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Was the New Deal Contractionary?†

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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 article, 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 1929–1933 period.

This article studies the NIRA in a dynamic stochastic 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

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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, 2004) and Eggertsson (2006, 2008), 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 modern undergraduate macroeconomic *and* microeconomic textbooks. The macroeconomic argument against the NIRA was first articulated by Keynes in an open letter to FDR in the *New York Times* on December 31, 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 US 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 (2003), 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 article 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

[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 IVE and confirm their result in the present model.

deflationary to being inflationary, thus eliminating the deflationary spiral of 1929–1933. 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 29, 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 assumptions have to be abandoned, and the article argues that this is necessary for an accurate account of this period.

Policymakers during the Great Depression claimed that the main purpose of NIRA was to increase prices and wages to break the deflationary spiral of 1929–1933.[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 article 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 finds 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 1933–1937, and monthly industrial production more than doubled, as shown in Figure 1.[3] While 1933–1937 registers the strongest growth in US 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 1933–1937, some may argue it should have grown even faster and registered more than 9 percent per year average growth in that period. Another explanation is that there was a serious recession in 1937–1938. If the economy had maintained the momentum of the recovery and avoided the recession of 1937–1938, GDP would have reached trend in 1938.[4] To large extent, therefore, explaining the slow recovery is the same as explaining the recession of 1937–1938. This challenge is taken in Eggertsson and Pugsley (2006), which attributes the recession in 1937 to the administration's reneging on its commitment to

[2] *The Wall Street Journal*, for example, reports that FDR declared on May 1, 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 suggests that the economy was 10 percent above trend in 1929, while they assume it was at trend at that time.

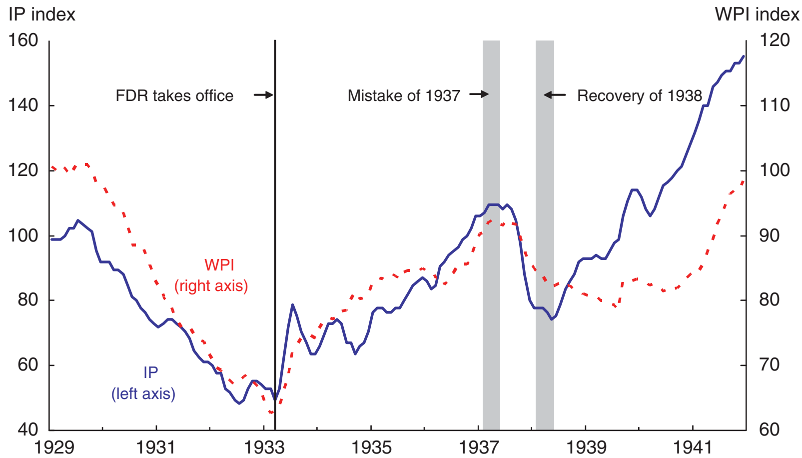

Figure 1. Economic Conditions in the 1930s (1929 = 100)

Note: Both wholesale prices (WPI) and industrial production (IP) collapsed in 1929–1933 but abruptly started to recover in March 1933, when FDR took power and announced the New Deal.

Source: Federal Reserve Board, NBER Macrohistory Database

inflation, an interpretation that is consistent with this article. Here, I do not address the "Mistake of 1937" and focus instead on 1933–1937.

The New Deal policy studied in the article 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 can still be expansionary in the *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 article. The article 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 article is a relatively standard New Keynesian general equilibrium model 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 article is on the recovery period 1933–1937, which was characterized by relatively modest inflation on average, a condition under which the Calvo assumption seems a reasonable approximation.

[5] See, e.g., Gertler and Leahy (2008), and Woodford (2009) for more detailed microfoundations. Online Appendix C, on the AER 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 properties the results rely on. Online Appendix D shows that the main result is also unaffected by endogenous capital accumulation.

The basic channel for the economic expansion in this article 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), Eggertsson and Woodford (2003, 2004), Jung, Teranishi, and Watanabe (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 facilitates this commitment because it reduces deflation in all 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 policymakers described this policy at the time, as the article documents. Eggertsson (2011) uses the basic "AS-AD" representation developed here to address the marginal effect of a host of other policy instruments. Eggertsson (2011) 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).

I. The Model

This section summarizes the microfoundations of the 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, $C_t \equiv \left[\int_0^1 c_t(i)^{\theta/(\theta-1)} di\right]^{(\theta-1)/\theta}$ with $\theta > 1$, P_t is the Dixit-Stiglitz price index, $P_t \equiv \left[\int_0^1 p_t(i)^{1-\theta} di\right]^{1/(1-\theta)}$, $l_t(j)$ 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, $u(\cdot)$ is a concave function and $v(\cdot)$ an increasing convex function, both satisfying standard properties. Financial markets are complete, and the household faces a budget constraint of the form

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

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

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 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 and $u_{c,t}$ is the marginal utility of consumption at time t. 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 anticompetitive 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 $y_t(i) = Y_t((p_t(i))/P_t)^{-\theta}$, nominal profits (sales revenues in excess of labor costs) in period t of the supplier of good i are given by

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

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 firm's 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, $\omega_{2t} = 0$.

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

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

[7] A marginal labor tax, rebated lump sum to the households, has the same effect.
[8] A consumption tax—rebated either to consumers or to firms lump sum—would introduce the same wedge.

which says that the firm will charge a markup $(\theta/(\theta - 1))(1/(1 - \omega_{2t}))$ 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 $1 + \omega_t \equiv (1 + \omega_{1t})/(1 - \omega_{2t})$. In steady state I assume that this variable equals $(\theta - 1)/\theta$ 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-Salido (2007) refer to it as the "inefficiency gap," while authors such as Chari, Kehoe, and McGrattan (2007) and a host of others refer to it 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 $1 - \alpha$ 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 that only the ratio $(1 + \omega_{1t})/(1 - \omega_{2t})$ 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 nonlinear equilibrium conditions that define an equilibrium are summarized in Appendix A.

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 $\hat{Y}_t$

[9] The study of the "labor wedge" has its origin in Parkin (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 abstracting 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 percent. 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 United States, 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 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.

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

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

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

$$\text{(6)} \qquad AS \quad \pi_t = \kappa\tilde{Y}_t + \beta E_t\pi_{t+1} + \kappa\varphi\hat{\omega}_t,$$

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

$$\text{(7)} \qquad ZB \quad i_t \geq 0.$$

An approximate equilibrium can now be defined as a collection of stochastic processes for the endogenous variables $\{\tilde{Y}_t, \pi_t\}$ given the exogenous process $\{r_t^e\}$ and decision rules for the policy variables $\{\hat{\omega}_t, i_t\}$ that solve (5)–(7).

II. Deflation and Output Collapse under Emergency Conditions

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

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

Panel A in Figure 2 illustrates this assumption graphically. Under this assumption, the deflationary 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]

[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

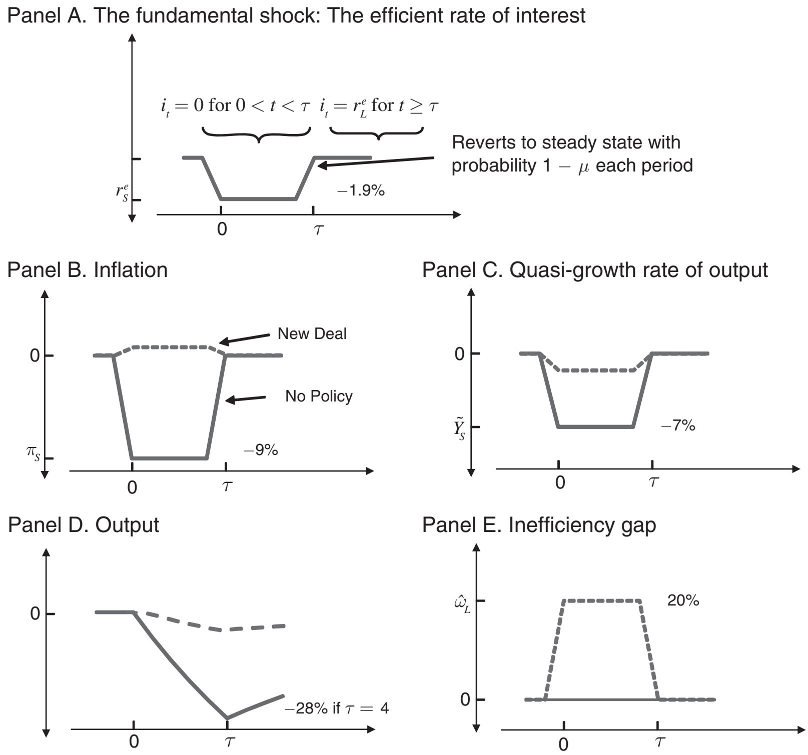

Figure 2. Comparing the Equilibrium under the New Deal and No Policy

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 $\phi_\pi + \phi_y(1 - \beta)/(4\kappa) > 1$. 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, and the assumption that the zero bound is not binding in the long run $t \geq \tau$, monetary policy takes the form[12]

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 wants 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 et al. (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 at positive interest rate in periods $t \geq \tau$ such that $\pi_t = \tilde{Y}_t = 0$ (note that here we are abstracting from the possibility that the zero bound can be binding due to self-fulfilling expectations and instead focusing on the case in which it is only binding due to real shocks). The equilibrium interest rate of 0 in period $0 < \tau < t$ follows from the fact that $r_t^e < 0$ implies a negative nominal interest rate if $i_t = r_t^e + \phi_\pi \pi_t + \phi_y \tilde{Y}_t$.

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

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

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

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

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

where we have taken account of the fact 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.

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 3. It applies to equilibrium determination only 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 $1/(1 - \mu)$. 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 IIIB), this backward bending shape of the aggregate demand is special to the zero bound, and will be key to understanding the main result. Turning to the AS equation (13), its slope is now steeper because the expectation of future deflation

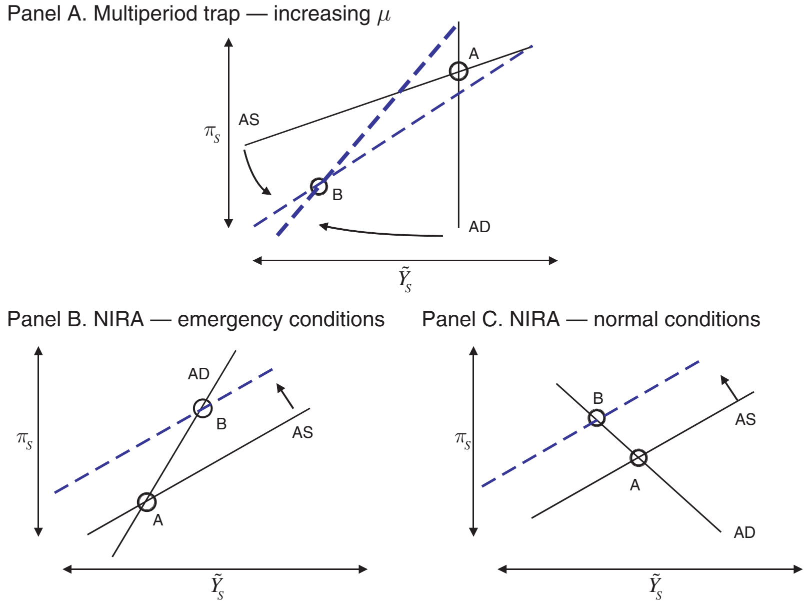

Figure 3. Comparative Statics

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 2.

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 μ π_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 its 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 3, and the model eventually explodes. At a critical value $1 > \overline{\mu} > 0$ when $L(\overline{\mu}) = 0$ in A1, the two curves are parallel, and no solution exists. The point $\overline{\mu}$ 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

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

and the assumption that the zero bound is not binding in the long run).[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*

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

$$\begin{aligned} (15)\qquad \tilde{Y}_t^D &= \frac{1-\beta\mu}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\sigma r_S^e < 0 \quad \text{if} \quad t<\tau \quad \text{and} \\ \tilde{Y}_t^D &= 0 \quad \text{if} \quad t \geq \tau. \end{aligned}$$

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 3. 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 3 applies only in the "depression" state which we denote as "short run." This is illustrated in Figure 2, which shows the solution for an arbitrary contingency in which the shock lasts for τ periods. While panels A–E in Figure 2 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 in 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 1929–1933. Maximizing this posterior gives us the mode.

In Figure 2 we see that for a shock of -2 percent to the efficient rate of interest, which has a probability of 22 percent to return to steady state each year, the model generates deflation of -9 percent, associated with a decline in the quasi-growth rate of output to -7 percent. The decline in the quasi-growth rate of output implies a sustained decline in output over the period of the deflationary shock (the figure illustrates the case in which $\tau = 4$ where output declines by a third). Observe that an exogenous reversal in the shock r_S^e to steady state cannot explain the recovery in the

[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.

Table 1—Priors and Posteriors

		Priors			Posteriors			
Parameters	Distributions	10	50	90	10	50	90	Mode
α	Beta	0.5269	0.6651	0.7862	0.5841	0.687	0.7782	0.6634
β	Beta	0.9833	0.9908	0.9956	0.9824	0.9902	0.9953	0.9925
$1\text{-}\mu$	1-Beta	0.0424	0.0924	0.1678	0.048	0.0736	0.1058	0.0599
$\tilde{\nu}$	Gamma	0.4362	0.918	1.6702	0.5228	0.9422	1.5748	0.7279
r_L^e	Beta	−2.5267	−1.9735	−1.5074	−2.7514	−2.1525	−1.6563	−1.9264
ρ	Uniform	0.1	0.5	0.9	0.6847	0.8281	0.9273	0.9238
$\tilde{\sigma}$	Gamma	0.8742	0.9967	1.1301	0.8934	1.0186	1.1504	0.9931
θ	Gamma	6.3991	9.7017	13.9855	6.9433	10.2007	14.2411	8.9626

Note: All parameters are reported on quarterly basis, except for r_L^e, which is reported in annual percentage terms.

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 1933–1937, 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 rates 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 also 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 risk free nominal bond with negative nominal returns if they can alternatively hold cash.

III. Was the New Deal Contractionary?

A. *Expansionary NIRA under Emergency Conditions*

Can the government break the contractionary spiral observed in Figure 2 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

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

with $\phi_\omega < 0$ and

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

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 IVA), 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 reinflate 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

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

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 3. 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 3. 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 3. 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*

$$\tilde{Y}_t^{ND} = \frac{1}{(1-\mu)(1-\beta\mu) - \mu\sigma\kappa}\left[(1-\beta\mu)\sigma r_S^e + \mu\kappa\sigma\varphi\hat{\omega}_S\right] > \tilde{Y}_t^D \text{ if } t < \tau$$

and $\tilde{Y}_t^{ND} = 0$ if $t \geq \tau$

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

so that NIRA is expansionary.

To underline the dynamic nature of this policy, Figure 2 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 $\hat{\omega}_S$ 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 $\hat{\omega}_S$ assumed in the figure is derived in Section IVA). 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 4 shows the implied recovery in the model, assuming there was no policy in 1929–1933, 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 percent of the recovery in output and 70 percent 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

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

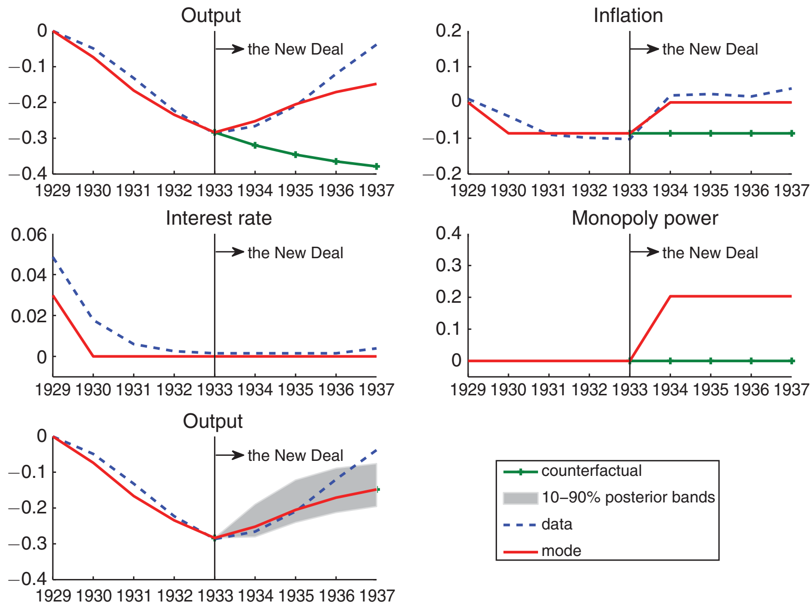

Figure 4. Data on Output and Simulated Output from the Model with and without the New Deal (NIRA)

1937, instead of registering the robust recovery seen in the data. This counterfactual history is shown by the line labeled "counterfactual" in the figures.

Figure 4 (last panel) gives one way of thinking about sensitivity by showing 10 to 90 percent bands for the posterior distribution for output in the period 1934–1937 using the simulated posterior of the model described in the Appendix. The tenth to ninetieth 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 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. The 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 a 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 $\hat{\omega}_S$ is set at its 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.

[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.

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 1. 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.

B. *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 ($\tilde{Y}_S$, π_S) plane, as shown in Figure 3, 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 3 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 A*1 *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 the deflationary shock is not large enough to create excess deflation and output gap, then the NIRA is contractionary, since then interest rate will increase in response to the policy. This gives explicit justification for the sunset provision in the original Act passed by Congress in 1933: NIRA was useful only to battle the emergency.

IV. Extensions

A. *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 Lancaster (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 $\pi_t = \tilde{Y}_t = 0$. This corresponds to the first-best. It is then also easy to confirm that the necessary conditions for implementing the first-best is that $i_t = r_t^e$ and $\hat{\omega}_t = 0$. One interpretation of the baseline rule is just a naïve 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.

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*

[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.

optimal second-best policy is that the other necessary condition $\hat{\omega}_t = 0$ *is also violated*, *so that* $\hat{\omega}_t = \phi_\omega^{o*} r_t^e > 0$ where ϕ_ω^o is given in Appendix C.

PROOF:

See Appendix.

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 4 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

$$\phi_\omega = \phi_\omega^o = -\varphi^{-1} \frac{\sigma + \sigma^2 \lambda \dfrac{\mu}{1-\mu} [1 - \beta\mu] \kappa^{-1}}{\left[1 - \mu + \lambda \delta_c^2 \sigma^2 \dfrac{\mu^2}{1-\mu}\right]}.$$

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.

B. *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 4).

Consider the following specification of monetary and fiscal policy.

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

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

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

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

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 an 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.

ASSUMPTION A2: *The monetary expansion* π^* *and the fiscal expansion* $\hat{G}_S$ *are such that* $\pi^* + [\phi_\pi \pi^G + \phi_y Y^G]\hat{G}_S \leq -r_S^e$ *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 A*1 *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 to write out the AS and AD equations in periods $0 < t < \tau$ when the zero bound is binding:

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

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

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 5 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 1933–1937 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.

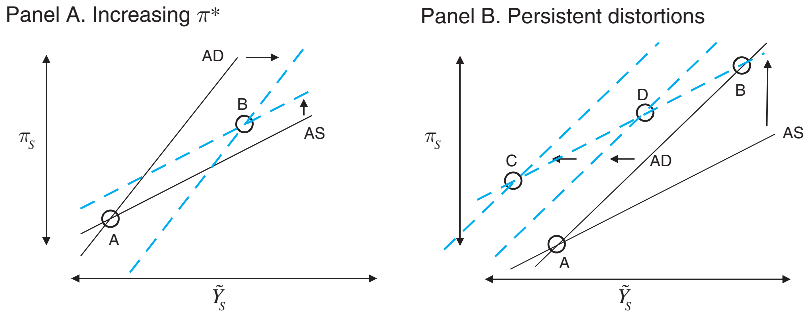

FIGURE 5

C. *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

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

and

$$(26) \qquad \hat{\omega}_t = \delta \hat{\omega}_{t-1} \geq 0 \quad \text{when} \quad t \geq \tau.$$

Observe that an *ad hoc* policy as in (26) is always suboptimal and cannot be motivated by the same microfoundations as the baseline policy. It is of some interest to explore, however, since one can imagine unmodeled "political economy" reasons for why it might be hard to eliminate policy distortions immediately as soon as the "emergency" defined by the deflationary shock is over.

Monetary policy follows the baseline specification (20). Using the method of undetermined coefficients, this implies that in period $t \geq \tau$, $\tilde{Y}_t = \tilde{Y}^\omega \hat{\omega}_t$ 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* $\delta(1 - \beta\mu) \times [1 - ((1 + \sigma\phi_y - \delta)/(\phi_\pi - \delta))(1/(1 - \beta\mu))]\tilde{Y}^w + (\sigma\mu\kappa\varphi)/(1 - \mu) > 0$.

PROOF:

See Appendix.

To understand the condition stipulated in Proposition 6, write the AD and AS equations in period $t < \tau$ as

$$(27)\quad AD\quad \tilde{Y}_S = \mu\tilde{Y}_t + (1-\mu)\tilde{Y}^w\delta\omega_S + \sigma\mu\pi_S + \sigma(1-\mu)\pi^w\delta\omega_S + \sigma r^e_S$$

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

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 than 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 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.

D. *A Multisector Economy*

For simplicity, we maintained the assumption throughout the paper that all sectors look the same, and that, hence, the increase in monopoly power is symmetric across all sectors.[19] How do the results change if we assume instead that the change in monopoly power applies to only a subset of the industries? It is often suggested that the increase in monopoly power applied to only 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 I, 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), $\gamma_1 = n_2\kappa((1+\omega\eta)/(\omega+\sigma^{-1})) > 0$, and $\gamma_2 = n_1\kappa((1+\omega\eta)/(\omega+\sigma^{-1})) < 0$, and $\hat{p}_{Rt} \equiv \log(p_{2t}/p_{1t})$ 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

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

applies to only 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 Subsection IVA, 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 Subsection IVA 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) and is now given by

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

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

E. *Increased Flexibility*

Given that one of the key assumptions required for the result is price rigidity it 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 3, 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. Equation (15) in Proposition 1 indicates that the Mundell effect will always dominate at zero interest rates. This result indicates that higher price flexibility will

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

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 article collapse, because in that case, by definition, the equilibrium output has to be equal to the natural rate of output.

F. *Further Extensions*

The basic objective of this article 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 1929–1937. 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 models share the same basic structure with the current article. Studying the Great Depression in a more complete DSGE model, and allowing for a 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 1933–1937 (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 1933–1937, then firms did not only start hiring new (unemployed) workers, they also started utilizing more fully the existing capital stock.

V. 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 3, 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 relative to the old-fashioned 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 modeling of expectations, and 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 article: Can a policy that reduces the *natural rate of output* increase *equilibrium output*? One reason for posing this question right at the start was that it put 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 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 an 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 1933–1937 much slower. The key element of the current model, relative to that study, is that we include a deflationary shock, r_t^e, that makes the zero bound binding. As we already saw in Section B, 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, as 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 deflationary shocks.

Accordingly, we have now seen that three key assumptions are needed for the main result: (i) expectations are endogenous, (ii) prices are not perfectly flexible,

[21] Online Appendix C shows that the Bordo, Erceg, and Evans (2000) assumption of nominal wages rather than prices does not affect the result.

and (iii) large enough deflationary shocks make the zero bound binding. In the absence of *any* of these assumptions, the central result cannot be obtained. Of these three assumptions, the article has nothing new to say about the first two, which have been at the heart of macroeconomic research over the past decades, except perhaps to clarify how important they are for studying the New Deal.

It seems 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 1929–1933 when it became negative. Hence, that the short-term 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. Can this be supported by the data?

Figure 6 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 commodity futures data. All these measures are supportive of deflationary shocks (i.e., shock to the "efficient rate of interest") as important to understanding 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 1929–1933 and turned negative in 1933–1937. Also 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's being responsible for the contraction). If the deflationary shocks had been 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 Figure 6 is explained exclusively by an *increase in inflation expectation*. Hence the estimates in Hamilton (1992) and Cecchetti (1992) suggest a large change in inflation expectations around 1933, which is consistent with the main hypothesis of the paper.

VI. Conclusion

This article 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 United States. 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 policymakers during the Great Depression. The NIRA was always considered a temporary recovery measure due to the emergency created by the deflationary spiral observed

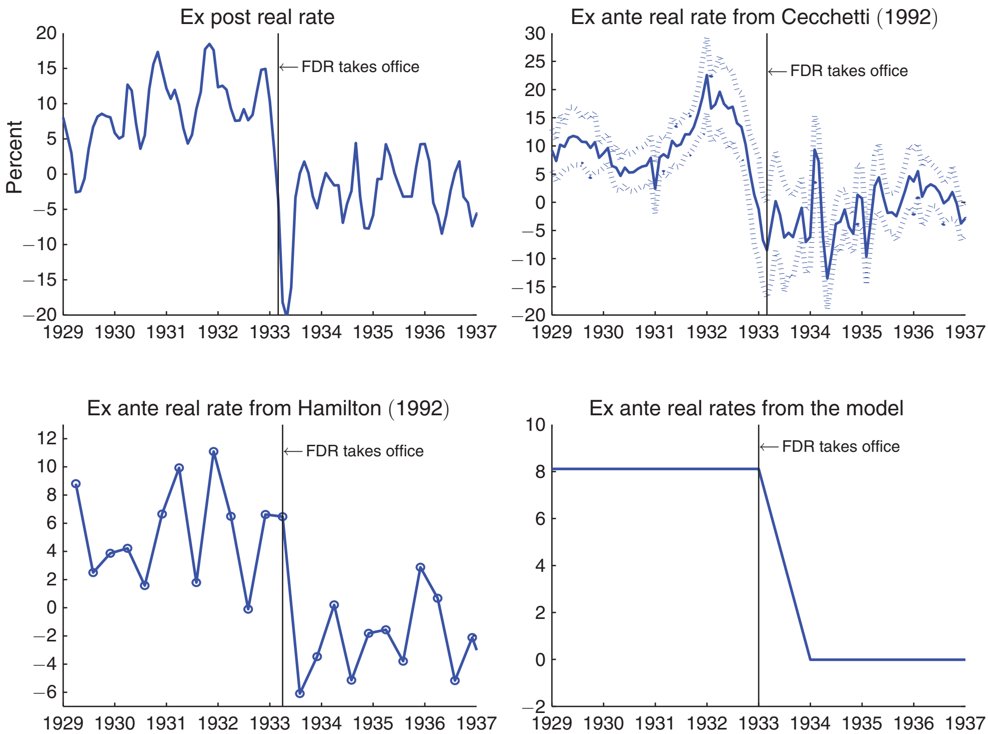

Figure 6. Real Interest Rates Collapsed around the Implementation of the New Deal Consistent with the Theory of the Article

in 1929–1933. 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.

Appendix A: Nonlinear Equilibrium Conditions

This Appendix summarizes the nonlinear 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

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

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

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

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

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

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

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 given some policy rule for $\{i_t, \omega_{1t}, \omega_{2t}\}$. The steady state of the model is $\bar{\imath} = \beta^{-1} - 1$, $(1 + \omega_1)/(1 - \omega_2) = (\theta - 1)/\theta$, $\Pi_t = P_t/(P_t - 1) = p_t^*/(p_t^* - 1) = 1$, $Y_t = \bar{Y}$. The result of the positive analysis of the article does not depend on the fact that we approximate the model around the fully efficient steady state; doing the approximation for $(1 + \omega_1)/(1 - \omega_2) < (\theta - 1)/\theta$ would not change the key propositions. It would, however, change the normative analysis (Section IVA) 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 $(1 + \omega_1)/(1 - \omega_2) = (\theta - 1)/\theta$ 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 $\sigma \equiv -\bar{u}_c/(\bar{u}_{cc}\bar{Y})$, where a bar denotes that the variables [or functions] are evaluated in steady state and $r_t^e \equiv \log \beta^{-1} + \hat{\xi}_t - E_t \hat{\xi}_{t+1}$. 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 $\hat{\omega}_t \equiv \log((1 + \omega_t)/(1 + \bar{\omega}))$, $\varphi \equiv 1/(\sigma^{-1} + \upsilon)$, $\kappa \equiv ((1 - \alpha)(1 - \alpha\beta)/\alpha)((\sigma^{-1} + \upsilon)/(1 + \nu\theta))$ and $\nu \equiv \bar{v}_{ll} L / \bar{v}_l$.

[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.

Appendix B: Bayesian Calibration

B1. *Likelihood and Priors*

Under the assumption there is an iid normally distributed random discrepancy between the model and the data specified in the text the log of the posterior likelihood of the model is

$$\log L = \sum_{t=1929}^{1933} - \frac{(\pi_t^{model} - \pi_t^{data})^2}{2\sigma^2_{\pi,t}} - \frac{(\hat{Y}_t^{model} - \hat{Y}_t^{data})^2}{2\sigma^2_{Y,t}} + \sum_{\psi_s \in \Omega} f(\psi_s), \tag{33}$$

where $\hat{Y}_t^{model}$ and π_t^{model} are given by (15) and (14). I write the likelihood conditional on the hypothesis that the shock r_S^e 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 straightforward 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.[24] 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 two–standard deviation shock to a process fitted to ex ante real interest rates in postwar 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

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

for several years. All these priors are specified as distributions, and Table 1 gives information on this. Observe that the values of $\sigma^2_{\pi,t}$ and $\sigma^2_{Y,t}$ measure how much we want to match the data against the priors. I choose it to be $\sigma_\pi = \sigma_Y = 0.1$, for all periods but one, 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 emphasis of the article 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 a high degree of habit persistence (see, e.g., Giannoni and Woodford 2005).[25] If we assume a point prior on the habit parameter of 0, then the output collapse is immediate, and the recovery is also much faster than seen in the data. None of the qualitative conclusions, however, relies 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 4 much, but does change the mode estimated for the other parameters.

B2. *Markov Chain Monte Carlo Algorithm for Simulating the Posterior*

We use a Metropolis algorithm to simulate the posterior distribution (33). Let $\mathbf{y}^T$ denote the set of available data and $\boldsymbol{\Omega}$ the vector of coefficients and shocks. Moreover, let $\boldsymbol{\Omega}^j$ denote the jth draw from the posterior of $\boldsymbol{\Omega}$. The subsequent draw is obtained by drawing a candidate value, $\tilde{\boldsymbol{\Omega}}$, from a Gaussian proposal distribution with mean $\boldsymbol{\Omega}^j$ and variance s$\mathbf{V}$. We then set $\boldsymbol{\Omega}^{(j+1)} = \tilde{\boldsymbol{\Omega}}$ with probability equal to

$$\min\left\{1, \frac{p(\boldsymbol{\Omega}/\mathbf{y}^T)}{p(\boldsymbol{\Omega}^j/\mathbf{y}^T)}\right\}.$$

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

The algorithm is initialized around the posterior mode, found using a standard Matlab maximization algorithm. We set $\mathbf{V}$ 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.

[25] Other studies, e.g., Smets and Wouters (2007), find that this parameter is closer to 0.7. The reason for this difference is that Smets and Wouters include several other real frictions that generate endogenous propagation, that we abstracted from for simplicity. Authors that assume a simple structure such as the one here, i.e., a model without capital, also estimate a very high habit. Examples include Giannoni and Woodford 2005.

Appendices C–F

Please refer to the AER website. Online Appendix C contains proofs of propositions, Appendix E considers various extensions of the model, such as different price and wage rigidity assumptions and a model with endogenous capital, while Appendix F considers optimal policy under commitment and discretion.

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