Was the New Deal Contractionary?

Extended version with Extened Appendix

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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. The main reason for this divergence is that the current model incorporates nominal frictions and the zero bound on the short term interest rate, 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 expected inflation, thereby lowering real interest rates and stimulating spending.

Key words: Great Depression, the New Deal, zero interest rates, deflation.
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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 all the way to the modern literature, 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 stated goal of these emergency actions was to battle the downward spiral of wages and prices observed in the 1929-33 period.

This paper studies the NIRA in a stochastic dynamic general equilibrium (DSGE) model with staggered price setting. The NIRA creates distortions that move the natural level of output away from the efficient level by temporarily increasing the monopoly power of firms and workers. This is expansionary due 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 NIRA increases inflation expectations because it helps workers and firms to increase prices and wages, and thus reduces, or even eliminates, deflation. 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 the short-term nominal interest rate. In this case, the policy reduces output through traditional channels, i.e., by reducing economic efficiency. The NIRA is expansionary in the model because it is a response to the "emergency" conditions created by deflationary shocks. Building on Eggertsson and Woodford (2003,4) and Eggertsson (2006,8), excessive deflation follows from persistent deflationary shocks that imply that a negative real interest rate is needed to implement 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 NIRA is helpful because it breaks 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 U.S. Great Depression. An elegant and well known 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 (2007) to mention just a few.

Given this broad consensus, it is perhaps 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.[1] The logic of the argument, however, is far from new. The argument is that these policies were expansionary because they changed expectations from being deflationary to being inflationary, thus eliminating the deflationary spiral of 1929-33. This made lending cheaper and thus stimulated demand. This was also 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 play little or no role. The other literature cited above misses it because it assumes one or all of the following (i) flexible prices, (ii) no shocks and/or (iii) abstract from the zero bound. For NIRA to be expansionary all three

[1] 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 5.6 and confirm their result in the present model.

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.[2] 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, NIRA is still expansionary. Eggertsson (2008) studies the contribution of more standard monetary and fiscal policy to the recovery during the Great Depression and find that they can account for the bulk of the recovery but not all of it. The New Deal's NIRA may thus be the missing link.

Annual GDP grew by 39 percent in 1933-37 and monthly industrial production more than doubled, as shown in Figure 2.[3] 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. 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 very 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 is that there was a serious recession in 1937-38. If the economy had maintained the momentum of the recovery and avoided the recession of 1937-38, GDP would have reached trend in 1938.[4] 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, an interpretation that is consistent with this paper. Here I do not address the "Mistake of 1937" and focus instead on 1933-37.

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 of this kind are still expansionary in *short-run,* i.e. through the duration of the deflationary emergency, but contractionary in the *long-run.* 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).

The model used in this paper is a relatively standard New Keynesian general equilibrium model

[2] The *Wall Street Journal*, for example, reports that Franklin Delano Roosevelt declared 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.

[3] 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.

[4] 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 was 10 percent above trend in 1929, while they assume it was at trend at that time.

without capital. A key assumption is nominal frictions in price setting. The particular form of the frictions, however, is not crucial. 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]).[5] It is worth noting that the main focus of the paper is on the recovery period 1933-37, which was characterized by relatively modest inflation on average, a condition under which the Calvo assumption seems a reasonable approximation.

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 NIRA 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. A key innovation is to show how NIRA fits into an "inflation program", which comes naturally out of the model and fits well with the recent literature, but perhaps even more interestingly also fits well with how policy makers described this policy at the time, as the paper documents. Eggertsson (2010) uses the basic "AS-AD" representation developed here to address the marginal effect of a host of other policy instruments. Eggertsson (2010) shows that variation in some labor taxes shows up similarly as NIRA, and the same applies to VAT taxes, as discussed in Eggertsson and Woodford (2004).

2 The model

This section summarizes the microfoundations of model, which is standard[6], focusing on the new element, that is how the government can change the natural rate of output by facilitating unions and/or monopoly power of firms. Further details are relegated to the Appendix but the impatient reader can skip directly to the linearized version of the model that starts with equation 5.

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 β is a discount factor, C_t is a Dixit-Stiglitz aggregate of consumption of each of a continuum of differentiated goods, $C_t \equiv \left[\int_0^1 c_t(i)^{\frac{\theta}{\theta-1}} di \right]^{\frac{\theta-1}{\theta}}$ with $\theta > 1$, P_t is the Dixit-Stiglitz price index,$P_t \equiv$

[5] See e.g. Gertler and Leahy (2008) and Woodford (2009) for more detailed microfoundations. Appendix C which is available on the authors website shows that the results are unchanged assuming rigid wages instead of prices, or if the price frictions are represented by staggered price setting such as the familiar textbook New Classical Phillips curve as, e.g., in Kydland and Prescott (1977). It also discusses the general poperties the results relies on. Appendix D shows that the main result is also unaffected by endogenous capital accumulation.

[6] See e.g. Clarida, Gali and Gertler (1999) and Woodford (2003).

$\left[\int_0^1 p_t(i)^{1-\theta}di\right]^{\frac{1}{1-\theta}}$, $l_t(j)$ is the quantity supplied of labor of type j; H_t^c and $H_t^l(j)$ are external consumption and labor habits as in Eggertsson (2008). Each industry j employs an industry-specific type of labor, with its own wage $W_t(j)$. The disturbance ξ_t is a preference shock, $u(.)$ is a concave function, and $v(.)$ an increasing convex function, both satisfying standard properties. Financial markets are complete and the household faces a budget constraint of the form

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

where $Q_{t,T}$ is the nominal stochastic discount factor, A_t is beginning of period wealth, $Z_t(i)$ is profits of firm i, $W_t(j)$ is the wage earned by labor of type j, and T_t is taxes. The household chooses labor, consumption and its asset holdings.

Each good i is supplied by a 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. Each good is produced with a common production function $y_t(i) = l_t(i)$ where $l_t(i)$ is the industry-specific labor hired by firm i. The representative household decides on its labor supply by choice of $l_t(j)$ so that

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

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 labor market markup. The household takes this markup 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 the markup $\omega_{1t}(j)$ the government can restrict labor supply and thus increase real wages relative to the case in which labor markets are perfectly competitive. The government can do this by facilitating union bargaining or by other anti-competitive policies in the labor market.[7]

The supplier of good i sets its price and then hires the labor inputs necessary to meet demand. Given the allocation of demand across goods by households, 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

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

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. The markup $\omega_{2t}(j)$ 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. 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.[8] In the absence of any government intervention, $\omega_{2t} = 0$.

[7] A marginal labor tax, rebated lump sum to the households, has the same effect.

[8] A consumption tax – rebated either to consumers or firms lump sum – would introduce the same wedge.

If prices are fully flexible, $p_t(i)$ is chosen in each period to maximize (2). This leads to the first-order condition for the firm's maximization

$$p_t(i) = \frac{\theta}{\theta - 1} \frac{W_t(j)}{1 - \omega_{2t}(j)} \tag{3}$$

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 (1) and (3) then gives an aggregate supply equation

$$\frac{\theta - 1}{\theta} = \frac{1 + \omega_{1t}}{1 - \omega_{2t}} \frac{v_{l,t}}{u_{c,t}} \tag{4}$$

assuming that the markups are set symmetrically across sectors. I define $1+\omega_t \equiv \frac{1+\omega_{1t}}{1-\omega_{2t}}$. In steady state I assume that this variable equals $\frac{\theta-1}{\theta}$ which implies that variations in it away from steady state indexes the overall degree of inefficiency in the economy created by the two markup variables. This variable thus creates a "gap" between the natural rate of output (i.e. the allocation under flexible prices) and the efficient rate of output (i.e. the first best allocation). Previous authors, such as Gali, Gertler and Lopez-Salida (2007) refer to it as the "inefficiency gap", while authors such as Chari, Kehoe and McGrattan (2007) and host of other authors refer to at as the "labor wedge"[9].

Instead of assuming flexible prices, I assume that the firm chooses its price optimally but at staggered intervals. It revisits its price decision with a probability α in each period as in Calvo (1983). 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. Since all output is consumed, and production is linear in labor, this implies that in equilibrium $H_t^c = H_t^l = \rho Y_{t-1}$.

The government can have an effect on the equilibrium allocation through three policy instruments, the choice of ω_{1t},ω_{2t} and by its choice of the nominal interest rate i_t which I assume that the government can set directly. It can be shown the that only the ratio $\frac{1+\omega_{1t}}{1-\omega_{2t}}$ matters for the equilibrium determination (what we define as ω_t) and hence policy can be thought of as the choice of the sequence $\{\omega_t, i_t\}$. We assume that the nominal interest rate cannot be negative, so this policy choice is constrained by $i_t \geq 0$.[10] The set of non-linear equilibrium conditions that define and equilibrium are summarized in Appendix A.

[9] The study of the "labor wedge" has its origin in Parkins (1988).

[10] I do not model explicitly the transaction frictions that give rise to this bound, see Eggertsson and Woodford (2003) for this extension and a justification for abtracting from these frictions in the current context. Note that the important thing about this constraint is not that it is exactly zero , as opposed to, say -0.25 or 0.25 or 1%. What is relevant is that there is a constraint on interest rate policy, so that rates can go no further down once short term bonds and money become close to perfect substitutes, and increasing the money supply has no effect on demand. In the crisis of 2008 in the US, for example, the relevant bound was closer to 0.25 percent, as the Fed determined it could destabilize money markets to go much below that. In that case, however, macro conditions justified considerable further cuts if not for this constraint, and furthermore banks held large excess reserves implying close

I now summarize the model in log-linear form. Definitions of individual coefficients, as a function of the structural parameters, are given in Appendix A. Let $\hat{Y}_t$ denote log-deviation of output from its deterministic steady state, while $\tilde{Y}_t \equiv \hat{Y}_t - \gamma \hat{Y}_t$ is the quasi-growth rate. π_t denotes aggregate inflation, while i_t is now the log of the gross nominal interest rate. Since all production is consumed, the consumption Euler equation can be log-linearized to yield

$$IS \qquad \tilde{Y}_t = E_t \tilde{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) \tag{5}$$

where $\sigma > 0$. Equation (5) 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, r_t^e, which is a exogenous (it is a function of the preference shock ξ_t). I refer to equation (5) as the *IS* equation. The Euler equation of the firms pricing problem, together with the aggregate price dynamics can be approximated to yield

$$AS \qquad \pi_t = \kappa \tilde{Y}_t + \beta E_t \pi_{t+1} + \kappa \varphi \hat{\omega}_t \tag{6}$$

where $\kappa > 0$, and both β and φ are between 0 and 1. 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 *Aggregate Supply* equation, or *AS equation*. If the government increases monopoly power of workers or firms, a higher $\hat{\omega}_t$, this increases inflation other things constant. Finally the zero bound

$$ZB \qquad i_t \geq 0. \tag{7}$$

An approximate equilibrium can now be defined as collection of stochastic processes for the endogenous variables $\{Y_t, \pi_t\}$ given the exogenous process $\{r_t^e\}$ and decision rules for the policy variables $\{\omega_t, i_t\}$ that solve (5)-(7)

3 Deflation and output Collapse under emergency conditions

The Great Depression in the model comes about due to an exogenous shock which trigger the "emergency conditions" in the model.

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

substitutability of money and bonds. During the Great Depression, the nominal interest rate paid on three month Treasuries was very close to zero, for example at 0.06 in January 1934 and banks held large amount of excess reserves. The analytics of what follows would be same if we assume the bound is some number i^m which is binding but may be different from 0.

Panel (a) in Figure 3 illustrates this assumption graphically. Under this assumption, the shock r_t^e remains negative, in the depression state or "short run" denoted S, until some stochastic date τ, when it returns to its long run steady state $r_L^e = \bar{r}$. This happens due to a shock to preferences, but more sophisticated interpretations are possible, however, such as shocks originating from a banking crisis.[11]

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

$$i_t = \max\{0, r_t^e + \phi_\pi \pi_t + \phi_y \tilde{Y}_t\} \tag{8}$$

$$\hat{\omega}_t = 0 \tag{9}$$

where $\phi_\pi + \frac{1-\beta}{4\kappa}\phi_y > 1$. This monetary policy is standard and implies that the government seeks to stabilize inflation at zero and output at potential. The baseline assumption about the NIRA 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[12]

$$i_t = r_L^e = \bar{r} \text{ for } t \geq \tau \tag{10}$$

$$i_t = 0 \text{ for } 0 < t < \tau \tag{11}$$

Closed form solutions for the other endogenous variables can now be derived assuming (8)-(11). 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., $\pi_t = \pi_S$ (with probability μ). Hence the solution in $t < \tau$ satisfies the AD and the AS equations

$$AD \qquad \tilde{Y}_S = \mu \tilde{Y}_S + \sigma \mu \pi_S + \sigma r_S^e \tag{12}$$

$$AS \qquad \pi_S = \kappa \tilde{Y}_S + \beta \mu \pi_S \tag{13}$$

where we have taken account of that $E_t \pi_{t+1} = \mu \pi_S$, $E_t \tilde{Y}_{t+1} = \mu \tilde{Y}_S$ and that (11) says that $i_t = 0$ when $t < \tau$. Note that by substituting the monetary policy rule into the IS equation, we now have an aggregate demand equation, or AD equation, that determines the total number of goods demanded in the economy, given monetary policy.

[11] 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 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. The decline in r_t^e is due to a shock to preferences. Everyone suddenly want to save more so that the real interest rate has to decline for output to stay constant. Curdia and Eggertsson (2009), building on Curdia and Woodford (2008), show that a model with financial frictions can also be reduced to equations (5)-(6). In this more sophisticated model the shock r_t^e corresponds to an exogenous increase in the probability of default by borrowers. A similar story is explored in Del Negro, Ferrero, Eggertsson and Kiyotaki (2009) and Eggertsson and Krugman (2010).

[12] The equilibrium interest rate shown in (10) 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 $i_t = r_t^e + \phi_\pi \pi_t + \phi_y \tilde{Y}_t$.

To understand better the equilibrium implied by equations (12) and (13), it is helpful to graph the two equations in $(\tilde{Y}_S, \pi_S)$ space. Consider first the special case in which $\mu = 0$, i.e. the shock r_S^e reverts back to steady state in period 1 with probability 1. This case is shown in panel (a) in Figure 4. 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 AD curve and pinned down by the shock r_t^e. For a given level of output, then, inflation is determined by where the AS curve intersects the AD 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 AD and the AS curves, and the equilibrium is determined at the intersection of the two dashed curves, at point B. Observe that the AD equation is no longer vertical but upward sloping in inflation, i.e., higher inflation *expectations* $\mu\pi_S$ increase output. The reason is that for a given nominal interest rate ($i_S = 0$ 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 $\mu\pi_S$, causes current consumption to be relatively more expensive than future consumption, thus suppressing spending. Observe, furthermore, the presence of the expectation of future contraction, $\mu\tilde{Y}_S$, on the right-hand side of the AD equation. The expectation of future contraction makes the effect of both the shock and the expected deflation even stronger, by a factor of $\frac{1}{1-\mu}$. Note the unusual shape of the AD curve: It is upward sloping in inflation and output. As we will see later in the paper (see section 4.2), this backward bending shape of the the aggregate demand is special to the zero bound, and will be key to understand the main result. Turning to the AS equation (13), 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 $\mu\pi_S$ on the right-hand side of the AD equation. This increases the real interest rate and suppresses demand. Second, the expectation of future output contraction, captured by the $\mu\tilde{Y}_S$ term on the right-hand side of the AD 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 AS equation.

The vicious deflationary spiral described above amplifies the contraction without a bound as μ increases. As μ increases, the AD curve becomes flatter and the AS curve steeper, and the cutoff point moves further down in the $(\tilde{Y}_S, \pi_S)$ plane in panel (a) of Figure 4 and the model eventually explodes. 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.*[13] In the remainder of the paper we assume that μ is small enough so that the deflationary black hole is avoided and the solution is well defined, unique and bounded (this is guaranteed by the inequality in assumption A1).[14] To summarize, solving the AD and AS equations with respect to π_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:*

$$\pi_t^D = \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\kappa\sigma r_S^e < 0 \text{ if } t < \tau \text{ and } \pi_t^D = 0 \text{ if } t \geq \tau \tag{14}$$

$$\tilde{Y}_t^D = \frac{1-\beta\mu}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\sigma r_S^e < 0 \text{ if } t < \tau \text{ and } \tilde{Y}_t^D = 0 \text{ if } t \geq \tau \tag{15}$$

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 τ, and the equilibrium depicted in Figure 4 applies only in the "depression" state what we denote as "short run". This is illustrated in Figure 3, which shows the solution for a arbitrary contingency in which the shock lasts for τ periods. While panels (a)-(e) in Figure 3 take the same form for any parameter values satisfying A1, and any contingency $t < \tau$, the figure also reports the quantitative value of each variable. This is helpful to get some quantitative sense for the result and for some of the numerical experiments in coming sections.

All the numerical experiments are done using the values for the parameters and shocks that are listed Table 1 under the heading "mode". These values were obtained using Bayesian methods (see Appendix B). The mode was constructed as follows. First, we form priors about the parameters and shocks. They are shown in Table 1 and discussed in Appendix B. The second step is to combine the priors with data on output and inflation for the five year period 1929-1933 and construct a posterior distribution. Thus the posterior is constructed to match the downturn of 1929-33. Maximizing this posterior gives us the mode.

In Figure 3 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

[13] As μ approaches $\bar{\mu}$ from below, the contractionary forces of the model are so strong that the model collapses, and the linear approximation is no longer valid. Beyond $\bar{\mu}$ there equilibrium is indeterminate. 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.

[14] A deflationary solution always exists as long as the shock μ 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.

deflationary shock (the figure illustrates the case in which $\tau = 4$ where output declines by a third). Observe that an exogenous reversal in the shock r_S^e to steady state cannot explain the recovery in the data, according to the model. The reason for this is that such a theory of the recovery would imply an increase in the nominal interest rate. That contradicts the data. Accordingly we explore the extent to which the NIRA can quantitatively account for the recovery observed in the data in 1933-37, keeping constant to shock r_t^e constant in the low state r_S^e. Hence we attempt to explain the recovery *exclusively* through the change in policy.

While the short term nominal interest rate on risk-free debt is zero, it is expected to increase in the future because the shock is expected to revert back to steady state. This implies that long-term interest rate are predicted to be above zero, according to the model, but according to the expectation hypothesis of the term structure the long-rate will depend on the current and expected future short rates. This is consistent with the data from the Great Depression. If we include private debt with default risk (as in e.g. Curdia and Woodford (2008)), then the short-term nominal interest rate paid on those bonds would be positive. None of this changes the constraint imposed by the zero bound, which arises due to the fact that money is a viable store of value in the economy, and hence savers would never be willing to hold a bond with negative nominal returns if they can alternatively hold cash with zero nominal returns.

4 Was the New Deal contractionary?

4.1 Expansionary NIRA under emergency conditions

Can the government break the contractionary spiral observed in Figure 3 by increasing the monopoly power of firms and workers. To analyze this question, we assume that the interest rate is again given by (10) and (11) but that the government implements New Deal according to the policy rule

$$\hat{\omega}_S = \phi_\omega r_S^e > 0 \text{ when } 0 < t < \tau \tag{16}$$

with $\phi_\omega < 0$ and

$$\hat{\omega}_t = 0 \text{ when } t \geq \tau. \tag{17}$$

There are two reasons for considering this policy rule. The first is theoretical. As I will show a policy of this form can be derived from microfoundations, either by assuming that the government was following the optimal forward looking policy (see section 5.1), or by assuming a Markov perfect equilibrium (see Appendix E which also analyses the Ramsey allocation). The second reason is empirical. As discussed in the introduction, NIRA was an "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 NIRA 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 AD and AS equations. While the AD equation is unchanged, the AS equation is now

$$AS \qquad \pi_S = \kappa \tilde{Y}_S + \beta \mu \pi_S + \kappa \varphi \hat{\omega}_S \tag{18}$$

where the NIRA policy appears on the right-hand side. An increase in $\hat{\omega}_S$ shifts the AS curve leftward, denoted by a dashed line in panel (b) in Figure 4. Why does the AS curve shift? Consider a policy that facilitates 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 AS 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 AS curve to the left. A new equilibrium is formed at the intersection of the dashed AS curve and the AD curve at higher output and prices, i.e., at point B in panel (b) in Figure 4. 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 AD 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 AD equation, leading to a higher demand, which again increases inflation according to the AS equation, feeding into even higher output in the AD equation and so on, leading to a virtuous feedback circle between the two equations, converging to point B in panel (b) in Figure 4. Note that it is not contemporaneous inflation that has the expansionary effect according to the AD equation. It is the *expectation* of higher prices in the future, $\mu\pi_S$, 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 NIRA. Suppose A1, $\mu > 0$, that monetary policy is given by (10) and (11), and that the government adopts the NIRA given by (16) and (17). Then output and inflation are increasing in $\hat{\omega}_S$, and given by*

$$\begin{aligned} \tilde{Y}_t^{ND} &= \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}[(1-\beta\mu)\sigma r_S^e + \mu\kappa\sigma\varphi\hat{\omega}_S] > \tilde{Y}_t^D \ \textit{if } t < \tau \\ \textit{and } \tilde{Y}_t^{ND} &= 0 \ \textit{if } t \geq \tau \end{aligned}$$

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

so that NIRA is expansionary.

To underline the dynamic nature of this policy, Figure 3 shows the evolution of the policy variables, 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 ω_S 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 ω_S assumed in the figure is derived in section 5.1). 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.

Figure 6 shows the implied recovery in the model, assuming there was no policy in 1929-33, and then a new policy regime in 1933. There is a vertical line denoting when FDR came into power. The figures compare the output of the model to the data using the mode of the calibration outlined in last section.[15] 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.

Figure 6 (last panel) 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 described in the Appendix. 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.[16] 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 NIRA was entirely responsible for the recovery (although this is close to being possible with some probability

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

[16] 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.

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 NIRA may be the missing link. It remains an important task to jointly estimate the contribution of each policy in order for a more complete answer, an exercise which should also include richer set of data than the bare minimum we have studied here.

The figures represent a best-case scenario for the New Deal. This is because in the calibration of $\hat{\omega}_S$ 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 $\hat{\omega}_S$ although we will see in Proposition 5 that this does not change the result qualitatively.

Observe one important implication of the theory when one interprets the data, for example, the increase in industrial production in the summer of 1933 shown in Figure 2. The theory suggests that the reversal in output should happen *when the policy is announced,* not when it is implemented. This is because as we have already seen it is the shift in inflation expectations that drives the result. Consistent with this, we see that industrial production starts growing immediately when FDR takes power in march 1933 (in the figure we draw a line when FDR takes power) and announces a policy of inflating the economy.

4.2 Contractionary NIRA under normal conditions

In the absence of the "emergency conditions" created by the large deflationary shocks in the last section, the model behaves as one would expect from standard economic logic. The NIRA is contractionary under normal conditions. The reason is that, in this case, the real interest rate endogenously rises in response to the NIRA, instead of falling and thus the NIRA contracts demand rather than increasing it.

To see this, assume that monetary policy follows once again the baseline policy (8) but that the shock is small enough so that $r_S^e > 0$ (A similar result can be shown using several other commonly used policy rules). In this case the zero bound is no longer binding. The AS equation is unchanged from equation (18) while the AD equation can now be written as

$$\tilde{Y}_S = -\sigma \frac{\phi_\pi - \mu}{1 + \phi_y - \mu} \pi_S + \frac{\sigma}{1 + \phi_y - \mu} r_S^e$$

where we have substituted for $i_S = r_S^e + \phi_\pi \pi_S + \phi_y \tilde{Y}_S$ using the monetary policy rule (8). The fact that the interest rate does not collapse to zero but is instead given by $i_S = r_S^e + \phi_\pi \pi_S + \phi_y \tilde{Y}_S$ implies an important difference in the AD curve. Because $\phi_\pi > \mu$, this implies that the AD curve is downward sloping in inflation in the $(\tilde{Y}_S, \pi_S)$ plane, as shown in Figure 4, panel (c), and no longer has the unusual "backward bending" shape. In fact, the model now collapses down to exactly the same type of "AS-AD" diagram one finds in most undergraduate textbooks.

Panel (c) in Figure 4 shows the consequence of increasing the $\hat{\omega}_S$ under normal conditions. While the New Deal again increases inflation, it reduces output at the same time. What's going on is that the central bank responds to inflation pressures by raising interest rates more than one

by one (in accordance to the Taylor principle), in contrast to the previous case, when the central bank kept the interest rate at zero. Hence aggregate demand contracts. The following proposition follows directly.

Proposition 3 *Suppose the shock in A1 is not satisfied because the shock is not large enough so that $r_t^e > 0$. Then NIRA is contractionary.*

This proposition thus clarifies that we need "emergency conditions" to obtain the key result. If there are no large intertemporal shocks that create excess deflation and output gap, then the NIRA is contractionary, since then there will be no reason for interest rates to drop in response to the policy. This gives explicit justification for the sunset provision in the original Act passed by Congress in 1933: NIRA was only useful to battle the emergency.

5 Extensions

5.1 The New Deal as a theory of the optimal second best

So far we have studied the New Deal policies as reduced-form policy functions motivated by the historical record. Here we derive them from "microfoundations" and show that the New Deal is an interesting example of the "optimal second best" as in Lipsey and Lancester (1956). The government maximizes the utility of the representative household

$$U_t \approx -\frac{1}{2}\sum_{t=0}^{\infty}\beta^t\{\pi_t^2 + \lambda\tilde{Y}_t^2\} + t.i.p \tag{19}$$

where *t.i.p.* denotes terms independent of policy and $\lambda = \kappa/\theta$.[17] A first best equilibrium is 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. The first best social planner's problem is to maximizes (19) subject to (5) and (6), taking the process for $\{r_t^e\}$ as given. The second best social planner's problem also takes into account the zero-bound constraint (7). It is obvious from (19) that the best the government can do is to achieve $\pi_t = \tilde{Y}_t = 0$. This corresponds to the first best. It is then also easy to confirm that the necessary conditions for implementing the first best solution is that $i_t = r_t^e$ and $\hat{\omega}_t = 0$. One interpretation of the baseline rule is just a naive implementation of these necessary conditions "whenever possible". The first condition 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 one necessary condition for the first best has to be violated due to the zero bound. This leads directly to the study of the optimal second best.

[17] 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.

To study optimal second best policy, one needs to take a stance on whether there are any additional restrictions on government policy. The central result of this section assumes optimal policy from a forward looking-perspective (OFP) as in Eggertsson and Woodford (2003,2004). OFP 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 rule. The central proposition of this section follows.

Proposition 4 *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 and is proved in the Appendix. 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 3 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., $\hat{\omega}_t > 0$.

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 and we pick the parameter ϕ_ω using this expression in our simulation.[18] An important question is whether the results are overturned once we allow for more policy options, such as expansionary monetary and fiscal policy. This is one of the issues we now turn to.

5.2 Expansionary monetary and fiscal policy together with the New Deal

It is well documented that in 1933 FDR also pursued expansionary monetary and fiscal policy (see e.g. Eggertsson (2008)). We have not discussed either so far. Is the NIRA expansionary in the model if the government also stimulated spending by a monetary and fiscal expansion? This section shows that, conditional on the deflationary shock, the NIRA remains expansionary as long as a simple condition is satisfied in equilibrium: The central bank does not raise the nominal interest rate in response to the NIRA. As we have already seen this condition was satisfied in the data (Figure 6).

Consider the following specification of monetary and fiscal policy.

$$i_t = \max\{0, r_t^e + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(\tilde{Y}_t - \tilde{Y}^*)\} \tag{20}$$

[18] Appendix E shows that the same is true for a Markov Perfect Equilibrium of the model, and also illustrates the Ramsey allocation.

$$\hat{G}_t = \hat{G}_S > 0 \quad \text{for} \quad 0 < t < \tau \tag{21}$$

$$\hat{G}_t = 0 \quad \text{for} \quad t \geq \tau \tag{22}$$

Here we allow for a permanent increase in the growth rate of the money supply by π^*, as commitment to a permanent increase in the growth rate of money, while a expansionary fiscal policy is modeled as a temporary increase in government spending during the time of the crisis. We impose the following limit on the monetary and fiscal expansion.

A2 – Monetary and fiscal policy restrictions: The monetary expansion π^* and the fiscal expansion G_S are such that $\pi^* + [\phi_\pi \pi^G + \phi_y Y^G]\hat{G}_S \leq -r_S$ where $\pi^G, Y^G > 0$ are coefficients given in the proof of Proposition 5.

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.

Proposition 5 *Suppose that monetary policy is given by (20), fiscal policy by (21) and (22), and the New Deal by (16)-(17) and that A1 holds. Then (i) for any monetary policy $\pi^* \geq 0$, and fiscal policy $\hat{G}_S > 0$ 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 AS and AD equations in periods $0 < t < \tau$ when the zero bound is binding:

$$AD \qquad \tilde{Y}_S = \mu \tilde{Y}_S + (1-\mu)\tilde{Y}^* + \sigma\mu\pi_S + \sigma(1-\mu)\pi^* + \sigma r_S^e + (1-\mu)\hat{G}_S \tag{23}$$

$$AS \qquad \pi_S = \kappa \tilde{Y}_S + \beta\mu\pi_S + \beta(1-\mu)\pi^* + \kappa\varphi\hat{\omega}_S - \kappa\varphi\hat{G}_S. \tag{24}$$

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 π^* and $\tilde{Y}^*$ while r_t^e remains negative (this is condition A2). Intuitively the proof of the proposition can now be seen by simply observing that the slope of the AD and AS equation in $(\tilde{Y}_S, \pi_S)$ space remains the same, the expansionary monetary and fiscal policy only shifts these curves but does not change their slopes, as can be seen in panel (a) of Figure 5 which shows the effect of an expansionary monetary policy. Importantly the second part of Proposition 4 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 to confirm that monetary and fiscal policy actions did not eliminate the expansionary effect of the New Deal. As we have already seen the interest rate remained zero during this period, thus suggesting that NIRA was expansionary according to the model.

5.3 A persistent New Deal policy

So far we have assumed that the New Deal policies are temporary, as stipulated in the NIRA passed by Congress in 1933. In particular, 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*. 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 δ. The policy takes the form

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

and

$$\hat{\omega}_t = \delta \hat{\omega}_{t-1} \geq 0 \text{ when } t \geq \tau \tag{26}$$

Observe that an *ad hoc* policy as in (26) is always sub-optimal and cannot be motivated by the same microfoundations as the baseline policy. It is of some interest to explore, however, since one can imagine unmodelled "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 (20). 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 6. 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 6 *Suppose A1, $\mu > 0$, and that $\hat{\omega}_t$ follows (25)-(26) instead of (16)-(17). 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 6, write the AD and AS equations in period $t < \tau$ as

$$AD \qquad \tilde{Y}_S = \mu\tilde{Y}_t + (1-\mu)Y^w\delta\omega_S + \sigma\mu\pi_S + \sigma(1-\mu)\pi^w\delta\omega_S + \sigma r_S^e \tag{27}$$

$$AS \qquad \pi_S = \kappa\tilde{Y}_S + \beta\mu\pi_S + \beta(1-\mu)\delta\pi^w w_S + \kappa\varphi\hat{\omega}_S \tag{28}$$

It is helpful to study panel (b) of Figure 5. Observe first that when $\delta = 0$ the New Deal is always expansionary. Consider now $\delta > 0$. Consider first the AS equation. The increase in $\hat{\omega}_S$ shifts the AS curve upward. With the additional prospect of higher inflation in period $t \geq \tau$ (corresponding to the third term on the right), this policy shifts the AS curve even further, thus working in favor of making the New Deal policy *even more expansionary that previously*, as shown at point B in panel (b) in Figure 5. The effect on the AD equation, however, is ambiguous and depends on the value of ϕ_π, ϕ_y, and δ (see e.g. points C and D in panel (b) of Figure 5) If we assume a reasonable

values for ϕ_π and ϕ_y, such as for example 1.5 and 0.25 the New Deal is expansionary. One has to assume extreme values in the parameter space to cause a short-run contraction. 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.

5.4 A multisector economy

For simplicity, we maintained the assumption throughout the paper is that all sectors look the same, and that hence, the increase in monopoly power is symmetric across all sectors.[19] How do the result change if we assume instead, that the change in monopoly power only applies to a subset of the industries? It is often suggested that the increase in monopoly power only applied to a subset of industries during the New Deal (see e.g. Cole and Ohanian (2004)). Here we will see that this does not change the results qualitatively.

Instead of assuming that the consumption index that enters the utility function is defined by CES index as in section 2, let us suppose instead that it is a CES aggregate of two subindices $C_t \equiv (n_1^{1/\eta} C_{1t}^{(\eta-1)/\eta} + n_2^{1/\eta} C_{2t}^{(\eta-1)/\eta})^{\eta/(\eta-1)}$ which corresponds to two sectors in the economy. Then, as shown in Woodford (2003), for each sector there is a sectorial inflation rate that is related to the aggregate output as

$$\pi_{jt} = \kappa \tilde{Y}_t + \gamma_j \hat{p}_{R_t} + \beta E_t \pi_{jt+1} + \kappa \varphi_j \omega_{jt}$$

for $j = 1, 2$ where κ is defined as before (see Appendix A), $\gamma_1 = n_2 \kappa \frac{1+\omega\eta}{\omega+\sigma^{-1}} > 0$ and $\gamma_2 = n_1 \kappa \frac{1+\omega\eta}{\omega+\sigma^{-1}} < 0$ and $\hat{p}_{Rt} \equiv \log \frac{p_{2t}}{p_{1t}}$ is the relative price of the goods from the two sectors. Now ω_{jt} is the inefficiency gap in each sector and we can consider an experiment in which NIRA only applies to one sector. We now can see that if we define $\pi_t \equiv n_1 \pi_{1t} + n_2 \pi_{2t}$ and $\omega_t = n_1 \omega_{1t} + n_1 \omega_{2t}$ we obtain exactly the same AS relationship as in (6). This means that, to a first order, all our previous results remain unchanged with the exception of those in section 5.1 which we return to shortly. One interesting aspect of the extended model is that output may even decline in the cartelized sector, depending on the relative price shift. The robust prediction is only that overall output increases in response to NIRA.[20]

While sectorial heterogeneity has no first order effect in the model, it matters to a second order. This means that the result we derived in section 5.1 changes because Proposition 4 relies not only on the first order dynamics of the model but also depends on the period utility (to a second order) is now given by

$$\sum_{j=1}^{2} \lambda_{\pi j} \pi_{jt}^2 + \lambda_y \tilde{Y}_t^2 + \lambda_R \hat{p}_{Rt}^2$$

What does this mean? Its means that if NIRA only applies to a subset of the economy, it is more costly because it leads to some relative price distortion which are suboptimal. It remains the case, however, that NIRA is an optimally second best policy as long as the zero bound is binding.

[19] I thank an anonymous referee for raising my attention to the importance of this assumption.

[20] This is because while we have $\hat{Y}_t \equiv n_1 \hat{Y}_{1t} + n_2 \hat{Y}_{2t}$, where $\hat{Y}_{1t} \equiv \log(\frac{Y_{1t}}{Y})$, $\hat{Y}_{2t} \equiv \log(\frac{Y_{2t}}{Y})$ we also have $\log(\frac{Y_{2t}}{Y_{1t}}) = -\eta p_{R,t}$. This means that even if $\hat{Y}_t$ goes up, what happens to output in each sector depends on $p_{R,t}$.

5.5 Increased flexibility

Given that one of the key assumption required for the result is price rigidity is seems important to ask: How sensitive are the results to the assumed degree of price flexibility? 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 (14) and (15) reveal the puzzling conclusion that the higher the price flexibility (i.e., the higher the parameter κ), the stronger the output collapse in the absence of the New Deal policies (this can also be seen in Figure 4, but a higher κ results in a steeper AS curve), and consequentially the more impact the policy has. 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 AD 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 (15) 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.

5.6 Further extensions

The basic objective of this paper has been to illuminate how a New Deal policy can be expansionary in the baseline New Keynesian model. Accordingly, with minor exceptions, I have tried to stay as close as possible to the most basic version of that model, as for example illustrated in Clarida, Gali and Gertler (1999) and Woodford (2003). This allowed us to study the evolution of aggregate output, inflation and the nominal interest rate and we have studied the extent to which the model can replicate the data from 1929-37. Furthermore it has allowed us to consider several extensions of the baseline in a condensed form. It seems worth commenting briefly, however, on the extent to which the model can be extended to match the macroeconomic data at a more detailed and disaggregated level.

The Appendix shows that the basic conclusion holds up with an endogenous capital stock. It does not attempt, however, to match the data on investment. There seems little reason to expect that this cannot be done in a more detailed model, for example, along the lines of Christiano,

Eichenbaum and Evans (2005) or Smets and Wouters (2007), but both model share the same basic structure with the current paper. Studying the Great Depression in a more complete DSGE model, and allowing for variety of frictions and policies, while taking the zero bound explicitly into account, remains a major area for future research. One attractive feature of these models is that they encompass variable capital utilization which can explain one source of the recovery our model is silent about. It has been documented that total factor productivity increased considerably during the upturn in 1933-37 (see e.g. data in Kehoe and Prescott (2007)). A natural explanation for this in the context of these models is that the existing capital stock in 1933 was not being fully utilized, but as production started increasing during the recovery in 1933-37, then firms did not only start hiring new (unemployed) workers, they also started utilizing more fully the existing capital stock.

6 Comparisons to the existing literature

We have shown that NIRA was expansionary according to a standard New Keynesian model under the conditions that arguably characterized the Great Depression. This is contrary to a long standing literature on this subject. What is the reason for the difference? Traditional Keynesian analysis graphs up aggregate demand as a downward sloping relationship in inflation-output space, as shown in panel (c) in Figure 4, a figure found in most undergraduate textbooks. In this standard figure as one reduces aggregate supply, this will increase prices but at the same time contract demand as it is downward sloping in inflation. What we have shown, however, is that once one incorporates the zero bound, and expectations, demand starts sloping upward in the price-output space under certain emergency conditions that we defined. The key to this result is that we have extended the analysis relive to the old fashion Keynesian model by incorporating expectations. This allowed us to show that aggregate demand becomes upward sloping in inflation at the zero bound because higher inflation expectation will then increase demand due to the implied reduction in the real interest rate. Since Keynesian analysis typically assumes that expectations are exogenous this effect is not incorporated. Thus the key difference relative to old Keynesian analysis lies in the explicit modelling of expectations and how the NIRA was important in changing deflationary expectations to inflationary ones, much as argued by policymakers at the time.

Turning to the subsequent literature I find it useful to organize that discussion by reminding the reader of the first question posed in the paper: Can a policy that reduces the *natural rate of output* increase *equilibrium output*? One reason to pose this question right at the start, is that it puts on the table a basic property of the policy experiment : *The policy we consider reduces the natural rate of output.* The natural rate of output, defined by Milton Friedman (1968), is the output that would be produced in the absence of nominal frictions, i.e., if prices are flexible. Using equation (4), we obtain for the natural rate of output

$$\tilde{Y}_t^n = -\varphi\hat{\omega}_t. \tag{29}$$

This illustrates that in our model then when prices are flexible the New Deal policy always

generates a output contraction. Notice that our model is at its core a neoclassical growth model (although we abstract from capital). This clarifies that the assumption of *price rigidities* is at the heart of the expansionary effect of the New Deal policy. It also clarifies that the relatively large literature that has studied the effect of the New Deal in models with flexible prices and finds that these policies are contractionary is in fact consistent with our model and corresponds to the special case in which $\alpha = 0$ (examples include those mentioned in the introduction such as Cole and Ohanian (2004)).

Equation (29) already tells us that models with flexible prices will make the New Deal contractionary, at least if they have the basic structure of the neoclassical growth model (which applies to most modern macro model). This does not explain, however, why some other recent studies which have nominal frictions also come to this conclusion. Studies of this kind include Bordo, Erceg and Evans (2000).[21] That paper also includes nominal rigidities but finds that the New Deal policies made the recovery in 1933-37 much slower. The key element of the current model, relative to that study, is that we include an intertemporal shock that makes the zero bound binding. As we already saw in section 4.2, the key condition for the New Deal to be expansionary is that the zero bound is binding. If not then the AD curve has its normal shape, like in the old Keynesian analysis, and NIRA becomes contractionary. Thus once again, the model studied here is indeed consistent with prior DSGE literature on this subject, but corresponds to the case in which the zero bound is not directly imposed, and/or there are no intertemporal shocks.

Accordingly, we have now seen that three key assumptions needed for the main result that (i) expectations are endogenous, (ii) prices are not perfectly flexible. and (iii) there are intertemporal shocks that make the zero bound binding, i.e. shocks that create a Great Depression scenario with excess deflation and an output slack. In the absence of *any* of these assumptions, the central result cannot be obtained. Of these three assumptions, the paper has nothing new to say about the first two, which has been at the heart of macroeconomic research over the past decades, except perhaps to clarify how important these assumptions are for studying the New Deal.

It seem reasonable to ask, however, is there any evidence for assumption (iii)? According to the theory, the output collapse is partially explained by real rates failing to follow the "efficient rate of interest" in 1929-33 when it became negative. Hence that real interest rates are "too high" is the main culprit for the output collapse and deflation in the model. The recovery, then, is explained by the fact that real rates went down significantly due to policy changes in 1933, including the NIRA, which triggered an increase in inflation expectations.

Figure 7 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. This data is supportive of intertemporal shocks as important to understand this period and they do follow the basic patterns predicted by the model. The real rates were very high by historical norms during the contractionary phase in 1929-33 and turned negative in 1933-37. Also

[21] Appendix C shows that Bordo et al (2000) assumption of nominal wages rather than prices does not affect the result.

observe that we can exclude the hypothesis that the shocks were over in 1933 at least according to this model, which would then be an alternative hypothesis for the recovery (conditional on the shock being responsible for the contraction). If the intertemporal shocks were over in 1933 then the real rate would have reverted back to steady state and the nominal interest rate would have risen as well. This, however, did not happen. Instead real interest rates turned negative, with inflation only slightly positive. The nominal interest rate, however, stayed at zero throughout the whole recovery period. Note that because the nominal interest rate stayed at zero during this period, the drop in the real interest rate shown in 7 is explained exclusively be an *increase in inflation expectation.* Hence the estimates in Hamilton (1992) and Cecchetti (1992) are consistent with a large change in inflation expectations around 1933, which is consistent with the main hypothesis of the paper.

7 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 NIRA 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 1929-33. 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. More generally, this suggests the difficulty of analyzing the effect of a given government policy, if one does not have an explicit theory of what gave rise to the policy response in the first place. That conclusion harks back to Lipsey and Lancaster's (1956) classic theory of the optimal second best.

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Appendix A: Non-linear equilibrium conditions

This appendix summarizes the non-linear set of equilibrium conditions that are needed to define the equilibrium and a steady state. It also shows the coefficients in the log-linearizes solution reported in the text.[22] The first order condition of the households problem is

$$u_{c,t}\xi_t = \beta E_t \left[u_{c,t+1}\xi_{t+1}(1+i_t)\frac{P_t}{P_{t+1}} \right], \tag{30}$$

Household optimization also requires that the paths of aggregate real expenditure and the price index satisfy the conditions $\sum_{T=t}^{\infty} \beta^T E_t u_{c,T}\xi_T Y_T < \infty$ and $\lim_{T\to\infty} \beta^T E_t[u_{c,T}\xi_T A_T/P_T] = 0$ looking forward from any period t.[23] The optimal labor decision is given in the text by (1). All output is consumed so that $Y_t = C_t$.

Turning to the firms, 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 implies the first-order condition

$$E_t \left\{ \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} u_{c,T}\xi_T (\frac{p_t^*}{P_T})^{-\theta} Y_T [(1-\omega_{2T})\frac{p_t^*}{P_T} - \frac{\theta}{\theta-1}(1+\omega_{1T})\frac{v_{l,T}}{u_{c,T}}] \right\} = 0. \tag{31}$$

where (1) is used to substitute out for wages. Finally, the Dixit-Stiglitz formulation of the price index, together with the Calvo pricing assumption implies

$$P_t = \left[(1-\alpha)p_t^{*1-\theta} + \alpha P_{t-1}^{1-\theta} \right]^{\frac{1}{1-\theta}}. \tag{32}$$

Equilibrium can now be defined as *collection of stochastic processes* $\{Y_t, P_t, p_t^*, i_t, \omega_{1t}, \omega_{2t}\}$ that satisfies these conditions, together with the zero bound, and the given some policy rule for $\{i_t, \omega_{1t}, \omega_{2t}\}$. The steady state of the model is is $\bar{\imath} = \beta^{-1} - 1$, $\frac{1+\omega_1}{1-\omega_2} = \frac{\theta-1}{\theta}$, $\Pi_t = \frac{P_t}{P_{t-1}} = \frac{p_t^*}{p_{t-1}^*} = 1$, $Y_t = \bar{Y}$. The result of the positive analysis of the paper does not depend on the fact that we approximate the model around the fully efficient steady state, doing the approximation for $\frac{1+\omega_1}{1-\omega_2} < \frac{\theta-1}{\theta}$ would not change the key propositions. It would however change the normative analysis (section 5.1) a bit, because then we would need a theory of why the government does not eliminate all monopoly power in the economy when it can. The interpretation of $\frac{1+\omega_1}{1-\omega_2} = \frac{\theta-1}{\theta}$ is that the government puts in place antitrust laws against unions and firm collusion.

Log-linearizing around this steady state the consumption Euler equation (30) yields (5) in the text with $\sigma \equiv -\frac{\bar{u}_c}{\bar{u}_{cc}Y}$ where a bar denotes that the variables [or functions] are evaluated in

[22] For a step by step derivation of a very similar model, see Woodford (2003).

[23] The first condition 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 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 transversality condition is always satisfied.

steady state and $r_t^e \equiv \log \beta^{-1} + \hat{\xi}_t - E_t \hat{\xi}_{t+1}$. The Euler equation (31) of the firms-maximization problem, together with the price dynamics (32), can be approximated to yield(6) in the text with $\hat{\omega}_t \equiv \log((1+\omega_t)/(1+\bar{\omega}))$, $\varphi \equiv \frac{1}{\sigma^{-1}+\upsilon}$, $\kappa \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} \frac{\sigma^{-1}+\upsilon}{1+\nu\theta}$ and $\nu \equiv \frac{\bar{v}_{ll} L}{\bar{v}_l}$.

8 Appendix B:Proofs of Propositions

Proof of Proposition 3: The social planner's problem at date t is

$$\min_{\pi(r^e),\hat{Y}(r^e),\hat{\omega}(r^e),i(r^e)} E_t \sum_{T=t} \beta^{T-t} \{\pi_T^2 + \lambda \tilde{Y}_T^2\}$$
$$\text{s.t. (5), (6) and (7)}$$

The minimization problem can be solved by forming the Lagrangian

$$\begin{aligned} L_0 &= E_0 \sum_{t=0}^{\infty} \beta^t \{\frac{1}{2}\pi(r_t^e)^2 + \frac{1}{2}\lambda \tilde{Y}(r_t^e) + \psi_1(r_t^e)[\pi(r_t^e) - \kappa \tilde{Y}(r_t^e) - \kappa\varphi\hat{\omega}(r_t^e) - \beta\pi(r_{t+1}^e)] \quad (33) \\ & \psi_2(r_t^e)[\tilde{Y}(r_t^e) - \tilde{Y}(r_{t+1}^e) + \sigma i(r_t^e) - \sigma\pi(r_t^e) - \sigma r_t^e] + \psi_3(r_t^e) i(r_t^e)\} \end{aligned}$$

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, $\pi_S, \tilde{Y}_S, i_S, \omega_S$ or $\pi_L, \tilde{Y}_L, i_L, \omega_L$. 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_L to r_S is "remote," i.e., arbitrarily close to zero. The Lagrangian used to find the optimal value for $\pi_L, \tilde{Y}_L, i_L, \hat{\omega}_L$ (i.e., the Lagrangian conditional on being in the L state) can be simplified to yield[24]

$$L_0 = \frac{1}{1-\beta}\{\frac{1}{2}\pi_L^2 + \frac{1}{2}\lambda \tilde{Y}_L + \psi_{1L}((1-\beta)\pi_L - \kappa \tilde{Y}_L - \kappa\varphi\hat{\omega}_L) + \psi_{2L}(i_L - \pi_L - r_L) + \psi_{3L} i_L\}$$

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

$$\pi_L = \tilde{Y}_L = \hat{\omega}_L = 0 \quad (34)$$

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

$$i_L = r_L \quad (35)$$

$$\hat{\omega}_L = 0. \quad (36)$$

Taking this solution as given and substituting it into equations (5) and (6), the social planner's feasibility constraints in the states in which $r_t^n = r_S$ are

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

[24] 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.

$$(1-\mu)\tilde{Y}_S = -\sigma i_S + \sigma\mu\pi_S + \sigma r_S^e)$$

$$i_S \geq 0$$

Consider the Lagrangian (33) given the solution (34)-(36). 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 (34)-(36) the Lagrangian at a date t in which the economy is in the low state can be written as:

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

Differentiating this Lagrangian yields

$$\pi_S + (1-\beta\mu)\psi_{1S} - \sigma\mu\psi_{2S} = 0 \tag{37}$$

$$\lambda\tilde{Y}_S - \kappa\psi_{1S} + \alpha\psi_{2S} = 0 \tag{38}$$

$$-\kappa\varphi\psi_{1S} = 0 \tag{39}$$

$$\sigma\psi_{2S} + \psi_{3S} = 0 \tag{40}$$

and the complementary slackness condition

$$i_S \geq 0,\ \psi_{3S} \geq 0,\ i_S\psi_{3S} = 0 \tag{41}$$

where $\psi_{1S,}$ ψ_{2S} and ψ_{3S} are the Lagrangian multipliers associated with the constraints. Consider now the optimal second best solution in which the government can use both policy instruments. Observe first that $i_S = 0$. This leaves six equations with six unknowns $(\pi_S, \tilde{Y}_S, \omega_{S,}\psi_{1S,}\psi_{2S,}\psi_{3S})$ and equations (37)-(40) together with AD and AS equations) that can be solved to yield

$$\begin{aligned} \tilde{Y}_S &= \frac{\sigma\delta_c}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_S^e < 0, \quad \pi_S = -\frac{\sigma^2\lambda\frac{\mu}{1-\mu}}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_S^e > 0, \\ \hat{\omega}_S &= -\varphi^{-1}\frac{\sigma+\sigma^2\lambda\frac{\mu}{1-\mu}[1-\beta\mu]\kappa^{-1}}{[1-\mu+\lambda\delta_c^2\sigma^2\frac{\mu^2}{1-\mu}]} r_S^e > 0 \end{aligned}$$

The proposition follows directly.

Proof of Proposition 4: Start by deriving A2, the condition for positive interest rates. Assuming $i_S > 0$, then $i_S = r_S^e + \pi^* + \phi_\pi(\pi_S - \pi^*) + \phi_y(\tilde{Y}_S - Y^*)$. Substituting this into the AD equation and solving the AD and AS equations together we obtain

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

$$\pi_S - \pi^* = \frac{(1-\mu)\kappa}{1-\beta\mu+\kappa\sigma(\phi_\pi-\mu)}\hat{G}_S + \frac{\kappa\psi(1-\mu+\sigma\phi_y)}{1-\mu\beta+\kappa\sigma(\phi_\pi-\mu)}\omega_S$$

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 (20), we see that for $\omega_S \geq 0$ 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 AD and AS equation gives

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

and

$$(\pi_S - \pi^*) = \frac{1}{1-\beta\mu}[\kappa(Y_S - Y^*) + \kappa\psi\omega_S]$$

which proves part (i).

Proof of Proposition 6: 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 ω_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 AD and AS equation for $t \leq \tau$

$$\tilde{Y}_S = \mu\tilde{Y}_S + (1-\mu)Y^w\delta\omega_S + \sigma\mu\pi_S + \sigma(1-\mu)\pi^w\delta\omega_S + \sigma r_S$$

$$\pi_S = \kappa\tilde{Y}_S + \beta\mu\pi_S + \beta(1-\mu)\pi^w\delta\omega_S + \kappa\varphi\omega_S$$

solving these together to yield

$$\tilde{Y}_S = \frac{(1-\beta\mu)\sigma}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}r_S + \{\frac{(1-\mu)(1-\beta\mu)\delta[1-\frac{1+\sigma\phi_y-\delta}{\phi_\pi-\delta}]}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}Y^w + \frac{\sigma\mu[\beta(1-\mu)\pi^w\delta+\kappa\varphi]}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\}\omega_S$$

Manipulating the term in the curly bracket, using the expression for π^w, proves the result.

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

$$\log L = \sum_{t=1929}^{1933} -\frac{(\pi_t^{model} - \pi_t^{data})^2}{2\sigma_{\pi,t}^2} - \frac{(Y_t^{model} - Y_t^{data})^2}{2\sigma_{Y,t}^2} + \sum_{\psi_s \in \Omega} f(\psi_s) \tag{42}$$

where Y_t^{model} and π_t^{model} are given by (15) and (14). I write the likelihood conditional on the hypothesis that the shock r_S is in the "low state", i.e. the value of the shock in the short run.

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., π_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 Ω 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, shown in Table 1, are chosen so that θ 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 β 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 σ and ν, 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.[25] Since there is no general agreement about what value to assign to the habit-persistence parameter ρ, a uniform prior was chosen between 0 and 1. The priors for the shocks, however, are chosen as follows. It is assumed that the mean of the shock r_S^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 $\sigma_{\pi,t}^2$ and $\sigma_{Y,t}^2$ 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]).[26] If we assume a point prior on the habit parameter of 0, then the output

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

[26] Other studies, e.g. Smets and Wouters (2007), find that this parameter is closer to 0.7. The reason for this

Parameters	Distributions	Priors			Posteriors			Mode
		10%	50%	90%	10%	50%	90%	
α	Beta	0.527	0.665	0.786	0.558	0.656	0.759	0.657
β	Beta	0.983	0.991	0.996	0.983	0.990	0.996	0.990
μ	1-Beta	0.832	0.908	0.958	0.894	0.933	0.962	0.930
$\widetilde{\nu}$	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
ρ	Uniform	0.100	0.500	0.900	0.823	0.890	0.943	0.924
$\widetilde{\sigma}$	Gamma	0.874	0.997	1.130	0.890	1.012	1.143	0.972
θ	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.

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 Figure 6 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 (42) . Let y^Tdenote the set of available data and Ω the vector of coefficients and shocks. Moreover, let Ω^j denote the jth draw from the posterior of Ω. The subsequent draw is obtained by drawing a candidate value, $\tilde{\Omega}$, from a Gaussian proposal distribution with mean Ω^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.

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].

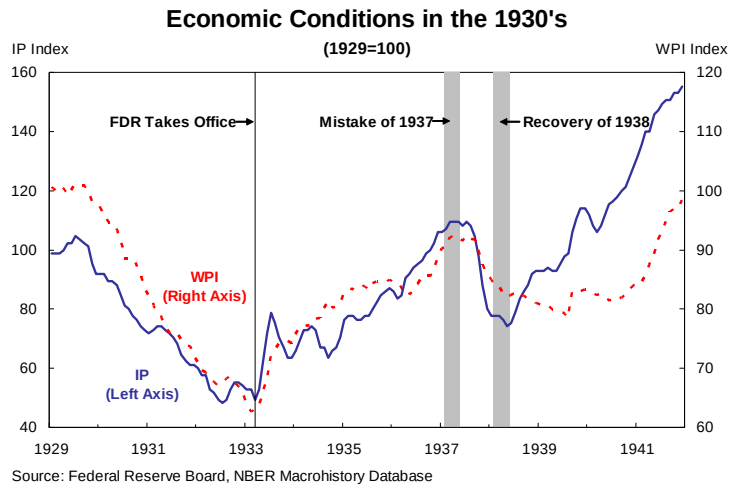

Figure 2: Both whole-sale prices (WPI) and industrial production (IP) collapsed in 1929-33 but abruptly started to recover in March 1933, when FDR took power and announced the New Deal.

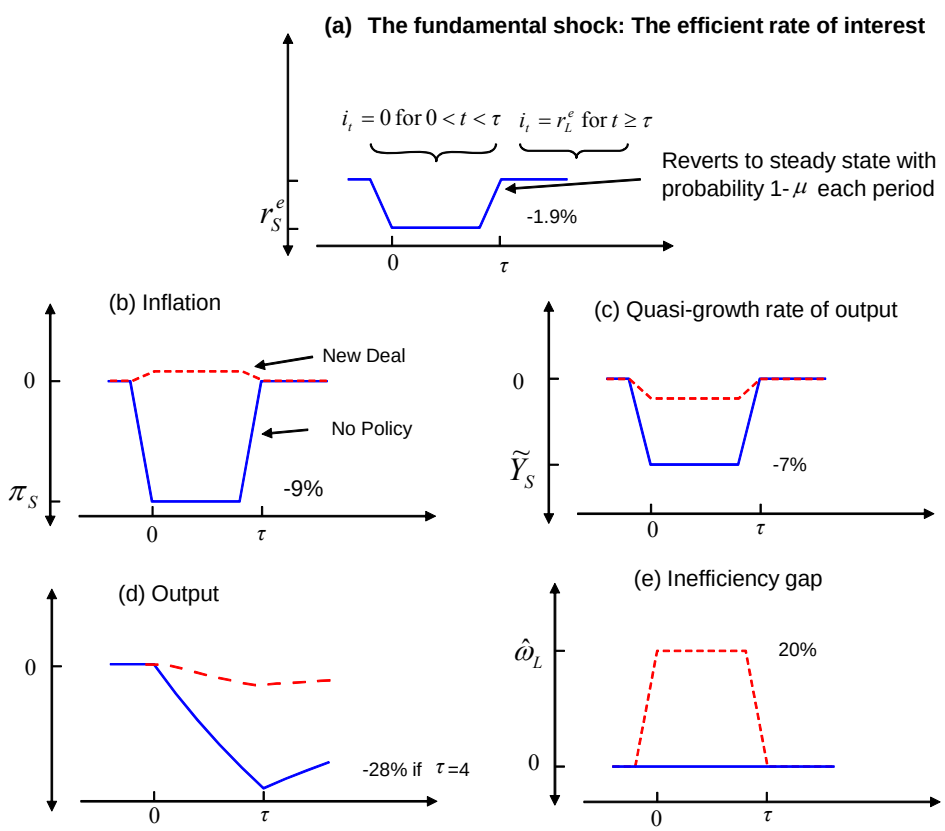

Figure 3: Comparing the equilibrium under the New Deal and no policy.

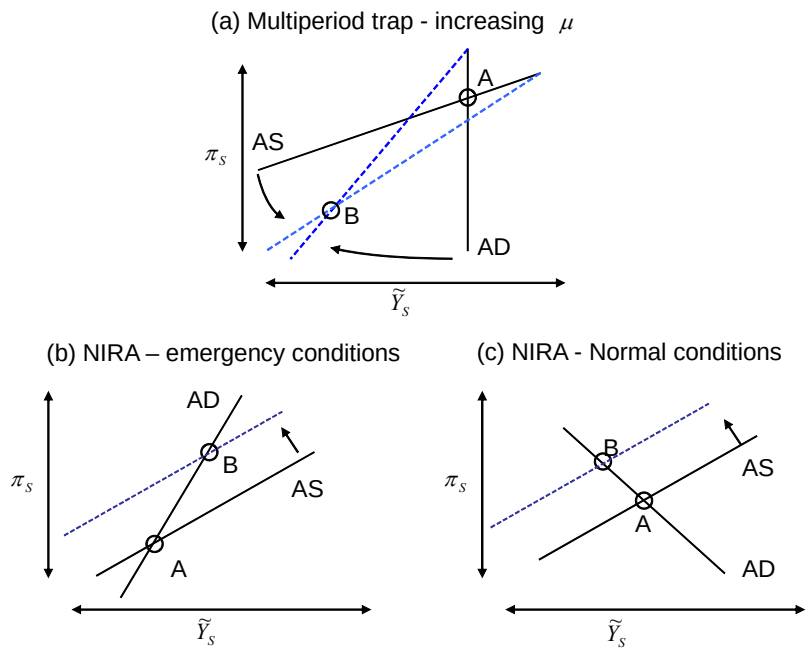

Figure 4: Comparative statics

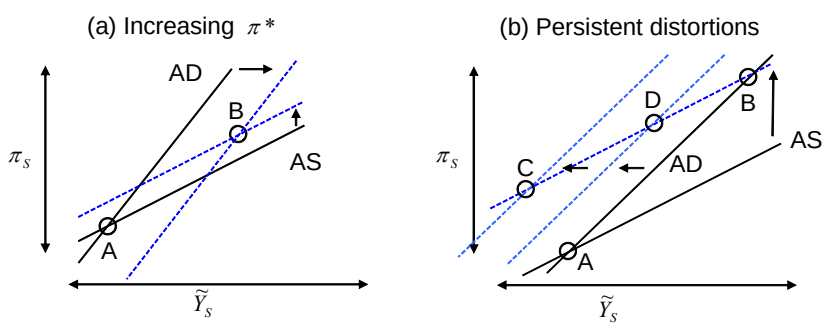

Figure 5: Comparative statics

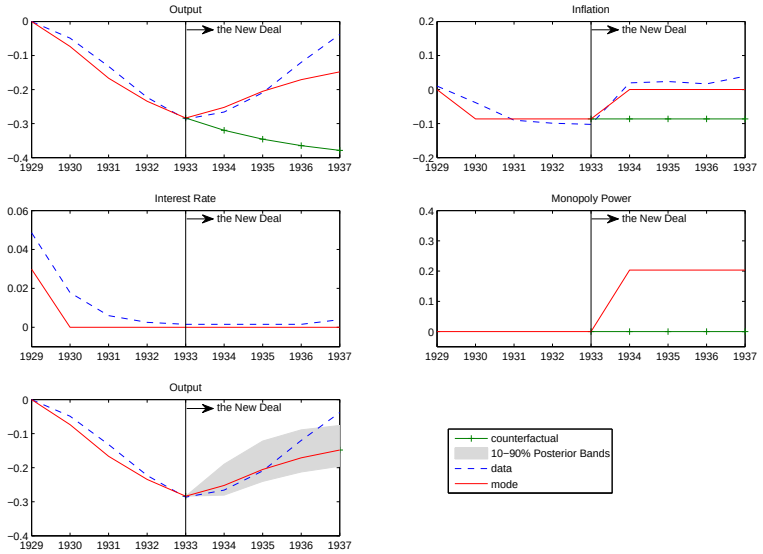

Figure 6: Data on output and simulated output from the model with and without the New Deal (NIRA).

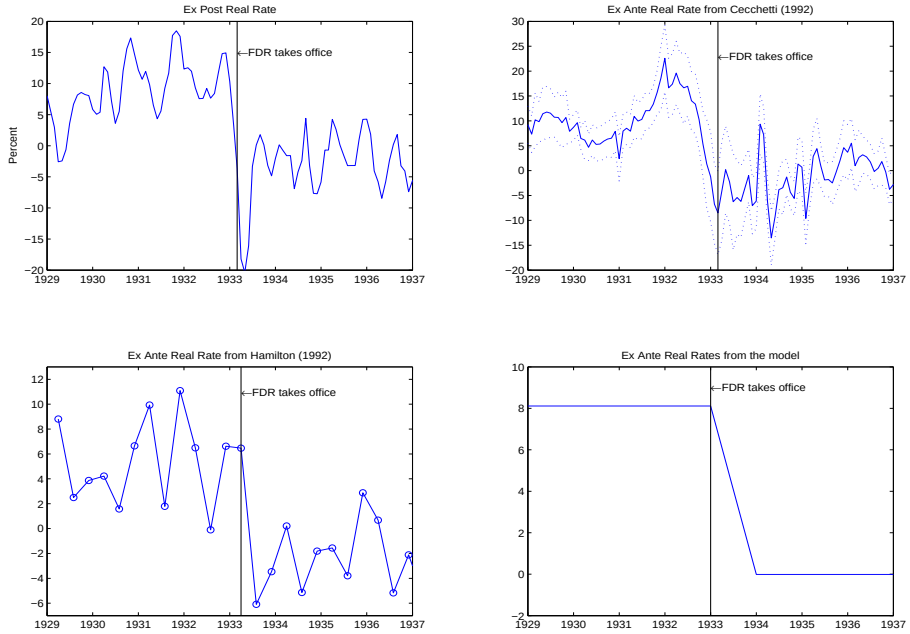

Figure 7: Real interest rates collapsed around the implementation of the New Deal consistent with the theory of the paper.

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 AS curve, i.e. there will be a positive relationship between inflation and output, and the NIRA 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 (5.6) but instead by

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

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

$$L_t(i) \equiv \left[\int_0^1 l_t(i,j)^{(\theta_w-1)/\theta_w} dj\right]^{\theta_w/(\theta_w-1)} \tag{43}$$

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 (30),the transversality condition, and the zero bound condition, are required for a rational expectation equilibrium consistent with households maximization. Note, however, that condition (1), 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 Λ_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 ω_{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

$$E_t\sum_{T=t}^{\infty}(\alpha_w\beta)^{T-t}\frac{u_{c,T}}{P_T}\xi_T L_T W_T^{\theta_w}(1-\omega_{1T})[W_t^*-\frac{\theta_w}{\theta_w-1}\frac{1}{1-\omega_{1T}}\frac{v_l}{u_c}P_T]=0 \tag{44}$$

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

$$W_t=[(1-\alpha_w)EW_t^{*1-\theta_w}+\alpha_w W_{t-1}^{1-\theta_w}]^{1/(1-\theta_w)} \tag{45}$$

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 (43) 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

$$P_t=\frac{\theta}{\theta-1}\frac{1}{1-\omega_{2t}}W_t \tag{46}$$

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 the conditions outlined above 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 ω_t is defined as the ratio of the two distortions, but for simplicity I only allow for variations in ω_{2t}. A linear approximation around the steady state will once again yield an unchanged AD equation and the zero bound. Instead of the AS equation, however, we now have a log-linear approximation of (44) and (45) that yields

$$AS1 \qquad \pi_t^w = \kappa_w \tilde{Y}_t + \beta E_t \pi_{t+1}^w + \kappa_w \varphi \omega_t \tag{47}$$

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 46 yields

$$AS2 \qquad \pi_t = \pi_t^w \tag{48}$$

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 (5),(7), (47) and (48) for a given stochastic process for the exogenous shock $\{r_t^e\}$. Observe that these equations, one AS2 is substituted into AS1, 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 7 *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 1-6 follow unchanged replacing κ with κ_w.*

Proof. See equation (47) and (48) ■

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 AS equation takes the form

$$AS \qquad \pi_t = \kappa_p \tilde{Y}_t + E_{t-1}\pi_t + \kappa_p \varphi \omega_t \tag{49}$$

where κ_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 ι 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 AD equation and zero bound are unchanged.

Under A1 the AS equation 49 can be written as

$$(1-\mu)\pi_S = \kappa_p \tilde{Y}_S + \kappa_p \varphi \hat{\omega}_S \tag{50}$$

Observe that this equation is identical to the AS equation 18 when $\beta = 1$. To summarize:

Proposition 8 *Expectation Augmented Phillips curve equivalence. Suppose that the AS equation is replaced with an expectation augmented Phillips curve from the microfoundations explained above. Then Proposition 1-6 follow unchanged for replacing κ with κ_p and setting $\beta = 1$ in our previous expression.*

Proof. See equation 50 ■

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 β 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 **??** is helpful to clarify this. In the model, alternative specifications for nominal frictions only change the AS equation. All that is needed for the result, is that the AS curve is upward sloping in $(\tilde{Y}_S, \pi_S)$ 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 AS 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 (AS equation). We now turn to alternative specification for the AD 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

$$I_t(i) = I(\frac{K_{t+1}(i)}{K_t(i)}, \xi_t)K_t(i) \tag{51}$$

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 λ 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

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

which is identical to the period profit (2) 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.

$$-I'(I_t^N(i), \xi_t) + E_t Q_{t+1}\Pi_{t+1}[\rho_{t+1}(i) + I'(I_{t+1}^N(i), \xi_{t+1})I_{t+1}^N - I(I_{t+1}^N(i), \xi_{t+1})] \tag{52}$$

where

$$\rho_t(i) \equiv \frac{\alpha}{1-\alpha}\frac{l_t(i)}{K_t(i)}W_t(j) \tag{53}$$

There is an analogous Euler equation to (31) 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:

$$\pi_t = \zeta \hat{s}_t + \beta E_t \pi_{t+1} + \zeta \hat{\omega}_{2t} \tag{54}$$

where $\zeta \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha\phi}$ and $\pi_t \equiv \log \Pi_t$. The coefficient ϕ 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[27]

$$\hat{s}_t = (1+\nu)\hat{L}_t + \tilde{\sigma}^{-1}\delta_c^{-1}\hat{C}_t - \hat{Y}_t \tag{55}$$

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 (52) is

$$\hat{I}_t^N = \beta E_t \hat{I}_{t+1}^N - \frac{1}{\phi^{II}}(i_t - E_t\pi_{t+1} - r_t^I) + \frac{1}{\phi^{II}}\beta\bar{\rho}E_t\hat{\rho}_{t+1} \tag{56}$$

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 ρ_t yields

$$\hat{\rho}_t = (1+\nu)\hat{L}_t + \tilde{\sigma}^{-1}\delta_c^{-1}\hat{C}_t - \hat{K}_t \tag{57}$$

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

$$\hat{I}_t^N \equiv \hat{K}_{t+1} - \hat{K}_t \tag{58}$$

Linearizing (51) yields

$$\hat{I}_t = \delta_K \hat{I}_t^N + \lambda\delta_K\hat{K}_t \tag{59}$$

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

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t = \hat{C}_t + \delta_K\hat{I}_t^N + \lambda\delta_K\hat{K}_t \tag{60}$$

Linearizing the consumption Euler equation yields

$$\hat{C}_t = E_t\hat{C}_{t+1} - \tilde{\sigma}\delta_c(i_t - E_t\pi_{t+1} - r_t^c) \tag{61}$$

[27] 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

$$\hat{Y}_t = (1 - \phi_h^{-1})\hat{K}_t + \phi_h^{-1}\hat{L}_t \tag{62}$$

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 ω_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 ϕ^{II}.

D.3 The efficient rate of interest

Observe that in the current model we have two spending Euler equations – (56) and (61) – 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 ϕ^{II} I follow Christiano and Davis (2006) by assuming that $\phi^{II} = \lambda^{-1}$ (see further discussion in that paper). As ϕ^{II} increases the variable capital stock model collapses to the fixed capital stock model. Using these parameter values the implied value of ϕ 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

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

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

The value of the shock in the case of the fixed capital stock model is estimated as r_S^e is -1.92% (in annual percentage terms) and the value of μ is 0.89. As already noted, I do not estimate the model with variable capital but instead choose the shock informally by selecting r_S^e and μ 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.[28] This results in that r_S^e is -0.9% and $\mu = 0.86$ in the model with variable capital stock. Instead of deriving the optimal second best ω_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 8-10 shows the results. Figure 8 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 8). In either case, the difference between the two models is small. The second figure 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_S^e state for a very long time.

8.1 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 ϕ^{II} among other things). There appears to be little reason to believe that the extension to a MPE with

[28] 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.

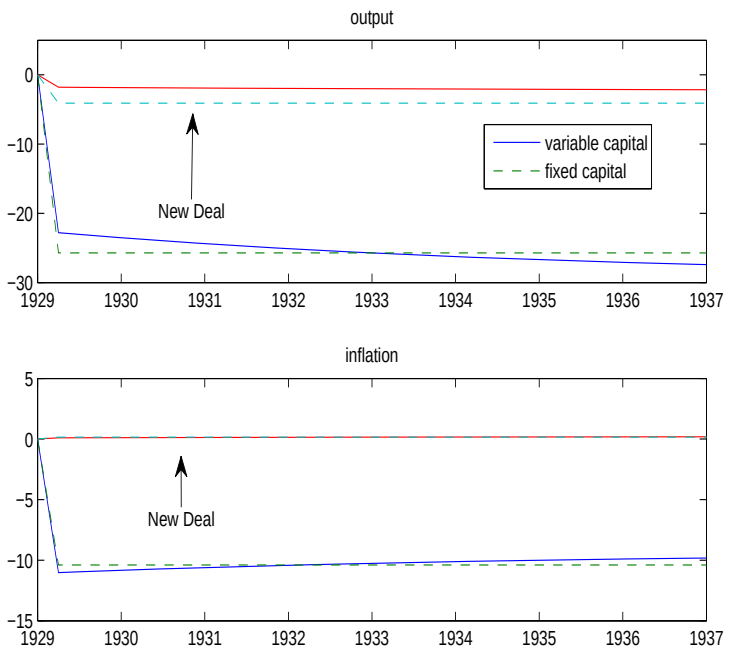

Figure 8: Comparing the solution assuming a fixed vs endogenous capital stock, conditional on a negative shock.

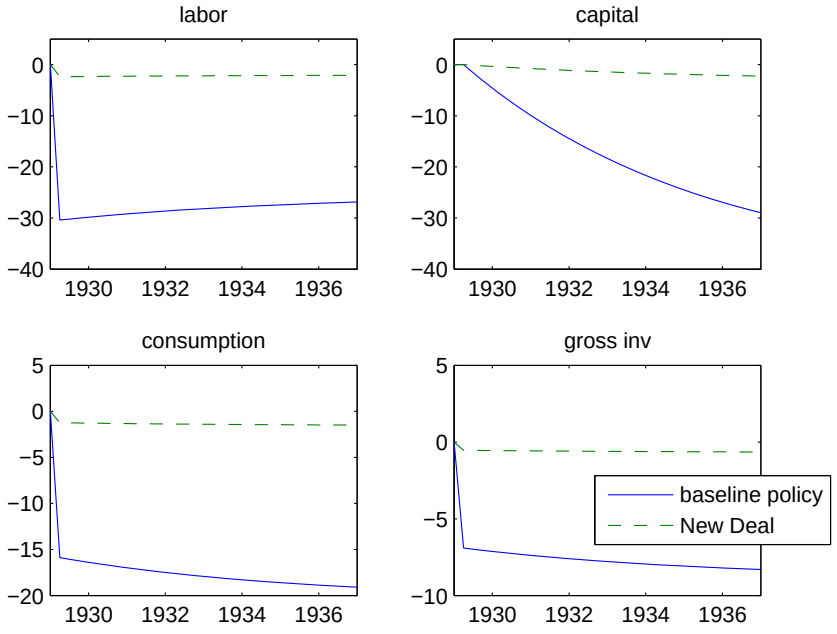

Figure 9: The solution assuming endogenous capital stock, conditional on a negative shock.

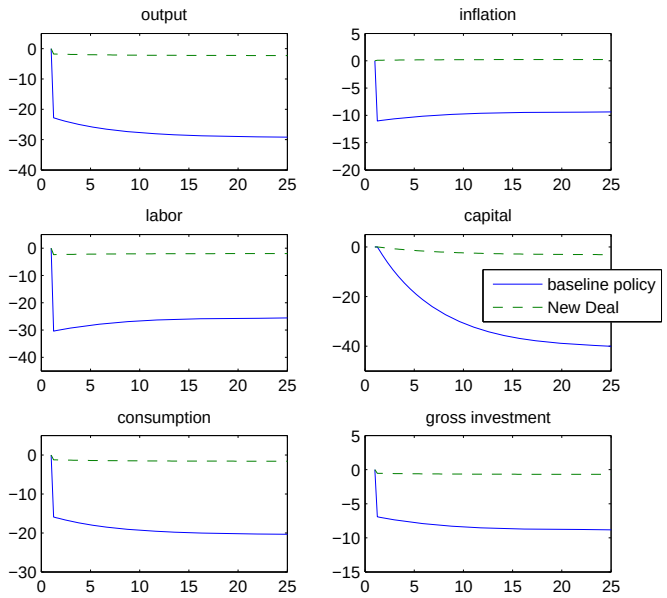

Figure 10: The long-run assuming endogenous capital and a negative shock.

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 AD 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 implement the NIRA policy 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 the text, because showing that the government at time t chooses to use a particular policy instrument (e.g. ω_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).[29] 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

$$L_t = -E_t \begin{bmatrix} \frac{1}{2}\{\pi_t^2 + \lambda_y \tilde{Y}_t^2\} \\ +\phi_{1t}\{\pi_t - \kappa\tilde{Y}_t + \kappa\tilde{Y}_t^e - \frac{\kappa}{\sigma^{-1}+\upsilon}\hat{\omega}_t - \beta\bar{\pi}(r_t^e)\} \\ +\phi_{2t}\{\tilde{Y}_t - \bar{Y}(r_t^e) + \sigma(i_t - \bar{\pi}(r_t^e) - r_t^e)\} + \phi_{3t} i_t \end{bmatrix} \tag{63}$$

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

$$\pi_t + \phi_{1t} = 0 \tag{64}$$

$$\lambda_y(\tilde{Y}_t - \tilde{Y}_t^e) - \kappa\phi_{1t} + \phi_{2t} = 0 \tag{65}$$

$$-\kappa\varphi\phi_{2t} = 0 \tag{66}$$

$$\sigma\phi_{2t} + \beta^{-1}\phi_{3t} = 0 \tag{67}$$

$$\phi_{3t} \geq 0, \ \phi_{3t} i_t = 0 \tag{68}$$

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 (66). 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 (64)-(68) and the IS and AS equations is:

$$\tilde{Y}_t = \frac{\sigma}{1-\mu} r_S^e \text{ if } t < \tau \text{ and } \tilde{Y}_t = 0 \text{ if } t \geq \tau \tag{69}$$

$$\pi_t = 0 \ \forall t \tag{70}$$

$$\tilde{Y}_t^n = \frac{\sigma}{1-\mu} r_S^e \text{ if } t < \tau \text{ and } \tilde{Y}_t^n = 0 \text{ if } t \geq \tau \tag{71}$$

[29] 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.

$$\hat{\omega}_t = -\frac{\sigma}{1-\mu}\varphi^{-1} r_S^e > 0 \text{ if } t < \tau \; \hat{\omega}_t = 0 \text{ if } t \geq \tau \tag{72}$$

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:

$$L_t = E_t \left[\begin{array}{c} \frac{1}{2}\{\pi_t^2 + \lambda \hat{Y}_t^2\} + \phi_{1t}(\pi_t - \kappa \tilde{Y}_t - \frac{\kappa}{\sigma^{-1}+\upsilon}\hat{\omega}_t - \beta \pi_{t+1}) \\ +\phi_{2t}(\tilde{Y}_t - \tilde{Y}_{t+1} + \sigma i_t - \sigma \pi_{t+1} - \sigma \hat{r}_t^e) + \phi_{3t} i_t \end{array} \right] \tag{73}$$

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 11 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

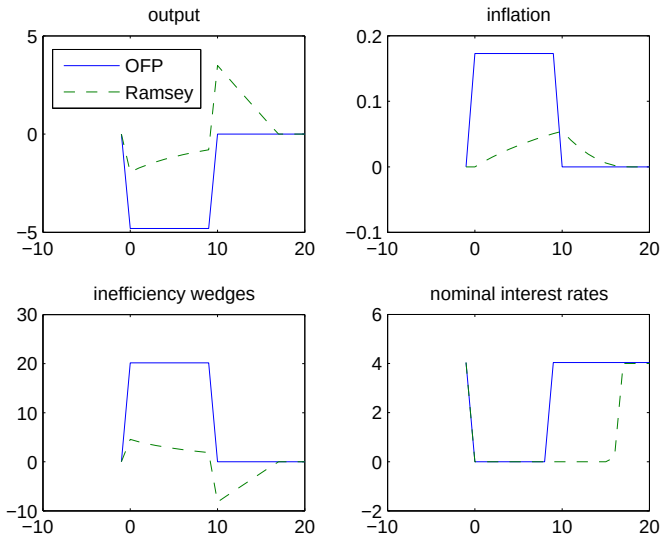

Figure 11: The qualitative features of the optimal forward looking and Ramsey policy are the same. The key difference is that the Ramsey policy achieves a better outcome by manipulating expectations about policy at the time at which the deflationary shocks have subsided.

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 ω_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.