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# Was the New Deal Contractionary?

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**Abstract**

Can government policies that increase the monopoly power of firms and the militancy of unions increase output? This paper studies this question in a dynamic general equilibrium model with nominal frictions and shows that these policies are expansionary when certain "emergency" conditions apply. These emergency conditions—zero interest rates and deflation—were satisfied during the Great Depression in the United States. Therefore, the New Deal, which facilitated monopolies and union militancy, was expansionary, according to the model. This conclusion is contrary to the one reached by a large previous literature, e.g. Cole and Ohanian (2004), that argues that the New Deal was contractionary. The main reason for this divergence is that the current model incorporates nominal frictions so that inflation expectations play a central role in the analysis. The New Deal has a strong effect on inflation expectations in the model, changing excessive deflation to modest inflation, thereby lowering real interest rates and stimulating spending.

Key words: Great Depression, the New Deal, zero interest rates, deflation.
JEL classification: E52, E62, E65, N12.

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# 1 Introduction

Can government policies that reduce the *natural level* of output increase *actual* output? In other words, can policies that are *contractionary* according to the neoclassical model, be *expansionary* once the model is extended to include nominal frictions? For example, can facilitating monopoly pricing of firms and/or increasing the bargaining power of workers' unions increase output? Most economists would find the mere question absurd. This paper, however, shows that the answer is yes under the special "emergency" conditions that apply when the short-term nominal interest rate is zero and there is excessive deflation. Furthermore, it argues that these special "emergency" conditions were satisfied during the Great Depression in the United States.

This result indicates that the National Industrial Recovery Act (NIRA), a New Deal policy universally derided by economists ranging from Keynes (1933) to Friedman and Schwartz (1963), and more recently by Cole and Ohanian (2004), increased output in 1933 when Franklin Delano Roosevelt (FDR) became the President of the United States. The NIRA declared a temporary "emergency" that suspended antitrust laws and facilitated union militancy to increase prices and wages. The goal of these emergency actions was to battle the downward spiral of wages and prices observed in the 1929-33 period. While the New Deal involved many other policies, the paper refers on several occasions, with some abuse of language, to the NIRA as simply *the New Deal.*

This paper studies the New Deal in a dynamic general equilibrium model with sticky prices. In the model, the New Deal creates distortions that move the natural level of output away from the efficient level by increasing the monopoly power of firms and workers.[1] Following a previous literature, these distortions are called policy "wedges" because they create a wedge between the marginal rate of substitution between hours and consumption on the one hand and the marginal rate of transformation on the other. The definition of the wedges is the same as, e.g., in Mulligan (2002) and Chari, Kehoe, and McGrattan's (2006) analyses of the Great Depression.[2] Their effect on output, however, is the opposite. While these authors find that the policy wedges reduce output in a model with flexible prices, I find that they increase output once the model is extended to include nominal frictions and special "emergency" conditions apply.

The New Deal policies, i.e. the wedges, are expansionary owing to an expectations channel. Demand depends on the path for current and expected short-term real interest rates and expected future income. The real interest rate, in turn, is the difference between the short-term nominal interest rate and expected inflation. The New Deal increases inflation expectations because it helps workers and firms to increase prices and wages. Higher inflation expectations decrease real interest rates and thereby stimulate demand. Expectations of similar policy in the future increase demand further by increasing expectations about future income.

Under regular circumstances, these policies are counterproductive. A central bank that targets price stability, for example, will offset any inflationary pressure these policies create by increasing

[1] The natural level of output is the output if prices are flexible and the efficient output is the equilibrium output in the absence of any distortions, nominal or real. These concepts are formally defined in the model in section (3).

[2] See also Hall (1997) for discussion of the labor wedge.

the short-term nominal interest rate. In this case, the policy wedges reduces output through traditional channels. The New Deal policies are expansionary in the model because they are a response to the "emergency" conditions created by deflationary shocks. Building on Eggertsson and Woodford (2003), excessive deflation is shown to follow from persistent deflationary shocks that imply that a negative real interest rate is needed for the efficient equilibrium. In this case, a central bank, having cut the interest rate to zero, cannot accommodate the shocks because that would require a negative nominal interest rate, and the nominal interest rate cannot be negative. The deflationary shocks, then, give rise to a vicious feedback effect between current demand and expectations about low demand and deflation in the future, resulting in a *deflationary spiral*. The New Deal policies are helpful because they break the deflationary spiral, by helping firms and workers to prevent prices and wages from falling.

The theoretical results of the paper stand at odds with both modern undergraduate macroeconomic and microeconomic textbooks. The macroeconomic argument against the NIRA was first articulated by John Maynard Keynes in an open letter to Franklin Delano Roosevelt in the *New York Times* on December 31st 1933. Keynes's argument was that demand policies, not supply restrictions, were the key to recovery and that to think otherwise was "a technical fallacy" related to "the part played in the recovery by rising prices." Keynes's logic will be recognized by a modern reader as a basic IS-LM argument: A demand stimulus shifts the "aggregate demand curve" and thus increases both output and prices, but restricting aggregate supply shifts the "aggregate supply curve" and while this increases prices as well, it contracts output at the same time. Keynes's argument against the NIRA was later echoed in Friedman and Schwartz's (1963) classic account of the Great Depression and by countless other authors.

The microeconomic argument against the NIRA is even more persuasive. Any undergraduate microeconomics textbook has a lengthy discussion of the inefficiencies created by the monopoly power of firms or workers. If firms gain monopoly power, they increase prices to increase their profits. The higher prices lead to lower demand. Encouraging workers' collusion has the same effect. The workers conspire to prop up their wages, thus reducing hours demanded by firms. These results can be derived in a wide variety of models and have been applied by several authors in the context of the Great Depression in the U.S. An elegant example is Cole and Ohanian (2004), but this line of argument is also found in several other important recent papers, such as Bordo, Erceg, and Evans (2000), Mulligan (2002), Christiano, Motto, and Rostagno (2004) and Chari, Kehoe, and McGrattan (2006).

Given this broad consensus, it is not surprising that one of the authors of the NIRA, Regford Guy Tugwell, said of the legislation that "for the economic philosophy which it represents there are no defenders at all." To my knowledge, this paper is the first to formalize an economic argument in favor of these New Deal policies.[3] The logic of the argument, however, is far from new. The argument is that these policies were expansionary because they changed expectations from being

[3] The closest argument is made in Tobin (1975) and De Long and Summers (1986). They show that policies that make a sticky price economy more "rigid" may stabilize output. I discuss this argument in section 8 and confirm their result in the present model.

deflationary to being inflationary, thus eliminating the deflationary spiral of 1929-33. This made lending cheaper and thus stimulated demand. This also was the reasoning of the architects of the NIRA. The *New York Times*, for example, reported the following on April 29th 1933, when discussing the preparation of the NIRA

> A higher price level which will be sanctioned by the act, it was said, will encourage banks to pour into industry the credit now frozen in their vaults because of the continuing downward spiral of commodity prices.

The Keynesian models miss this channel because expectations cannot influence policy. Bordo et al. (2000), Mulligan (2002), Cole and Ohanian (2004), Christiano et al. (2004) and Chari et al. (2006) miss it because they assume one or all of the following (i) flexible prices, (ii) no shocks and/or (iii) abstract from the zero bound. For the New Deal to be expansionary all three assumptions have to be abandoned and the paper argues that this is necessary for an accurate account of this period.

Policy makers during the Great Depression claimed that the main purpose of NIRA was to increase prices and wages to break the deflationary spiral of 1929-33.[4] There were several other actions taken to increase prices and wages, however. The most important ones were an aggressive monetary and fiscal expansion and the elimination of the gold standard. The paper shows that even if the government pursues other inflationary policies, such as a monetary and fiscal expansion, the New Deal is still expansionary under certain conditions that are shown to have been satisfied during this period. The New Deal policy studied in the paper is a temporary emergency measure. Arguably, however, a subset of the New Deal legislation turned out to be more persistent. An extension of the model shows that a long-lasting policy distortion is still expansionary in *short-run,* i.e. through the duration of the deflationary emergency, but contractionary in the *long-run*.

Under certain conditions, the standard neoclassical growth model predicts that policy distortions can increase output. Imagine, for example, a permanent labor tax levied on households and that the proceeds are thrown into the sea. To make up for lost income, the households work more and hence aggregate output increases (under certain restrictions on utility and taxes). The role of the policy distortions in this paper is *unrelated* to this well-known example. According to our analysis, the natural level of output (which corresponds to the equilibrium output in the neoclassical model) unambiguously *decreases* as a result of the policy distortions. It is the *interaction* of *nominal frictions,* the *policy wedges*, and deflationary shocks that causes the output expansion. Moreover, while increasing the policy distortions always *reduces* welfare in the neoclassical model, it *increases* welfare in this paper. The paper thus establishes a new foundation of the New Deal as the optimal second best policy, in the classic sense of Lipsey and Lancaster (1956).

[4] The *Wall Street Journal*, for example, reports that Franklin Delano Roosevelt declared the following after a joint meeting with the Prime Minister of Canada on May 1st of 1933:

> We are agreed in that our primary need is to insure an increase in the general level of commodity prices. To this end simultaneous actions must be taken both in the economic and the monetary fields.

The action in the "economic field" FDR referred to was the NIRA.

The basic channel for the economic expansion in this paper is the same as in many recent papers that deal with the problem of the zero bound, such as, for example, Krugman (1998), Svensson (2001), and Eggertsson and Woodford (2003,2004), Jung et al. (2005), Adam and Billi (2006), and Eggertsson (2006,2008), to name only a few. In these papers there can be an inefficient collapse in output if there are large deflationary shocks so that the zero bound is binding. The solution is to commit to higher inflation. The New Deal policies facilitate this commitment because they reduce deflation in states of the world in which the zero bound is binding, beyond what would be possible with monetary policy alone.

## 2 Some Historical Background

Excessive deflation helps explain the output collapse during the Great Depression: Double-digit deflation raised real interest rates in 1929-33 as high as 10-15 percent while the short-term nominal interest rates collapsed to zero (the short-term rate as measured by three-month Treasury bonds, for example, was only 0.05 percent in January 1933). The high real interest rates depressed spending. Output contracted by a third in 1929-33 and monthly industrial production lost more than half its value, as shown in Figure 2.

In the model, the New Deal transforms deflationary expectations into inflationary ones. Deflation turned into inflation in March 1933, when FDR took office and announced the New Deal. Output, industrial production, and investment responded immediately. Annual GDP grew by 39 percent in 1933-37 and monthly industrial production more than doubled, as shown in Figure 2. This is the greatest expansion in output and industrial production in any four year period in U.S. history outside of wartime.

The NIRA was struck down by the Supreme Court in 1935. Many of the policies, however, were maintained in one form or another throughout the second half of the 1930s, a period in which the short-term nominal interest rate remained close to zero. Some authors, such as Cole and Ohanian (2004), argue that other policies that replaced them had a similar effect.

While 1933-37 registers the strongest growth in U.S. economic history outside of wartime, there is a common perception among economists that the recovery from the Great Depression was very slow (see, e.g., Cole and Ohanian [2004]). One way to reconcile these two observations is to note that the economy was recovering from an extremely low level of output. Even if output grew rapidly in 1933-37, some may argue it should have grown even faster and registered more than 9 percent average growth in that period. Another explanation for the perception of "slow recovery" is that there was a serious recession in 1937-38. Much of the discussion in Cole and Ohanian (2004), for example, focuses on comparing output in 1933 to output in 1939, when the economy was just starting to recover from the recession in 1937-38 (see Figure 2). If the economy had maintained the momentum of the recovery and avoided the recession of 1937-38, GDP would have reached trend in 1938.[5] By some other measures, such as monthly industrial production,

[5] This conclusion is drawn by using the data from Romer (1988), which covers 1909-1982, and estimating a linear trend. This trend differs from the one assumed by Cole and Ohanian (2004) because it suggest that the economy

the economy had already reached trend before the onset of the recession of 1937 (see Eggertsson and Pugsley [2006] and Figure 2).[6] To large extent, therefore, explaining the slow recovery is the same as explaining the recession of 1937-38. This challenge is taken in Eggertsson and Pugsley's (2006), who attributes the recession in 1937 to the Administration reneging on its commitment to inflation. In this paper, however, I do not address the mistake of 1937, and accordingly focus on the recovery period 1933-37.

## 3 The Wedges and the Model

This section extends the microfoundations of a standard general equilibrium model to allow for distortionary policy wedges. The next section characterizes the equilibrium by a log-linear approximation, so a reader not interested in the microeconomic details can go directly to that section. The sources of the wedges are government policies that facilitate monopoly pricing of firms and unions. For simplicity, the model abstracts from endogenous variations in the capital stock, assumes perfectly flexible wages, monopolistic competition in goods markets, and rigid prices.

It is worth commenting briefly on these modelling choices. One simplification is that the model abstract from endogenous capital accumulation. Appendix D shows that including capital spending has relatively small quantitative effect on output and inflation. It does, however, complicate the analytics and precludes closed form solutions. A key assumption is nominal frictions in price setting. The particular form of the frictions, however, is not crucial for the results. Firms adjust prices at random intervals as in Calvo (1983), not only because of simplicity, but because this has become the most common assumption in the literature (and has been subject to relatively extensive empirical testing, beginning with the work of Gali and Gertler [1999] and Sbordone [2002]). Moreover the resulting firm's Euler equation has been derived from relatively detailed microfoundations, see e.g. Gertler and Leahy (2007) who derive it assuming physical menu costs, and Woodford (2008) who derives it assuming imperfect information. Appendix C shows that the results are unchanged assuming rigid wages instead of prices, or if the price frictions are represented by the familiar textbook New Classical Phillips curve as, e.g., in Kydland and Prescott (1977).

A representative household maximizes the utility

$$E_t \sum_{T=t}^{\infty} \beta^{T-t} \xi_T \left[ u(C_T - H_T^c) - \int_0^1 v(l_T(j) - H_T^l(j)) dj \right],$$

where $\beta$ is a discount factor, $C_t$ is a Dixit-Stiglitz aggregate of consumption of each of a continuum

was 10 percent above trend in 1929, while they assume it was at trend at that time, because that is where their sample starts.

[6] This is also consistent with what policy makers believed at the time. FDR said in his State of the Union address in January 1937, for example, "Our task has not ended with the end of the depression." His view was mostly informed by the data on industrial production.

of differentiated goods,

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

with an elasticity of substitution equal to $\theta > 1$, $P_t$ is the Dixit-Stiglitz price index,

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

$l_t(j)$ is the quantity supplied of labor of type $j$; $H_t^c$ and $H_t^l(j)$ are external consumption and labor habits. The habits are introduced to improve the quantitative fit, as has become common in the literature, but none of the analytical results depend on this auxiliary assumption. Each industry $j$ employs an industry-specific type of labor, with its own wage $W_t(j)$. The disturbance $\xi_t$ is a preference shock, $u(.)$ is a concave function, and $v(.)$ an increasing convex function.

Financial markets are complete and there is no limit on borrowing against future income. As a consequence, a household faces an intertemporal budget constraint of the form

$$E_t \sum_{T=t}^{\infty} Q_{t,T} P_T C_T \leq A_t + E_t \sum_{T=t}^{\infty} Q_{t,T} \left[ \int_0^1 Z_T(i) di + \int_0^1 W_T(j) l_T(j) dj - T_T \right]$$

looking forward from any period $t$. Here $Q_{t,T}$ is the stochastic discount factor by which the financial markets value random nominal income at date $T$ in monetary units at date $t$, (note that the riskless nominal interest rate on one-period obligations purchased in period $t$ is a solution to the equation $E_t Q_{t,t+1} = \frac{1}{1+i_t}$), $A_t$ is the nominal value of the household's financial wealth at the beginning of period $t$, $Z_t(i)$ is nominal profits (revenues in excess of the wage bill) in period $t$ of the supplier of good $i$, $W_t(j)$ is the nominal wage earned by labor of type $j$ in period $t$, and $T_t$ is net nominal tax liabilities in period $t$.

Optimizing household behavior implies the following necessary conditions for a rational-expectations equilibrium. Optimal timing of household expenditure requires that aggregate demand for the composite good satisfy an Euler equation of the form

$$u_{c,t} \xi_t = \beta E_t \left[ u_{c,t+1} \xi_{t+1} (1 + i_t) \frac{P_t}{P_{t+1}} \right], \tag{2}$$

where $i_t$ is the riskless nominal interest rate on one-period obligations purchased in period $t$ and $u_{c,t}$ denotes marginal utility of consumption at time $t$ (exclusive of the preference shock). Household optimization requires that the paths of aggregate real expenditure and the price index satisfy the conditions

$$\sum_{T=t}^{\infty} \beta^T E_t u_{c,T} \xi_T Y_T < \infty, \tag{3}$$

$$\lim_{T \to \infty} \beta^T E_t [u_{c,T} \xi_T A_T / P_T] = 0 \tag{4}$$

looking forward from any period $t$.[7]

Without entering into the details of how the central bank implements a desired path for the short-term interest rate, it is important to observe that it cannot be negative as long as people have the option of holding currency that earns a zero nominal return as a store of value.[8] Hence the zero lower bound

$$i_t \geq 0. \tag{5}$$

It is convenient to define the price for a one-period real bond. This bond promises its buyer to pay one unit of a consumption good at date $t+1$, with certainty, for a price of $1+r_t$. This is the short-term real interest rate. It follows from the household maximization problem that the real interest rate satisfies

$$u_{c,t}\xi_t = (1+r_t)\beta E_t u_{c,t+1}\xi_{t+1} \tag{6}$$

Each differentiated good $i$ is supplied by a single monopolistically competitive producer. As in Woodford (2003) there are many goods in each of an infinite number of "industries"; the goods in each industry $j$ are produced using a type of labor specific to that industry and also those firms change their prices at the same time.[9] Each good is produced in accordance with a common production function

$$y_t(i) = l_t(i), \tag{7}$$

where $l_t(i)$ is the industry-specific labor hired by firm $i$. The representative household supplies all types of labor and consumes all types of goods.[10] It decides on its labor supply by choice of $l_t(j)$ so that every labor supply of type $j$ satisfies

$$\frac{W_t(j)}{P_t} = [1+\omega_{1t}(j)]\frac{v_{l,t}(j)}{u_{c,t}} \tag{8}$$

where $v_{l,t}(j)$ denotes the marginal disutility of working at time $t$ (exclusive of the preference shock) for labor of type $j$. The term $\omega_{1t}(j)$ is a distortionary wedge as in Chari, Kehoe, and McGrattan (2006) or what Benigno and Woodford (2003) call a "labor market markup". The household takes this wedge as exogenous to its labor supply decisions. If the labor market is perfectly flexible, then $\omega_{1t}(j) = 0$. Instead, I assume that by varying this wedge the government can restrict labor supply and thus increase real wages relative to the case in which labor markets

[7] Condition (3) is required for the existence of a well-defined intertemporal budget constraint, under the assumption that there are no limitations on the household's ability to borrow against future income, while the transversality condition (4) must hold if the household exhausts its intertemporal budget constraint. In equilibrium, $A_t$ measures the total nominal value of government liabilities, which are held by the household. For simplicity, I assume throughout that the government issues no debt so that (4) is always satisfied.

[8] While no currency is actually traded in the model, it is enough to assume that the government is committed to supply currency in an elastic supply to derive the zero bound. The zero bound is explicitly derived from money demand in Eggertsson and Woodford (2003).

[9] See further discussion in Woodford (2003), Chapter 3.

[10] We might alternatively assume specialization across households in the type of labor supplied; in the presence of perfect sharing of labor income risk across households, household decisions regarding consumption and labor supply would all be as assumed here. Assuming a common labor market would yield the same qualitative results.

are perfectly competitive. The government can do this by facilitating union bargaining or by other anti-competitive policies in the labor market. A marginal labor tax, rebated lump sum to the households, has the same effect.[11]

The supplier of good $i$ sets its price and then hires the labor inputs necessary to meet any demand that may be realized. Given the allocation of demand across goods by households in response to the firm's pricing decisions, given by $y_t(i) = Y_t(\frac{p_t(i)}{P_t})^{-\theta}$, nominal profits (sales revenues in excess of labor costs) in period $t$ of the supplier of good $i$ are given by

$$Z_t(i) = [1 - \omega_{2t}(j)]p_t(i)Y_t(p_t(i)/P_t)^{-\theta} + \omega_{2t}(j)p_t^j Y_t(p_t^j/P_t)^{-\theta} - W_t(j)Y_t(p_t(i)/P_t)^{-\theta} \tag{9}$$

where $p_t^j$ is the common price charged by the other firms in industry $j$ and $p_t(i)$ is the price charged by each firm.[12] The wedge $\omega_{2t}(j)$ denotes a monopoly markup of firms – in excess of the one implied by monopolistic competition across firms – due to government-induced regulations. A fraction $\omega_{2t}(j)$ of the sale revenues of the firm is determined by a common price in the industry, $p_t^j$, and a fraction $1 - \omega_{2t}(j)$ by the firms own price decision. (Observe that in equilibrium the two prices will be the same.) A positive $\omega_{2t}(j)$ acts as a price collusion because a higher $\omega_{2t}(j)$, in equilibrium, increases prices and also industry $j$'s wide profits (local to no government intervention). A consumption tax – rebated either to consumers or firms lump sum – would introduce the same wedge. In the absence of any government intervention, $\omega_{2t} = 0$.

If prices are fully flexible, $p_t(i)$ is chosen in each period to maximize (9). This leads to the first-order condition for the firm's maximization

$$p_t(i) = \frac{\theta}{\theta - 1}\frac{W_t(j)}{1 - \omega_{2t}(j)} \tag{10}$$

which says that the firm will charge a markup $\frac{\theta}{\theta-1}\frac{1}{1-\omega_{2t}(j)}$ over its labor costs due to its monopolistic power. As this equation makes clear, a positive value of $\omega_{2t}(j)$ creates a distortion by increasing the markup industry $j$ charges beyond what is socially optimal. Under flexible prices, all firms face the same problem so that in equilibrium $y_t(i) = Y_t$ and $p_t(i) = P_t$ and $l_t(j) = L_t = Y_t$. Combining (8) and (10) then gives an aggregate supply equation

$$\frac{\theta - 1}{\theta} = \frac{1 + \omega_{1t}}{1 - \omega_{2t}}\frac{v_{l,t}}{u_{c,t}} \tag{11}$$

assuming that the wedges are set symmetrically across sectors.

To close the model, we need to specify the evolution of the external habits. The consumption habit is proportional to aggregate consumption from the last period, while the labor habit is proportional to aggregate labor from the last period.[13] Since all output is consumed, and production

[11] Hence an alternative interpretation of the policy is that it corresponds to variations in a labor tax, see Chari, Kehoe and McGrattan (2006) for further discussion about the interpretation of this wedge, and how it relates to the existing literature on the Great Depression.

[12] In equilibrium, all firms in an industry charge the same price at any time. But we must define profits for an individual supplier $i$ in the case of contemplated deviations from the equilibrium price.

[13] Where aggregate labor is defined as a Dixit-Stiglitz index of each sector-specific labor input, analogous to the consumption habit.

is linear in labor, this implies that in equilibrium

$$H_t^c = H_t^l = \rho Y_{t-1}$$

$$u_{c,t} = u_c(Y_t - \rho Y_{t-1})$$

$$v_{l,t} = v_l(y_t(j) - \rho Y_{t-1})$$

Equilibrium output in the flexible price economy is called the natural rate of output.

**Definition 1** *A flexible price equilibrium is a collection of stochastic processes for* $\{P_t, Y_t, i_t, r_t, \omega_{1t}, \omega_{2t}\}$ *that satisfy (2), (5), (6), and (11) for a given sequence of the exogenous processes* $\{\xi_t\}$ and an initial condition $Y_{-1}$. *The output in this equilibrium is called the natural rate of output and is denoted* $Y_t^n$.

Observe that the natural level of output does not depend on the nominal interest rate $i_t$, since it is independent of the price level. Its does, however, depend on the other policy instruments $\omega_{1t}$ and $\omega_{2t}$. From Definition 1 we saw that all that matters is the ratio $1 + \omega_t \equiv \frac{1+\omega_{1t}}{1-\omega_{2t}}$. Suppose the government sets this ratio $\omega_t$ so that the resulting flexible price allocation maximizes the utility of the representative household. We call this allocation the efficient allocation and output and real interest rate the efficient level of output and and the efficient interest rate.

**Definition 2** *An efficient allocation is the flexible price equilibrium that maximizes social welfare. The equilibrium output in this equilibrium is called the efficient output and is denoted* $Y_t^e$ *and the real interest rate is the efficient level of interest and denoted* $r_t^e$.

Proposition 8 in the Appendix shows that the government should set the wedges to $1 + \omega_t = \frac{1+\omega_{1t}}{1-\omega_{2t}} = \frac{\theta-1}{\theta}$ to achieve the efficient allocation. In this equilibrium the wedges are set to eliminate the distortions created by the monopolistic power of the firms and the efficient rate of output is a constant $\bar{Y}^e$ determined by (11). Because the efficient rate of output is a constant we see from equation (6) that the efficient rate of interest is $r_t^e = \xi_t / E_t \xi_{t+1} - 1$. The reason we define the efficient rate of interest is that it is a convenient way of summarizing the shocks in the approximate equilibrium of the next section. It will also play a key role in section 9.

The efficient and natural rates are theoretical concepts that we will find convenient to use in coming section but they do not describe the actual equilibrium allocation, because instead of being flexible we assume that prices remain fixed in monetary terms for a random period of time. Following Calvo (1983), suppose that each industry has an equal probability of reconsidering its price each period. Let $0 < \alpha < 1$ be the fraction of industries with prices that remain unchanged in each period. In any industry that revises its prices in period $t$, the new price $p_t^*$ will be the same. The maximization problem that each firm faces at the time it revises its price is

$$\max_{p_t^*} E_t \left\{ \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} Q_{t,T} [(1-\omega_{2T}) p_t^* Y_T (p_t^*/P_T)^{-\theta} + \omega_{2T} p_t^j Y_T (p_t^j/P_T)^{-\theta} - W_T(j) Y_T (p_t^*/P_T)^{-\theta}] \right\}$$

The price $p_t^*$ is defined by the first-order condition

$$E_t \left\{ \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} u_{c,T} \xi_T (\frac{p_t^*}{P_T})^{-\theta} Y_T [(1-\omega_{2T}) \frac{p_t^*}{P_T} - \frac{\theta}{\theta - 1}(1+\omega_{1T}) \frac{v_{l,T}}{u_{c,T}}] \right\} = 0. \qquad (12)$$

where (8) is used to substitute out for wages and the stochastic discount factor has been substituted out using

$$Q_{t,T} = \beta^{T-t} \frac{u_{c,T} \xi_{t+1} P_t}{u_{c,t} \xi_t P_T}.$$

The first-order condition (12) says that the firm will set its price to equate the expected discounted sum of its nominal price to a expected discounted sum of its markup times nominal labor costs. Finally, equation (1) implies a law of motion for the aggregate price index of the form

$$P_t = \left[ (1-\alpha) p_t^{*1-\theta} + \alpha P_{t-1}^{1-\theta} \right]^{\frac{1}{1-\theta}}. \qquad (13)$$

Equilibrium can now be defined as follows.

**Definition 3** *A sticky price equilibrium is a collection of stochastic processes* $\{Y_t, P_t, p_t^*, i_t, r_t, \omega_{1t}, \omega_{2t}\}$ *that satisfies (2), (5), (6),(12), and (13) for a given sequence of the exogenous shocks* $\{\xi_t\}$ *and an initial condition* $(Y_{-1}, P_{-1})$.

A steady state of the model is defined as a constant solution when there are no shocks. Proposition 9 in Appendix A proves that a social planner can implement the efficient equilibrium in the steady state of the sticky price model.[14] This steady state is the point around which we approximate the model in the next section.

# 4 Approximate Sticky Price Equilibrium

To characterize the equilibrium we approximate the sticky price model in terms of log-deviations from the steady state defined in the last section. The consumption Euler equation (2) can be approximated as[15]

$$CE \qquad \tilde{Y}_t = E_t \tilde{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) \qquad (14)$$

where $\pi_t \equiv \log P_t/P_{t-1}$,$\tilde{Y}_t \equiv \hat{Y}_t - \rho \hat{Y}_{t-1}$, $\hat{Y}_t \equiv \log Y_t/\bar{Y}^e$ and $\sigma \equiv -\frac{\bar{u}_c}{\bar{u}_{cc}\bar{Y}}$ (where bar denotes that the variables [or functions] are evaluated in steady state) and $r_t^e \equiv \log \beta^{-1} + \hat{\xi}_t - E_t \hat{\xi}_{t+1}$ summarizes the exogenous disturbances where $\hat{\xi}_t \equiv \log \xi_t/\bar{\xi}$. Observe that the way the exogenous

[14] This steady state is $\bar{r} = \bar{\imath} = \beta^{-1} - 1$, $\frac{1+\omega_1}{1-\omega_2} = \frac{\theta-1}{\theta}$, $\Pi_t = \frac{P_t}{P_{t-1}} = \frac{p_t^*}{p_{t-1}^*} = 1$, $Y_t = \bar{Y}^e$

[15] The $i_t$ in this equation actually refers to $\log(1+i_t)$ in the notation of the previous section, i.e. the natural logarithm of the gross nominal interest yield on a one-period riskless investment, rather than the net one-period yield. Also note that this variable, unlike the others appearing in the log-linear approximate relations, is not defined as a deviation from steady-state value. I do this to simplify notation, i.e., so that I can express the zero bound as the constraint that $i_t$ cannot be less than zero. Also note that I have also defined $r_t^n$ to be the log level of the gross level of the natural rate of interest rather than a deviation from the steady-state value $\bar{r} = \beta^{-1} - 1$.

disturbance (the preference shock) enters this equation can be summarized by $r_t^e$. Using equation (6), the composite disturbance $r_t^e$ can be interpreted as a log-linear approximation of the efficient rate of interest. Equation (14) says that the quasi-growth rate of output depends on expectations of the future growth rate and the difference between the real interest rate and the efficient rate of interest. I refer to equation (14) as the *Consumption Euler* equation, or *CE equation.* The interest rate now refers to $\log(1+i_t)$ in terms of our previous notation, so that once again we can express the zero bound as

$$ZB \qquad i_t \geq 0. \tag{15}$$

The Euler equation (12) of the firm-maximization problem, together with the price dynamics (13), can be approximated to yield[16]

$$FE \qquad \pi_t = \kappa \tilde{Y}_t + \beta E_t \pi_{t+1} + \kappa \varphi \hat{\omega}_t \tag{16}$$

where $\hat{\omega}_t \equiv \log((1+\omega_t)/(1+\bar{\omega}))$, $\varphi \equiv \frac{1}{\sigma^{-1}+\upsilon}$, $\kappa \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} \frac{\sigma^{-1}+\upsilon}{1+\nu\theta}$ and $\nu \equiv \frac{\bar{v}_{ll} L}{\bar{v}_l}$. This equation says that inflation, determined by the pricing decisions of the firms, depends on the quasi-growth rate of output, expected inflation, and the policy wedge. I refer to this equation as the *Firm Euler* equation, or *FE equation.* Observe that if the government increases monopoly power of workers or firms, a higher $\hat{\omega}_t$, inflation increases other things constant.

An approximate equilibrium is defined as follows.

**Definition 4** *An approximate equilibrium is a collection of stochastic processes for the endogenous variables* $\{\tilde{Y}_t, \pi_t, i_t, \hat{\omega}_t\}$ *that satisfy (14),(15), and (16) for a given sequence of the exogenous shock* $\{r_t^e\}$.

# 5 Deflation and an Output Collapse under a Baseline Policy

This section explores the equilibrium outcome when $r_t^e$ is temporarily negative. This shock generates the Great Depression in the model.

**A1 – The Great Depression structural shocks:** $r_t^e = r_L^e < 0$ *unexpectedly at date* $t = 0$. *It returns back to steady state* $r_H^e = \bar{r}$ *with probability* $1-\mu$ *in each period. The stochastic date the shock returns back to steady state is denoted* $\tau$. *To ensure a bounded solution, the probability* $\mu$ *is such that* $L(\mu) = (1-\mu)(1-\beta\mu) - \mu\sigma\kappa > 0$.

Panel (a) in Figure 3 illustrates this assumption graphically. Under this assumption, the shock $r_t^e$ remains negative, in the depression state denoted $L$, until some stochastic date $\tau$, when it returns to steady state. This assumption is the same as in Krugman (1998), Eggertsson and Woodford (2003), and Auerbach and Obstfeld (2005). Eggertsson (2008) argues that this kind of disturbance is necessary to explain a simultaneous decline in interest rates, output, and inflation

[16] For a textbook derivation, see e.g. Woodford (2003) Proposition 3.5. The extension to include the wedges is straight forward given equations (12) and (13).

seen in the data during the Great Depression in the United States, while other common sources of business cycles are unable to explain the pattern in the data.[17] A productivity shock can also generate a temporarily negative efficient rate of interest, i.e., an expectation of lower future productivity can generate negative $r_L^e$.[18] Appendix D discusses the shocks that generate a negative $r_t^e$ when there is endogenous capital accumulation.

Policy is characterized by rules for $i_t$ and $\hat{\omega}_t$. The baseline assumption is

$$i_t = \max\{0, r_t^e + \phi_\pi \pi_t + \phi_y \tilde{Y}_t\} \tag{17}$$

$$\hat{\omega}_t = 0 \tag{18}$$

where $\phi_\pi + \frac{1-\beta}{4\kappa}\phi_y > 1$. The monetary policy specification is relatively standard and implies that the government seeks to stabilize inflation at zero and output around potential. The assumption about the policy wedge is that the government does not seek to vary monopoly power of firms and workers over the business cycle. Under assumption A1, it is easy to show that the monetary policy takes the form[19]

$$i_t = r_H^e \text{ for } t \geq \tau \tag{19}$$

$$i_t = 0 \text{ for } 0 < t < \tau \tag{20}$$

Section 9 shows that the equilibrium policy given by (19) and (20) can be derived from micro-foundations if one assumes the constraint $\hat{\omega}_t = 0$ and that the government sets monetary policy according to "optimal forward-looking perspective." Furthermore, it is equivalent to the Markov perfect equilibrium (MPE) of the model under the constraint $\hat{\omega}_t = 0$ as shown in Appendix E. Finally, it is worth noting that the equilibrium policy is also consistent with a simple policy rule that aims at setting inflation at zero "whenever possible." Based on narrative accounts, Eggertsson (2008) argues that this description of policy captures important elements of the Federal Reserve policy in 1929-33.

It is easy to derive the solution in closed form for the other endogenous variables assuming (17)-(20). In the periods $t \geq \tau$ the unique bounded solution is $\pi_t = \tilde{Y}_t = 0$. In periods $t < \tau$ assumption A1 implies that inflation in the next period is either zero (with probability $1-\mu$) or the same as at time $t$, i.e., $\pi_t = \pi_L$ (with probability $\mu$). Hence the solution in $t < \tau$ satisfies the CE and the FE equations

$$CE \qquad \tilde{Y}_L = \mu \tilde{Y}_L + \sigma\mu\pi_L + \sigma r_L^e \tag{21}$$

$$FE \qquad \pi_L = \kappa \tilde{Y}_L + \beta\mu\pi_L \tag{22}$$

[17] Assuming that $\xi_t$ follows the same two-state Markov process as $r_t^e$ in A1 and indexing the depression state by $L$, A1 is satisfied if $\xi_L < -\frac{\bar{r}}{1-\mu}$.

[18] All the results of the paper apply under this alternative specification if one replaces output $\tilde{Y}_t$ with the output gap $\tilde{Y}_t - \tilde{Y}_t^e$ where $\tilde{Y}_t^e$ refers to the deviation of the quasi-growth rate of the efficient rate of output from steady state (but $\tilde{Y}_t^e = 0$ at all times if we assume only preference shocks).

[19] The equilibrium interest rate shown in (19) follows from that $\phi_\pi + \frac{1-\beta}{4\kappa}\phi_y > 1$ implies a unique bounded solution in periods $t \geq \tau$ such that $\pi_t = \tilde{Y}_t = 0$. The equilibrium interest rate of 0 in period $0 < \tau < t$ follows from that $r_t^e < 0$ implies a negative nominal interest rate if $i_t = r_t^e + \phi_\pi \pi_t + \phi_y \tilde{Y}_t$.

where we have taken account of that $E_t\pi_{t+1} = \mu\pi_L$, $E_t\tilde{Y}_{t+1} = \mu\tilde{Y}_L$ and that (20) says that $i_t = 0$ when $t < \tau$.

To understand better the equilibrium defined by equations (21) and (22), it is helpful to graph the two equations in $(\tilde{Y}_L, \pi_L)$ space. Consider first the special case in which $\mu = 0$, i.e. the shock $r_L^e$ reverts back to steady state in period 1 with probability 1. This case is shown in panel (a) in Figure 4 and it only applies to equilibrium determination in period 0. The equilibrium is shown where the two solid lines intersect at point A. At point A, output is completely demand determined by the vertical CE curve and pinned down by the shock $r_t^e$.[20] For a given level of output, then, inflation is determined by where the FE curve intersects the CE curve.

Consider now the effect of increasing $\mu > 0$. In this case, the contraction is expected to last for longer than one period. Because of the simple structure of the model, and the two-state Markov process for the shock, the equilibrium displayed in the figure corresponds to all periods $0 \leq t < \tau$. The expectation of a possible future contraction results in movements in both the CE and the FE curves, and the equilibrium is determined at the intersection of the two dashed curves, at point B. Observe that the CE equation is no longer vertical but upward sloping in inflation, i.e., higher inflation *expectations* $\mu\pi_L$ increase output. The reason is that for a given nominal interest rate ($i_L = 0$ in this equilibrium), any increase in expected inflation reduces the real interest rate, making current spending relatively cheaper, and thus increasing consumption demand. Conversely, expected deflation, a negative $\mu\pi_L$, causes current consumption to be relatively more expensive than future consumption, thus suppressing spending. Observe, furthermore, the presence of the expectation of future contraction, $\mu Y_L$, on the right-hand side of the CE equation. The expectation of future contraction makes the effect of both the shock and the expected deflation even stronger, by a factor of $\frac{1}{1-\mu}$. Turning to the FE equation (22), its slope is now steeper because the expectation of future deflation will lead the firms to cut prices by more for a given output slack, as shown by the dashed line. The net effect of the shift in the curves is a more severe contraction and deflation shown by the intersection of the two dashed curves at point B in panel (a) of Figure 3.

The more severe depression at point B is triggered by several contractionary forces. First, because the contraction is now expected to last more than one period, output is falling in the price level, because there is expected deflation, captured by $\mu\pi_L$ on the right-hand side of the CE equation. This increases the real interest rate and suppresses demand. Second, the expectation of

[20] A higher efficient rate of interest, $r_L^e$, corresponds to an autonomous increase in the willingness of the household to spend at a given nominal interest rate and expected inflation and thus shifts the CE curve. Note that the key feature of assumption A1 is that we are considering a shock that results in a negative efficient interest rate, that in turn causes the nominal interest rate to decline to zero. Another way of stating this is that it corresponds to an "autonomous" decline in spending for given prices and a nominal interest rate. This shock thus corresponds to what the old Keynesian literature referred to as "demand" shocks, and one can interpret it as a stand-in for any exogenous reason for a decline in spending. Observe that in the model all output is consumed. If we introduce other sources of spending, such as investment, a more natural interpretation. lf a decline in the efficient interest rate is an autonomous shock to the cost of investment in addition to the preference shock (see further discussion in Appendix D).

future output contraction, captured by the $\mu Y_L$ term on the right-hand side of the CE equation, creates an even further decline in output. Third, the strong contraction, and the expectation of it persisting in the future, implies an even stronger deflation for given output slack, according to the FE equation. Observe the vicious interaction between the contractionary forces in the CE and FE equations. Consider the pair $\tilde{Y}_L^A, \pi_L^A$ at point A as a candidate for the new equilibrium. For a given $\tilde{Y}_L^A$, the strong deflationary force in the FE equation reduces expected inflation so that we have to have $\pi_L < \pi_L^A$. Due to the expected deflation term in the CE equation this again causes further contraction in output, so that $\tilde{Y}_L < \tilde{Y}_L^A$. The lower $\tilde{Y}_L$ then feeds again into the FE equation, triggering even further deflation, and thus triggering a further drop in output according to the CE equation, and so on and on, leading to a vicious deflation-output contractionary spiral that converges to point B in panel (a), where the dashed curves intersect.

The vicious deflationary spiral described above amplifies the contraction without a bound as $\mu$ increases. As $\mu$ increases, the CE curve becomes flatter and the FE curve steeper, and the cutoff point moves further down in the $(Y_L, \pi_L)$ plane in panel (a) of Figure 4. At a critical value $1 > \bar{\mu} > 0$ when $L(\bar{\mu}) = 0$ in A1, the two curves are parallel, and no solution exists. The point $\bar{\mu}$ is called a *deflationary black hole.*[21] In the remainder of the paper we assume that $\mu$ is small enough so that the deflationary black hole is avoided and the solution is well defined and bounded (this is guaranteed by the inequality in assumption A1).[22] To summarize, solving the CE and FE equations with respect to $\pi_t$ and $\tilde{Y}_t$, we obtain the next proposition.

**Proposition 1** ***Output and Deflationary Spiral under the Benchmark Policy***. *If A1, then the evolution of output and inflation under the benchmark policy is:*

$$\pi_t^D = \frac{1}{(1-\mu)(1-\beta\mu) - \mu\sigma\kappa}\kappa\sigma r_L^e < 0 \text{ if } t < \tau \text{ and } \pi_t^D = 0 \text{ if } t \geq \tau \tag{23}$$

$$\tilde{Y}_t^D = \frac{1-\beta\mu}{(1-\mu)(1-\beta\mu) - \mu\sigma\kappa}\sigma r_L^e < 0 \text{ if } t < \tau \text{ and } \tilde{Y}_t^D = 0 \text{ if } t \geq \tau \tag{24}$$

The two-state Markov process for the shock assumed in A1 allows us to collapse the model into two equations with two unknown variables, as shown in Figure 4. It is important to keep in mind, however, the stochastic nature of the solution. The output contraction and the deflation last only as long as the stochastic duration of the shock, i.e., until the date $\tau$, and the equilibrium depicted in Figure 4 applies only in the "depression" state. This is illustrated in Figure 3, which shows the solution for a arbitrary contingency in which the shock lasts for $\tau$ periods. While panels (a)-(e) in Figure 3 take the same form for any parameter values satisfying A1, and any

[21] As $\mu$ approaches $\bar{\mu}$ from below, the contractionary forces of the model are so strong that the model collapses, and the approximation is no longer valid. The term "deflationary black hole" was first coined by Paul Krugman in "Crisis in Prices?" *New York Times*, December 31, 2002, p. A19 in a slightly different context.

[22] A deflationary solution always exists as long as the shock $\mu$ is close enough to 0 because $L(0) > 0$ (at $\mu = 0$ the shock reverts back to steady state with probability 1 in the next period). Observe, furthermore, that $L(1) < 0$ and that in the region $0 < \mu < 1$ the function $L(\mu)$ is strictly decreasing, so there is some critical value $\bar{\mu} = \mu(\kappa, \sigma, \beta) < 1$ in which $L(\mu)$ is zero and the model has no solution.

contingency $t < \tau$, the figure also reports the quantitative value of each variable using the mode of the Bayesian estimation of the model shown in Table 1 (and discussed in more detail in section 7), with the numbers reported in annual frequencies. We see that for a shock of -2 percent to the efficient rate of interest, which has a probability of 22 percent to return to steady state each year, the model generates deflation of -9 percent, associated with a decline in the quasi-growth rate of output to -7 percent. The decline in the quasi-growth rate of output implies a sustained decline in output over the period of the deflationary shock (the figure illustrates the case in which $\tau = 4$ where output declines by a third). The large quantitative effects of the shock at any time $t$ is created by a combination of the deflationary shock $r_L^e$ in period $t < \tau$, but more importantly, the *expectation* that there will be deflation and output contraction in future periods $t + j < \tau$ for $j > 0$. The deflation in period $t + j$ in turn depends on expectations of deflation and output contraction in periods $t + j + i < \tau$ for $i > 0$, leading to the vicious deflationary spiral.

# 6 Was the New Deal Contractionary?

## 6.1 Expansionary New Deal policies

Can the government break the contractionary spiral observed in Figure 3 by increasing the distortionary wedges through New Deal policies? To analyze this question, we assume that the interest rate is again given by (19) and (20) but that the government implements New Deal according to the policy rule

$$\hat{\omega}_L = \phi_\omega r_L^e > 0 \text{ when } 0 < t < \tau \tag{25}$$

with $\phi_\omega < 0$ and

$$\hat{\omega}_t = 0 \text{ when } t \geq \tau. \tag{26}$$

There are two reasons for considering this policy rule. The first is theoretical. As I will show in section 9, a policy of this form can be derived from microfoundations, either by assuming that the government was following the optimal forward looking policy, or by assuming a Markov perfect equilibrium. The second reason is empirical. As discussed in the introduction, the NIRA was "emergency" legislation that was installed to reflate the price level. The NIRA 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 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 the increase in inefficiency wedges was expected to be temporary as an emergency measure and to last only as long as the shock (which creates the deflationary "emergency" in the model).

Consider now the solution in the periods when the zero bound is binding but the government follows this policy. Output and inflation again solve the CE and FE equations. While the CE equation is unchanged, the FE equation is now

$$FE \qquad \pi_L = \kappa\tilde{Y}_L + \beta\mu\pi_L + \kappa\varphi\hat{\omega}_L \tag{27}$$

where the policy wedge appears on the right-hand side. An increase in $\hat{\omega}_L$ shifts the FE curve leftward, denoted by a dashed line in Figure 5. Why does the FE curve shift? Consider a policy wedge created by a cartelization of firms in each industry in the economy. The firms are now in a position to charge a higher markup on their products than before. This suggests that they will increase their prices relative to the prior period for any given level of production in the depression state, hence shifting the FE curve. Increasing the bargaining power of workers has exactly the same effect. In this case, the marginal cost of the firms increases, so in equilibrium they pass it into the aggregate price level in the depression state, also shifting the FE curve to the left. A new equilibrium is formed at the intersection of the dashed FE curve and the CE curve at higher output and prices, i.e., at point B in Figure 5. The general equilibrium effect of the policy distortions is therefore an output expansion.

The intuition for this result is that the expectation of this "emergency policy" curbs deflationary expectations *in all states of the world in which the shock* $r_t^e$ *is negative.* This shifts the real interest rate from being very high (due to high expected deflation) to being relatively low – even negative for a large enough policy shift – which increases spending according to the CE equation. The effect on output is quantitatively very large owing to the opposite of the vicious output-deflation feedback circle described in the last section: In response to the policy shift, higher inflation expectations reduce real interest rates and increase output demanded by the CE equation, leading to a higher demand, which again increases inflation according to the FE equation, feeding into even higher output in the CE equation and so on, leading to a virtuous feedback circle between the two equations, converging to point B in Figure 5. Note that it is not contemporaneous inflation that has the expansionary effect according to the CE equation. It is the *expectation* of higher prices in the future, $\mu\pi_L$, that reduces the real interest rate (or, more precisely, the expectation of less deflation in the future relative to the earlier equilibrium). Hence it is the fact that people stop expecting ever falling prices that results in the output expansion. Solving the two equations together proves the next proposition, which is the key result of the paper.

**Proposition 2** *Expansionary New Deal Policies. Suppose A1,* $\mu > 0$, *that monetary policy is given by (19) and (20), and that the government adopts the NIRA given by (25) and (26).*

*Then output and inflation are increasing in $\hat{\omega}_L$ and given by*

$$\tilde{Y}_t^{ND} = \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}[(1-\beta\mu)\sigma r_L^e + \mu\kappa\sigma\varphi\hat{\omega}_L] > \tilde{Y}_t^D \text{ if } t < \tau$$
$$\text{and } \tilde{Y}_t^{ND} = 0 \text{ if } t \geq \tau$$

$$\pi_t^{ND} = \frac{\kappa}{1-\beta\mu}(\tilde{Y}_t^{ND} + \varphi\hat{\omega}_L) > \pi_t^D \text{ if } t < \tau \text{ and } \tilde{Y}_t^{ND} = 0 \text{ if } t \geq \tau$$

To underline the dynamic nature of this policy, Figure 3 shows the evolution of the policy wedge, output, and inflation in response to the shock in period $t < \tau$ and compares the equilibrium in the absence of this policy. A key feature of the New Deal policy is that the increase in the policy wedge $\omega_L$ is *only temporary and lasts only as long as the duration of the deflationary shock*. As the figure reveals, the quantitative effect of this policy is large for both inflation and output, as shown by the dashed line. If the New Deal is implemented, then, instead of deflation, there is modest inflation (the optimal level of $\omega_L$ assumed in the figure is derived in section 9). And while there is a collapse in output in the absence of the New Deal policy, there is only a modest decline under the New Deal. As we will see in section 7, the difference between these two outcomes can explain a substantial part of the recovery in 1933-37.

### 6.2 Can a reduction in the natural rate of output increase equilibrium output?

The first question we asked in the introduction of the paper was whether a policy that reduces the natural rate of output can increase equilibrium output. As already noted in Definition 1, the natural rate of output, originally defined by Milton Friedman, is the output that would be produced in the absence of nominal frictions, i.e., if prices were completely flexible. Using equation (11), we obtain

$$\tilde{Y}_t^n = -\varphi\hat{\omega}_t. \tag{28}$$

This equation says that an increase in the policy wedge reduces the quasi-growth rate of the natural level of output. From Proposition 2 we see, therefore, that a policy that *reduces* the natural level of output *increases* equilibrium output when there is excessive deflation.

This result is helpful in understanding how the key result of this paper relates to a large literature that argues that the New Deal was contractionary, such as Mulligan (2002), Cole and Ohanian (2004), and Chari, Kehoe, and McGrattan (2006). These papers assume that prices are flexible. Equation (28) says that the policy we are considering also reduces the natural level of output, i.e., equilibrium output if prices are flexible. Hence our result is consistent with these papers but under the assumption that $\alpha \to 0$, i.e., in the limit as prices become fully flexible. Once we introduce nominal frictions the result is overturned. Another important difference from this earlier literature is that we assume underlying deflationary shocks. We return to this important difference in section 8, where we compare our results to Cole and Ohanian's in the calibrated model and to other studies that include nominal frictions such as Bordo, Erceg, and Evans (2000) and Christiano et al. (2004).

### 6.3 Do expansionary monetary and fiscal policies overturn the result?

It is well documented that in 1933 FDR also pursued expansionary monetary and fiscal policy to increase inflation. Is the New Deal expansionary in the model if the government also stimulates spending by a monetary and fiscal expansion? This section shows that the New Deal remains expansionary as long as a simple condition is satisfied in equilibrium: The government does not raise the nominal interest rate in response to the New Deal policy. Section 7 confirms that this condition is satisfied in the data in 1933-37, but interest rates stayed close to zero throughout the recovery period.

Expansionary monetary policy is modeled as a commitment to a higher growth rate of the money supply in the future, i.e., at $t \geq \tau$. As shown by several authors, such as Eggertsson and Woodford (2003) and Auerbach and Obstfeld (2004), it is only the expectation about future money supply (once the zero bound is no longer binding) that matters at $t < \tau$ when the interest rate is zero. Expansionary fiscal policy is modeled as a temporary expansion in government real spending on goods and services. Government spending is denoted by $G_t$, so that now output is $Y_t = G_t + C_t$, and it enters additive-separately in the utility of the household.[23] The government has access to lump-sum taxes so the financing of these expenditures is irrelevant.

Consider the following monetary policy:[24]

$$i_t = \max\{0, r_t^e + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(\tilde{Y}_t - \tilde{Y}^*)\} \tag{29}$$

where $\pi^*$ denotes the implicit inflation target of the government and $\tilde{Y}^* = (1-\beta)\kappa^{-1}\pi^*$ is the implied long-run output quasi-growth target. Under this policy rule, a higher $\pi^*$ corresponds to a credible inflation commitment. Consider a simple money constraint as in Eggertsson (2008), $M_t/P_t \geq \chi Y_t$ where $M_t$ is the money supply and $\chi > 0$. Then a higher $\pi^*$ corresponds to a commitment to a higher growth rate of the money supply in $t \geq \tau$ at the rate of $\pi^*$. The assumption about policy in (17) is a special case of this policy rule with $\pi^* = 0$.

Consider the following fiscal policy:

$$\hat{G}_t = \hat{G}_L > 0 \ \text{ for } \ 0 < t < \tau \tag{30}$$

$$\hat{G}_t = 0 \ \text{ for } \ t \geq \tau \tag{31}$$

Under this specification, the government increases spending in response to the deflationary shock and then reverts back to steady state once the shock is over.[25] We impose the following limit on the monetary and fiscal expansion.

[23] Introducing government spending into the model in this way is relatively standard. See e.g. Eggertsson (2008) although that paper assumes distortionary taxation. For simplicity, we assume that in steady state $\bar{G} = 0$, so the defintions of the structural parameters remain unchanged. We define $\hat{G}_t \equiv \log G_t - \log \bar{Y}$.

[24] The proposition can be extended to include a time-varying inflation target $\pi_t^*$ or, instead, a price level target $p_t^*$.

[25] This equilibrium form of policy is derived from microfoundations in Eggertsson (2008) assuming a Markov perfect equilibrium.

**A2 – Monetary and fiscal policy restrictions:** The monetary expansion $\pi^*$ and the fiscal expansion $G_L$ are such that $\pi^* + [\phi_\pi \pi^G + \phi_y Y^G]\hat{G}_L \leq -r_L$ where $\pi^G, Y^G > 0$ are coefficients given in the proof of Proposition 3.

The following proposition proves that as long as assumptions A1-A2 are satisfied, the New Deal is expansionary. The second part of the proposition proves that if, in equilibrium, the interest rate is zero in period $0 < t \leq \tau$, then A2 has to be satisfied.[26]

**Proposition 3** *Suppose that monetary policy is given by (29), fiscal policy by (30) and (31), and the New Deal by (25)-(26) and that A1 holds. Then (i) for any monetary policy* $\pi^* \geq 0$, *and fiscal policy* $\hat{G}_L > 0$ *the New Deal is expansionary if A2 (ii) If* $i_t = 0$ *in* $0 \leq t < \tau$ *then monetary and fiscal policy satisfy A2.*

**Proof.** See Appendix ■

To understand the logic of this proposition, it is helpful write out the FE and CE equations in periods $0 < t < \tau$ when the zero bound is binding:

$$CE \qquad \tilde{Y}_L = \mu \tilde{Y}_L + (1-\mu)\tilde{Y}^* + \sigma\mu\pi_L + \sigma(1-\mu)\pi^* + \sigma r_L^e + (1-\mu)\hat{G}_L \tag{32}$$

$$FE \qquad \pi_L = \kappa Y_L + \beta\mu\pi_L + \beta(1-\mu)\pi^* + \kappa\varphi\hat{\omega}_L - \kappa\varphi\hat{G}_L. \tag{33}$$

Observe that the two equations are the same as before if $\pi^* = G_L = 0$, as in Figure 5. Consider first the effect of increasing $\pi^* = 0$ to a positive number $\pi^* > 0$. As shown in Figure 4, panel (b), this shifts the CE curve to the right and the FE curve to the left, increasing both inflation and output. The logic is straight forward: A higher inflation target in period $t \geq \tau$ reduces the real rate of interest in period $t < \tau$, thus stimulating spending in the depression state. This, however, does not *qualitatively* change the effect of a New Deal policy. While the new equilibrium is associated with higher output and inflation than before, the effect of increasing $\hat{\omega}_L$ remains the same because the slopes of the two curves are unchanged. The key condition for this result is that the change in the implicit inflation target from 0 to $\pi^*$ is still small enough to satisfy A2. The effect of an increase in $\hat{G}_L$ is qualitatively similar, i.e., while the fiscal expansion shifts both curves and increases output and prices, it does not change the relative slopes of the two curves.

The reason why the New Deal remains expansionary despite monetary and fiscal expansion is that the central bank does not increase the interest rate in response to the policy, because inflation and the quasi-growth rate of output are below $\pi^*$ and $\tilde{Y}^*$ while $r_t^e$ remains negative (this is condition A2). Importantly the second part of Proposition 3 shows that if the nominal interest rate remains at zero in equilibrium, then condition A2 has to be satisfied, which means that we can simply look at the data in 1933-37 (see section 7) to confirm that monetary and fiscal policy actions did not eliminate the expansionary effect of the New Deal.

[26] What is important here is not that the interest rate is exactly zero, but that the central bank does not raise the nominal interest rate in response to the New Deal. One could extend the monetary policy rule (29) to include instead a bound that is positive.

## 6.4 Contractionary New Deal policies

### 6.4.1 Contractionary policy at positive interest rates

This section shows that, in the absence of large enough deflationary shocks, the New Deal is contractionary. The reason is that, in this case, the monetary policy responds to the New Deal by raising the nominal interest rate. Assume that monetary policy follows once again the baseline policy (17) but that the shock is small enough so that $r_L^e > 0$ (thus violating A2 for $\pi^* = G_L = 0$). The AS equation is unchanged from equation (27) while the CE equation can now be written as

$$\tilde{Y}_L = -\sigma \frac{\phi_\pi - \mu}{1 + \phi_y - \mu} \pi_L + \frac{\sigma}{1 + \phi_y - \mu} r_L^e$$

where we have substituted for $i_L = r_L^e + \phi_\pi \pi_L + \phi_y \tilde{Y}_L$ using the monetary policy rule (17). The fact that the interest rate does not collapse to zero but is instead given by $i_L = r_L^e + \phi_\pi \pi_L + \phi_y \tilde{Y}_L$ implies an important difference in the CE curve. Because $\phi_\pi > \mu$, this implies that the CE curve is downward sloping in inflation in the $(\tilde{Y}_L, \pi_L)$ plane, as shown in Figure 4, panel (c). The central bank responds to inflation pressures by raising interest rates more than one by one, in contrast to the previous case, when the central bank kept the interest rate at zero. Panel (c) in Figure 4 shows the consequence of increasing the wedge $\hat{\omega}_L$ under this assumption. While the New Deal again increases inflation, it reduces output at the same time, as summarized in the following proposition.

**Proposition 4** *Suppose condition A2 is violated so that the short-term nominal interest rate is positive. Then the New Deal is contractionary.*

The proof follows from the argument above, and it is straight-forward to generalize it to positive $\pi^*$ and $\hat{G}_L$.

Observe that panel (c) of Figure 4 is identical to an "AS and AD" diagram of a simple textbook IS-LM model, where the CE curve refers to the traditional "AD curve" and the FE curve to the "AS curve." Hence the argument we have just sketched out for a contractionary New Deal policy echoes the comments made by Keynes in 1933, who stated, "While restricting supply will increase prices, it will reduce output at the same time." The figure clarifies, however, that this is true in our model only under the assumption that the central bank offsets the increase in prices by raising interest rates. Two crucial assumptions separate our analysis from that of Keynes. The first is the assumption that the central bank does not raise interest rates in response to the policy. The second, no less important, is the effect the policy has on expectations about future prices, but expectations are assumed to be exogenous in the IS-LM model.

### 6.4.2 Contractionary persistent policies

So far we have assumed that the New Deal policies are temporary, as stipulated in the NIRA. In particular, we assumed that the policy is terminated as soon as the shock has subsided. We now consider the consequence of a more permanent policy distortion and show that, under plausible parameter restrictions, the New Deal is still expansionary in the *short run*.[27] With persistent distortions, however, it is contractionary in the *long run*.

Consider a policy that is not terminated immediately once the "emergency" has subsided but dies out at a rate $\delta$. The policy takes the form

$$\hat{\omega}_L = \phi_\omega r_L^e > 0 \text{ when } 0 < t < \tau \tag{34}$$

and

$$\hat{\omega}_t = \delta\hat{\omega}_{t-1} \geq 0 \text{ when } t \geq \tau \tag{35}$$

Observe that an *ad hoc* policy as in (35) is always sub-optimal and can therefore not be motivated by microfoundations as the baseline policy (see section 9 that studies the microfoundations of the government's policy). It is of some interest to explore, however, since one can imagine unmodeled "political economy" reasons for why it might be hard to eliminate policy distortions immediately as soon as the "emergency" defined by the deflationary shock is over.

Monetary policy follows the baseline specification (29). Using the method of undetermined coefficients, this implies that in period $t \geq \tau$, then $\tilde{Y}_t = \tilde{Y}^\omega\hat{\omega}_t$ and $\pi_t = \pi^\omega\hat{\omega}_t$ where $\tilde{Y}^w < 0$ and $\pi^w$ >0 are coefficients given by the proof of Proposition 5. A negative $\tilde{Y}^\omega$ establishes that the New Deal is contractionary in the long run. The following proposition also characterizes the conditions under which a New Deal is still expansionary in the short run.

**Proposition 5** *Suppose A1,* $\mu > 0$, *and that* $\hat{\omega}_t$ *follows (34)-(35) instead of (25)-(26). Then (i) the New Deal is contractionary in the long run (i.e., at t* $\geq\tau$*) as long as* $\delta > 0$ *and (ii) expansionary in the short run (i.e., at t* $<\tau$*) as long as* $\delta(1-\beta\mu)[1-\frac{1+\sigma\phi_y-\delta}{\phi_\pi-\delta}\frac{1}{1-\beta\mu}]\tilde{Y}^w + \frac{\sigma\mu\kappa\varphi}{1-\mu} > 0$.

Proof: See Appendix.

To understand the condition stipulated in Proposition 5, write the CE and FE equations in period $t < \tau$ as

$$CE \qquad \tilde{Y}_L = \mu\tilde{Y}_t + (1-\mu)Y^w\delta\omega_L + \sigma\mu\pi_L + \sigma(1-\mu)\pi^w\delta\omega_L + \sigma r_L^e \tag{36}$$

$$FE \qquad \pi_L = \kappa\tilde{Y}_L + \beta\mu\pi_L + \beta(1-\mu)\delta\pi^w w_L + \kappa\varphi\hat{\omega}_L \tag{37}$$

It is helpful to study panel (d) of Figure 4 to understand the different forces that guarantee that the New Deal is expansionary in the short run, even if contractionary in the long run. Observe first that when $\delta = 0$, the condition in the proposition is always satisfied and the New Deal is always expansionary as we found in Proposition 2. Consider now $\delta > 0$. The increase in the policy wedge has an effect on both the FE and CE equations. Consider first the FE equation. As we have emphasized before, the increase in $\hat{\omega}_L$ shifts the FE curve upward. With the additional prospect of higher inflation in period $t \geq \tau$ (corresponding to the third term on the right), this

[27] It seems clear, at least in retrospect, that some elements of the NIRA became relatively permanent fixtures of U.S. legislation, such as several labor laws covering unions. Observe, however, that even if some aspects of the NIRA became permanent, this does not suggest that the policy wedge $\omega_L$ was permanent since in some cases the Administration leaned on unions, facilitated by the legislation, to reduce labor markups (e.g., during WWII).

policy shifts the FE curve even further, thus working in favor of making the New Deal policy *even more expansionary*, as shown at point B in panel (d) in Figure 4. The effect on the CE equation, however, is ambiguous and depends on the value of $\phi_\pi$, $\phi_y$, and $\delta$. The second term on the right-hand side of the CE equation suggests that a persistent policy distortion reduces demand because it lowers expectations about future output at dates $t \geq \tau$. On the other hand, the fourth term on the right-hand side suggests persistent distortions increase demand because they increase inflation at dates $t \geq \tau$, thus reducing the real rate of interest at dates $t < \tau$. These two effects can either cancel each other (point B), reduce the expansion (point D), or even lead to a contraction (point C). Which effect is stronger?

If we assume a realistic value for $\phi_\pi$ and $\phi_y$, such as for example 1.5 and 0.25, the condition in Proposition 5 is satisfied for any $\delta$ under the baseline parameterization of the model. One has to assume extreme values in the parameter space to cause a short run contraction.[28] Hence we conclude that even if the New Deal is assumed to be persistent, this policy is still expansionary in the short run but contractionary in the long run.

# 7 Bayesian Calibration

While all the results in this paper are based on closed-form analytical solutions, it is useful to put some numbers on them for illustration. This is also useful for understanding if the model can replicate the data for reasonable parameters and shocks. To put some discipline on the calibration I choose parameters to maximize the posterior likelihood of the model using standard Bayesian methods as detailed below.

Figures 6-8 show annual data for inflation, output, and interest rates for the period 1929-37 in fiscal years with dashed lines.[29] The vertical line denotes when FDR came to power and announced the New Deal. As the figure illustrates, the data register a robust recovery in inflation and output with FDR's inauguration, while the nominal interest rate remains close to zero. The most interesting aspect of the calibration is to ask to what extent the New Deal can explain the recovery in output and inflation observed in data in 1933-37.

Observe first that an exogenous reversal in the shock $r_L^e$ to steady state cannot explain the recovery in the data, according to the model. The reason for this is that this theory of the recovery would imply an increase in the nominal interest rate, which contradicts the data. Accordingly we explore the extent to which New Deal can quantitatively account for the recovery observed in the data in 1933-37, keeping constant to shock $r_t^e$ in the low state $r_L^e$. Hence we attempt to explain the recovery *exclusively* through the observed change in policy.

[28] See section 7, which uses the data from 1929-33 to estimate the parameters of the model. Note that $\phi_\pi, \phi_y$, and $\delta$ are not identified in the estimation. For the New Deal to be contractionary note that even in the extreme case when $\phi_\pi \to \infty$, which eliminates the fourth term in the CE equation and makes persistent policies as contractionary as possible in the short run, we need a very high value for $\delta$ for the policy to be contractionary.

[29] Each fiscal year ends in June. Hence 1933 denotes June 1932 to June 1933. The data is taken from Eggertsson (2008).

The model is calibrated to match the period 1929-33 as closely as possible using Bayesian methods. The reason for choosing this narrow window is that several other policies were implemented in 1933-37, besides the National Industrial Recovery Act. These policies included an aggressive monetary and fiscal expansion and an abolishment of the gold standard. Since we are studying only one policy, I would be biasing the estimation in favor of the New Deal if the model is matched to the entire period under the assumption that NIRA was the only policy. Hence, choosing a narrow window of data stacks the cards against the quantitative success of the New Deal in explaining the recovery.

To replicate the data, we assume that in the period 1929-33 the equilibrium is given by Proposition 1, assuming that the economy was subject to the shock $r_L^e$ given by A1 starting in 1929. We assume that the shock stays in the $r_L^e$ state in 1929-37. We assume that the New Deal is implemented in 1933 as in Proposition 2, assuming that the coefficient $\phi_\omega$ is chosen optimally (see explicit derivation of the optimal $\phi_\omega$ in Proposition 7). We assume that the policy is unanticipated. The calibrated solution implied by Proposition 1 in 1929-33 and by Proposition 2 for 1933-37 is shown in Figures 6-8 denoted "mode."

Figures 6-8 show the mode of the calibration. The calibration suggests that the New Deal can explain about 55% of the recovery in output and 70% of the recovery in inflation comparing 1937 to 1933. In the absence of any policy, deflation would have continued, and output would have continued on a downward trajectory, reaching close to 40 percent away from its 1929 level in 1937, instead of registering the robust recovery seen in the data. This counterfactual history is shown by the line labelled "counterfactual" in the figures.

In the calibration, we need to determine the parameters $(\beta, \sigma, \theta, \nu, \alpha, \rho)$ (which in turn determine $\kappa$) and the shock process governed by $(r_L^e, \mu)$. Observe that because we assume that $r_t^e$ is in the low state we can treat $(r_L^e, \mu)$ as parameters in the model evaluation.[30] Denote the parameters by the vector $\Omega$, which is the object of choice in the model evaluation. The vector $\Omega$ satisfies condition A1 since the inequality in that condition is required for a bounded solution.[31] There is a random discrepancy between the data and the model so that $\pi_t^{model} = \pi_t^{data} + \epsilon_t^\pi$ and $\hat{Y}_t^{model} = \hat{Y}_t^{data} + \epsilon_t^Y$ where the $\epsilon$'s are iid and normally distributed shocks with variances $\sigma_{\pi,t}^2$ and $\sigma_{Y,t}^2$, usually referred to as "measurement errors" in the literature. The parameters are chosen to maximize the likelihood of observing the data, given the model. The choice of $\Omega$ is constrained by prior distributions about $\Omega$ that are meant to capture prior outside information as is standard in calibration exercises.[32] For example, the estimation would penalize heavily an "unrealistic"

[30] In principle we do not need to assume that $r_t^e$ is in the low state, but could instead derive this a as a result of the model evaluation if we include data on interest rates. Because $r_t^e$ in the high state would imply positive interest rates, the estimation would put very low probability on $r_t^e$ being in the high state according to the posterior of the model.

[31] In principle this is not needed but makes the computation easier. Parameter values that do not satisfy A1 yield values for inflation and output that are very different from the data and would thus be heavily penalized (if A1 the only solution of the model implies positive inflation and no contraction in output) . Hence parameter values that violate A1 would get very low weight according to the posterior of the model.

[32] Although it is often assumed that these are parameters as opposed to districution, which is why I term this

choice for price rigidities – of, say, expected duration of two years – or an extremely large value for the shock. The posterior of $\Omega$ is derived using standard Bayesian methods (see, e.g., An and Schorfeide [2007]) for the period 1929-33 using the data on output and inflation. The posterior likelihood is characterized analytically in Appendix B.

The priors, shown in Table 1, are chosen so that $\theta$ has a mean of 10 (consistent with markup of 10 percent), price rigidities are consistent with prices being adjusted on average once every three quarters, and $\beta$ is consistent with a 4 percent average annual interest rate. The distributions for the priors, along with 10-90 percentiles, are shown in Table 1. To form priors over $\sigma$ and $\nu$, the following functional form for utility is assumed:

$$U_t = \frac{(C_t - H_t^c)^{1-\tilde{\sigma}^{-1}}}{1-\tilde{\sigma}^{-1}} - \psi \int \frac{(l_t(i) - H_t^l)^{1+\tilde{\nu}}}{1+\tilde{\nu}} di$$

and the mean of the preference parameters $\tilde{\sigma}$ and $\tilde{\nu}$ is consistent with logarithmic utility in consumption and quadratic disutility of working, a common specification in the literature.[33] Since there is no general agreement about what value to assign to the habit-persistence parameter $\rho$, a uniform prior was chosen between 0 and 1. The rational for the priors is described further in Appendix B.

Table 1 shows the priors for the distribution of the parameters and shocks and compares with the posterior distributions, i.e., the implied distribution of each parameter taking into account the data. The posterior distribution is computed using a Metropolis-Hastings algorithm. The priors and posteriors for the parameters are relatively similar in Table 1, but with one exception. While the prior on the habit-persistence parameter is a uniform distribution from 0 to 1, the posterior is relatively tight with a relatively high estimated mode. This is because the model is completely forward looking with the exception of the habit-persistence parameter, which generates the inertial output movements in the figures. This parameter is doing all the work in making the output decline in 1929-33 gradual rather than immediate (without habits, output would have dropped right away in 1929 due to the assumption about a two-state Markov process for the shock).[34]

"Bayesian" calibration.

[33] Note that $\tilde{\sigma} = \frac{\sigma}{1-\rho}$ and $\tilde{\nu} = \nu(1-\rho)$.

[34] The calibrated parameters in Table 1 almost entirely conventional in the literature with the possible exception of the habit-persistence parameter, which is sligtly higher than is sometime assumed. Other studies, e.g. Smets and Wouters (2007), find that this parameter is closer to 0.7. The reason for this difference is that Smets and Wouters include several other real frictions that generate endogenous propogation, that we abstracted from for simplicity. Authors that assume a simple stucture such as the one here, i.e. a model without capital, also estimate a very high habit. Examples include Giannoni and Woodford [2004].

If we assume a point prior on the habit parameter of 0, then the output collapse is immediate, and the recovery is faster. None of the qualitative conclusions, however, rely on assuming habit persistence, although the quantitative results are sensitive to this specification. Choosing a point prior for any of the other parameters has a relatively small quantitative effect on any of the results. (For example, if we assume a point prior on prices being more flexible, e.g., $\alpha = 0.5$, this does not change the results reported in Figures (6)-(8) much, but does change the mode for the other parameters).

Figure 10 gives one way of thinking about sensitivity by showing 10 to 90 percent bands for the posterior distribution for output growth in the period 1934-37 using the simulated posterior of the model. The 10 to 90 percentiles of the posterior distribution of the parameters in Table 1 give an idea of the range of parameters that generate the different paths underlying the figure.[35] Overall, the figure suggests that the model is consistent with a relatively strong effect of the New Deal policies for the parameter distributions considered. The relatively weak priors imposed, however, do not allow us to conclude that the National Industrial Recovery Act was entirely responsible for the recovery (although this is close to being possible with some probability according to the simulation). Evidently more was needed, which suggests that other policies are needed for a full account of the recovery. This is consistent with Eggertsson (2008), who suggests that monetary and fiscal coordination in 1933 can explain the bulk of the recovery. This result thus suggests that the National Industrial Recovery Act may be the missing link. It remains an important task to jointly estimate the contribution of each policy.

The figures represent a best-case scenario for the New Deal provide an upper bound on its effectiveness. This is because in the calibration the wedge $\hat{\omega}_L$ is set at the optimal level assuming no other policy was in place during this period. Introducing monetary and fiscal policy would reduce the optimal level of $\hat{\omega}_L$ although we have already shown in Proposition 3 that this would not change the result qualitatively.

# 8 A Comparison to Cole and Ohanian's Results

This section compares the paper's results to Cole and Ohanian's (2004) results and clarifies the reasons for the differences. It also relates the findings to some other prominent papers in the literature. In contrast to this paper, Cole and Ohanian find that the New Deal was contractionary. A key assumption is that they assume that the shocks that caused the Great Depression in 1929-33 were largely over in 1933 (completely so in 1936) and then they compute the transition paths of the economy for given initial conditions. They show that the recovery, given these initial conditions, is slower than implied by the standard growth model and explain the slow recovery by the New Deal.

Figure 11 shows the evolution of output under the assumption that the shocks perturbing the economy have subsided in 1933,[36] using a parameterization of the model similar to Cole and Ohanian's (i.e., $\sigma = \nu = 1$ with no habit persistence [$\rho = 0$] and flexible prices [$\alpha = 0$]).[37] The

[35] Observe that the band is tight around 1933 because we chose the measurement error to be small at that time, because we wanted the model to match the output drop before the policy change as closely as possible.

[36] Cole and Ohanian assume that there there are some shocks in 1934 and 1935 but this is immaterial to the main point of the comparizon, however, so I do not incorporate them in the similation.

[37] If the central bank targets price stability, the assumed degree of price rigidities is irrelevant since there are no shocks and the sticky price model replicates the corresponding flexible price model. One may alternatively think of the simulation denoted "Cole-Ohanian" as coming from a flexible price model. Note that Cole and Ohanian's model also has some additional features that are abstracted from here, such as an endogenous capital stock. These features, however, are not essential to the point.

line denoted "Cole-Ohanian benchmark" shows that, in this case, the recovery is much faster than in the data. As has already been stressed, the prediction of the current model is consistent with Cole and Ohanian's result: Increasing monopoly power of firms and workers reduces output in the absence of deflationary shocks. In the absence of shocks, then output is equal to the natural rate of output, and shown in formula (28). The line denoted "Cole and Ohanian New Deal" uses formula (28) to compute the extent to which output contracts if the New Deal is implemented. In this simulation, we use the same value for $\hat{\omega}_L$ as in the simulations for our earlier figures. Figure 11 compares Cole and Ohanian's benchmark scenario with the benchmark from this paper with the line denoted "Eggertsson benchmark," using the parameter configurations described in the last section. We see that, in this case, the output continues to decline in the absence of the New Deal, so the question to answer is the opposite from that in Cole and Ohanian's paper. It is not why the recovery was so slow, but why the economy recovered at all. As the line "Eggertsson New Deal" shows, we observe that the New Deal contributed to the recovery while not completely explaining it.

The figure illustrates that the path for equilibrium output is similar across the two models. The difference mainly lies in the counterfactual. Which counterfactual is the relevant one? The answer to that question, in the context of this model, boils down to this: Were there intertemporal disturbances during this period that needed to be accommodated by inflationary policy? If the recovery in 1933-37 was due to the subsiding of negative shocks, the model has a clear prediction: The short term nominal interest rate should have *risen*, as can be seen by equation (19). Instead, interest rates stayed at zero throughout 1933-37, without creating significant inflationary pressures, as shown in Figure 8. This suggests continuing negative intertemporal disturbances during this period, according to the model.

Hence the key hypothesis this paper relies on is the presence of negative intertemporal disturbances throughout the period. According to this theory, the output collapse is explained by real rates failing to follow the "efficient rate of interest" in 1929-33, and hence real interest rates that are too high are the main culprit for the output collapse. The recovery is explained by the fact that real rates went down significantly due to policy changes in 1933. Figure 12 shows three estimates of short-term real rates that are consistent with this story. The first shows ex post real rates, the second ex ante real rates as measured by Cecchetti (1992) using term structure data, and the third ex ante rates as estimated by Hamilton (1992) using futures data.

All the estimates tell the same story, which is consistent with the current theory but contradicts the one suggested by Cole and Ohanian. Observe that while our theory requires real rates to go down significantly in 1933 to explain the recovery (and stay modestly negative in 1933-37), Cole and Ohanian's theory suggests that interest rates should have stayed at or above steady state during the recovery, and hence cannot explain the collapse in real rates. Panel (d) in Figure 12 compares the real rates predicted by this paper to the prediction of the model using Cole and Ohanian's parameterization.[38] It should be stressed, however, that the failure of RBC models to

[38] Note that in their paper they only report the predictions of the model for 1934-37, and hence I denote 1929-33 by a dashed line. Arguably the real rate should have jumped up even higher around the turning point, since then

match data on prices (e.g., factor prices, equity prices, and so on) is widely known in the literature and is not special to the data from the Great Depression. In this respect, the failure of Cole and Ohanian's model to match real interest rate data is not surprising.

Apart from the intertemporal shock, a key difference from Cole and Ohanian's work is the assumed degree of price rigidity. If prices were perfectly flexible, then the output would be equal to the natural rate of output. Thus when prices are perfectly flexible, the model delivers the same result as Cole and Ohanian's analysis, i.e., the New Deal policies reduced output. How sensitive are the results to the assumed degree of price rigidity? A well-known weakness of the Calvo pricing model is that it assumes that the frequency of price adjustment is constant and thus independent of policy. One may wonder to what extent the result changes if, for given value of the shocks and the other structural parameters, this frequency increases. Somewhat surprisingly, the quantitative result becomes even stronger as prices become more flexible. The formulas in (23) and (24) reveal the puzzling conclusion that the higher the price flexibility (i.e., the higher the parameter $\kappa$), the stronger the output collapse in the absence of the New Deal policies (this can also be seen in Figure 4, but a higher $\kappa$ results in a steeper FE curve). This is paradoxical because, when prices are perfectly flexible, output is constant.

The somewhat subtle forces at work here were first recognized by Tobin (1975) and De Long and Summers (1986). These authors show that more flexible prices can lead to the expectation of further deflation in a recession. If demand depends on expected deflation, as the CE equation in our model, higher price flexibility can lead to ever lower demand in recession, thus increasing output volatility. This dynamic effect, called the "Mundell effect," must be weighted against the reduction in the static output inflation trade-off in the AS curve due to higher price flexibility. In some cases, the Mundell effect can dominate, depending on the parameters of the model. Formula (24) in Proposition 1 indicates that the Mundell effect will always dominate at zero interest rates. This result indicates that higher price flexibility will make the New Deal policies even more beneficial in the model, since it attenuates the output collapse in their absence. Only in the very extreme case when prices are perfectly flexible does the result of the paper collapse, because in that case, by definition, the equilibrium output has to be equal to the natural rate of output.

The simulations reported in Figure 11 are also helpful for understanding the relationship between this paper and Bordo et al. (2000), who also assume nominal rigidities. If there are no shocks, the path of output in 1933-37 denoted "Cole and Ohanian" would in fact be identical even if we assume nominal rigidities, i.e. $\alpha > 0$, assuming the government targets zero inflation. This is because when there are no shocks the model with nominal frictions yields identical allocations as a flexible price model, since in this case output perfectly tracks the natural level of output. This suggests that under the assumption of no intertemporal shocks a model with nominal frictions

people started expecting higher future output. To the extent that people expected the contraction in 1929-33, this would have resulted in negative real interest rate during that period, another contradiction of the real interest rate predicted by the model relative to the data. Observe that Cole and Ohanian's model is more complex than the result from the simple model reported here, but the same points applies.

also predicts a decline in output for 1933-37 in response to the New Deal. This may explain the difference between the current paper and Bordo et al (2000) who assume no intertemporal shocks. My conjecture is that the same basic insight holds true for the more complicated model by Christiano et al. (2004).[39]

## 9 The New Deal as a Theory of the Optimal Second Best

So far we have studied the consequences of the New Deal policies assuming reduced-form policy functions, motivated by the historical record. In this section we derive the policy from "micro-foundations" and show that the New Deal is an interesting example of the "optimal second best" as defined by Lipsey and Lancester (1956). By microfoundations I mean that the equilibrium behavior of the government is derived from an explicit maximization problem.

To determine policy from microfoundations, we need to specify the objective of the government. It is assumed that the government maximizes the utility of the representative household. The household utility can be summarized by a second-order Taylor expansion yielding[40]

$$U_t \approx -\frac{1}{2}\sum_{t=0}^{\infty}\beta^t\{\pi_t^2+\lambda\tilde{Y}_t^2\}+t.i.p \tag{38}$$

where $t.i.p.$ denotes terms independent of policy and $\lambda = \kappa/\theta$.[41] This suggests that social welfare is maximized when inflation is stable at zero and the equilibrium output is constant at the efficient rate of output. A first best equilibrium is usually defined as a solution to a social planner's problem that does not impose some particular constraint of interest. The second best equilibrium is the solution to the social planner's problem when the particular constraint of interest is imposed.[42] In this paper it is the zero-bound constraint that gives rise to the second best planning problem.

**Definition 5** *The first best policy is a solution of a social planner's problem that does not take account of the zero bound on the short-term interest rate. The second best policy is a solution to a social planner's problem that takes the zero bound into account.*

The first best social planner's problem is to maximizes (38) subject to the CE equation (14) and FE equation (16), taking the process for $\{r_t^e\}$ as given. The second best social planner's problem

[39] That paper does have other shocks, but does not impose the zero bound directly. One needs to impose the zero bound to find an expansionary effect of the New Deal.

[40] As shown by Woodford (2003), given that I only characterize fluctuations in the endogenous variables to the first order, I only need to keep track of welfare changes to the second order.

[41] This follows from Propositions 6.1, 6.3, and 6.4 in Woodford (2003) with appropriate modifications of the proofs, taking into account the wedges and the habit-persistence parameters. For the proof of 6.1, we need the modification that $\Phi_y = 0$ because we expand around the fully efficient steady state and replace equation E.6 on p. 694. The rest follows unchanged.

[42] There are many examples of restrictions imposed on a social planner's problems that give rise to second best analysis, such as legal, institutional, fiscal, or informational constraints (see e.g. Mas-Colell, Winston and Green [1995]). The distinction between a first and a second best social planner's problem is not always sharp because it is not always obvious if a constraint makes a social planner's problem "second best" rather than "first best."

takes into account the zero-bound constraint (5) in addition to the CE and FE equations. It is obvious from (38) that the best the government can do is achieve $\pi_t = \tilde{Y}_t = 0$, which corresponds to the first best. We can now confirm the following result.

**Proposition 6** *Necessary conditions for implementing the first best solution in which $\tilde{Y}_t = 0$ and $\pi_t = 0$ are that the government sets its policy instruments so that*

$$i_t = r_t^e \tag{39}$$

$$\hat{\omega}_t = 0 \tag{40}$$

**Proof.** Substitute $\pi_t = 0$ and $\hat{Y}_t = 0$ into equation (14) $\Longrightarrow i_t = r_t^e$. Use $\pi_t = 0$ and $\tilde{Y}_t = 0$ in equation (16)$\Longrightarrow \hat{\omega}_t = 0$ ■

Condition (39) says that the nominal interest rate should be set equal to the efficient level of interest. There is no guarantee, however, that this number is positive, in which case this necessary condition has to be violated due to the zero bound on the short-term interest rate. This leads directly to the study of the optimal second best.

Before going further, it is interesting to observe that Proposition 6 gives one interpretation of the equilibrium policy (18) -(20). Suppose a policy maker interprets Proposition 6 by trying to achieve the necessary condition for the first best as closely as possible. This would imply setting $\hat{\omega}_t = 0$ at all times and then sets $i_t = r_t^e$ unless it is constrained by the zero bound, in which case it sets $i_t = 0$. This lead to an identical policy as that prescribed by the baseline policy.

To study optimal policy, one needs to take a stance on whether there are any additional restrictions on government policy beyond those prescribed by the private-sector equilibrium conditions. The central result of this section will be cast assuming that government conducts optimal policy from a forward looking-perspective (OFP) as in Eggertsson and Woodford (2003,2004). The optimal policy from a forward-looking perspective is the optimal commitment under the restriction that the policy can be set only as a function of the physical state of the economy. It can be interpreted as the "optimal policy rule" assuming a particular restriction on the form of the policy rule.

In the approximate sticky price equilibrium, there is only one physical state variable $r_t^e$. The definition of an optimal forward-looking policy is that it is the optimal policy commitment subject to the constraint that policy can only be a function of the physical state.

**Definition 6** *The optimal policy from a forward-looking perspective is a solution of a social planner's problem in which policy in each period depends only on the relevant physical state variables. In the approximated sticky price equilibrium the policy is a collection of functions $\pi(r^e), Y(r^e), \omega(r^e), i(r^e)$ that maximize social welfare.*

The proof of Proposition 7 in Appendix A writes out the social planners problem explicitly. The first part of the proposition shows that in period $t \geq \tau$ we obtain

$$\pi_t = \tilde{Y}_t = \hat{\omega}_t = 0 \tag{41}$$

and

$$i_t = r_t^e \tag{42}$$

In period $t < \tau$ the optimal plan satisfies the following first-order conditions with respect to $\pi_L$, $\hat{Y}_L, \omega_L$ and $i_L$, respectively,

$$\pi_L + (1 - \beta\mu)\psi_{1L} - \sigma\mu\psi_{2L} = 0 \tag{43}$$

$$\lambda\tilde{Y}_L - \kappa\psi_{1L} + \alpha\psi_{2L} = 0 \tag{44}$$

$$-\kappa\varphi\psi_{1L} = 0 \tag{45}$$

$$\sigma\psi_{2L} + \psi_{3L} = 0 \tag{46}$$

and the complementary slackness condition

$$i_L \geq 0,\ \psi_{3L} \geq 0,\ i_L\psi_{3L} = 0 \tag{47}$$

where $\psi_{1L}$, $\psi_{2L}$ and $\psi_{3L}$ are the Lagrangian multipliers associated with the FE, CE and ZB constraints.

Consider first the optimal-forward looking policy under the constraint that $\hat{\omega}_t = 0$, which is one of the conditions for the benchmark policy (so that (45) cannot be satisfied). The solution of the conditions above (replacing (45) with $\hat{\omega}_t = 0$) then takes exactly the same form as shown for the benchmark policy in (20) and (19), i.e. $\pi_t$ and $\tilde{Y}_t$ are given by (23) and (24) and $i_t = 0$. This suggest that the benchmark policy can be interpreted as the *optimal forward-looking policy under the constraint that the government cannot use $\hat{\omega}_t$ to stabilize output and prices.* Hence the OFP constrained by $\hat{\omega}_t = 0$ provides natural microfoundations for government behavior used to derive Proposition 1. One rationale for $\hat{\omega}_t = 0$ would be a "flawed economic theory" based upon a first best analysis such as the one in Proposition 6 if an economist draws the mistaken conclusion on its basis that the government should eliminate monopoly power of firms and workers at all times.

An important element of the OFP when $\hat{\omega}_t = 0$ is that the government is unable to commit to higher future money supply, i.e., to any inflation at date $t \geq \tau$. The reason for this is that the OFP says that policy commitments can only depend on the "state variables" of the economy, i.e. $r_t^e$. At time $t \geq \tau$ the state variable has reverted back to steady state. From period $\tau$ onwards, however, since the model is purely forward looking the policy cannot depend on past economic conditions. Since the government maximizes the utility function (38) from $\tau$ onwards, it can achieve this by setting inflation and the quasi growth rate of output to zero as in (41). Given this solution $i_t = 0$ in period $t < \tau$ which is the maximum monetary accommodation in that period. The result is the deflation spiral analyzed in section 5. This solution is identical to the Markov Perfect Equilibrium of the model (assuming $\hat{\omega}_t = 0$) and illustrates what Eggertsson (2006) coins the "deflation bias" of discretionary policy. The reason why this solution suggests a deflation bias is that the deflation and depression could largely be avoided by a commitment to low interest rate, inflation and an output boom in period $t \geq \tau$ of the form analyzed by Eggertsson and Woodford (2003). This commitment, however, is precluded by the assumption of either OFP or MPE. The government has, however, another policy instrument at it's disposal, namely $\hat{\omega}_t$.

Consider now the optimal second best solution in which the government can use both policy instruments. Observe first that $i_L = 0$. This leaves six equations with six unknowns ($\pi_L, \tilde{Y}_L, \omega_L, \psi_{1L}, \psi_{2L}, \psi_{3L}$) and equations (43)-(46) together with IS and AS equations) that can be solved to yield

$$\tilde{Y}_L = \frac{\sigma\delta_c}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_L^e < 0 \tag{48}$$

$$\pi_L = -\frac{\sigma^2\lambda\frac{\mu}{1-\mu}}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_L^e > 0 \tag{49}$$

$$\hat{\omega}_L = -\varphi^{-1}\frac{\sigma+\sigma^2\lambda\frac{\mu}{1-\mu}[1-\beta\mu]\kappa^{-1}}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_L^e > 0 \tag{50}$$

The central proposition of this section follows directly.

**Proposition 7** *The New Deal as a Theory of Second Best. Suppose the government is a purely forward-looking social planner and A1. If the necessary condition for the first best $i_t = r_t^e$ is violated due to the zero bound, so that $i_t > r_t^e$, then the optimal second best policy is that the other necessary condition $\hat{\omega}_t = 0$ is also violated, so that $\hat{\omega}_t > 0$.*

This proposition is a classic second best result. To cite Lipsey and Lancaster (1956): "The general theorem of the second best states that if one of the Paretian optimum conditions cannot be fulfilled, a second best optimum is achieved only by departing from all other conditions." Because $i_t \neq r_t^e$ the general theorem of the second best says that $\hat{\omega}_t \neq 0$.

What is perhaps surprising about Proposition 7 is not so much that both of the necessary conditions for the first best are violated but the way in which they are departed from. The proposition indicates that, to increase output, the government should *facilitate monopoly power of workers and firms to stimulate output and inflation,* i.e., $\hat{\omega}_t > 0$. This goes against the classic microeconomic logic that facilitating monopoly power of either firms and workers reduces output. Another noteworthy feature of the proposition is its unequivocal force. *The result holds for any parameter configuration of the model.*

Observe that the policy implied by OFP is identical to that used to derive Proposition 2 if we assume $\phi_\omega = -\varphi^{-1}\frac{\sigma+\sigma^2\lambda\frac{\mu}{1-\mu}[1-\beta\mu]\kappa^{-1}}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]}$. The OFP thus provides natural microfoundations for government policy under the New Deal. Appendix B illustrates that the Markov perfect equilibrium (MPE) of the model is almost identical to the OFP and provides alternative microfoundations for the government's behavior. The reason why I use the OFP instead is that an MPE is not based upon a well-defined social planning problem because it is a solution to a game between the current government and future governments, as further discussed in Appendix B, and is thus inappropriate to discuss second best policies. Appendix B also shows the Ramsey equilibrium, in which case the government can fully commit to future policy. As is well known in the literature, see, e.g., Eggertsson and Woodford (2003), an appropriate commitment to future monetary policy can to a large extent eliminate the deflation and output collapse associated with large deflationary shocks. But as shown in Eggertsson (2006), this policy suffers from a several dynamic inconsistency problem (unlike the New Deal policy illustrated here). Appendix B shows, however, that even in the extreme case when the government can fully commit to future monetary policy, a New Deal is still optimal as a second best policy, i.e., it is optimal to increase monopoly power in periods $0 < t < \tau$. It's effect on output, however, is quantitatively smaller.

# 10 Conclusion

This paper shows that an increase in the monopoly power of firms or workers unions can increase output. This theoretical result may change the conventional wisdom about the general equilibrium effect of the National Industrial Recovery Act during the Great Depression in the U.S. It goes without saying that this does not indicate that these policies are expansionary under normal circumstances. Indeed, the model indicates that facilitating monopoly power of unions and firms reduces output in the absence of shocks leading to inefficient deflation. It is only under the condition of excessive deflation and an output collapse that these policies are expansionary. The historical record suggests that there was at least some understanding of this among policy makers during the Great Depression. The NIRA was always considered a temporary recovery measure due to the emergency created by the deflationary spiral observed in the 1929-33 period. This result provides a new perspective on a policy that has been frowned upon by economists for the past several hundred years, dating at least back to Adam Smith who famously claimed that the collusion of monopolies to prop up prices was a conspiracy against the public.

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## Appendix A: Propositions and Proofs

Section 3 cites two propositions in the text, one that derives the efficient wedges and a second that characterizes the efficient steady state around which we approximate the model. They follow below.

**Proposition 8** *In the efficient equilibrium, the government sets* $\frac{1+\omega_{1t}}{1-\omega_{2t}} = \frac{\theta-1}{\theta}$ *and output is a constant,* $Y_t^e = Y^e$*, determined by (11), assuming an initial condition* $Y_{-1} = Y^e$*.*

**Proof.** The constraints (2), (5), and (6) play no role apart from determining the nominal prices, and real and nominal interest rates are thus redundant in writing the social planner's problem.[43] The Lagrangian for optimal policy can thus be written as

$$E_0 \sum_{t=0}^{\infty} \beta^t \{u(Y_T - \rho Y_{t-1})\xi_t - v(Y_t - \rho Y_{t-1})\xi_t + \psi_{1t}\{\frac{\theta-1}{\theta} - \frac{1+\omega_{1t}}{1-\omega_{2t}} \frac{v_{l,t}}{u_{c,t}}\}.$$

The first-order condition with respect to $Y_t$ can be written as

$$u_{c,t}\xi_t - v_{l,t}\xi_t - \beta\rho E_t(u_{c,t+1} - v_{l,t+1})\xi_{t+1} - \psi_{1t}\frac{\partial \frac{1+\omega_{1t}}{1-\omega_{2t}}\frac{v_{l,t}}{u_{c,t}}}{\partial Y_t} + \rho\beta\psi_{1t+1}\frac{\partial \frac{1+\omega_{1t+1}}{1-\omega_{2t+1}}\frac{v_{l,t+1}}{u_{c,t+1}}}{\partial Y_{t+1}}$$

where I have used the form of the utility function to substitute out for the derivative of $\partial Y_t$ in terms of $\partial Y_{t+1}$ so that I can forward this equation. Forwarding and using $0 < \beta\rho < 1$, and assuming a bounded solution, we obtain

$$u_{c,t}\xi_t - v_{l,t}\xi_t - \psi_{1t}\frac{\partial \frac{1+\omega_{1t}}{1-\omega_{2t}}\frac{v_{l,t}}{u_{c,t}}}{\partial Y_t} = 0 \quad (51)$$

The first-order conditions with respect to $\omega_{1t}$ and $\omega_{2t}$ say that

$$\psi_{1t} = 0 \quad (52)$$

Substituting this into (51), we obtain that $\frac{v_{l,t}}{u_{c,t}} = 1$. Substitute this into (11) to obtain $Y_t^e - \rho Y_{t-1}^e = \tilde{Y}$ where $\tilde{Y}$ is a unique constant. The initial condition implies the result. ■

**Proposition 9** *If there are no shocks such that $\xi_t = \bar{\xi}$, then in a sticky price equilibrium (i) a social planner can achieve the efficient equilibrium by selecting $i_t = 1/\beta - 1$ and $\frac{1+\omega_{1t}}{1-\omega_{2t}} = \frac{\theta-1}{\theta}$ and ensure that $P_{t+1} = P_t = \bar{P}$, $Y_t = Y_t^n = Y_t^e$ and (ii) the efficient equilibrium is the optimal allocation.*

**Proof.** To prove the first part, observe that if $P_t = \bar{P}$ for all $t$, then $p_t^* = P_t$. This implies that condition (12) is identical to (11) so that the sticky price allocation solves the same set of equations as the flexible price allocation. Then the first part of the proposition follows from Proposition 8. The second part of this proposition can be proved by following the same steps as Benigno and Woodford (2003) (see Appendix A.3 of their paper). They show a deterministic solution of a social planner's problem that is almost identical to this one, except that in their case the wedge is set to collect tax revenues. ■

The following propositions were stated in the text, and the proofs follow:

**Proposition 4** Suppose that monetary policy is given by (29), fiscal policy by (30) and (31), and the New Deal by (25)-(26) and that A1 holds. Then (i) for any monetary policy $\pi^* \geq 0$, and fiscal policy $\hat{G}_L > 0$ the New Deal is expansionary if A2 (ii) If $i_t = 0$ in $0 \leq t < \tau$ then monetary and fiscal policy satisfy A2.

[43] This can be shown formally by adding the constraints to the Lagrangian problem and show that the Lagrance multipliers of these constraints are zero.

**Proof.** Start by deriving A2, the condition for positive interest rates. Assuming $i_L > 0$, then $i_L = r_L^e + \pi^* + \phi_\pi(\pi_L - \pi^*) + \phi_y(\tilde{Y}_L - Y^*)$. Substituting this into the CE equation and solving the CE and FE equations together we obtain

$$Y_L - Y^* = -\frac{\sigma(\phi_\pi - \mu)\kappa\psi}{(1-\mu+\sigma\phi_y)(1-\mu\beta)+\kappa\sigma(\phi_\pi-\mu)}\omega_L + \frac{(1-\mu)(1-\beta\mu)}{(1-\mu+\sigma\phi_y)(1-\beta\mu)+\kappa\sigma(\phi_\pi-\mu)}\hat{G}_L$$

$$\pi_L - \pi^* = \frac{(1-\mu)\kappa}{1-\beta\mu+\kappa\sigma(\phi_\pi-\mu)}\hat{G}_L + \frac{\kappa\psi(1-\mu+\sigma\phi_y)}{1-\mu\beta+\kappa\sigma(\phi_\pi-\mu)}\omega_L$$

which defines $Y^G \equiv \frac{(1-\mu)(1-\beta\mu)}{(1-\mu+\sigma\phi_y)(1-\beta\mu)+\kappa\sigma(\phi_\pi-\mu)}$ and $\pi^G \equiv \frac{(1-\mu)\kappa}{1-\beta\mu+\kappa\sigma(\phi_\pi-\mu)}$. Substituting this solution into the policy rule (29), we see that for $\omega_L \geq 0$ then A2 has to be satisfied, which proves part (ii) of the proposition. Consider now the first part of the proposition. If A2, then interest rates are zero and solving the CE and FE equation gives

$$\begin{aligned}(\tilde{Y}_L - \tilde{Y}^*) \quad = \quad & \frac{\kappa\psi}{(1-\mu)(1-\beta\mu)-\sigma\mu\kappa}\omega_L + \frac{(1-\beta\mu)\sigma}{(1-\mu)(1-\beta\mu)-\sigma\mu\kappa}\pi^* \\ & + \frac{(1-\beta\mu)(1-\mu)}{(1-\mu)(1-\beta\mu)-\sigma\mu\kappa}\hat{G}_L + \frac{\sigma(1-\beta\mu)}{(1-\mu)(1-\beta\mu)-\sigma\mu\kappa}r_L^e\end{aligned}$$

and

$$(\pi_L - \pi^*) = \frac{1}{1-\beta\mu}[\kappa(Y_L - Y^*) + \kappa\psi\omega_L]$$

which proves part (i). ■

**Proposition 6** *Suppose A1 and that $\omega_t$ follows (35) instead of (25)-(26). Then (i) the New Deal is contractionary in the long run (i.e at $t \geq \tau$) as long as $\delta > 0$ and (ii) expansionary in the short run (i.e., at $t < \tau$) as long as $\delta(1-\beta\mu)[1 - \frac{1+\sigma\phi_y-\delta}{\phi_\pi-\delta}\frac{1}{1-\beta\mu}]Y^w + \frac{\sigma\mu\kappa\varphi}{1-\mu} > 0$.*

**Proof.** For solution at $t \geq \tau$, substitute $\tilde{Y}_t = \tilde{Y}^w\omega_t, \pi_t = \pi^w\omega_t$ into $\tilde{Y}_t = \tilde{Y}_{t+1} - \sigma\phi_\pi\pi_t - \sigma\phi_y\tilde{Y}_t + \sigma\pi_{t+1}$, $\pi_t = \kappa\tilde{Y}_t + \beta\pi_{t+1} + \kappa\varphi\omega_t$ using $\omega_t = \delta\omega_{t-1}$ and match coefficients to yield $\tilde{Y}^w = -\frac{\varphi}{1+\frac{(1-\beta\delta)(1+\sigma\phi_y-\delta)}{\kappa\varphi\sigma(\phi_\pi-\delta)}} < 0$, $\pi^w = \frac{(1+\sigma\phi_y-\delta)\kappa\varphi}{[(1-\beta\delta)(1+\sigma\phi_y-\delta)+\kappa\sigma(\phi_\pi-\delta)]} > 0$. Note that for $\omega_t$ to be positive at $t \geq \tau$ we need $\delta > 0$. This proves the first part of the proposition. To prove the second part of the proposition, substitute this into the CE and FE equation for $t \leq \tau$

$$Y_L = \mu Y_L + (1-\mu)Y^w\delta\omega_L + \sigma\mu\pi_L + \sigma(1-\mu)\pi^w\delta\omega_L + \sigma r_L$$

$$\pi_L = \kappa Y_L + \beta\mu\pi_L + \beta(1-\mu)\pi^w\delta\omega_L + \kappa\varphi\omega_L$$

solving these together to yield

$$Y_L = \frac{(1-\beta\mu)\sigma}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}r_L + \{\frac{(1-\mu)(1-\beta\mu)\delta[1-\frac{1+\sigma\phi_y-\delta}{\phi_\pi-\delta}]}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}Y^w + \frac{\sigma\mu[\beta(1-\mu)\pi^w\delta+\kappa\varphi]}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\}\omega_L$$

Manipulating the term in the curly bracket, using the expression for $\pi^w$, proves the result. ■

**Proposition 7** *The New Deal as a Theory of Second Best. Suppose the government is a purely forward-looking social planner and A1. If the necessary condition for the first best $i_t = r_t^e$ is violated due to the zero bound, so that $i_t > r_t^e$, then the optimal second best policy is that the other necessary condition $\hat{\omega}_t = 0$ is also violated, so that $\hat{\omega}_t > 0$.*

**Proof.** The proof follows directly from (48)-(50), which in turn follow from (41)-(47) This proof shows how one can derive the latter set of conditions from a social planners problem. The social planner's problem at date $t$ is

$$\min_{\pi(r^e),\hat{Y}(r^e),\hat{\omega}(r^e),i(r^e)} E_t \sum_{T=t} \beta^{T-t}\{\pi_T^2 + \lambda \tilde{Y}_T^2\}$$
$$\text{s.t. (5), (14), (16)}$$

The minimization problem can be solved by forming the Lagrangian

$$\begin{aligned} L_0 \quad = \quad & E_0 \sum_{t=0}^{\infty} \beta^t \{\frac{1}{2}\pi(r_t^e)^2 + \frac{1}{2}\lambda \tilde{Y}(r_t^e) + \psi_1(r_t^e)[\pi(r_t^e) - \kappa \tilde{Y}(r_t^e) - \kappa\varphi\hat{\omega}(r_t^e) - \beta\pi(r_{t+1}^e)] \\ & \psi_2(r_t^e)[\tilde{Y}(r_t^e) - \tilde{Y}(r_{t+1}^e) + \sigma i(r_t^e) - \sigma\pi(r_t^e) - \sigma r_t^e] + \psi_3(r_t^e) i(r_t^e)\} \end{aligned} \quad (53)$$

where the functions $\psi_i(r^e)$, $i = 1, 2, 3$, are Lagrangian multipliers. Under $A1$, $r_t^e$ can take only two values. Hence each of the variables can take only on one of two values, $\pi_L, \tilde{Y}_L, i_L, \omega_L$ or $\pi_H, \tilde{Y}_H, i_H, \omega_H$. I find the first-order conditions by setting the partial derivative of the Lagrangian with respect to these variables equal to zero. In A1, it is assumed that the probability of the switching from $r_H$ to $r_L$ is "remote," i.e., arbitrarily close to zero. The Lagrangian used to find the optimal value for $\pi_H, \tilde{Y}_H, i_H, \hat{\omega}_H$ (i.e., the Lagrangian conditional on being in the H state) can be simplified to yield[44]

$$L_0 = \frac{1}{1-\beta}\{\frac{1}{2}\pi_H^2 + \frac{1}{2}\lambda\tilde{Y}_H + \psi_{1H}((1-\beta)\pi_H - \kappa\tilde{Y}_H - \kappa\varphi\hat{\omega}_H) + \psi_{2H}(i_H - \pi_H - r_H) + \psi_{3H} i_H\}$$

It is easy to see that the solution to this minimization problem is

$$\pi_H = \tilde{Y}_H = \hat{\omega}_H = 0 \quad (54)$$

and that the necessary conditions for achieving this equilibrium (in terms of the policy instruments) are that

$$i_H = r_H \quad (55)$$

$$\hat{\omega}_H = 0. \quad (56)$$

which gives us conditions (41) and (42) in the text. Taking this solution as given and substituting it into equations (14) and (16), the social planner's feasibility constraints in the states in which $r_t^n = r_L$ are

$$(1-\beta\mu)\pi_L = \kappa\tilde{Y}_L + \kappa\varphi\hat{\omega}_L$$

[44] In the Lagrangian, we drop the terms involving the L state because these terms are weighted by a probability that is assumed to be arbitrarily small.

$$(1-\mu)\tilde{Y}_L = -\sigma i_L + \sigma\mu\pi_L + \sigma r_L^e)$$

$$i_L \geq 0$$

Consider the Lagrangian (53) given the solution (54)-(56). There is a part of this Lagrangian that is weighted by the arbitrarily small probability that the low state happens (which was ignored in our previous calculation). Conditional on being in that state and substituting for (54)-(56) the Lagrangian at a date $t$ in which the economy is in the low state can be written as:

$$\begin{aligned} L_t &= E_t \sum_{T=t}^{\infty} \beta^{T-t} \{ \frac{1}{2}\pi(r_T^e)^2 + \frac{1}{2}\lambda\tilde{Y}(r_T^e) + \psi_1(r_T^e)[\pi(r_T^e) - \kappa\tilde{Y}(r_T^e) - \kappa\varphi\hat{\omega}(r_T^e) - \beta\pi(r_{T+1}^e)] \\ &\quad + \psi_2(r_T^e)[\tilde{Y}(r_T^e) - \tilde{Y}(r_{T+1}^e) + \sigma i(r_T^e) - \sigma\pi(r_T^e) - \sigma r_T^e] + \psi_3(r_T^e) i(r_T^e)\} \\ &= \frac{1}{1-\beta\mu}\{\frac{1}{2}\pi_L^2 + \frac{1}{2}\lambda\tilde{Y}_L^2 \\ &\quad + \psi_{1L}((1-\beta\mu)\pi_L - \kappa\tilde{Y}_L - \frac{\kappa}{\sigma^{-1}+\upsilon}\hat{\omega}_L) \\ &\quad + \psi_{2L}((1-\mu)\tilde{Y}_L + \sigma i_L - \sigma\mu\pi_L - \sigma r_L^n) + \psi_{3L} i_L\} \end{aligned}$$

Differentiating this Lagrangian yields conditions (43)-(47). ■

# Appendix B: Bayesian Calibration

## B.1 Likelihood and priors

Under the assumption about the random discrepancy between the model and the data specified in the text the log of the posterior likelihood of the model is

$$\log L = \sum_{t=1929}^{1933} -\frac{(\pi_t^{model} - \pi_t^{data})^2}{2\sigma_{\pi,t}^2} - \frac{(Y_t^{model} - Y_t^{data})^2}{2\sigma_{Y,t}^2} + \sum_{\psi_s\in\Omega} f(\psi_s) \tag{57}$$

where $Y_t^{model}$ and $\pi_t^{model}$ are given by (24) and (23). I write the likelihood conditional on the hypothesis that the shock $r_L$ is in the "low state." Observe that the data are in annual frequencies, while the model is parameterized in quarterly frequencies. The mapping between the quarterly observation of the model and the annual data is a straight-forward summation (e.g., $\pi_t^{model}$ is the sum of inflation over four quarters in the model). The functions $f(\psi_s)$ measure the distance of the variables in $\Omega$ from the priors imposed where the parameters and shocks are denoted $\psi_s \in \Omega$. The distance functions $f(\psi_s)$ are given by the statistical distribution of the priors listed in Table 1. I use gamma distribution for parameters that are constrained to be positive and beta distribution for parameters that have to be between 0 and 1.

The priors for the parameters were already explained in the text. The priors for the shocks, however, are chosen as follows. It is assumed that the mean of the shock $r_L^e$ in the low state is equivalent to a 2 standard deviation shock to a process fitted to ex ante real interest rates in post-war data. While ex ante real rates would be an accurate measure of the efficient rate of interest only in the event output was at its efficient rate at all times, this gives at least some sense of a reasonably "large" shock as a source of the Great Depression. The prior on the persistence of the shock is that it is expected to reach steady state in 10 quarters, which is consistent with the stochastic process of estimated ex ante real rates. It also seems reasonable to suppose that in the midst of the Great Depression people expected it to last for several years. All these priors are specified as distributions, and Table 1 gives information on this. Observe that the values of $\sigma^2_{\pi,t}$ and $\sigma^2_{Y,t}$ measure how much we want to match the data against the priors. I choose it to be $\sigma_\pi = \sigma_Y = 0.1$, for all but one periods, so that the one standard deviation in the epsilon leads to a 10 percent discrepancy between the model and the data. For 1933, however, I assumed that the measurement error is 0.01. I assumed this because I wanted the model to match the deflation and output collapse just prior to the New Deal as closely as possible. since the main emphasize of the paper is to understand the effect of the policy around the turning point of the Great Depression.

The estimated parameters in Table 1 are almost entirely conventional in the literature with the exception of the habit-persistence parameter, which is relatively high, although there are some examples in the literature that estimate such high degree of habit persistence (see, e.g., Giannoni and Woodford [2004]). If we assume a point prior on the habit parameter of 0, then the output collapse is immediate, and the recovery is also much faster than seen in the data. None of the qualitative conclusions, however, rely on assuming habit persistence, although the quantitative results are sensitive to this specification. Choosing a point prior for any of the other parameters has a relatively small quantitative effect on any of the results. (For example, if we assume a point prior on prices being more flexible, e.g., $\alpha = 0.5$, this does not change the results reported in Figures (6)-(8) much, but does change the mode estimated for the other parameters).

### B.2 Markov chain Monte Carlo algorithm for simulating the posterior

We use a Metropolis algorithm to simulate the posterior distribution (57) . Let $y^T$denote the set of available data and $\Omega$ the vector of coefficients and shocks. Moreover, let $\Omega^j$ denote the jth draw from the posterior of $\Omega$. The subsequent draw is obtained by drawing a candidate value, $\tilde{\Omega}$, from a Gaussian proposal distribution with mean $\Omega^j$ and variance sV. We then set $\Omega^{(j+1)} = \tilde{\Omega}$ with probability equal to

$$\min\{1, \frac{p(\Omega/y^T)}{p(\Omega^j/y^T)}\}$$

If the proposal is not accepted, we set $\Omega^{(j+1)} = \Omega^j$.

The algorithm is initialized around the posterior mode, found using a standard Matlab maximization algorithm. We set $V$ to the inverse Hessian of the posterior evaluated at the mode, while $s$ is chosen in order to achieve an acceptance rate approximately equal to 25 percent. We run two chains of 100,000 draws and discard the first 20.000 to allow convergence to the ergodic distribution.

## Appendix C-E

Please see attachment or http://www.ny.frb.org/research/economists/eggertsson/papers.html.

| Parameters | Distributions | Priors | | | Posteriors | | | Mode |
|---|---|---|---|---|---|---|---|---|
| | | 10% | 50% | 90% | 10% | 50% | 90% | |
| $\alpha$ | Beta | 0.527 | 0.665 | 0.786 | 0.558 | 0.656 | 0.759 | 0.657 |
| $\beta$ | Beta | 0.983 | 0.991 | 0.996 | 0.983 | 0.990 | 0.996 | 0.990 |
| $\mu$ | 1-Beta | 0.832 | 0.908 | 0.958 | 0.894 | 0.933 | 0.962 | 0.930 |
| $\tilde{\nu}$ | Gamma | 0.436 | 0.918 | 1.670 | 0.345 | 1.348 | 2.017 | 0.728 |
| $r_L^e$ | Beta | -2.527 | -1.974 | -1.507 | -2.615 | -1.973 | -1.539 | -1.926 |
| $\rho$ | Uniform | 0.100 | 0.500 | 0.900 | 0.823 | 0.890 | 0.943 | 0.924 |
| $\tilde{\sigma}$ | Gamma | 0.874 | 0.997 | 1.130 | 0.890 | 1.012 | 1.143 | 0.972 |
| $\theta$ | Gamma | 6.399 | 9.702 | 13.986 | 6.497 | 9.827 | 14.408 | 10.1688 |

Figure 1: Table 1: Priors and Posteriors. All parameters are reported on quarterly basis, except for $r_L^e$ which is reported in annual percentage terms.

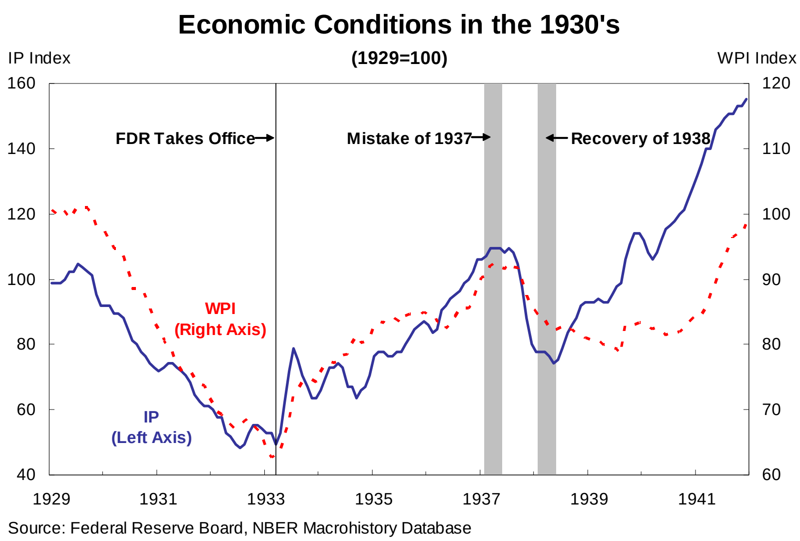


Figure 2: Both whole-sale prices (WPI) and industrial production (IP) collapsed in 1929-33 but abruptly started to recover in March 1933, when FDR took power and announced the New Deal.

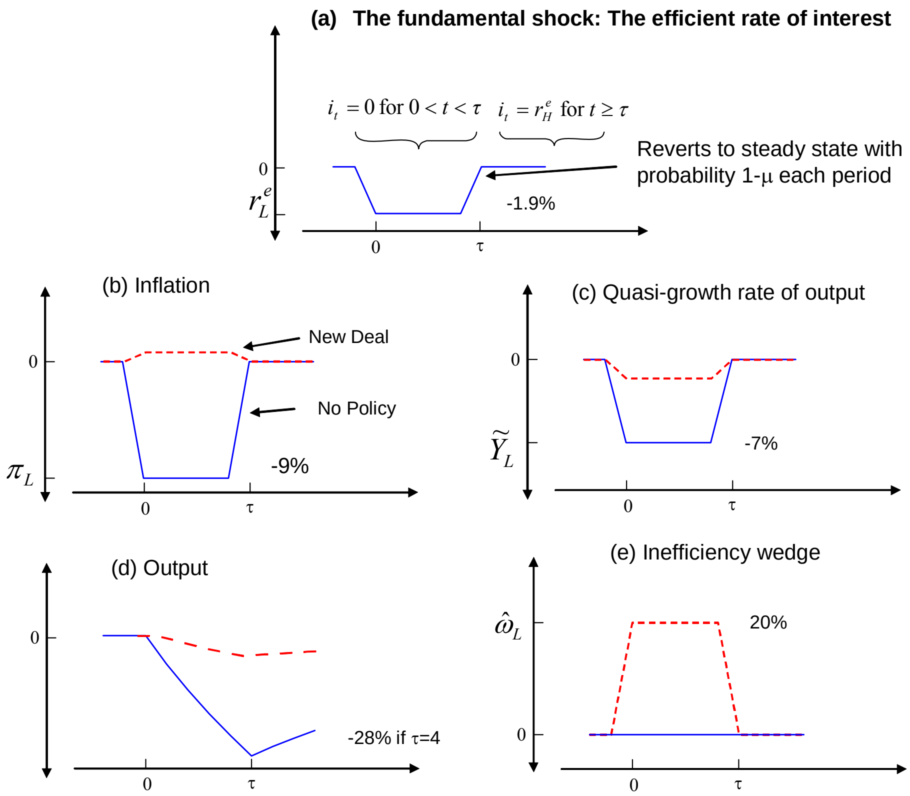


Figure 3: Comparing the equilibrium under the New Deal and no policy.

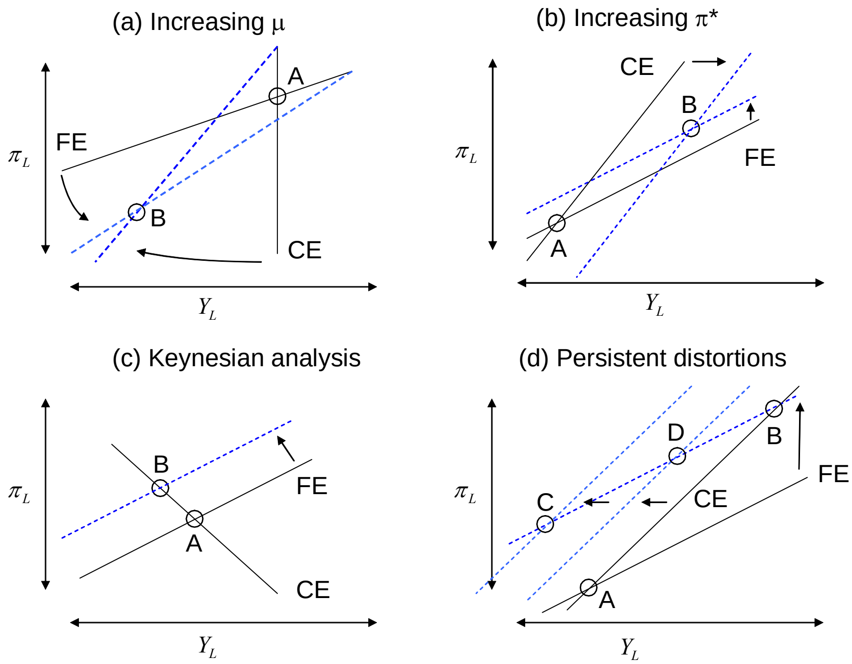


Figure 4: Comparative statics.

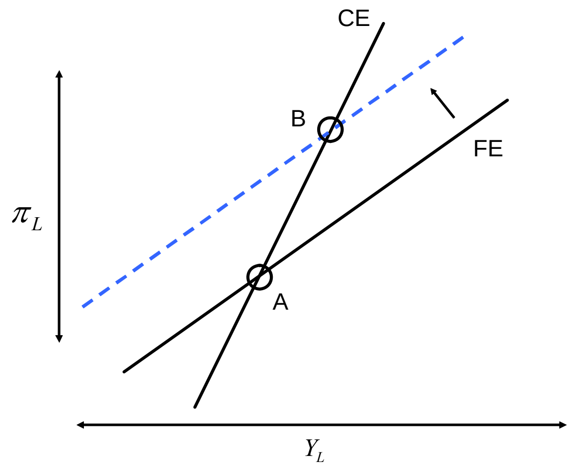


Figure 5: The main result: The New Deal is expansionary in the model.

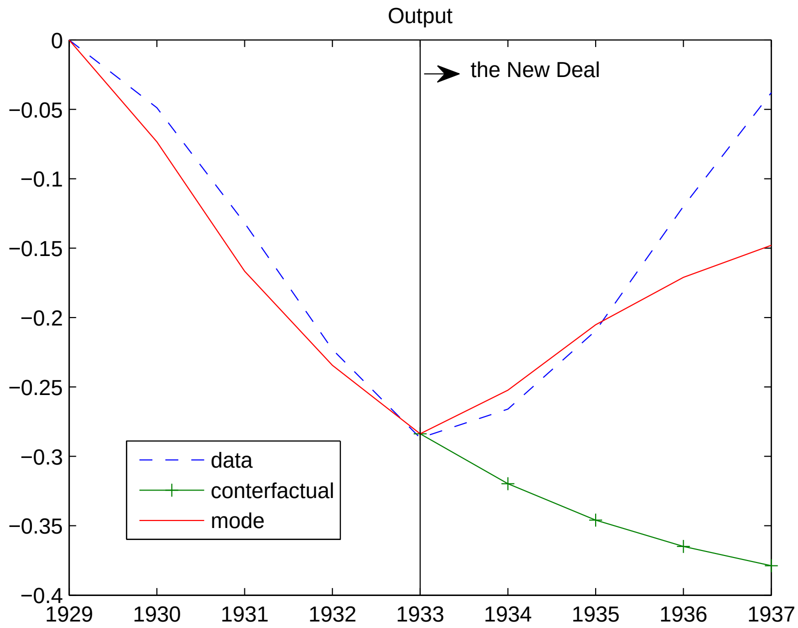


Figure 6: Data on output and simulated output from the model with and without the New Deal (NIRA).

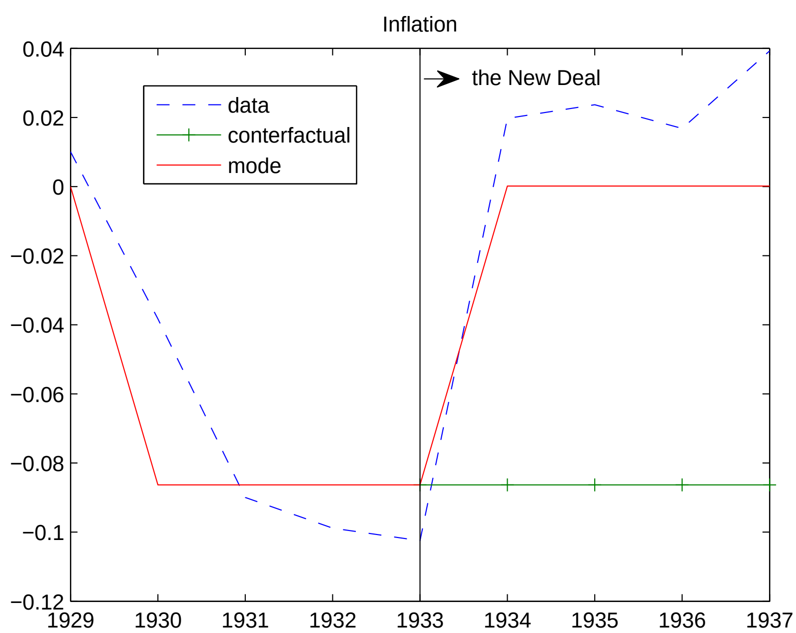


Figure 7: Data on inflation and simulated inflation from the model with and without the New Deal (NIRA).

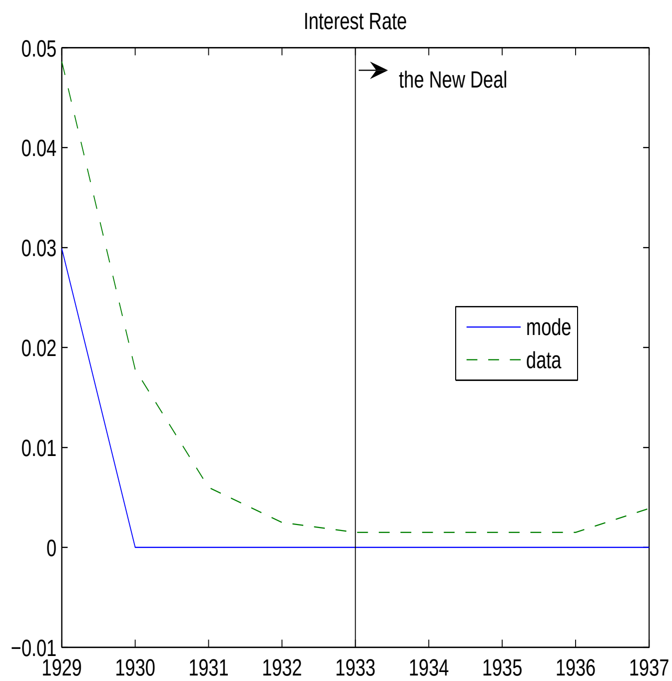


Figure 8: Short term interest rates from the data and the simulated model.

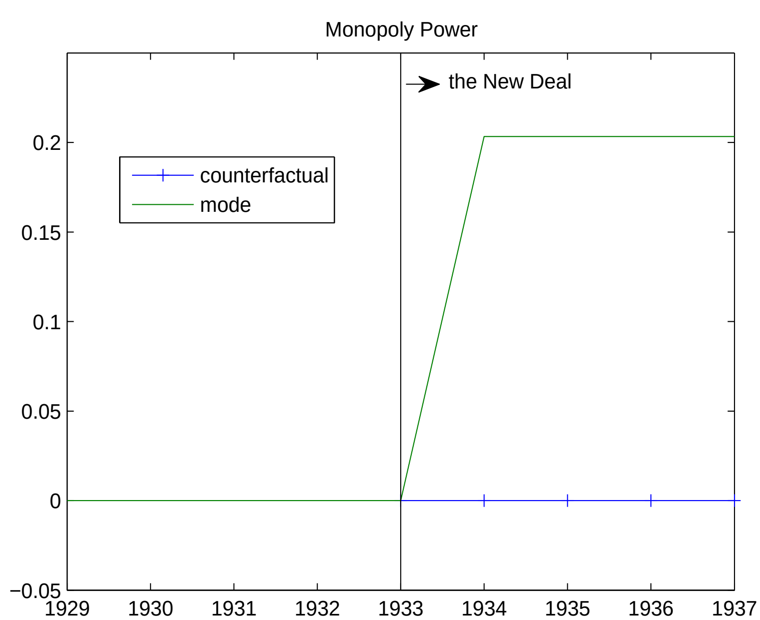


Figure 9: Simulated rise in monopoly power from the model associated with the New Deal (NIRA).

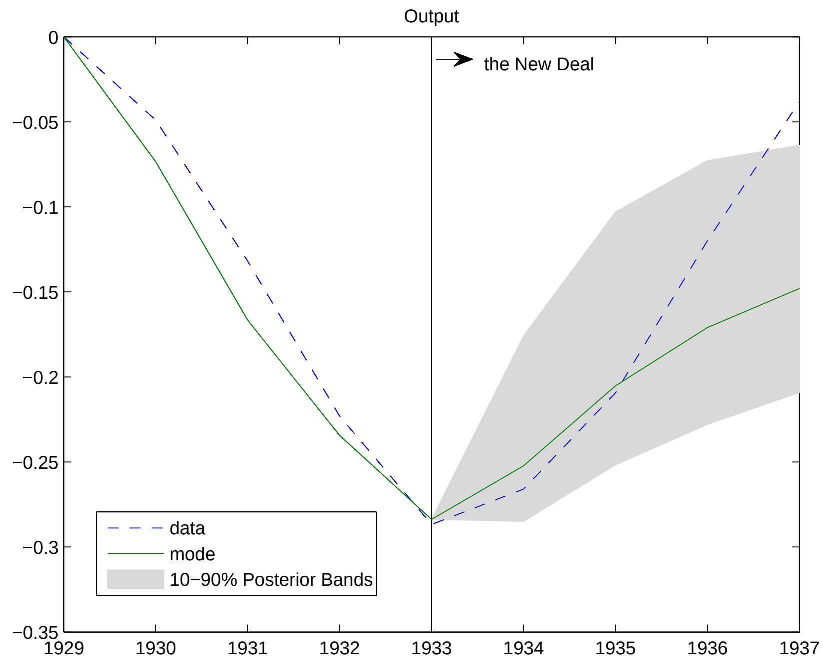


Figure 10: Predicted effect of the New Deal, taking into account uncertaitly of the underlying shocks and parameters.

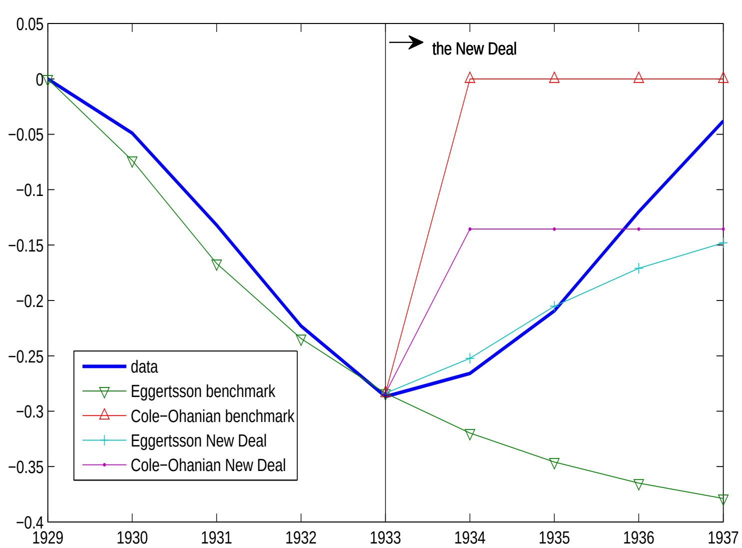


Figure 11: Comparison to Cole and Ohanian's (2004) results.

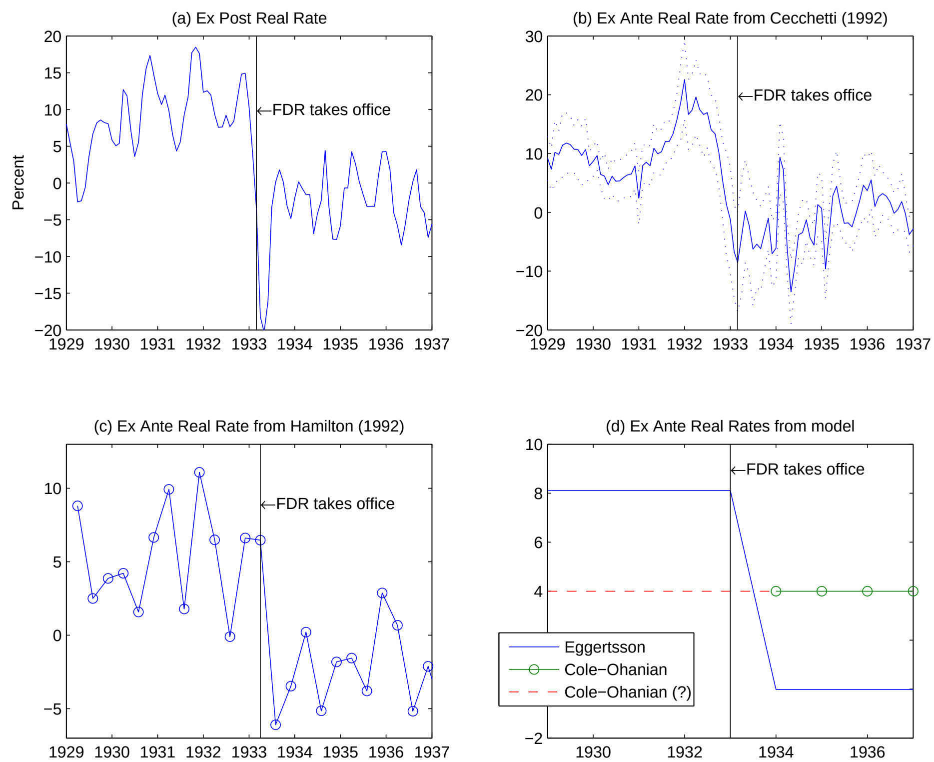


Figure 12: Real interest rates collapsed around the implementation of the New Deal consistent with the theory of the paper.

## Appendix C: Notes on Alternative Nominal Frictions (not intended for publication)

The purpose of these notes is to ask whether the main result is sensitive to the source of nominal rigidities. In the paper we assumed that prices were rigid, while wages were perfectly flexible. Keynes originally focused on wage rigidities as opposed to rigid prices, and some of the literature, such as the paper by Bordo et al (2000) assumes that wages are rigid, while prices are flexible. Section C.1 shows that the results of the paper are unchanged if prices are perfectly flexible but wages are set in a staggered way. Section C.2 shows that the same applies under another common specification for nominal rigidities. My conjecture is that a similar results are likely to be found in any model with nominal rigidities, because any theory of nominal rigidities that I am aware of will result in an upward sloping FE curve, i.e. there will be a positive relationship between inflation and output, and the New Deal will shift this relationship upward in a output inflation space. This conjecture is further discussed in section C.3

### C.1 Rigid Wages

This section incorporates wage rigidities, following the work of Erceg, Henderson and Levin (2000). The exposition follows chapter 4.1 in Woodford (2003). The basic structure of the model is the same as the text but with some modification in the wage setting as outlined below. The production function of each firm is no longer given by (7) but instead by

$$y_t(i) = L_t(i),$$

where $L_t(i)$ is a CES of the individual labor types of labor supply

$$L_t(i) \equiv \left[ \int_0^1 l_t(i,j)^{(\theta_w - 1)/\theta_w} dj \right]^{\theta_w/(\theta_w - 1)} \tag{58}$$

where $l_t(i,j)$ is the labor of type $j$ hired by firm $i$. It follows that the aggregate demand for labor of type $j$ on the part of wage-taking firms is given by

$$L_t(j) = L_t(\frac{W_t(j)}{W_t})^{-\theta_w}$$

where $L_t$ is aggregate labor demand (because there is continuum of firms of measure 1 then $L_t = L_t(j)$), $W_t(j)$ is the wage of labor of type $j$, and $W_t$ is the aggregate wage Dixit-Stiglitz index

$$W_t \equiv \left[ \int_0^1 W_t(j)^{1-\theta_w} di \right]^{\frac{1}{1-\theta_w}}$$

Once again conditions (2),(3), (4), (5) are required for a rational expectation equilibrium consistent with households maximization. Note, however, that condition (8), derived by the household optimal labor supply, is not included in this list. This is because we now assume nominal frictions in the wage setting. More specifically we assume that the wage for each type of labor is set by the monopoly supplier of that type of labor, who then stands ready to supply as many hours of work as turns out the be demanded at that wage. We assume independent wage setting decision of each type $j$, made under the assumption that the choice of that wage setter has no effect upon the aggregate wage or hours. Furthermore, as in the Calvo model of staggered price setting, each wage is adjusted with a probability $1-\alpha_w$ each period, for some $0<\alpha_w<1$. In particular each wage $W_t(j)$ is chosen to maximize

$$E_t\sum_{T=t}^{\infty}(\alpha_w\beta)^{T-t}[\Lambda_T(1-\omega_{1t}(j))W_t(j)L_T(W_t(j))+\Lambda_T\omega_{1t}(j)\int_{i\in[0,1]\text{ and }i\neq j}W_t(i)L_T(i)di-v(L_T(W_t(j))\xi_T]$$

where $\Lambda_T$ is the representative households's marginal utility of nominal income in period T. Analogous to our firm price setting assumption we assume that only a fraction $(1-\omega_{1t}(j))$ of the wages of each wage setters accrue to the household that supplies that type of labor, while the remainder $\omega_{1t}(j)$ is redistributed to the other suppliers of labor. The term $\omega_{1t}(j)$ represents a wage collusion term, a positive $\omega_{1t}$ implies that the wage setters will set wages at a level that is higher than implied by the monopolistic competitive equilibrium and thus corresponds to a "labor wedge".

The solution to this maximization problem satisfies the first order condition

$$E_t\sum_{T=t}^{\infty}(\alpha_w\beta)^{T-t}\frac{u_{c,T}}{P_T}\xi_T L_T W_T^{\theta_w}(1-\omega_{1T})[W_t^*-\frac{\theta_w}{\theta_w-1}\frac{1}{1-\omega_{1T}}\frac{v_l}{u_c}P_T]=0 \quad (59)$$

where we assume that the wedge $\omega_{1t}(j)$ is set symmetrically across labor types and $W_t^*$ denotes the optimal wage of the wage setters that adjust their price at time t. The wage index satisfies the law of motion

$$W_t=[(1-\alpha_w)EW_t^{*1-\theta_w}+\alpha_w W_{t-1}^{1-\theta_w}]^{1/(1-\theta_w)} \quad (60)$$

The firms profits are again given by

$$Z_t(i)=(1-\omega_{2t}(i))y_t(i)p_t(i)-\omega_{2t}(i)y_t^i-W_tL_t(i)$$

The only difference with respect to firm profit in the text is that the last term, because now the firm does not hire only one labor type, but the bundle given by (58) at the price $W_t$. Because we assume prices are flexible, optimal price setting then implies

$$p_t(i)=\frac{\theta}{\theta-1}\frac{1}{1-\omega_{2t}}W_t=0$$

It follows that the aggregate price level is given by

$$P_t=\frac{\theta}{\theta-1}\frac{1}{1-\omega_{2t}}W_t \quad (61)$$

An sticky price equilibrium can now be defined as a collection of stochastic processes for $\{Y_t,P_t,W_t^*,W_t,i_t,\omega_{1t},\omega_{2t}\}$ that satisfy (2),(3), (4), (5) and (59)-(61) for a given stochastic process for the exogenous shock $\{\xi_t\}$ and an initial condition $(Y_{-1},P_{-1})$. The model is linearized around the same steady state as before, with the only difference that it is assumed that $1-\bar{\omega}_2 = \frac{\theta}{\theta-1}$ and $1-\bar{\omega}_1 = \frac{\theta^w}{\theta^w-1}$ i.e. each wedge is eliminates the monopoly distortions in the goods and labor markets respectively. Again $\omega_t$ is defined as the ratio of the two distortions, but for simplicity I only allow for variations in $\omega_{2t}$. A linear approximation around the steady state will once again yield an unchanged CE equation and the zero bound. Instead of the FE equation, however, we now have a log-linear approximation of (59) and (60) that yields

$$FE1 \qquad \pi_t^w = \kappa_w \tilde{Y}_t + \beta E_t \pi_{t+1}^w + \kappa_w \varphi \omega_t \tag{62}$$

where $\pi_t^w \equiv \log W_t - \log W_{t-1}$ and $\kappa_w \equiv \frac{(1-\alpha_w)(1-\alpha_w\beta)}{\alpha_w}\frac{\sigma^{-1}+\nu}{1+\nu\theta_w}$. A linear approximation of 61 yields

$$FE2 \qquad \pi_t = \pi_t^w \tag{63}$$

An approximate sticky wage equilibrium is now defined as a collection of stochastic processes for the endogenous variables $\{\tilde{Y}_t, \pi_t, \pi_t^w, i_t, \hat{\omega}_t\}$ that satisfy (14),(15), (62) and (63) for a given stochastic process for the exogenous shock $\{r_t^e\}$. Observe that these equations, one FE2 is substituted into FE1, are precisely the same as before, and hence all the propositions in the paper follow unchanged if we assume wage frictions instead of pricing frictions. To summarize:

**Proposition 10** *Wage and Price friction equivalence. Suppose that wages are set in a staggered way as in Calvo (1983) but prices flexible and the wedges determined as explained in the text above. Then Proposition 1-7 follow unchanged replacing $\kappa$ with $\kappa_w$.*

**Proof.** See equation (62) and (63) ■

### C.2 New Classical Phillips Curve

Consider now an alternative pricing Euler equation, namely the one common in the earlier literature on price frictions. Suppose that the FE equation takes the form

$$FE \qquad \pi_t = \kappa_p \tilde{Y}_t + E_{t-1}\pi_t + \kappa_p \varphi \omega_t \tag{64}$$

where $\kappa_p$ is a coefficient greater than zero. This form of "expectation augmented" or "New Classical" Phillips curve is common in the early rational expectation literature, see e.g. Kydland and Prescott (1977) and Barro and Gordon (1983) classic papers. A Phillips curve of this form is derived from the same microfoundations as in the main text in Woodford (2003) under the assumption that a fraction $\iota$ set their prices one period in advance and a fraction $1-\iota$ has flexible prices. The term involving the wedge can be derived in exactly the same way as in the main text. Under these alternative microfoundations $\kappa_p \equiv \frac{\iota}{1-\iota}\frac{\nu+\sigma^{-1}}{1+\nu\theta}$ and the CE equation and zero bound are unchanged.

Under A1 the FE equation 64 can be written as

$$(1-\mu)\pi_L = \kappa_p \tilde{Y}_L + \kappa_p \varphi \hat{\omega}_L \tag{65}$$

Observe that this equation is identical to the $FE$ equation 27 when $\beta = 1$. To summarize:

**Proposition 11** *Expectation Augmented Phillips curve equivalence. Suppose that the FE equation is replaced with an expectation augmented Phillips curve from the microfoundations explained above. Then Proposition 1-7 follow unchanged for replacing $\kappa$ with $\kappa_p$ and setting $\beta = 1$ in our previous expression.*

**Proof.** See equation 65 ■

Observe that we do not need $\beta = 1$ in the microfoundation that underlie the expectation augmented Phillips curve. We only set $\beta = 1$ in the expressions in the text to make the Calvo model equivalent to the model with the expectation augmented Phillips curve (where $\beta$ can take any value).

### C.3 General comment on other nominal frictions

The two subsections above illustrate two examples of alternative nominal frictions in which case the results are identical to those in the text. The main result of the paper, however, is more general than these examples and likely to hold in most models that incorporate nominal frictions. Figure 5 is helpful to clarify this. In the model, alternative specifications for nominal frictions only change the FE equation. All that is needed for the result, is that the FE curve is upward sloping in $(\tilde{Y}_L, \pi_L)$ space (i.e. higher quasi-growth rate of output demanded by consumer is associated with higher rate of price increase) and that this relationship is shifted to the left with the policy wedge. I am not aware of any theory of nominal frictions that does not result in a firm Euler equation in which case prices are positively related to output. Moreover, any theory of monopolistic competition will result in price increases if the government facilitates cartelization , i.e., the FE curve will shift to the left. Hence my conjecture is that the key result will hold for any reasonable description of nominal frictions, even if the exact expressions in the main text may change a bit.

## Appendix D: Notes on Endogenous Capital (not intended for publication)

Appendix C was concerned with variations in the model that change or replace the firm Euler equation (FE equation). We now turn to alternative specification for the CE equation, which determines spending decisions. Perhaps the most obvious source of spending variations abstracted from in the paper is investment spending, but all production is consumed in the model in the text. The purpose of these notes is to consider whether investment spending changes the results in a fundamental way. This has been suggested by some authors such as Christiano (2004) in a related context. We find that endogenous capital accumulation has very little effect as long as we consider intertemporal disturbances that affect the consumption and investment Euler equation in the same way (an assumption that is consistent with the criteria for the shock in the paper, i.e., that the shock reduces the efficient rate of interest). The basic finding is in line with recent results in the literature, such as Woodford (2005), that argues that the fixed capital stock model provides a reasonable approximation to a model with endogenous capital stock. For simplicity this section only considers the most simple variation of the model in the text by assuming no habits, as in Woodford (2005).

## D.1 Model

The household maximization problem is the same as in the paper and the same set of equations apply. For the firms I assume a firm specific convex cost of investment as in Christiano (2004) and Woodford (2005). To increase the capital stock to $K_{t+1}(i)$ in the next period from $K_t(i)$ the firm needs to buy

$$I_t(i) = I(\frac{K_{t+1}(i)}{K_t(i)}, \xi_t)K_t(i) \tag{66}$$

of the consumption good. The function $I$ satisfies $I(1,\bar{\xi}) = \lambda$, $I'(1,\bar{\xi}) = 1$, $I''(1,\bar{\xi}) = \phi^{II} \geq 0$, $I^{\xi}(1,\bar{\xi}) = 0$, $I^{I\xi}(1,\bar{\xi}) \neq 0$. The variable $\lambda$ corresponds to the depreciation rate of capital. At time $t$ the capital stock is predetermined. I allow for the vector of fundamental shocks to appear in the cost of adjustment function. This is important to generate the same kind of shocks as considered in the paper (namely variations in the efficient rate of interest) and is the key difference relative to Christiano (2004). The shock in the cost of adjustment, in addition to the wedges, is the only difference relative to Woodford (2005). Accordingly the description of the model below is brief [readers can refer to Woodford (2005) for details].

Here $I_t(i)$ represents to purchases of firm $i$ of the composite good, defined over all the Dixit-Stiglitz good varieties, so that we can write

$$y_t(i) = Y_t(\frac{p_t(i)}{P_t})^{-\theta}.$$

Output is produced with the Cobb Douglas function

$$y_t(i) = AK_t(i)^{1/\phi_h - 1}l_t(i)^{1/\phi_h}$$

Firm $i$ in industry $j$ maximize present discounted value of profits and where the period profit is now given by

$$Z_t(i) = [1-\omega_{2t}(j)]p_t(i)y_t(i) + \omega_{2t}(j)p_t^jY_t(p_t^j/P_t)^{-\theta} - W_t(j)l_t(i) - P_tI_t(i)$$

which is identical to the period profit (9) apart from the presence of the variable firm specific investment represented by the last term. Let us denote $I_t^N(i) \equiv \frac{K_{t+1}(i)}{K_t(i)}$ as the net increase in the capital stock in each period. Endogenous capital accumulation gives rise to the following first order condition.

$$-I'(I_t^N(i),\xi_t) + E_tQ_{t+1}\Pi_{t+1}[\rho_{t+1}(i) + I'(I_{t+1}^N(i),\xi_{t+1})I_{t+1}^N - I(I_{t+1}^N(i),\xi_{t+1})] \tag{67}$$

where

$$\rho_t(i) \equiv \frac{\alpha}{1-\alpha}\frac{l_t(i)}{K_t(i)}W_t(j) \tag{68}$$

There is an analogous Euler equation to (12) in the text for the price setting that is complicated by the fact that we need to keep track of the capital stock of each firm (see Woodford [2005] for details).

### D.2 Approximate Equilibrium

Let us now linearize the model around the efficient steady state with zero inflation. The firm Euler equation is:

$$\pi_t = \zeta \hat{s}_t + \beta E_t \pi_{t+1} + \zeta \hat{\omega}_{2t} \tag{69}$$

where $\zeta \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha\phi}$ and $\pi_t \equiv \log \Pi_t$. The coefficient $\phi$ is defined in equation 3.23 in Woodford (2005) (note that the arguments of this equation involve the solutions of several polynomials in that paper). The variable $\hat{s}_t$ is a log-linerization of real marginal costs (in deviation from steady state) given by[45]

$$\hat{s}_t = (1+\nu)\hat{L}_t + \tilde{\sigma}^{-1}\delta_c^{-1}\hat{C}_t - \hat{Y}_t \tag{70}$$

where $\tilde{\sigma} \equiv -\frac{u_c}{u_{cc}C}$, $\delta_c \equiv \frac{C}{Y}, \nu \equiv \frac{v_{;;}L}{v_l}, \hat{C}_t \equiv \log \frac{C_t}{Y}$, $\hat{L}_t \equiv \log \frac{L_t}{L}$. Equation (67) is

$$\hat{I}_t^N = \beta E_t \hat{I}_{t+1}^N - \frac{1}{\phi^{II}}(i_t - E_t\pi_{t+1} - r_t^I) + \frac{1}{\phi^{II}}\beta\bar{\rho}E_t\hat{\rho}_{t+1} \tag{71}$$

where $r_t^I \equiv \log \beta^{-1} - I^{I\xi}\xi_t + \beta I^{I\xi}E_t\xi_{t+1}$ and $\hat{\rho}_t = \log \frac{\rho_t}{\bar{\rho}}$, $\hat{I}_t^N = \log I_t^N$.

Observe that this IS equation takes the same form as the consumption Euler equation and this is the reason for why the extension yields similar results once it is assumed that $r_t^I$ – the shock to the investment Euler equation – parallels the shock to the consumption Euler equation (more on this below). Linearizing the definition of $\rho_t$ yields

$$\hat{\rho}_t = (1+\nu)\hat{L}_t + \tilde{\sigma}^{-1}\delta_c^{-1}\hat{C}_t - \hat{K}_t \tag{72}$$

where $\hat{K}_t \equiv \log \frac{K_t}{K}$. Linearizing the definition of $I_t^N$ yields

$$\hat{I}_t^N \equiv \hat{K}_{t+1} - \hat{K}_t \tag{73}$$

Linearizing (66) yields

$$\hat{I}_t = \delta_K \hat{I}_t^N + \lambda\delta_K\hat{K}_t \tag{74}$$

$\delta_K \equiv \frac{K}{Y}$. Linearizing the resource constraint $Y_t = C_t + I_t$ yields

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t = \hat{C}_t + \delta_K\hat{I}_t^N + \lambda\delta_K\hat{K}_t \tag{75}$$

Linearizing the consumption Euler equation yields

$$\hat{C}_t = E_t\hat{C}_{t+1} - \tilde{\sigma}\delta_c(i_t - E_t\pi_{t+1} - r_t^c) \tag{76}$$

[45] The real marginal cost for firm i in industry j is

$$s_t(i) = \frac{W(j)}{\phi_h^{-1}K_t(i)^{1-\phi_h^{-1}}l_t(i)^{\phi_h^{-1}-1}}$$

where $r_t^e \equiv \log\beta^{-1} + \frac{\bar{u}_{c\xi}}{\bar{u}_c}\xi_t - \frac{\bar{u}_{c\xi}}{\bar{u}_c}E_t\xi_{t+1}$. The production function is

$$\hat{Y}_t = (1-\phi_h^{-1})\hat{K}_t + \phi_h^{-1}\hat{L}_t \tag{77}$$

where I have assumed no productivity shocks. An approximate equilibrium is a collection of stochastic processes for $\{\hat{Y}_t, \hat{L}_t, \hat{C}_t, \hat{K}_{t+1}, \hat{I}_t^N, \hat{I}_t, \hat{\rho}_t, i_t, \hat{s}_t, \hat{\omega}_t\}$ for a given a stochastic process for the exogenous shocks $\{r_t^I, r_t^C\}$. Observe that to close the model we need two equations to determine policy (rules that governs $\omega_t$ and $i_t$) and need to specify the exogenous processes $r_t^I$ and $r_t^C$.Observe that if $\phi^{II} \to \infty$ then this model collapses to the one in the text. The question is whether the main result is overturned for intermediate values of $\phi^{II}$.

## D.3 The efficient rate of interest

Observe that in the current model we have two spending Euler equations – (71) and (76) – the first relating investment to current and expected future short-term real interest rates and the second consumption to current and expected future real short term interest rates. Our definition of the shocks in the paper was that it was they correspond to intertemporal disturbances that only changes the efficient rate of interest, leaving the efficient level of output and consumption constant (this criteria for the shock is made more explicit in somewhat more detail in Eggertsson [2008] who argues that a shock of this kind is natural candidate for the Great Depression). It is easy to see that in the model with endogenous capital, the disturbance that satisfies this criteria is one in which $r_t^c = r_t^I = r_t^e$. This kind of disturbance leads to a decline in the efficient rate of interest, leaving the efficient level of output, capital, investment and consumption constant.

This shock has different properties than the one studied in Christiano (2004). In his model the shock he considers is only a shock to the discount factor in the household utility. This does not satisfy the criteria in the paper, because a shock that only affects the consumption Euler equation will then lead to an increase in investment that offsets this shock, having a much smaller effect on the efficient interest rate. The fact that the shock only appears in the consumption Euler equation also has the implication that it perturbs the efficient allocation for investment, capital, output and consumption. This kind of shock is less appealing for my purposes because it would imply that the Great Depression was associated with an investment boom. Instead investment collapsed together with output and consumption during the Great Depression, consistent with the assumption that the investment Euler equation was subject to an identical shock. More generally if one thinks of the intertemporal disturbance as a reduced form representation of financial frictions it makes sense to assume that it affected the cost of lending by both consumers and firms in the same way.

## D.4 Calibration

To calibrate the model we re-estimate the fixed capital stock model abstracting from habits. This yields the following estimate for the structural parameters $\tilde{\sigma} = 0.9956, \nu = 0.8795$, $\alpha = 0.7846$, $\theta = 10.07$. I do not estimate the variable capital stock model, but instead parameterize it using these estimate and assume the following values for the other parameters, $\phi_h^{-1} = 0.75$ and $\lambda = 0.05$

(which is the depreciation rate). In the steady state $\delta_K = 2.72$ and $\delta_C = 0.7832$. To calibrate the cost function $\phi^{II}$ I follow Christiano and Davis (2006) by assuming that $\phi^{II} = \lambda^{-1}$ (see further discussion in that paper). As $\phi^{II}$ increases the variable capital stock model collapses to the fixed capital stock model. Using these parameter values the implied value of $\phi$ is 8.08.

I consider here the consequence of a policy regime of the following kind (which is identical to the baseline policy in the main text for the fixed capital stock model).

$$\pi_t = 0 \text{ for } t \geq \tau$$

$$i_t = 0 \text{ for } t \leq \tau$$

The shock takes the form

$$r_t^e = r_t^I = r_t^C = 1/\beta - 1 \text{ for } t \geq \tau$$

$$r_t^e = r_t^I = r_t^C = r_L^e < 0 \text{ for } t \geq \tau$$

The value of the shock in the case of the fixed capital stock model is estimated as $r_L^e$ is $-1.92\%$ (in annual percentage terms) and the value of $\mu$ is 0.89. As already noted, I do not estimate the model with variable capital but instead choose the shock informally by selecting $r_L^e$ and $\mu$ such that inflation and output corresponds to the one in the model with fixed capital stock in 1933, assuming that the shock occurred in 1929.[46] This results in that $r_L^e$ is $-0.9\%$ and $\mu = 0.86$ in the model with variable capital stock. Instead of deriving the optimal second best $\omega_t$ in the variable capital model, I choose it such that the inflation outcome under the New Deal is identical to the inflation outcome in the fixed capital stock model in 1933.

Figures 13-15 shows the results. Figure 13 shows the fixed capital stock solution with dashed line and the variable capital solution with solid line. The figure shows the outcome under the assumption the shock hits in 1929 and stays there until 1939. It considers both the outcome under the baseline policy, and in the case the New Deal is implemented in 1929 (this solution corresponds to the smaller contraction in both output and inflation in Figure 13 ). In either case, the difference between the two models is small. The second figures shows how the decline in output is distributed between a decline in gross investment and consumption. Figure 3 shows the long run evolution of the model if it stays in the $r_L^e$ state for a very long time.

## 10.1 D.5 General comments

The key difference between the result here and the one in Christiano (2004) is the way in which the shock is introduced. Once it satisfies the criteria in the paper for the efficient rate of interest, the results are similar across the two models. The shock that satisfies the criterion of the paper is slightly smaller in the variable capital model, although I do not know if this will hold for all parameterization (my conjecture is that this depends on the calibrated value of $\phi^{II}$ among other things). There appears to be little reason to believe that the extension to a MPE with

[46] This is essentially the same criteria as used in the estimation of the fixed capital stock model, altough in that case we do not only choose the shocks to satisfy this criterion but all the other parameters as well.

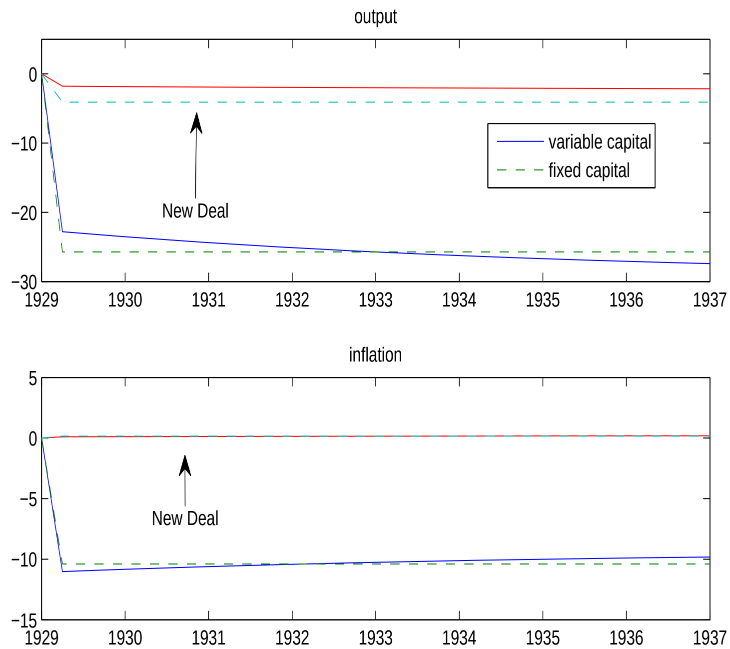


Figure 13: Comparing the solution assuming a fixed vs endogenous capital stock, conditional on a negative shock.

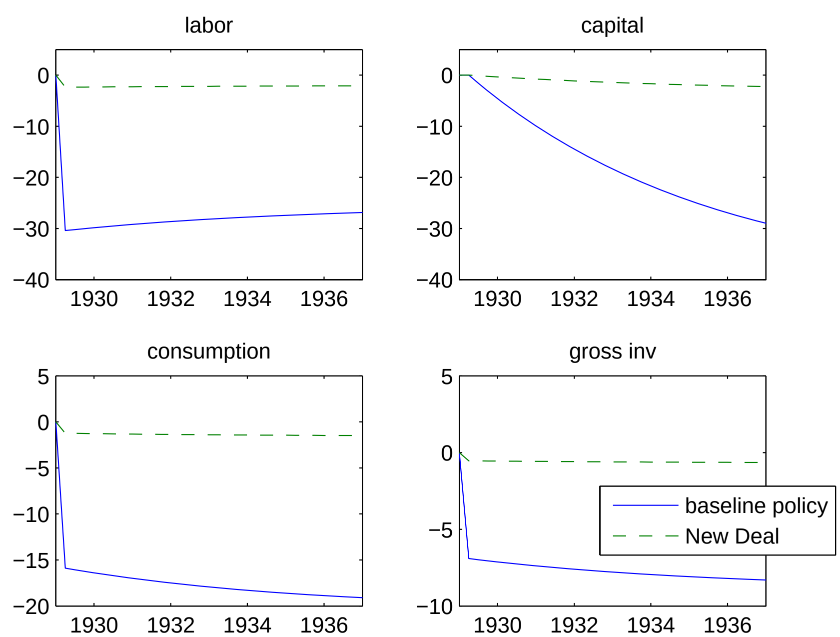


Figure 14: The solution assuming endogenous capital stock, conditional on a negative shock.

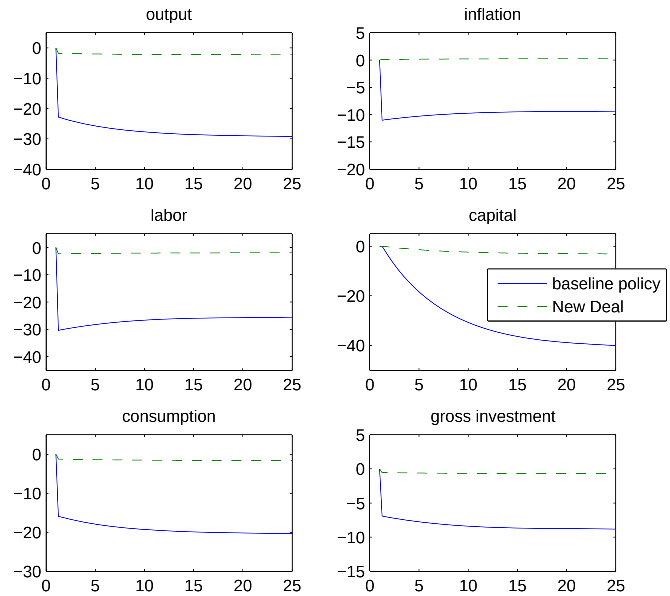


Figure 15: The long-run assuming endogenous capital and a negative shock.

external habits would yield substantially different results from those already in the paper, although this remains to be confirmed. Those results would be considerable more complicated to derive, however, because the model would have many more state variables so I would not be able to produce any closed form solution (although a numerical characterization is possible). Not only would the $K_t$ be a state, but also $L_{t-1}$ and $Y_{t-1}$. The key simplification in the model with fixed capital stock was the specification of the habit which meant that the state $Y_{t-1}$ dropped out and the model could be written in terms of quasi growth rate of output. This appears no longer possible in the variable capital model because the production function is not linear in labor. As a consequence one would need to replace all the propositions and derivation in the paper numerical simulations with relatively small returns in terms of quantitative fit.

More generally it is unlikely that alternative specification of the spending side of the economy will change the main result, that inflationary policies increase output when there is excessive deflation. The key for the result is that the CE equation is upward sloping expected inflation for a given nominal interest rate. In words, this just means that demand depend on the real interest rate. Even if we introduce additional sources of spending, such as investment, these spending components will also respond positively to a reduction in real interest rates, thus preserving the property of the model that generates the main result in the paper.

### D.5 References

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## Appendix E: Notes on Alternative Microfoundations for Government Policy (not intended for publication)

The main text considered the optimal forward looking policy as microfoundations for government behaviors. These notes consider two other common characterizations of the government, the optimal policy under commitment (or Ramsey policy) and the Markov Perfect Equilibrium ([MPE], i.e., when the government cannot make any credible commitments about future policy). As we will see the MPE is almost identical to the optimal forward looking policy in the example we are considering. The Ramsey policy is a bit different from the optimal forward looking policy because the government can now commit to lower future nominal interest rates once the deflationary shocks have subsided. Yet, the Ramey policy preserves the main result of the paper, i.e., it is optimal to increase the policy wedges for the duration of the deflationary shocks.

The appeal of the Ramsey solution is that it is the best possible outcome the planner can achieve. The main weakness for my purposes is that it requires a very sophisticated commitment that is subject to a serious dynamic inconsistency problem, especially in the example I consider. This casts doubt on how realistic it is as a description of policy making in the 1930's. The MPE, in contrast, is dynamically consistent by construct, and may thus capture actual policy making a little bit better. Its main weakness, however, is that it is not a well defined social planner's problem because each government is playing a game with future governments. The optimal MPE government strategy is therefore not a proper second best policy, as defined in Definition 5, because showing that the government at time $t$ chooses to use a particular policy instrument (e.g. $\omega_t$) is no guarantee that this is optimal. Indeed in certain class of games it is optimal to restrict the government strategies to exclude certain policy instruments or conform to some fixed "rules" (see e.g. Kydland and Prescott (1977)).

The optimal policy from a forward looking perspective studied in the main text strikes a good middle ground between Ramsey equilibrium and the MPE. It is a well defined planner's problem and thus appropriate to illustrate the point about the policy as "optimal second best". Yet it is very close to the MPE in the example I consider and thus not subject to the same dynamic inconsistency problem as the Ramsey equilibrium (as further discussed below). Furthermore it requires a relatively simple policy commitment by the government, which makes it a more plausible description of actual policy during the Great Depression, and it accords relatively well with narrative accounts of the policy.

### E.1 Markov Perfect Equilibrium

Optimal policy under discretion is standard equilibrium concept in macroeconomics and is for example illustrated in Kydland and Prescott (1977). It is also sometimes referred to as Markov Perfect Equilibrium (MPE).[47] The idea is that the government cannot make any commitments about future policy but instead reoptimizes every period, taking *future government actions* and the physical state as given. Observe that we have rewritten the model in terms of quasi growth rates of output and the growth rate of prices (inflation) so that the government's objective and the system of equations that determine equilibrium are completely forward looking. They only depend on the exogenous state $(r_t^e, \tilde{Y}_t^e)$. It follows that the expectations $E_t\pi_{t+1}$and $E_t\tilde{Y}_{t+1}$ are taken by the government as exogenous since they refer to expectations of variables that will be determined by future governments (I denote them by $\bar{\pi}(r_t^e)$ and $\bar{Y}(r_t^e)$ below). To solve the government's period maximization problem one can then write the Lagrangian

$$L_t = -E_t \left[ \begin{array}{c} \frac{1}{2}\{\pi_t^2 + \lambda_y \tilde{Y}_t^2\} \\ +\phi_{1t}\{\pi_t - \kappa\tilde{Y}_t + \kappa\tilde{Y}_t^e - \frac{\kappa}{\sigma^{-1}+\upsilon}\hat{\omega}_t - \beta\bar{\pi}(r_t^e)\} \\ +\phi_{2t}\{\tilde{Y}_t - \bar{Y}(r_t^e) + \sigma(i_t - \bar{\pi}(r_t^e) - r_t^e)\} + \phi_{3t}i_t \end{array} \right] \quad (78)$$

and obtain four first order conditions that are necessary for optimum and one complementary slackness condition

$$\pi_t + \phi_{1t} = 0 \quad (79)$$

$$\lambda_y(\tilde{Y}_t - \tilde{Y}_t^e) - \kappa\phi_{1t} + \phi_{2t} = 0 \quad (80)$$

$$-\kappa\varphi\phi_{2t} = 0 \quad (81)$$

$$\sigma\phi_{2t} + \beta^{-1}\phi_{3t} = 0 \quad (82)$$

$$\phi_{3t} \geq 0, \;\; \phi_{3t}i_t = 0 \quad (83)$$

Consider first the equilibrium in which the government does not use $\hat{\omega}_t$ to stabilize prices and output (i.e. $\hat{\omega}_t = 0$) in which case the equilibrium solves the first order conditions above apart from (81). In this case the solution is the same as the optimal forward looking policy subject to $\hat{\omega}_t = 0$ and thus also equivalent to the benchmark policy in Proposition 1.

Next consider the optimal policy when the government can use $\hat{\omega}_t$. In this case the solution that solves (79)-(83) and the IS and AS equations is:

$$\tilde{Y}_t = \frac{\sigma}{1-\mu} r_L^e \text{ if } t < \tau \text{ and } \tilde{Y}_t = 0 \text{ if } t \geq \tau \quad (84)$$

$$\pi_t = 0 \;\forall t \quad (85)$$

$$\tilde{Y}_t^n = \frac{\sigma}{1-\mu} r_L^e \text{ if } t < \tau \text{ and } \tilde{Y}_t^n = 0 \text{ if } t \geq \tau \quad (86)$$

[47] Although it is common in the literature that uses the term MPE to assume that the government moves before the private sector. Here, instead, the government and the private sector move simultaneously.

$$\hat{\omega}_t = -\frac{\sigma}{1-\mu}\varphi^{-1}r_L^e > 0 \text{ if } t < \tau \; \hat{\omega}_t = 0 \text{ if } t \geq \tau \tag{87}$$

The analytical solution above confirms the key insight of the paper, that the government will increase $\hat{\omega}_t$ to increase inflation and output when the efficient real interest rate is negative. There is however some qualitative difference between the MPE and the OFP. Under the optimal forward looking policy the social planner increases the wedge beyond the MPE to generate inflation in the low state. The reason for this is that under OFP the policy maker uses the wedge to generate expected inflation to lower the real rate of interest. In the MPE, however, this commitment is not credible and the wedge is set so that inflation is zero. The quantitative significance of the difference between MPE and OFP, however, is trivial using the parameterization of the paper.

## E.2 Ramsey Equilibrium

I now turn to the Ramsey equilibrium. In this case the government can commit to any future policy. The policy problem can then be characterized by forming the Lagrangian:

$$L_t = E_t \begin{bmatrix} \frac{1}{2}\{\pi_t^2 + \lambda \hat{Y}_t^2\} + \phi_{1t}(\pi_t - \kappa \tilde{Y}_t - \frac{\kappa}{\sigma^{-1}+\upsilon}\hat{\omega}_t - \beta \pi_{t+1}) \\ +\phi_{2t}(\tilde{Y}_t - \tilde{Y}_{t+1} + \sigma i_t - \sigma \pi_{t+1} - \sigma \hat{r}_t^e) + \phi_{3t} i_t \end{bmatrix} \tag{88}$$

which leads to the first order conditions:

$$\pi_t + \phi_{1t} - \phi_{1t-1} - \sigma\beta^{-1}\phi_{2t-1} = 0$$

$$\lambda \hat{Y}_t - \kappa\phi_{1t} + \phi_{2t} - \beta^{-1}\phi_{2t-1} = 0$$

$$\sigma\phi_{2t} + \phi_{3t} = 0$$

$$\phi_{1t} = 0$$

$$\phi_{3t} i_t = 0 \; i_t \geq 0 \text{ and } \phi_{3t} \geq 0$$

Figure 16 shows the solution of the endogenous variables, using the solution method suggested in Eggertsson and Woodford (2004) [the study optimal labor taxes under commitment which is identical to the case wee studying] and compares to the optimal forward looking policy studied in the main text. The calibration here is from their paper, and there is no habit persistence in the model. Again the solution implies an increase in the wedge in the periods in which the zero bound is binding. The wedge is about 5 percent initially. In the Ramsey solution, however, there is a commitment to reduce the wedge temporarily once the deflationary shocks have reverted back to steady state. There is a similar commitment on the monetary policy side. The government commits to zero interest rates for a considerable time after the shock has reverted back to steady state.

The optimal commitment thus also deviates from the first best in the periods $t \geq \tau$ both by keeping the interest rate at zero beyond what would be required to keep inflation at zero at that time and by keeping the wedge below its efficient level. This additional second best leverage – which the government is capable of using because it can fully commit to future policy – lessens

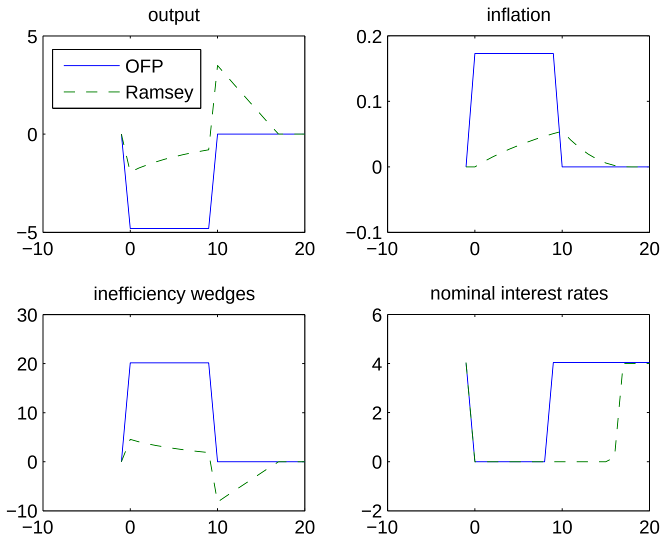


Figure 16: The qualitative features of the optimal forward looking and Ramsey policy are the same. The key difference is that the Ramsey policy achieves a better outcome by manipulating expectations about policy at the time at which the deflationary shocks have subsided.

the need to increase the wedge in period $t < \tau$. This is the main difference between the Ramsey equilibrium and the MPE and OFP. The central conclusion of the paper, however, is confirmed, the government increases the wedge $\omega_t$ to reduce deflation during the period of the deflationary shocks.

The key weakness of this policy, as a descriptive tool, is illustrated by comparing it to the MPE. The optimal commitment is subject to a serious dynamic inconsistency problem. To see this consider the Ramsey solution in periods $t \geq \tau$ when shocks have subsided. The government can then obtain higher utility by reneging on its previous promise and achieve zero inflation and output equal to the efficient level. This incentive to renege is severe in our example, because the deflationary shocks are rare and are assumed not to reoccur. Thus the government has strong incentive to go back on its announcements. This incentive is not, however, present to the same extent under optimal forward looking policy. Under the optimal forward looking policy the commitment in periods $t \geq \tau$ is identical to the MPE.