison, we covered these implications for temporary shocks in sections 3 and 4. We now examine them for permanent shocks.

[100]The distinction between real or nominal was not always clear in early Keynesian literature since the Hicksian IS-LM model assumed fully rigid prices, making the two the same.

Given the maturity of the ZLB literature, readers might find it peculiar that previous literature had not contemplated the possibility of permanently negative natural rates. The reason for this is twofold. As already discussed in section 2.1.4, what is needed is to abandon the standard IS equation common in the New Keynesian literature to be able to allow for the possibility of permanently negative real interest rates (and a simple model of heterogeneity as in Eggertsson and Krugman (2012) is not enough). The second and perhaps most important reason is that to pursue this line of thought, one needs to sacrifice one of the most sacred cows of modern macroeconomics since the 1970s: That there is no permanent trade-off between inflation and output so that in the long run output is not a vertical line in output, inflation space, which then by definition implies that variation in the Aggregate Demand has no effect on output.

Yet, recall, Hansen was interested in a permanent demand recession, so many modern models excluded the possibility of addressing his question and Summers' reformulation by assumption. Thus, not only was an open heart surgery of the IS curve of the New Keynesian model needed, but even more radically, one needed to replace the New Keynesian Phillips curve with a production side that permitted permanent trade-offs in a steady state, giving rise to the possibility of a demand recession of arbitrary duration.

5.1 A Simple Modern Model of Secular Stagnation

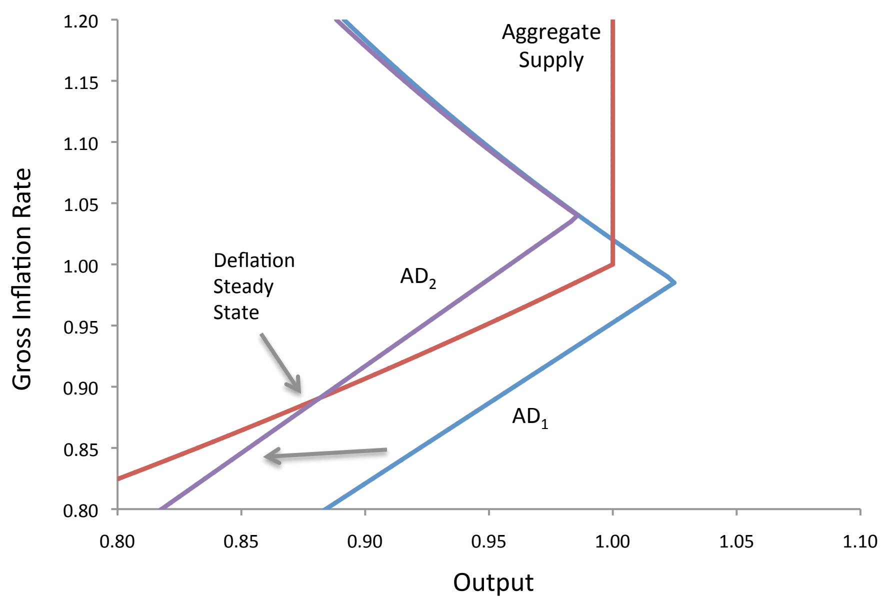


Figure 31: Steady-State Aggregate Demand and Aggregate Supply Curves

Here, we sketch out a simplified version of the first formal model of secular stagnation, that of Eggertsson and Mehrotra (2014). Relative to section 2, we now introduce price level determination and production. The presence of money leads to a consumption Euler equation that prices one-period risk-free debt, yielding a nominal interest rate controlled by the monetary authority. The pricing of one-period risk-free debt is:

$$\frac{1}{C_t^m} = \beta E_t \frac{1}{C_{t+1}^o}(1+i_t)\frac{P_t}{P_{t+1}}, \tag{94}$$

using the notation of section 2. We obtain the standard Fisher equation if we assume perfect foresight and then combine the middle equation of 15 and 94:

$$1 + r_t = \frac{1+i_t}{\Pi_{t+1}}. \tag{95}$$

Monetary policy is set according to a Taylor rule:

$$1 + i_t = \max\left(1, (1+i^*)\left(\frac{\Pi_t}{\Pi^*}\right)^{\phi_\pi}\right), \tag{96}$$

where ϕ_π and Π^* and i^* are parameters of the policy rule taken as given. The rule states that the central bank stabilizes inflation around the target Π^* associated with the steady-state interest rate i^* unless constrained by the ZLB.

A steady state is defined by all variables assuming a constant value. The derivation that led us to equation 18 in section 3 remains unchanged. However, we no longer treat Y as an endowment but as an endogenously determined variable representing aggregate demand, which has to equal aggregate supply in equilibrium. In steady state, this equation yields:

$$1 + r = \frac{1+\beta}{\beta}\frac{(1+g)D}{Y^d - D}, \tag{97}$$

where Y^d now represents aggregate demand instead of an income endowment.

Collecting the starred component of the monetary stance at positive interest as $m^* \equiv \frac{{\Pi^*}^{\phi_\pi}}{1+i^*}$ we can now rearrange 97 in terms of output demanded, substitute for the policy rule in the Fisher equation, and finally replace the real rate using the Fisher Equation 95 combined with the policy rule to arrive at:

$$Y^d = \begin{cases} D\left(1 + \frac{1+\beta}{\beta}(1+g)m^*\frac{1}{\Pi^{\phi_\pi - 1}}\right) & \text{for } i > 0, \\ D + \frac{(1+\beta)(1+g)D}{\beta}\Pi & \text{for } i = 0. \end{cases} \tag{98}$$

This AD equation has the same form as the AD considered for a temporary shock in figure 11. The fundamental difference is that it corresponds to a steady state. For example, this relationship can be permanently shifted by a slowdown in population growth $(1+g)$ and the change in the debt limit D. More generally, any force changing the relative demand for saving and investment, as discussed in section 2, shifts it. Such forces include rising inequality, increasing life expectancy, or growing government debt.

We close the model by specifying the production side. Economists like Hansen, following Hicks's original IS-LM model, would simplify the problem by depicting the red line as a straight horizontal one, reflecting fixed prices. This horizontal line, when positioned below the kink of the AD curve, would illustrate the futility of interest rate cuts.

Ever since Phillips (1958) work, economists have enriched the IS-LM model with a theory of inflation determination. Today's economists seem to agree that if inflation remains persistently high, expectations about future inflation will eventually adjust, eliminating any long-run trade-off between inflation and unemployment. Our model incorporates this idea with a vertical AS curve when inflation is sufficiently high (see the top half of the AS curve in figure 31).

In contrast, economists never reached a similar consensus about the long-run neutrality of inflation when inflation rates were very low. Tobin (1972) argued that during the Great Depression, firms were reluctant to cut nominal wages despite high unemployment, suggesting a permanent inflation-unemployment trade-off at low inflation. Later Akerlof et al. (1996) illustrate that the assumption of downward wages implies a long-run trade-off.[101] We incorporate this idea with an upward-sloping Phillips curve at low inflation (see the bottom half of the AS curve in figure 31).

Here, we sketch a parsimonious model capturing the gist of the idea: Households elastically supply labor at existing wages but reject work paying below the prevailing, downward rigid wage rate. In contrast, they happily work for higher wages. Yet the labor endowment is not infinite and capped at full employment, i.e., L^f.

A representative firm maximizes profits using the following technology :

$$Y_t = L_t^{\alpha}. \tag{99}$$

Here, $1 > \alpha > 0$ and L_t is labor the middle-aged generation supplies. The firm hires workers to decide production, taking the price level P_t and wage rate W_t as given, yielding the first-order condition:

$$\frac{W_t}{P_t} = L_t^{\alpha-1}. \tag{100}$$

[101] The idea of downward rigid nominal wages dates back at least to Malthus, who noted that "it very rarely happens that the nominal price of labor universally falls" (Malthus, 1798). Bewley (1999) interviewed corporate executives, documenting their reluctance to cut nominal wages. More recently, researchers have discovered substantial nominal wage rigidity using US administrative data (Fallick, Lettau and Wascher, 2011), worker surveys (Barattieri, Basu and Gottschalk, 2014), and cross-country data (Schmitt-Grohé and Uribe, 2016). Downward wages were also at the core of the original Phillips curve.

Nominal wages are downward rigid:

$$W_t = \max\{\tilde{W}_t, W_t^{flex}\}. \tag{101}$$

Here, $\tilde{W}_t$ is a wage norm, and W_t^{flex} is the wage rate if wages are flexible. This assumption says that households will not supply labor unless the salaries are at least equal to a social norm given by $\tilde{W}_t$. However, they are perfectly willing to work for higher wages; hence, if the market-clearing salary is higher than the wage norm, the firm will bid up the wages to the market-clearing level.

Keynes 's original idea was that wages are rigid downward — that is, workers would not accept a nominal wage rate lower than last year. Keynes's idea is one example of a wage norm. Here, we posit a norm that generalizes Keynes's idea modestly so that one can vary on the parameter, γ, so that wages are either perfectly downward rigid ($\gamma = 1$ or perfectly flexible, $\gamma = 0$)

$$\tilde{W}_t = W_{t-1}^{\gamma} \left(W_t^{flex}\right)^{1-\gamma}, \tag{102}$$

imposing a steady state and combining (99)-(102) yields the AS relationship:

$$Y^s = \begin{cases} Y^f & \text{for } \Pi \geq 1 \\ \\ Y^f \Pi^{\frac{1-\gamma}{\gamma}\frac{\alpha}{1-\alpha}} & \text{for } \Pi < 1, \end{cases} \tag{103}$$

where Y^f denotes output when the entire labor endowment has been exhausted. Figure 31 plots this relationship along with the AS curve, which stands vertical at positive inflation ($\Pi > 1$).[102] With deflation (or inflation below target), real wages exceed the market-clearing level, and firms do not hire all workers. The figure shows two AS-AD intersections: the upper one, where the natural rate of interest is positive (AD_1 and AS cross, shown with a positive inflation target), and the lower one, where the natural rate is sufficiently negative, shifting the AD curve to AD_2, and the interest rate is zero. The latter case features deflation and unemployment. This deflationary steady state (AD_2) is interesting because it represents *a permanent recession without any force pulling the economy to full employment*. Moreover, the price and wage market mechanisms do not generate a recovery. More flexible wages exacerbate the recession, another manifestation of the price-flexibility paradox from section 3. Eggertsson, Mehrotra and Robbins (2019) show that the model can generate output and inflation dynamics observed for the Long Recession in Japan via a permanent reduction in the natural interest rate.

5.2 Policy Implication of Secular Stagnation

Does the theory of secular stagnation imply different policy implications than a temporarily negative natural rate? Waiting for the shock to subside is not a good strategy, even if it is hard to escape the suspicion that this was the euro area's initial approach. Another immediate observation: forward

[102] In this case, the wage norm is not binding, wages are flexible, and the entire labor endowment is employed.

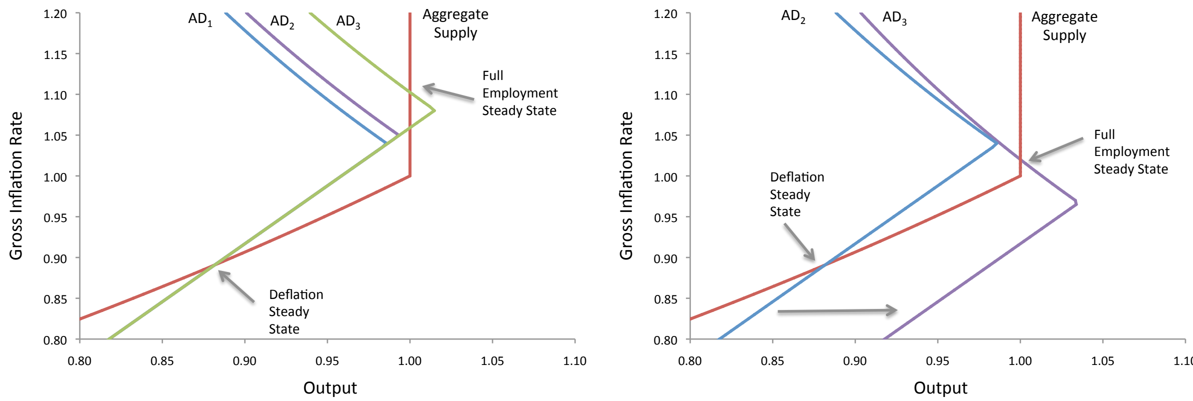


Figure 32: Monetary and Fiscal Policy Responses

guidance is ineffective if the ZLB is expected to last indefinitely; there is no gain from promising even lower rates if they are already at rock bottom.

Announcing a higher inflation target is not the panacea often presented in the literature when the natural rate is temporarily negative. At the core of the problem is what Krugman (1999) coins as the "law of the excluded middle". It highlights the first difficulty with announcing a higher inflation target. The problem is depicted in figure 32. If the announced target is too low (see AD_2 in the left-hand side panel of figure 32), it cannot be reached, even the public believes in the central bank's commitment and good intentions since the upper branch of the AD curve does not intersect the AS curve. A higher target shifts the AD curve upward (see AD_3 in the left panel of figure 32), where full employment is possible.

The second problem can arise even if the central bank announces a sufficiently high inflation target, which it has every intention to satisfy, as suggested by the full-employment steady state in figure 32. The problem is that this announcement itself does not eliminate the original secular stagnation equilibrium.

Fiscal policy remains potent in secular stagnation, playing an even more fundamental role than in sections 3 and 4. Successful fiscal policy shifts the AD curve rightward in figure 32, generating a unique full-employment equilibrium at point D. Sufficiently aggressive fiscal policy eliminates secular stagnation. However, budgetary policy operates differently in the overlapping generations model than in the standard New Keynesian model. With multiple generations, fiscal policy's distributional consequences become crucial; see Eggertsson, Mehrotra and Robbins (2019) for further discussion.

5.3 Abenomics: Japan and the Long Recession

Shinzo Abe was elected Prime Minister of Japan on December 26, 2012, and served until 2020, when he resigned due to health reasons. His platform, Abenomics, consisted of "three arrows": expansionary monetary policy, aggressive fiscal policy, and structural reforms. This agenda shared similarities with FDR's 1933 regime change and was commonly motivated by it.

Abe threatened to revise the law granting the Bank of Japan independence if it did not agree to increase its inflation target and engage in "unlimited easing" to achieve that aim.[103] The Japanese Parliament also passed a 2% increase in spending. However, actual spending was only about half of that.[104]

While the Abenomics experiment is relatively recent, and thus, a full assessment is only tentative, some observations can be made based on the last section on secular stagnation, considering Japan has been at or near the ZLB for about 30 years.

Early evaluations of Abenomics, such as Hausman and Wieland (2014), Romer (2014), Hausman and Wieland (2015), were relatively positive based upon the early success of Abenomics in 2013. However, the experience that emerged in the following years was mixed and is ripe for future research.

During the Abenomics period (2013–2020), inflation averaged 0.87%. This rate exceeded the near-zero inflation from 1996 to 2008 but fell well short of the 2% target Bank of Japan governor Haruhiko Kuroda promised in 2013. Kuroda pledged to achieve this target in two years through "open-ended asset purchases". GDP growth during Abenomics averaged 1.04%, slightly lower than the 1.18% average from 1996 to 2008.[105]

Hausman and Wieland (2015) suggests the lack of success of the regime change is partly explained by the imperfect credibility of the inflation target of the Bank of Japan, arguing that the BoJ would reduce the monetary stimulus before inflation reached the target just as they did in 2006 as we documented in section 2.

Our analysis of secular stagnation offers a different perspective, as shown in figure 32. If the natural interest rate were below -2%, no equilibrium would be consistent with achieving this inflation target. It must be large enough to accommodate the natural interest rate; for example, if it is -5%, the target must be 5% or more.

At a G7 meeting in Japan in 2016, one of this paper's authors discussed a critical policy dilemma with a senior Japanese policymaker regarding the uncertain natural interest rate. The Bank of Japan had failed to reach its 2 percent inflation target. When presented with the argument that 2 percent might be too low given the law of the excluded middle and that a higher target was necessary, the policymaker responded (paraphrased): "We promised 2 percent inflation and could not deliver. How seriously would the public take us if we announced an even higher target when we cannot reach 2 percent?" This exchange suggests that central banks should initially set higher inflation targets under

[103]See Hausman and Wieland (2014).

[104]ibid.

[105]Arguably, this is in part explained by an unfortunate increase in sales taxes in April 2014 (from 5 to 8 percent) and the second increase scheduled for October 2015 (from 8 to 10 percent). Previous governments had determined these policies before Shinzo Abe came to power.

such circumstances, since failing to achieve a lower target can damage their credibility and make it harder to raise targets later.

Comparing Abenomics to FDR's regime change is instructive. In the spring of 1933, FDR committed to increasing the price level to its 1926 levels, implying a 30% to 40% increase in the price level. While the administration was somewhat vague on this point, the general understanding was that the aim was to achieve this over 3-4 years. That would imply inflation in the 10 percent range p.a. This monetary regime change, even if just partially credible, could thus respond to a substantially negative natural rate of interest, unlike the regime change under Abenomics.

FDR implemented a substantially more significant fiscal expansion, and he aimed his supply-side policies primarily at raising prices instead of addressing longer-term structural issues.

5.4 Future Directions for Research: What will be the New Normal?

The literature we have reviewed shows that an economy can enter a liquidity trap due to either sharp, temporary forces or gradual, persistent ones. To date, however, the literature has not integrated these two perspectives. Here, we offer some speculative remarks about how such integration might look and argue that this line of research's conclusion is of central importance to the current policy strategy. We also offer speculative comment of the current state of affairs in the U.S.

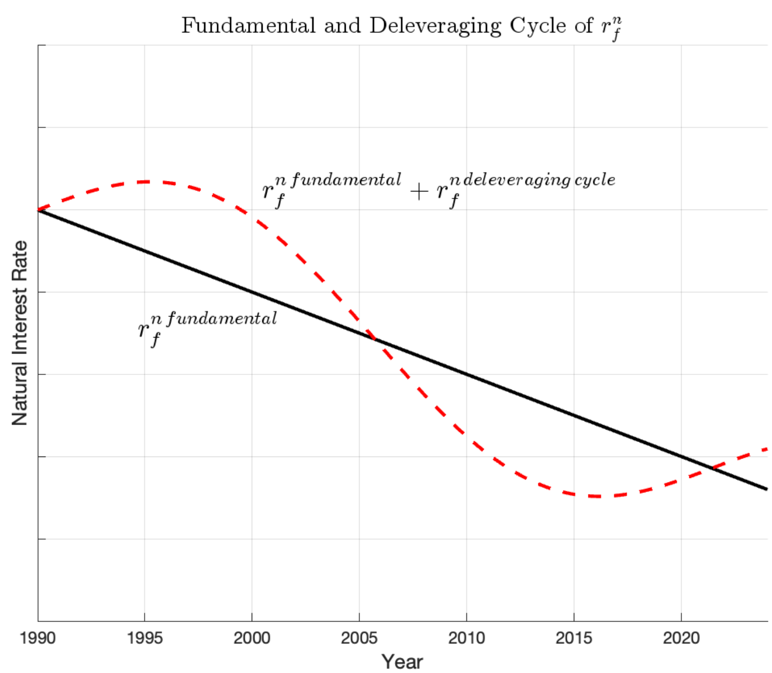


Figure 33: Combining a Debt Deleveraging and a Secular Stagnation Narrative

Figure 33 provides a graphical illustration of how such an integration might look. The figure highlights four points. First, temporary phenomena can mask the secular decline in interest rates, as evident in the data we showed in Figure 5. Second, temporary phenomena can lead to a sharper decline in interest rates than slow-moving forces would suggest if acting alone. Third, in this theoretical framework, once temporary factors disappear, the real interest rate should return to the trending lower level.

Fourth, at the time of this writing, an inflationary surge has followed the COVID-19 pandemic. If the secular stagnation hypothesis is correct, long-term interest rates will continue their downward trend, and the Federal Reserve will need to grapple with the ZLB going forward. The reason is that long-term trends, which drive the secular decline in the natural rate under the secular stagnation framework, remain in place. The trends in inequality and demographics have not changed since the COVID-19 pandemic began and are unlikely to change radically in the future. Yet, there is a recent great unknown that could upend all reasonable predictions. Before ending on that note, let us consider another trend.

One factor that could change the secular stagnation framework's prediction about the downward trend in the natural interest rate is the acceleration of productivity growth. Two points are worth mentioning here. First, the important innovation of recent years relates to the development of Artificial Intelligence technologies. At the time of writing, it remains unknown whether innovations in AI, while impressive, will translate into a positive productivity shock strong enough to pull the economy out of the secular stagnation equilibrium. We consider it reasonable to ponder such a scenario. Second, and somewhat less optimistically, a growing divergence exists in productivity growth between the US and Europe. This divergence is also prominent in the AI sector in terms of innovation and adoption. Given this dynamic, while the US has at least one clearly discernible candidate technology that could theoretically pull its economy out of the secular stagnation equilibrium, Europe lacks such a candidate technology.

U.S. President Trump's election introduces uncertainty through several proposed policies: major tariff increases, expulsion of 14 million undocumented immigrants, and possible pressure on the Federal Reserve to lower rates. Tariffs could raise prices, while a dramatic workforce reduction would plausibly increase wage pressures. Lower interest rates in this inflationary environment would further accelerate price increases. At sufficiently high inflation rates, the ZLB would not constrain policy. While budget deficit trajectories remain unclear, increasing public debt would push the natural interest rate upward. Pushing in the other direction is Trump's promised major reduction in government spending. Tax policy is also important. A tax policy that heavily favors those in the top 1 percent is more likely to increase savings and would put downward pressure on interest rates. Taken together, the environment is more uncertain than we have seen in a long time. The key unresolved question is how the myriad of policies promised will affect the investment-savings balance and thus the natural rate of interest. At this stage, it is impossible to know.

So far, Hansen's gloomy post-WWII prediction appears possible for both Europe and the U.S., but more probable for Europe, with little end in sight for Japan's Long Recession.

At the time of writing, the new normal for the U.S. natural rate of interest remains one of the great unknowns.

6 Conclusion

This survey has provided a unified theory of the Great Depression, the Great Recession, and Japan's Long Recession, identifying both fast-moving forces, such as financial crises, and slow-moving forces, such as demographic changes, as potential triggers for liquidity traps. We have analyzed the effectiveness of various monetary and fiscal policy interventions in these contexts.

A key lesson is that while sufficiently flexible and credible monetary policy can largely offset temporary shocks that lead to liquidity traps, fiscal support becomes crucial when central bank credibility is lacking or the underlying shocks are permanent. The US experience during the Great Depression vividly illustrates the power of coordinated monetary and fiscal expansion when credibility issues were acute.

Looking ahead, a critical question is whether the US and global economies will settle into a "new normal" of persistently low interest rates, akin to Japan's experience, once temporary inflationary pressures from the COVID-19 pandemic recede. The secular drivers identified in the literature, such as rising inequality and falling population growth, certainly point to that possibility.

In such a world, episodes in which monetary policy is constrained by the ZLB are likely to become more frequent and prolonged. Fiscal policy would then need to play a more active role in macroeconomic stabilization on an ongoing basis. Monetary policy frameworks may also need to adapt.

While the literature surveyed here has substantially advanced our understanding of liquidity traps, important questions remain. Integrating fast- and slow-moving forces into a unified framework, along with better characterizing the credibility challenges central banks face when interest rates are constrained, stand out as key priorities. Ultimately, developing a generalized and empirically grounded positive theory of policy regimes is essential.

Perhaps a more general lesson is that the prospect of major and persistent contractions cannot be ignored. The Great Depression was not an aberration but a warning of what can happen absent vigorous policy responses. In a world of low natural interest rates, macroeconomic policy will need to remain vigilant and creative. It is a challenge for which the stakes — for economic growth, social cohesion, and political stability — could hardly be higher.

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