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Great Expectations and the End of the Depression

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This paper suggests that the US recovery from the Great Depression was driven by a shift in expectations. This shift was caused by President Franklin Delano Roosevelt's policy actions. On the monetary policy side, Roosevelt abolished the gold standard and—even more importantly—announced the explicit objective of inflating the price level to pre-Depression levels. On the fiscal policy side, Roosevelt expanded real and deficit spending, which made his policy objective credible. These actions violated prevailing policy dogmas and initiated a policy regime change as in Sargent (1983) and Temin and Wigmore (1990). The economic consequences of Roosevelt are evaluated in a dynamic stochastic general equilibrium model with nominal frictions. (*JEL* D84, E52, E62, N12, N42)

What ended the Great Depression in the United States? This paper suggests that the recovery was driven by a shift in expectations. This shift was triggered by President Franklin Delano Roosevelt's (FDR) policy actions. On the monetary policy side, Roosevelt abolished the gold standard and announced an explicit policy objective of inflating the price level to pre-Depression levels. On the fiscal policy side, Roosevelt expanded real and deficit spending which helped make his policy objective *credible*. The key to the recovery was the successful management of expectations about *future policy*.

Roosevelt's rise to power is modeled as a *policy regime change*, as in Thomas Sargent (1983) and Peter Temin and Barry Wigmore (1990). This paper formalizes Temin and Wigmore's argument in a repeated game setting using a dynamic stochastic general equilibrium (DSGE) model and argues that the regime change can account for the recovery. In the model, a regime change means the elimination of certain "policy dogmas" that constrain the actions of the government. The regime change generates an endogenous shift in expectations due to a coordination of monetary and fiscal policy. This coordination ended the Great Depression by engineering a shift in expectations from "contractionary" (i.e., the private sector expected future economic contraction and deflation) to "expansionary" (i.e., the public expected future economic expansion and inflation). The expectation of higher future inflation lowered real interest rates, thus stimulating demand, while the expectation of higher future income stimulated demand by raising permanent income.

Roosevelt was elected president in November 1932 and inaugurated in March 1933, succeeding Herbert Hoover. This was at the height of the Great Depression, when the short-term nominal

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interest rate was close to zero and deflation was running at double digits (output contracted by 13.4 percent in 1932 and the CPI by 10.2 percent). Roosevelt immediately implemented several radical policies which had a strong impact on expectations. As if mobilizing the nation for war, the government went on an aggressive spending campaign, nearly doubling government consumption and investment in one year. This spending spree was not financed by tax increases, but instead by some of the largest budget deficits in US history outside of wartime. On the monetary side Roosevelt announced that the value of the dollar was no longer tied to the price of gold, effectively giving the administration unlimited power to print money. The overarching goal of these policies was to inflate the price level, and Roosevelt announced that this would be achieved through all possible means, stating: "If we cannot do this one way, we will do it another. Do it, we will."[1]

It is hard to overstate how radical the regime change was. "This is the end of Western civilization," declared Director of the Budget Lewis Douglas.[2] During Roosevelt's first year in office, several senior government officials resigned in protest.[3] These policies violated three almost universally accepted policy dogmas of the time: (a) the gold standard, (b) the principle of balanced budget, and (c) the commitment to small government. Interestingly, the end of the gold standard and the monetary and fiscal expansion were largely unexpected, since all these policies violated the Democratic presidential platform.

The data are highly suggestive of a regime change and a large shift in expectations. Figure 1 shows several measures of prices and economic activity with a vertical line denoting the month of Roosevelt's inauguration. Panels A–C show a one-year window for commodity prices, the stock market, and a monthly investment index, all of which are highly volatile and should respond strongly to a shift in expectations. All indicators rebounded strongly once Roosevelt took office. The stock market, for example, increased by 66 percent in Roosevelt's first 100 days and commodity prices skyrocketed. Similarly, investment nearly doubled in 1933 with the turnaround in March that year. Panels E and F take a broader view and show that Roosevelt's inauguration turned the persistent deflation in the wholesale and the consumer price indexes from 1929 to March 1933 into modest inflation from March 1933 to 1937. Roosevelt's inauguration also marked a turning point in monthly industrial production, which bottomed out in March 1933 after falling for three consecutive years. Overall, the comparison between Roosevelt's first term in office (1933–1937) and Herbert Hoover's last (1929–1933) is striking. Hoover's last term resulted in 26 percent deflation, while Roosevelt's first registered 13 percent inflation. Similarly, output declined 30 percent from 1929 to 1933. This was the worst depression in US history. In contrast, 1933–1937 registered the strongest output growth (39 percent) of any four-year period in US history outside of wartime. This dramatic turning point, the defining moment of the recovery, requires a careful description.

The turning point cannot be explained by contemporaneous changes in the money supply, as stressed by Temin and Wigmore (1990). As shown in panel D of Figure 1, the money supply did not change around the turning point.[4] The nominal value of the monetary base was lower, in fact, in the fall of 1933 than at the beginning of that year.[5] Similarly, the turning point cannot be explained by interest rate cuts. The short-term interest rate was already close to zero in the

[1] See Roosevelt (1933c).

[2] Cited in Kenneth Davis (1986, 107).

[3] These included Lewis Douglas. Acting Secretary of the Treasury Dean Acheson was forced to resign due to his opposition to unbalanced budgets and the elimination of the gold standard.

[4] There was a temporary increase in currency in circulation due to the banking crisis, but this was offset by a drop in nonborrowed reserves, leaving the monetary base virtually unchanged.

[5] Temin and Wigmore (1990) document that the real value of some broader monetary aggregates such as M2 declined considerably in 1933.

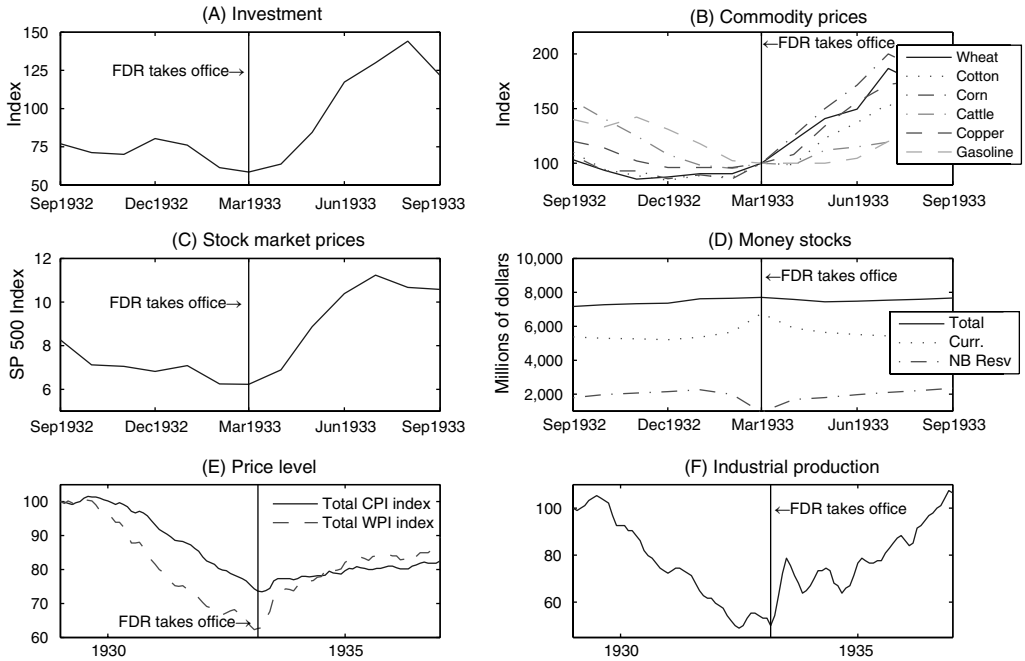

FIGURE 1

Notes: Investment, commodity prices, and the stock market rebounded once FDR took office. The large change in these forward-looking variables cannot be explained by contemporaneous changes in the money supply, which did not change around the turning point. Similarly, prices and industrial production reversed their three-year downward trend when FDR took office.

beginning of 1933, as can be seen in panel A of Figure 2. The yield on three-month Treasury bonds, for example, was only 0.05 percent in January 1933 and could clearly not go much lower due to the zero bound on the short-term nominal interest rate (which plays a prominent role in the theoretical analysis).

Yet, despite the fact that neither the nominal interest rate nor the money supply changed much at the turning point, the paper argues that the elimination of the policy dogmas drastically changed the *systematic* part of monetary policy, i.e., the framework that governed the policy setting *going forward*. What changed was expectations about how the interest rate and the money supply *would be set in the future, leading to a dramatic change in inflation expectations.* One way of seeing this in the data is to observe that the short-term *real* interest rate, the difference between the short-term nominal interest rate and expected inflation, collapsed around the turning point in 1933, dropping from high levels during 1929–1933 to modestly negative in 1933–1937. Figure 2 shows several measures of real interest rates that document this pattern.[6]

The main contribution of this paper is an analytical characterization of the Roosevelt regime change in a repeated game setting in a DSGE model. The paper considers the Markov Perfect Equilibria (MPE) of this game which stipulate that the government has limited ability to commit

[6] Panel B shows the ex post rate, panel C the ex ante rate with 95 percent confidence intervals estimated by Stephen Cecchetti (1992) using term-structure data, and panel D shows the ex ante rate estimated by James Hamilton (1992) using commodity futures.

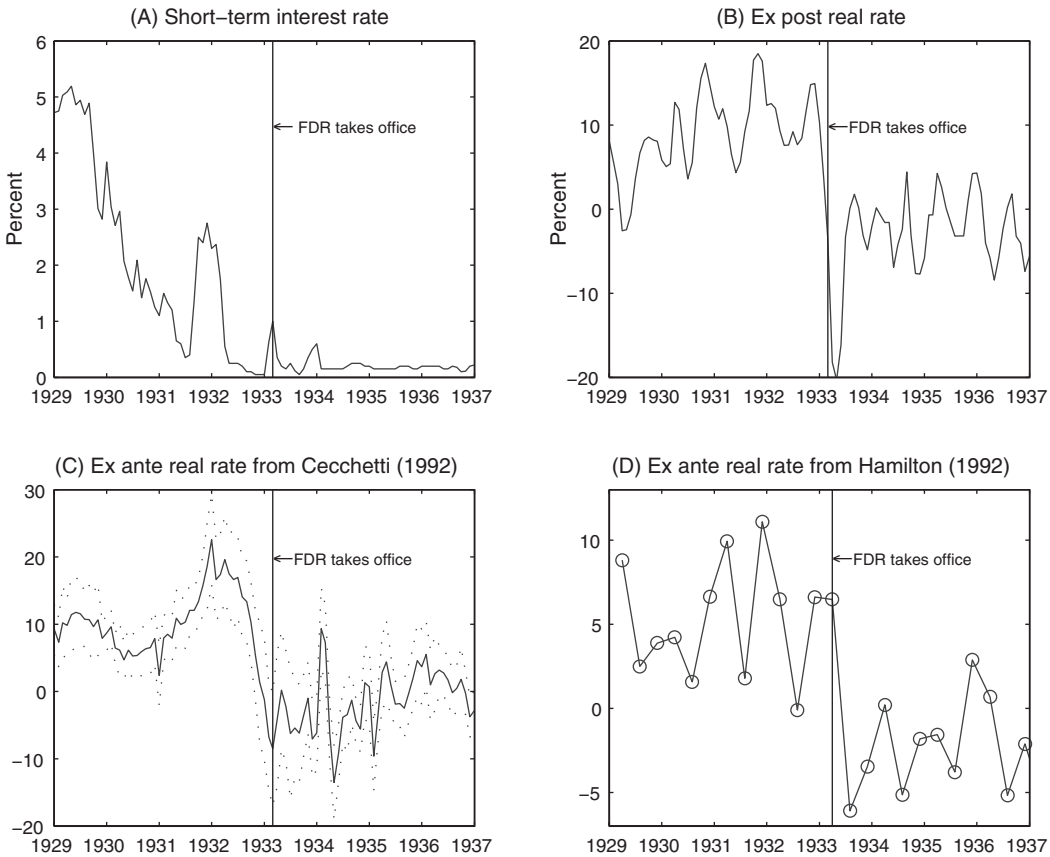

FIGURE 2

Notes: Real interest rates collapsed around the turning point, even if the short-term nominal interest rate did not change much. This suggests a large change in inflation expectations.

to future policy.[7] The Hoover Administration is constrained by the policy dogmas (i.e., the gold standard, balanced budget, and small government dogmas), while the Roosevelt Administration is not. The elimination of the policy dogmas triggers a swift change in expectations. All the key results are derived in closed form. While the results are analytical, the paper also puts quantitative flesh on the results by calibrating the model. The shocks are chosen to generate the Great Depression. The main question the numerical example answers is: taking these shocks as given, can the regime change generate the recovery observed in the data? According to the baseline calibration, the regime change accounts for about 70–80 percent of the recovery in inflation and output in 1933–1937. This suggests that additional reflationary policies such as the National Industrial Recovery Act (NIRA) are needed to explain the remaining fifth of the recovery.[8] Counterfactual experiments show the outcome if the Hoover regime had remained in place in

[7] Formally defined, for example, by Eric Maskin and Jean Tirole (2001). For an early example in macroeconomics, see Finn Kydland and Edward Prescott (1977), who refer to it as "optimal policy under discretion." For a more recent example, see Paul Klein, Per Krusell, and José Víctor Ríos Rull (2007) and Eggertsson and Eric Swanson (2007).

[8] See Eggertsson (2007b), who shows that these policies are expansionary in this model.

1933–1937. Then, output would have continued to decline and been about 30 percent lower in 1937 than in 1933 and 49 percent below the 1929 peak.

One of the most important assumptions in the paper is the presence of exogenous intertemporal shocks that imply the short-term real interest rate has to be negative to prevent a fall in output and the price level. These shocks are assumed to prevail throughout the contraction and the recovery period. The paper argues that these shocks are necessary to explain a simultaneous decline in the nominal interest rate, output, and prices observed in the data. But the paper also shows that a reversal of the exogenous shocks cannot explain the recovery, because that would imply a counterfactual increase in the short-term nominal interest rate (which remained close to zero throughout the recovery).

Milton Friedman and Anna Schwartz (1963), and a large literature that followed, suggest that the recovery from 1933–1937 was driven primarily by money supply increases. Nominal interest rates, however, were close to zero during this period. According to the model in this paper, a higher money supply increases demand only through lower interest rates, so at the zero lower bound it is *only through the expectation of future money supply, and thus future interest rates,* that the money supply affects spending. Through the expectation channel the main point of Friedman and Schwartz is confirmed in this paper: appropriate monetary policy was essential to end the Great Depression, and could have prevented it altogether. The twist is that this could be achieved only through the correct *management of expectations*, not contemporaneous increases in the money supply per se. Furthermore, in contrast to Friedman and Schwartz, fiscal policy plays a prominent role in the analysis in this paper, mainly by influencing expectations about the future money supply.

Several papers study the Great Depression in DSGE models, and the current paper shares many elements with them.[9] The main difference is the focus on the regime shift associated with Roosevelt's rise to the presidency, which is used to explain the recovery. While many of these papers recognize the importance of expectations, they do not model explicitly *why* and *how* they changed in 1933 with Roosevelt's inauguration.[10] In fact, a surprisingly large part of the literature treats the recovery as inevitable and/or exogenous and coincidental with Roosevelt inauguration, while in this paper output would have continued to contract in the absence of the regime change. Furthermore, most previous analyses do not take the zero bound on the short-term nominal interest rate explicitly into account. The short-term nominal interest rate remained at zero throughout the recovery phase 1933–37. This fact is important, according to the model, because it implies that monetary policy only operated through expectations. At a theoretical level, the focus on regime changes separates this paper from the large literature on the zero bound.[11]

[9] There are numerous examples. See, e.g., Robert E. Lucas and Leonard A. Rapping (1972); Michael Bordo, Christopher Erceg, and Charles Evans (2000); Lawrence Christiano, Roberto Motto, and Massimo Rostagno (2003); and Harold Cole and Lee Ohanian (2004).

[10] The emphasis on expectations is complementary to Sharon Harrison and Mark Weder (2006). The key difference is that Harrison and Weder assume that expectation fluctuations are due to exogenous nonfundamental sunspot shocks, while here they are endogenous due to policy changes.

[11] See, e.g., Paul Krugman (1998), Eggertsson and Michael Woodford (2003, 2004), Alan Auerbach and Maurice Obstfeld (2005), Eggertsson (2006), Olivier Jeanne and Lars E. O. Svensson (2007) and Klaus Adam and Roberto Billi (2007). See Svensson (2003) for a survey. Eggertsson and Benjamin Pugsley (2006) study the recession of 1937–1938 in an extension of the regime change model suggested in this paper. They argue that this episode provides additional evidence for the expectation channel suggested here and that recession can be explained by people's expectations that policy would revert back to a Hoover-style deflationary regime. Eggertsson and Pugsley's story also sheds light on the "slow recovery" from the Great Depression emphasized by many authors, such as Cole and Ohanian (2004), comparing the years 1933 and 1939. According to Eggertsson and Pugsley, the slowness of the recovery is mostly explained by the recession of 1937–1938.

I. The Turning Point: A Brief Historical Narrative

Roosevelt made several announcements in the early months of his administration that helped shape expectations about future policy. The overriding objective of monetary policy, according to Roosevelt, was reflation, i.e., to increase the price level, even at the expense of more traditional objectives such as the stable price of gold, which Roosevelt declared would be "subservient" to domestic recovery. Roosevelt's goal was to increase prices to their pre-Depression levels within one to three years. He stated this objective on several occasions. At a press conference on April 19, 1933, for example, Roosevelt stated the "definitive objective" of raising commodity prices. This press conference was called after Congress had passed the Thomas Amendment, a bill that gave Roosevelt broad powers to inflate and effectively eliminated the independence of the Federal Reserve.[12] Similarly, Roosevelt was quoted in the *Wall Street Journal* 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." Roosevelt reiterated this view in a radio address to the nation in one of his "fireside chats" on May 7.[13] By late spring, there could be no doubt in the minds of market participants that the administration was aiming to inflate.

Roosevelt did more than simply announce his desire to raise prices. He also took direct *actions* to achieve it, actions that can be interpreted as having made the policy objective of reflation *credible,* a point that the paper formalizes. Apart from eliminating the gold standard, further discussed in Section V, the most important action was an aggressive and visible expansion of the government.

By any measure, the increase in government spending was dramatic, but the spending spree clearly violated the prevailing policy dogma of small government. Table 1 records several measures of government spending. The federal government's consumption and investment, for example, was 90 percent higher in 1934 (Roosevelt's first full calendar year in office) than in 1932 (Hoover's last).[14] Other measures of federal spending also increased substantially. Table 1 also reports total government expenditures. This measure includes several transfer programs and the gold purchases of the Treasury that are not included in the consumption and investment statistic, but which had an important impact on the government budget.[15] This spending campaign was financed not by new taxes but by running budget deficits, thus violating another important policy dogma of the time: the budget should be balanced.

Deficit spending plays an important role in the model of the paper because it measures the change in the inflation incentive of the government, which is crucial to determining expectations about *the future money supply*. The deficit during Roosevelt's first fiscal year is one of the highest in US history outside of wartime. This helped to make a permanent increase in the money supply credible, thus firming up inflation expectations, because it was a critical strategy to finance the

[12] See FDR (1933a, vol. 1, 156–58).

[13] See FDR (1933a, "Radio Address of the President, May 7).

[14] Data in fiscal years were not available from NIPA, but I report other data on fiscal policy in fiscal years. The increase in federal government consumption was somewhat offset by reductions at the local government level. See Cary Brown (1956) for a discussion of local government spending.

[15] The gold inflows to the United States after 1933 are particularly important. The government stood ready to buy gold at a fixed price. The price of gold was changed throughout 1933 but was fixed in 1934 (see Scott Sumner 2004). The administration bought the gold by issuing nominal liabilities (i.e., government credit). On the government balance sheet, these purchases mainly showed up as nonborrowed reserves held by commercial banks at the Federal Reserve. Since the nominal interest rate was zero during this period, there was no meaningful difference between base money (defined as nonborrowed reserves plus currency in circulation) and short-term government debt. Both were nominal liabilities to private entities that carried zero interest. This means that the "gold program" pursued by FDR was important to make future inflation credible, because it increased the inflation incentive of the government, a conclusion that is at variance with a common verdict of FDR gold purchases.

Table 1—Measures of the Federal Deficit
(Millions of dollars)

	Fiscal years ending June of:											
	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941
Total GDP	97,400	83,800	67,600	57,600	61,200	69,600	78,500	87,800	89,000	89,100	96,800	114,100
Federal government consumption[1] and gross investment	1,830	1,879	1,892	2,286	3,278	3,374	5,565	5,092	5,719	6,018	6,472	17,973
Total expenditures	3,540	3,917	3,794	4,958	7,521	7,612	9,718	9,260	7,600	12,221	12,998	16,693
Federal expenditures (excl. gold)	3,320	3,577	4,659	4,598	6,541	6,412	8,228	7,580	6,840	9,141	9,468	13,653
Gold purchases[2]	220	340	−910	360	980	1,200	1,490	1,680	760	3,080	3,530	3,040
Total revenues	4,058	3,116	1,924	1,997	2,955	3,609	3,923	5,387	6,751	6,295	6,548	8,712
Total liabilities (stocks)	20,727	22,129	23,649	26,954	32,456	37,896	44,555	47,713	48,451	54,009	59,744	66,782
Monetary base	6,397	6,742	6,873	7,484	9,165	10,552	11,598	13,358	14,364	17,110	21,406	22,701
Currency in circulation	4,255	4,525	5,305	5,515	5,400	5,580	6,120	6,495	6,495	7,025	7,810	9,500
Nonborrowed reserves	2,142	2,217	1,568	1,969	3,765	4,972	5,478	6,863	7,869	10,085	13,596	13,201
Public debt[3]	14,330	15,387	16,776	19,470	23,291	27,344	32,957	34,355	34,087	36,899	38,338	44,081
Deficit measures (+)												
Expenditures excl. gold minus revenues	−738	461	2,735	2,601	3,586	2,803	4,305	2,193	89	2,846	2,920	4,941
Total expenditures minus revenues	−518	801	1,825	2,961	4,566	4,003	5,795	3,873	849	5,926	6,450	7,981
Change in total liabilities		1,402	1,520	3,305	5,503	5,440	6,659	3,158	738	5,558	5,735	7,038

Source: Fiscal year GDP, expenditures, and revenues are from the White House Office of Management and Budget; government consumption is taken from NIPA; all other series are found in the Board of Governors of the Federal Reserve publication *Banking and Monetary Statistics 1914–1941.*

[1] Reported in calendar years.

[2] Gold purchases are corrected for the reevaluation of gold against the dollar in 1934.

[3] Measures the total privately held debt of government direct and guaranteed securities.

government debt payments. The deficit is defined as the difference between the government's expenditures and tax revenues. Table 1 shows three estimates of the deficit, further described in the Appendix C. The estimate that corresponds most closely to the deficit in the model is the third one.[16] The deficit, according to this estimate, increased by 66 percent in the fiscal year June 1933 to June 1934 and stood at 9 percent of GDP in that fiscal year. The other estimates show a smaller, yet significant, increase. Leaving measurement issues aside, however, there is even stronger evidence for the regime change than reported in Table 1.

The most compelling evidence of the regime change is found in the primary sources on how fiscal policy was *determined*. The deficits during Hoover's presidency were almost entirely due to a collapse in output and the inability of the US Treasury to predict the associated fall in revenues. The deficit was not a deliberate policy; it accumulated despite President Hoover's frantic efforts to balance the budget by *tax rate increases*.[17] The deficit under Roosevelt, in contrast, was *deliberate* and a part of the reflation program expected to endure until the economy recovered.[18] Whereas the deficits were Hoover's miscalculation, they were Roosevelt's strategy (see

[16] This estimate takes account of the fact that any shortfall between expenditures and taxes can be financed in one of two ways: printing money or issuing government bonds. Deficit spending, therefore, can be measured as the change in the government's nominal liabilities in a given fiscal year—i.e., the government credit expansion—with government liabilities as the sum of government bonds and the monetary base. This way of estimating the deficit is also appealing because government liabilities are the relevant "state variable" in the model of the paper.

[17] President Hoover successfully sponsored a massive tax increase in late 1931 to recoup the decline in federal tax revenues. The maximum personal income tax rate rose from 25 to 63 percent. Corporate income taxes rose, estate taxes were doubled, and gift taxes reintroduced (see Temin and Wigmore 1990).

[18] See, e.g., the last Annual Report of the secretary of the treasury under Hoover compared to the first Annual Report by FDR's secretary. In June 1932, Treasury Secretary Mills reported to the House of Representatives a $2.5 billion deficit, which was projected to decline in the following two years. Despite the projected decline, the secretary

also quotes in Section IV). Roosevelt's actions thus satisfied Sargent's (1983) criteria for a regime change: "There must be an abrupt change in the continuing government policy, or strategy, for setting deficits now and in the future that is sufficiently binding to be believed."

It is quite likely that fiscal policy played a key role in firming up inflation expectations, since it was well understood at the time that deficit financing could lead to future inflation. In fact, the belief that deficits caused inflation was a foundation of the balanced budget dogma. Many commentators at the time, especially in the conservative press, were worried that Roosevelt's deficit spending would in fact be *too inflationary*.[19] As proof, many "sound money men" pointed toward the deficits of several European countries after World War I and the resulting hyperinflation.[20]

II. The Model and the Equilibrium Concept

This section outlines a simple variation of a relatively standard DSGE model, as, for example, in Richard Clarida, Jordi Galí, and Mark Gertler (1999), Woodford (2003), and Christiano, Eichenbaum, and Evans (2005), and defines the equilibrium concept used. A representative household maximizes expected utility over the infinite horizon:

$$E_t\left\{\sum_{T=t}^{\infty}\beta^{T-t}\left[u\left(C_T-H_T^c;\xi_T\right)+g\left(G_T;\xi_T\right)-v\left(L_T-H_T^l;\xi_T\right)\right]\right\}, \tag{1}$$

where C_t is a Dixit-Stiglitz aggregate of consumption of each of a continuum of differentiated goods

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

with elasticity of substitution equal to $\theta>1$, G_t is a Dixit-Stiglitz aggregate of government consumption defined in the same way, P_t is the Dixit-Stiglitz price index,

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

and L_t is hours worked. E_t denotes mathematical expectation conditional on information available in period t. The term ξ_t is a vector of exogenous shocks.[21] For each value of ξ_t the functions $u(\cdot;\xi_t)$ and $g(\cdot;\xi_t)$ are increasing and concave, while $v(\cdot;\xi_t)$ is increasing and convex. The terms H_t^c and H_t^l denote external consumption and work habits.[22]

was deeply perturbed and recommended radical government spending cuts because there "is no course for the government to follow but [...] to live within its income." One year later Secretary Woodin, then recently appointed by FDR, reported to Congress that the deficit had exploded to a whopping $ 3 billion, a number three time higher than Mills had predicted the year before (partially because of FDR's spending initiatives in the last quarter of the fiscal year). Instead of suggesting spending cuts, Secretary Woodin proposed one of the biggest government spending campaigned in US history. As for the deficit for the fiscal year 1934, he projected it to be even higher, or $6.6 billion, more than double the deficit in 1933.

[19] See the opinion piece, for example, in the *Wall Street Journal* on November 2, 1933, p. 6, under the heading "Unconvincing Reassurance."

[20] See Davis (1986, 107).

[21] This vector may include any number of terms such as "taste shocks" and, with modest modifications, "markup shocks" and "technology shocks" (see discussion in Section IIIB).

[22] The consumption habit has a long history in models of this class, especially in the asset market pricing literature, but also more recently in the sticky price DSGE models (see Frank Smets and Rafael Wouters (2003) and Christiano, Eichenbaum and Evans 2005). Labor habits similarly have a long track record in business cycle analysis, dating at least back to Kydland and Prescott (1982).

Only one-period riskless government bonds and money are traded, so the household faces the budget constraint

$$P_t C_t + B_t + M_t = (1 + i_{t-1}) B_{t-1} + M_t + P_t Z_t + P_t n_t L_t - P_t T_t,$$

where Z_t is a representative firm profit, T_t is taxes, M_t is money, B_t is one-period riskless bonds, i_t is one-period nominal risk-free interest rate, and n_t is real wages. The household maximizes utility subject to the budget constraint by its choice of asset holdings, labor, and consumption.

A continuum of firms on the unit interval maximize expected discounted profits. Firms produce subject to a production function that is linear in labor and the model abstracts from capital dynamics.[23] As in Julio Rotemberg (1982), firms face a resource cost of price changes $d(\Pi)$, where the function d satisfies $d(1) = d'(1) = 0$ and $d'' > 0$ for all Π. [24]

The first-order conditions of the household and firm maximization problems are summarized by two Euler equations. The household consumption decision satisfies the standard "IS equation"

$$u_{c,t} = (1 + i_t)\beta f_t^e, \tag{2}$$

where

$$f_t^e \equiv E_t u_{c,\,t+1}\, \Pi_{t+1}^{-1} \tag{3}$$

is an expectation variable, $\Pi_t \equiv P_t/P_{t-1}$, and the marginal utility of consumption at date t is $u_{c,t}$. The firm's optimal pricing decisions on the one hand, and the household's optimal labor supply decisions on the other, satisfy the "AS equation"

$$\Pi_t d'(\Pi_t) u_{c,t} = \theta[v_{y,t} - u_{c,t}]Y_t + \beta S_t^e, \tag{4}$$

where

$$S_t^e \equiv E_t \Pi_{t+1}\, d'(\Pi_{t+1}) u_{c,t+1} \tag{5}$$

is an expectation variable and the marginal disutility of working is $v_{y,t}$.[25] This equation is a standard "New Keynesian Phillips curve."[26]

The government pays an output cost of taxation (e.g., due to tax collection costs as in Guillermo Calvo 1978 and Robert J. Barro 1979b) captured by the function $s(T_t)$. For every dollar collected in taxes, $s(T)$ units of output are wasted without contributing anything to utility, and $s(T) \geq 0$, $s'(T) > 0$, and $s''(T) > 0$. Total government real spending, F_t, is

[23] Complementary notes, available on the author's Web site (available at www.ny.frb.org/research/economists/eggertsson/papers.html), show how the model can be extended to include capital with convex adjustment costs and illustrate that the results do not change much, while making the analytics considerably more complicated.

[24] For algebraic simplicity, I follow Rotemberg and Woodford (1997) by assuming a subsidy that eliminates the inefficiencies created by the monopoly power of the firms: $(1 + s) = \theta/(\theta - 1)$ (see Eggertsson 2006 for the general case).

[25] Here we use the fact that production is linear in labor to substitute L out of the disutility of labor function $v(\cdot)$. With some abuse of notation, the remainder of the paper refers to the derivative v_L and v_{LL} as v_y and v_{yy}.

[26] To a first order, an equivalent Phillips curve can be derived assuming Calvo staggered price setting, and the results of the paper are unchanged under this alternative pricing assumption. It would complicate the exposition of the nonlinear model somewhat, however, because price dispersion becomes an additional state variable. In the first-order approximation of the model, however, this additional state variable has no effect.

$$F_t = G_t + s(T_t) + A_t, \tag{6}$$

where A_t denotes residual government spending that does not contribute to utility.[27] The government budget constraint can be written as

$$w_t = (1 + i_t)[w_{t-1}\,\Pi_t^{-1} + F_t - T_t], \tag{7}$$

where $w_t \equiv [B_t(1 + i_t) + M_t]/P_t$ is the real value of the end-of-period government debt inclusive of interest payments. The government satisfies a debt limit

$$w_t \leq w^b, \tag{8}$$

which excludes Ponzi schemes. Market clearing implies

$$Y_t = C_t + F_t + d(\Pi_t). \tag{9}$$

The consumption habit is proportional to aggregate consumption from the last period (inclusive of government consumption). Similarly, the labor habit is proportional to aggregate labor from the last period in equal proportion. Because there is no investment in the model and production is linear,

$$H_t^c = H_t^l = \gamma Y_{t-1}. \tag{10}$$

This form of habit is assumed for tractability, since under this assumption Y_{t-1} is the only state variable in the model apart from real debt. The key results can be derived in closed form under this specification; moreover, the results can be written in terms of a quasi-difference variable in output, $Y_t - \gamma Y_{t-1}$, which corresponds to output in a model without habit.

It is important to observe that as long as the government is committed to supply a nominal claim ("money") with zero nominal return, there is a zero bound on the short-term nominal interest rate:

$$i_t \geq 0. \tag{11}$$

An equilibrium can be defined without any reference to the money supply, an abstraction used in much of the paper.

It is useful, however, to keep track of a money supply variable, since much of the earlier literature is cast in terms of money, and it is also helpful in analyzing the gold standard in Section V. A certain fraction of production needs to be held in money balances so the following inequality is satisfied:[28]

$$\frac{M_t}{P_t} \geq \chi_t Y_t, \tag{12}$$

where $\chi_t \equiv \chi(\xi_t)$ denotes the inverse of the velocity of money (when $i_t > 0$) and we allow for this variable to depend on the vector of fundamental shocks. The model abstracts from any effect

[27] We will need this residual for technical reasons when we define the Hoover regime (see footnote 34).
[28] As in Krugman (1998) and King and Wolman (2004).

money balances have on utility or welfare. At zero interest rate, this inequality is slack because the household is indifferent between holding money and bonds.

The focus of the paper is optimal policy under discretion where the discretion is constrained by certain policy dogmas. Under discretion, the government cannot commit to future policy. President Hoover, for example, could not commit to any actions for President Roosevelt.[29] The equilibrium under optimal policy under discretion is sometimes referred to as a Markov Perfect Equilibrium (e.g., Klein, Krusell, and Ríos Rull 2007; Eggertsson and Swanson 2007). The timing of events in the game is as follows. At the beginning of each period t, w_{t-1} and Y_{t-1} are predetermined state variables. At the beginning of the period, the shock ξ_t is realized and observed by the private sector and the government. The government chooses policy for period t given the current state, which is summarized by $(\xi_t, w_{t-1}, Y_{t-1})$, and the private sector forms expectations f_t^e and S_t^e. The private sector may condition its expectation at time t on the policy actions of the government, i.e., it observes the policy actions of the government in that period so that expectations are determined jointly with the other endogenous variables. The endogenous state variables in the model at time $t+1$ are w_t and Y_t. This implies that under discretionary policy the expectation variables f_t^e and S_t^e are a function of w_t, Y_t, and ξ_t:

$$f_t^e = \overline{f}^e(w_t, Y_t; \xi_t), \tag{13}$$

$$S_t^e = \overline{S}^e(w_t, Y_t; \xi_t). \tag{14}$$

Under discretion, the government maximizes the value function $J(w_{t-1}, Y_{t-1}; \xi_t)$ by its choice of the policy instruments (G_t, T_t, i_t), taking the expectation functions $\overline{f}^e(w_t, Y_t; \xi_t)$ and $\overline{S}^e(w_t, Y_t; \xi_t)$ as given because it cannot commit to future policy.[30]

We can now define the government maximization problem for arbitrary policy dogmas as[31]

$$J(w_{t-1}, Y_{t-1}; \xi_t) = \max_{G_t, T_t, i_t} \{[u(C_t - H_t^c; \xi_t) + g(G_t; \xi_t) - v(Y_t - H_t^l; \xi_t) + \beta E_t J(w_t, Y_t; \xi_{t+1})\} \tag{15}$$

s.t. (i) equations (2), (4), (6), (7), (8), (9), (10), (11), (13), and (14) are satisfied and (ii) policy dogmas are satisfied.[32] An equilibrium at date $t \geq 0$ is now defined as a collection of stochastic processes for the endogenous variables that solve the first-order conditions of the government's problem (15), the private-sector equilibrium conditions, and the policy dogmas for a given process for the exogenous variables $\{\xi_t\}$ and an initial state (w_{-1}, Y_{-1}).

[29] We do assume, however, that the government has to pay back the nominal value of any debt issued.

[30] Because the government is a large strategic player and moves simultaneously with the private-sector, it can choose a value for all the endogenous variables $(\Pi_t, C_t, Y_t, F_t, G_t, A_t, T_t, i_t, w_t)$ as long as they satisfy the private sector optimality conditions, the resource constraints, and whatever policy dogmas that may constrain the government. Observe here that the timing convention is different from that in many recent papers on policy discretion, where it is assumed that the government moves before the private sector within each period by selecting a number for their policy instrument (e.g., King and Wolman 2004; Stefania Albanesi, V. V. Chari, and Christiano 2003). This timing assumption often yields multiple equilibria.

While the equilibrium may be unique in the current framework, I do not prove global uniqueness. Instead, I show that the equilibrium is locally unique. The timing assumption here is the same as in Clarida, Galí, and Gertler (1999) and Woodford (2003). See Salvador Ortigueira (2006) and Eggertsson and Swanson (2007) for more discussion about timing.

[31] Observe that in this definition of the policy regime, it is assumed that i_t is the instrument of monetary policy. Appendix C defines the game with M_t being the government's choice variable, in which case M_{t-1} becomes a state.

[32] One can write the right-hand side of the problem (15) as a Lagrangian problem and obtain first-order conditions by setting the partial derivatives with respect to each of the variables $(\Pi_t, C_t, Y_t, i_t, F_t, T_t, G_t, w_t)$ to zero. In addition, there are two envelope conditions associated with the state variables w_{t-1} and y_{t-1}.

III. An Output Collapse and Excessive Deflation under the Hoover Policy Regime

This section outlines a policy regime, called the Hoover regime, that helps account for the large output decline observed during the Great Depression. The key elements of this regime are the policy dogmas.

A. *The Policy Dogmas*

First, there is a "small government" dogma such that real government spending is constant at all times:

$$F_t = \bar{F} = \bar{G} + s(T_t) + A_t. \tag{16}$$

This dogma captures Hoover's views on fiscal policy: the government should be kept "small" at its current level. We read, for example, in his address to the American Legion on September 21, 1931,[33] "Every additional expenditure placed upon our government in this emergency magnifies itself out of all proportion into intolerable pressures, whether it is by taxation or by loans. Either loans or taxes [...] will increase unemployment. [...] We can carry our present expenditures without jeopardy to national stability. We can carry no more without grave risks."

Second, there is a "balanced budget" dogma such that the government will never spend beyond its means. To formalize this, we assume that the government collects taxes to keep the real value of the debt constant:

$$w_t = w_{t-1} = \bar{w} \tag{17}$$

i.e., every new government expenditure needs to be financed by taxes. We can state this alternatively as

$$T_t = F_t + (\Pi_t^{-1} \frac{1}{1 + i_t}) \bar{w}, \tag{18}$$

which says that the government must raise taxes in every period to finance its current level of real spending and the real interest on its outstanding debt.[34] This dogma represents President Hoover's views at the time. In a statement to the press in the early stages of the Depression on July 18, 1930, for example, he stated:[35] "For the Government to finance by bond issues deprives industry and agriculture of just that much capital for its own use and for employment. Prosperity cannot be restored by raids on the public Treasury."

His views on deficits remained unchanged throughout the Depression although he was unable to prevent them during parts of his presidency.

DEFINITION 1 (The Hoover Policy Regime): *The government solves* (15) *where the policy dogmas are given by (i) the small government dogma* (16)*, and (ii) the balanced budget dogma* (17).

[33] Hoover (1934).

[34] In writing the two dogmas in this way, we abstract from any welfare effects of variations in taxes under the Hoover regime by setting $G_t = \bar{G}$ and assuming that the residual spending A_t in (16) adjusts to counteract any changes in tax collection costs. This simplifies the characterization of the Hoover regime considerably.

[35] Hoover (1934).

For simplicity, the "gold standard" dogma is excluded from the definition above, but President Hoover was a strong supporter of the gold standard. This dogma can be added without changing the results because the US government held gold in excess of the monetary base at the time, so this constraint was not binding (see Section V).

B. *Intertemporal Shocks: The Source of the Great Depression*

The shocks in the model are captured by the vector of exogenous shocks ξ_t, whose elements may contain arbitrarily many "fundamental" shocks. A key feature of the data in 1929–1933 is that the short-term nominal interest rate collapsed to zero while output and prices declined. Motivated by this fact, we follow Eggertsson and Woodford (2003) and Auerbach and Obstfeld (2005) by assuming that *purely intertemporal shocks* were responsible for the contraction, and show that these shocks can explain a simultaneous decline in interest rates, prices, and output in the MPE. Other common shocks in the business cycle literature, such as technology shocks, markup shocks (i.e. intratemporal shocks), or money demand shocks, do not have this property.[36]

Intertemporal shocks have been used to explain the Great Depression at least since John Hicks's (1937) illustration of Keynesian ideas in the IS-LM model. The idea is to model the Great Depression as being due to exogenous disturbances that imply a lower real interest rate is required for demand to remain unchanged. Several stories have been suggested in the literature as the source for these kinds of disturbances such as, for example, banking problems (Ben Bernanke 1983) and the stock market crash (Christina Romer 1992).

At the most general level, it is useful to define a purely intertemporal disturbance as one that reduces the efficient rate of interest. The *efficient* allocation is defined as the optimal or first-best solution under flexible prices, i.e., the solution under flexible prices once the fiscal instruments have been set at their optimal level. Each variable in the efficient allocation is denoted by a superscript e.[37] Formally, we assume a shock such that at time 0 the efficient rate of interest is negative so that

$$\text{A1a} \quad R_t^e = \frac{u_c(C_t^e - H_t^{c,e}; \xi_t)}{\beta E_t u_c(C_{t+1}^e - H_{t+1}^{c,e}; \xi_{t+1})} - 1 = R_L^e < 0 \text{ for } 0 \leq t < \tau \tag{19}$$

and the shock reverts back to steady state with probability α in each period. The stochastic period at which the fundamental shock reverts to steady state is τ, such that

$$\text{A1b} \quad R_t^e = 1/\beta - 1 \text{ for } t \geq \tau.$$

Equation (19) is the familiar consumption Euler equation that prices a one-period real bond. The parameter α satisfies

$$\text{A2} \quad \alpha > \bar{\alpha} \geq 0,$$

[36] Consider a productivity shock that enters as a multiplicative factor in the production function. A negative productivity shock, while decreasing output, *increases* the nominal interest rate with no change in inflation in an MPE (Woodford 2003). An exogenous increase in markup, which can be modeled as time-varying θ, will also reduce output in an MPE. At the same time, however, it *increases* the nominal interest rate and inflation in an MPE (Clarida, Galí, and Gertler 1999). Finally, consider a money demand shock as represented by variations in χ_t in equation (12). In an MPE equilibrium, the central bank will completely offset this shock with no effect on inflation, output, or interest rates.

[37] This concept is relatively well known in the literature, and is formally defined in a similar model in Eggertsson (2007b).

which imposes a bound on the persistence of the shock. This condition matters once we linearize the model under the Hoover regime, because a linear approximation is valid only as long as this bound is satisfied.[38] A *purely intertemporal shock* requires that other variables in the efficient allocation remain unchanged, i.e., the efficient level of output and government spending remain constant. This is an attractive assumption, because it implies that any drop in output is inefficient and entirely driven by the propagation mechanism of the model. This imposes the following two restrictions on how the shock enters the model:

$$\text{(20)} \qquad \text{P1} \quad u_c(C_t^e - H_t^{c,e}; \xi_t) - v_y(Y_t^e - H_t^{l,e}; \xi_t) - \beta\gamma E_t u_c(C_{t+1}^e - H_{t+1}^{c,e}; \xi_{t+1}) - \beta\gamma E_t v_y(Y_{t+1}^e - H_{t+1}^{l,e}; \xi_{t+1}) = 0,$$

$$\text{(21)} \qquad \text{P2} \quad -u_c(C_t^e - H_t^{c,e}; \xi_t) + g_G(G_t^e, \xi_t)(1 - s'(T_t^e)) = 0,$$

where $Y_t^e = \bar{Y}$, $C_t^e = \bar{C}$, $G_t^e = \bar{G}$, and $H_t^{c,e} = H_t^{l,e} = \gamma\bar{Y}$. Both (20) and (21) can be derived from a social planner's problem.

Example: A shock that satisfies P1 and P2 is a shock to the discount factor β_t, as in Christiano (2004) and Auerbach and Obstfeld (2004), so the utility function can be written as

$$E_t\left\{\sum_{T=t}^{\infty} \beta_T[u(C_T - H_T^c) + g(G_T) - v(L_T - H_T^l)]\right\}.$$

where β_T is a stochastic disturbance.[39]

In the next section we show that A1 and P1–P2 are enough to close a linear approximation of the model. Observe that we only consider a shock that implies a "low" or "high" state for R_t^e. We consider this simple stochastic process for two reasons. First, most of the results, and the criteria for choosing the shocks, can be written in closed form under this specification. Second, this assumption has theoretical appeal. Our interest is to explore if the Roosevelt regime can account for the recovery, taking the shocks as given. Under this specification, "taking the shocks as given" means that the shock stays in the "low" state for the entire recovery period (and this assumption is consistent with the data because the nominal interest rate stayed at zero throughout the recovery in 1933–1937). All the dynamics of the model, then, will be driven by its internal dynamics and the regime change, and we have the freedom to pick only the level of the shock R_L^e and its persistence α *at the beginning of the Great Depression in 1929.*

C. *Characterizing the Hoover Regime*

The solution is characterized by a linear approximation around a steady state using A1–A2 and P1–P2. The steady state is derived in Appendix C as the solution under the Hoover regime in the absence of shocks. The IS equation (2), together with (9), can be approximated to yield

[38] In the baseline calibration, the expected duration of the shock can be no longer than nine years for the approximation to remain valid.

[39] This example does not generalize to a model with capital. In this case, the fundamental shock also has to enter the capital adjustment cost function. See notes available on the author's Web site.

$$\tilde{Y}_t = E_t\tilde{Y}_{t+1} - \sigma\delta_c(i_t - E_t\pi_{t+1} - r_t^e) + \hat{F}_t - E_t\hat{F}_{t+1}, \tag{22}$$

where $\sigma \equiv -\bar{u}_c/[\bar{u}_{cc}(\bar{C} - \bar{H}^c)]$, $\delta_c \equiv (\bar{C} - \bar{H}^c)/\bar{Y}$, $\pi_t \equiv \log\Pi_t$ is inflation, the term $\hat{F}_t \equiv \log(F_t/\bar{Y})$, and $r_t^e \equiv \bar{r} + (\bar{u}_{c\xi}/\bar{u}_c)\,\xi_t - (\bar{u}_{c\xi}/\bar{u}_c)\,E_t\xi_{t+1}$, where r_t^e refers to $\log(1 + R_t^e)$ and $\bar{r} \equiv \log\beta^{-1}$. The term i_t now refers to $\log(1 + i_t)$ in the notation of the previous section, so we can still express the zero bound as

$$i_t \geq 0. \tag{23}$$

The term $\tilde{Y}_t$ is defined as $\tilde{Y}_t \equiv \hat{Y}_t - \gamma\hat{Y}_{t-1}$, where $\hat{Y}_t \equiv \log(Y_t/\bar{Y})$. The variable $\tilde{Y}_t$ is therefore a quasi-growth rate of output.[40] Equation (22) can be solved forward to illustrate that $\tilde{Y}_t$ depends not only on the current nominal interest rate and expected inflation but also on the entire expected path of future nominal interest rates and inflation.

Equation (4), together with (9), can be approximated as

$$\pi_t = \kappa\tilde{Y}_t - \kappa\psi\hat{F}_t + \beta E_t\pi_{t+1}, \tag{24}$$

where $\kappa \equiv \theta(\sigma^{-1}\delta_c^{-1} + \omega\delta_l)/d''$, $\psi \equiv \sigma^{-1}\delta_c^{-1}/(\sigma^{-1}\delta_c^{-1} + \omega\delta_l)$, $\omega \equiv \bar{v}_{yy}(\bar{Y} - \bar{H}^l)/\bar{v}_y$, and $\delta_l \equiv \bar{Y}/(\bar{Y} - \bar{H}^l)$. Solved forward, this equation says that inflation depends on the expected path of future marginal costs, which in turn depend on $\tilde{Y}_t$ and $\hat{F}_t$.

Finally, the budget constraint of the government is approximated by

$$w_t - \bar{w}i_t = \beta^{-1}w_{t-1} - \beta^{-1}\bar{w}\pi_t + \beta^{-1}\hat{F}_t - \beta^{-1}\hat{T}_t, \tag{25}$$

where $\hat{T}_t \equiv \log(T_t/\bar{Y})$ and the model is linearized around a given level for outstanding debt $\bar{w}$. The budget constraint says that for *a given* level of debt, monetary policy can influence government finances through two channels. The second term on the left indicates that a lower nominal interest rate will reduce the burden of debt rolled over to the next period. The second term on the right indicates that inflation will reduce the real value of outstanding debt because all the debt is issued in nominal terms (nominal bonds and the money supply).

Government policy satisfies the first-order conditions of the maximization problem (15) (shown in Appendix B). The policy dogmas can be approximated as

$$\hat{w}_t = \hat{F}_t = \hat{G}_t = 0, \tag{26}$$

$$\hat{T}_t = -\frac{1}{s'}\hat{A}_t = \bar{w}\beta(i_t - \bar{r}) - \bar{w}\pi_t. \tag{27}$$

These equations say that in order to keep the real debt constant the government will increase or reduce taxes to cover the interest rate burden of outstanding debt. The first-order conditions (with respect to π_t, Y_t, i_t) can be approximated as

$$\pi_t - \phi_{3t} = 0 \tag{28}$$

$$-(\tilde{Y}_t - E_t\tilde{Y}_{t+1}) - \theta(\phi_{3t} - \beta\gamma E_t\phi_{3t+1}) + \psi(\phi_{2t} - \beta\gamma E_t\phi_{2t+1}) + \sigma\delta_c\psi(\bar{f}_Y^e\phi_{2t} - \beta\bar{S}_Y^e\phi_{3t}), \tag{29}$$

$$\phi_{2t} + \beta^{-1}\gamma_{1t} = 0, \tag{30}$$

[40] The advantage of the external habit in consumption and labor is that all the results in the paper can be interpreted as referring to a model without habit, in which case $\tilde{Y}_t$ refers to output (because $\gamma = 0$).

and there is a complementary slackness condition due to the zero bound

$$\gamma_{1t}\, i_t = 0,\ i_t \geq 0,\ \gamma_{1t} \geq 0, \tag{31}$$

where the variables ϕ_{2t}, ϕ_{3t}, γ_{1t} are the Lagrangian multipliers associated with (22), (24), and the zero bound.

An approximate equilibrium under the Hoover regime solves (22)–(31) for a given path of $\{r_t^e\}$, but all the shocks are summarized by r_t^e. A complication arises because of the unknown expectation functions $\bar{f}_Y^e$ and $\bar{S}_Y^e$, but since equations (22)–(31) are completely forward looking, the determination of π_t and $\tilde{Y}_t$ does not depend on the endogenous state (Y_{t-1}, w_{t-1}), implying that $\bar{f}_Y^e = \bar{S}_Y^e = 0$.[41] Another complication is the zero bound on the short-term interest rate, which gives rise to the complementary slackness condition.

To deal with the zero bound, we solve the model in two steps. We first solve it for $t \geq \tau$, i.e., in the periods once the disturbance in the model, r_t^e, has reverted to steady state. It is easy to show that $\tilde{Y}_t = \pi_t = 0$ for $t \geq \tau$.[42] At this time, i_t is positive and inflation increases with the money supply. Then, we calculate expectations at time $t < \tau$, taking this solution as given. The IS and the AS constraints can then be written (the budget constraint plays no role due to the policy dogmas):

$$\tilde{Y}_{t,L} = (1-\alpha)E_{t,L}\tilde{Y}_{t+1} - \sigma\delta_C(i_{t,L} - (1-\alpha)E_{t,L}\pi_{t+1} - r_L^e), \tag{32}$$

$$\pi_{t,L} = \kappa\tilde{Y}_{t,L} + (1-\alpha)\beta E_{t,L}\pi_{t+1}, \tag{33}$$

where the notation (t, L) reminds the reader that the equations are written conditional on the shock being in the low state, and we have used the solution for $t > \tau$ to substitute out for the expectations.[43]

It can be shown that $i_{t,L} = 0$ at $t < \tau$ and these equations have a unique bounded solution that is only a function of the real shock r_L^e, such that $\pi_{t,L} = E_{t,L}\pi_{t+1} = \pi_L$ and $\tilde{Y}_t = E_{t,L}\tilde{Y}_{t+1} = \tilde{Y}_L$.[44] Substituting this into (32) and (33), we obtain the solution for output and inflation at time $t < \tau$:

$$\tilde{Y}_L = \frac{1-\beta(1-\alpha)}{\alpha(1-\beta(1-\alpha)) - \sigma\delta_c\kappa(1-\alpha)}\sigma\delta_c r_L^e < 0, \tag{34}$$

[41] This result can be derived formally by complementing the linearized system by a linear approximation of (3), (5), (13), and (14). Using methods of undetermined coefficients, the result obtains.

[42] In this case the zero bound is no longer binding, $i_t > 0$, and from (30) and (31) we see that $\gamma_{1t} = \phi_{2t} = 0$. Using this, we observe from (29) that a condition for a bounded solution is that $\beta\gamma < 1$, and using this to forward equation (28) we obtain $\tilde{Y}_t = \theta\phi_{3t}$. Substituting this into (28) and forwarding equation (24) yields $\tilde{Y}_t = [\beta/(1+\theta\kappa)]^j E_t\tilde{Y}_{t+j}$, implying that there is a unique bounded solution $\tilde{Y}_t = \pi_t = 0$ for $t > \tau$, as long as $\beta\gamma < 1$, since $0 < \beta < 1$ and $\theta, \kappa > 0$.

[43] For inflation expectations, for example, we have $E_t\pi_{t+1} = (1-\alpha)E_{t,L}\pi_{t+1} + \alpha E_{t,H}\pi_{t+1} = (1-\alpha)E_{t,L}\pi_{t+1}$.

[44] Observe that the central bank cannot achieve a solution in which $\pi_t = \tilde{Y}_t = 0$ in periods $t < \tau$. To see this, observe from equation (32) that this solution would imply that $i_{t,L} = r_L{}^e < 0$, which violates the zero bound. Instead of setting negative nominal interest rates, the central bank achieves maximum accommodation in period $t < \tau$ by setting $i_{t,L} = 0$. (This can formally be confirmed by inspecting (28)–(31), and the simplest way of proving that $i_t = 0$ in $t < \tau$ is using proof by contradiction.) Setting $i_{t,L} = 0$, the two equations (32) and (33) can be solved using standard solution methods for linear rational expectation models. A unique bounded solution exists as long as the characteristic equation of this system has two roots outside of the unit circle, which was confirmed for all the numerical exercises. The characteristic equation of the system is $\lambda^2 - \{1/(\beta(1-\alpha)) + [1/(1-\alpha)]\,[\kappa(\sigma/\beta)+1]\}\,\lambda + \{[1/(\beta(1-\alpha)^2)]\,[\kappa(\sigma/\beta)+1] - \kappa\,\sigma/(\beta^2(1-\alpha)^2)\}$.

$$\pi_L = \frac{1}{\alpha(1-\beta(1-\alpha)) - \sigma\delta_c\kappa(1-\alpha)}\kappa\sigma\delta_c r_L^e < 0. \tag{35}$$

To summarize:[45]

PROPOSITION 1 (Equilibrium Policy and Outcomes under the Hoover Regime): *If A1 and A2, then the equilibrium policy under the Hoover regime is:*

(i) Fiscal policy:

$$\hat{F}_t = \hat{G}_t = \hat{w}_t = 0 \quad \forall\, t, \tag{36}$$

$$\hat{T}_t = -\frac{1}{s'}\hat{A}_t = -\bar{w}\beta(i_t - \bar{r}) + \bar{w}\pi_t \quad \forall\, t. \tag{37}$$

(ii) Monetary policy:

$$i_t = r_t^e \text{ so that } \pi_t = 0 \text{ when } t \geq \tau, \tag{38}$$

$$i_t = 0 \text{ when } 0 \leq t < \tau. \tag{39}$$

(iii) Outcomes:

$$\tilde{Y}_L = \phi_y^H r_L^e < 0 \text{ if } t < \tau \text{ and } \tilde{Y}_t = 0 \text{ when } t \geq \tau, \tag{40}$$

$$\pi_L = \phi_\pi^H r_L^e < 0 \text{ if } t < \tau \text{ and } \pi_t = 0 \text{ when } t \geq \tau, \tag{41}$$

where $\phi_y^H, \phi_\pi^H > 0$ *are given by* (34) *and* (35).

This policy characterization implies that the Federal Reserve behaves as if it follows a strict zero-inflation target, but with the twist that it may not be able to achieve it if the efficient real rate of interest is negative. In this case, the Fed lowers the nominal interest rate to zero. Importantly, if the price level falls due to the zero bound, the fall in the price level will not be undone with subsequent inflation because the Federal Reserve will try to achieve zero inflation as soon as possible, i.e., as soon as the shock has reverted back to steady state at $t \geq \tau$.

The pursuit of low inflation appears to accord well with the narrative record of the Federal Reserve in the years before the onset of the Great Depression. While it was formally bound by the gold standard, one of its main objectives was to stabilize inflation, which is the reason why it did not increase the money supply corresponding to gold inflows in that period (see Section V). More surprisingly, perhaps, this behavior also accords well with narrative descriptions of the Federal Reserve in the midst of the Great Depression. At that time, even as the price level had dropped considerably, the Federal Reserve was not interested in allowing prices to rise to their previous levels. Instead, it was concerned with preventing *future inflation* as the economy would

[45] Observe that a bounded solution requires that $\alpha(1-\beta(1-\alpha)) - \sigma\delta_c\kappa(1-\alpha) > 0$. Under the Hoover regime, the value of $\bar{\alpha}$ in condition A2 is therefore the solution to the equation $\bar{\alpha}(1-\beta(1-\bar{\alpha})) - \sigma\delta_c\kappa(1-\bar{\alpha}) = 0$. A lower value of α means that the shock is more persistent. The value of α is critical for the amplification of the shock, as can be seen in equations (34) and (35).

start recovering, consistent with (38). The view of the Federal Reserve appears to have been that deflation was a necessary consequences of the speculative excesses of the past that had to be "purged."[46]

Table 2—Calibrated Parameters and Shocks

Parameters	Value
σ^{-1}	1
ω	1
γ	0.8
β	0.96
F/Y	0.1
θ	11
s'	0.1516
s''	1.5160
$1/(1-\zeta)$[a]	3
Shocks	**Value**
r_L^e	−0.0497
α	0.1406

[a] Expected duration of a newly set price in quarters.

D. *Accounting for the Downturn: A Calibrated Example*

While the results are analytical, it is of some interest to put some numbers on them. The parameters are taken from related literature and then the shocks chosen to match the contractionary phase of the Great Depression. This sets the stage for the key question the numerical example addresses: can a regime change explain the recovery in 1933–1937, *taking as given shocks that are large enough to generate the Great Depression in the model*?

Each period is a year, because our fiscal data are annual. The model dynamics are determined by the structural parameters (σ, ω, β, θ, d'', γ) and the steady-state relationships.[47] The first four are relatively standard values from the literature (discussed in Appendix A and shown in Table 2), while d'' is the second derivative of the cost of changing prices. To determine this parameter, the model is mapped into one with stochastic price adjustment, as in Calvo (1982), determined by the probability parameter ζ in Table 2. It is assumed that prices are adjusted on average once every nine months (see Appendix A). There is no common agreement on the value for γ, the habit persistence parameter. Some authors assume no habit persistence, while others, such as Marc Giannoni and Woodford (2005), estimate a consumption habit close to one. We experiment with several values for γ.[48]

The value of r_L^e is chosen to match the drop in output in 1933. The persistence of the shock, i.e., α, is chosen to minimize the distance of deflation in the data and in the model during the contractionary phase of the Great Depression. Appendix A derives a closed-form expression of the criteria for choosing the shocks. This procedure yields $r_L = -0.0497$ with $\alpha = 0.1406$ under the baseline calibration.[49] The line in Figure 3 marked Hoover regime shows the response of output, inflation, and the short-term nominal interest rate to a shock of this size and compares to the data. The output of the model is plotted under the contingency that r_t^e stay in the low state

[46] This has been considered somewhat of a puzzle in the literature, as noted, for example, by Alan Meltzer who writes: "As the world economy moved towards deflation and depression the Federal Reserve's principle concern was inflation. To contemporary economists, this concern is puzzling because the price level fell slowly from 1927–29, then more rapidly" (2003, 728). Meltzer also has extensive discussion on this in chapter 5 (273–80). The current paper suggests an interpretation of this behavior: it was a consequence of a purely *discretionary* behavior by the Federal Reserve, as further discussed in Section IIIE (see especially footnote 57).

[47] These parameters, in turn, determine the variables δ_c, δ_l, ψ, and κ in the linearized equations.

[48] See Section IVD and Eggertsson (2007a) for further discussion.

[49] This approach leaves out several important issues, such as a more detailed model of the shock that caused the Great Depression and the frequency of shocks of this magnitude. For work on the frequency of shocks that require negative real interest rates for full employment, see Lawrence Summers (1991), Rotemberg and Woodford (1997), Reifschneifer and Williams (2000) and Christiano (2004). Most authors find that a zero inflation target would imply that the zero bound is binding for a substantial amount of time, and that the reason we have not seen more episodes of that kind is that central banks tend to accommodate higher levels of inflation on average.

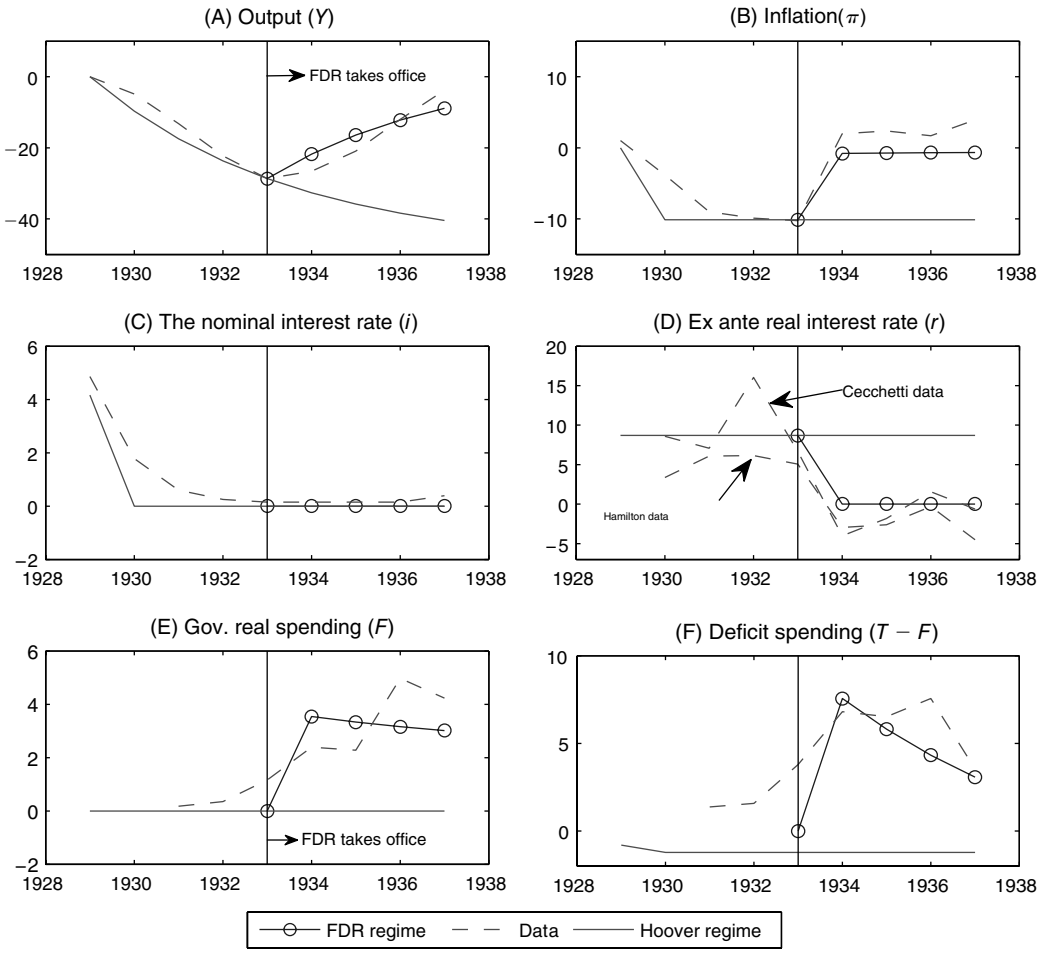

FIGURE 3

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

for the entire period 1929–1937. The data are in fiscal years so the year 1933 is the fiscal year ending in June 1933. [50]

As can be seen from the figure, the Hoover regime replicates the data relatively well for the period 1929–1933. A vertical line shows when Hoover lost power and Roosevelt came into

TABLE 3—PARAMETER RANGE THAT LEAVES RESULTS UNDER HOOVER UNCHANGED

	min	max
$1/(1-\zeta)$[a]	1.7	3.44
θ	1.8	14.8
ω	0.125	1.95
σ^{-1}	0.74	7.14
β	0.9040	1

[a] Expected duration of a newly set price in quarters.

[50] Inflation is measured in year-on-year changes in CPI and the short-term interest rate is measured as the yield on three month Treasury bonds in June of each year (see further discussion in the Appendix C). To compute year-on-year change in CPI in the fiscal year 1933, we use the beginning of March value of CPI, rather than June, just before FDR took power. Following Bordo, Erceg, and Evans (2000), none of the data is detrended but output is expressed in deviations from the 1929 peak.

office. This is where the output from the Hoover regime and the data diverge. Output continues to decline under the Hoover regime, reaching a nadir of −49 percent from steady state in 1937, but the data show a strong recovery. Section IV analyses whether the Roosevelt regime change can explain the recovery in the data.

Observe that according to Figure 3 the nominal interest rate collapses to zero immediately in the model, while it declined somewhat slower in the data. This suggests that actual policy in 1929–1933 was even more contractionary than suggested by the Hoover regime in the model. Eggertsson (2007a) quantifies the importance of this discrepancy and finds that taking it into account has a small quantitative effect.[51]

The solution under the Hoover regime in Figure 3 is insensitive to variations in the structural parameters $(\sigma, \omega, \beta, \theta, \zeta)$ as long as they remain in the region shown in Table 3, which includes most estimates of these parameters common in the literature. This is because different values of the structural parameters will result in a different choice for the shocks, according to the criteria derived in Appendix A. The figure is sensitive to variations in γ but this parameter helps account for the gradual decline in output, as discussed further in Section IVC.

E. *Discussion*

The contraction at any time $t \leq \tau$ in Figure 3 is created by a combination of the deflationary shocks in period $t < \tau$ but, more importantly, by the *expectation* that there will be deflation and output contraction in future periods $t + j < \tau$ for $j > 0$. (Recall that τ is the stochastic date at which the shock returns to steady state.) The deflation in period $t + j$ in turn depends on expectations of deflation and output contraction in periods $t + j + i < \tau$ for $i > 0$. This creates a vicious cycle that does not converge unless the restriction on α in A2 is satisfied.

To clarify this logic, forward IS equation (22) to yield

$$\tilde{Y}_t = E_t \tilde{Y}_T - E_t\left[\sum_{s=t}^{T-1} \sigma\delta_c(i_s - \pi_{s+1} - r_s^e) - (\hat{F}_s - \hat{F}_{s+1})\right], \tag{42}$$

which shows that the quasi-growth rate of output $\tilde{Y}_t$, depends not only on the current real rate $r_t = i_t - E_t\pi_{t+1}$, but also on the expectation of future real interest rates $E_t(i_{t+s} - \pi_{t+s+1})$.[52] Demand can be stabilized if the short-term real interest rate tracks r_t^e. If the policy regime aims at zero inflation, as under the Hoover regime, this cannot be achieved when r_t^e is negative because this would require a negative nominal interest rate. When $r_t^e < 0$ the real rate will then be higher than r_t^e, which leads to an output contraction according to (42), which in turn leads to deflation by the equation (24). Observe that because the shock r_t^e is persistent, people expect output contraction and deflation also to occur in the future, thereby increasing expected future real rates $E_t(i_{t+s} - \pi_{t+s+1})$, leading to an even greater contraction.[53]

Increasing the money supply has no effect in the model unless it changes expectations. The reason is that money supply affects spending through the short-term interest rate, which by 1933 was already close to zero, so money and bonds were perfect substitutes. Any money supply above

[51] Of even more trivial quantitative importance is if the nominal interest rate—as measured by three-month Treasury bonds—could have been lowered to exactly zero from their level of around 0.05–0.1 percent (see Eggertsson 2007a).

[52] By the expectation hypothesis, an alternative way of stating this is that demand depends on long-term real interest rates.

[53] Observe that the role of the AS equation is to determine the degree of deflation associated with a given output contraction. Because demand is decreasing with expectation of future deflation, the AS equation suggests that, for a given shock, the contraction is more severe the more flexible prices are in the model, as in James Tobin (1975) and J. Bradford De Long and Summers (1986).

$\chi Y_t P_t$ (see inequality (12)) during the period of zero interest rates at dates $t < \tau$ is thus consistent with the equilibrium. Furthermore, open market operations do not change expectations under the Hoover policy regime.[54] Since the private-sector expects inflation to be $\pi^* = 0$ as soon as the deflationary shocks subside, it will expect the central bank to reverse any money supply increase as soon as the shock subsides, no matter how large it is at time $t < \tau$. Any monetary expansion will thus be expected to be transitory and the irrelevance proposition of Eggertsson and Woodford (2003) applies.[55]

Why does the government not simply commit to increasing the money supply *in the future* (i.e., $t \geq \tau$) under the Hoover regime since this increases inflation expectations, which, in turn, stimulates demand (according to (42))? The reason is that inflation policy is not credible under the Hoover regime. Even if the government promises inflation in the future, it has an incentive to renege on this promise as soon as the deflationary shocks have subsided. This is what Eggertsson (2006) calls "the deflation bias of discretionary policy in a liquidity trap."[56]

While Figure 3 shows the solution assuming that r_L^e stays low for the entire period, Figure 4 shows the solution under the contingency that the shock reverts to normal at the end of the fiscal year 1933. If the shock reverts to normal, there is a recovery in both prices and output, and this is an alternative hypothesis to recovery in 1933–1937. Under this alternative hypothesis, it was a coincidence that the Roosevelt regime change and the turning point coincided.[57] The panel for the interest rate in Figure 4 shows that this alternative hypothesis is inconsistent with the data. If the intertemporal shocks were over in 1933, the model implies an increase in the nominal interest rate. Instead, the nominal interest rate stayed low throughout the recovery period, without exerting strong inflationary pressures.

IV. An Economic Expansion Under the Roosevelt Policy Regime

This section outlines the consequences of relaxing the policy dogmas. Abolishing these dogmas is defined as the policy regime change. Thus the regime change is modeled as follows:

$$\text{Hoover Regime} \rightarrow \text{(Unexpected) Elimination of Policy Dogmas} \rightarrow \text{Roosevelt Regime}$$

Both Roosevelt and Hoover maximize social welfare in the model, and their policy regimes are identical, apart from the policy dogmas that constrained Hoover.

DEFINITION 2 (The Roosevelt Regime): *The government solves* (15) *free from policy dogmas.*

[54] One can imagine a policy regime in which this is not the case. See, for example, Auerbach and Obstfeld (2004). Eggertsson (2007a) discusses how their policy regime relates to the one studied here.

[55] See further discussion in Eggertsson and Woodford (2003), who extend the result to purchases of various other classes of financial assets than short-term bonds.

[56] To obtain some further intuition, we can approximate the objective of the government under the Hoover policy regime by a second-order Taylor expansion of the utility of the representative household to yield $-E_t \sum_{T=t}^{\infty} \beta^{T-t} (\pi_T^2 + \lambda_y \tilde{Y}_t^2)$. The government can maximize this objective from period $t \geq \tau$ by setting $i_t = r_t^e$ and achieve zero inflation. Thus, while it can be good to increase inflation expectations in period $t < \tau$, the government has an incentive to renege on any inflationary promises once the shock has reverted, resulting in the deflation bias of discretionary policy.

[57] Or perhaps there were other elements of the regime change that are not modeled here that were responsible and worked through the efficient rate of interest.

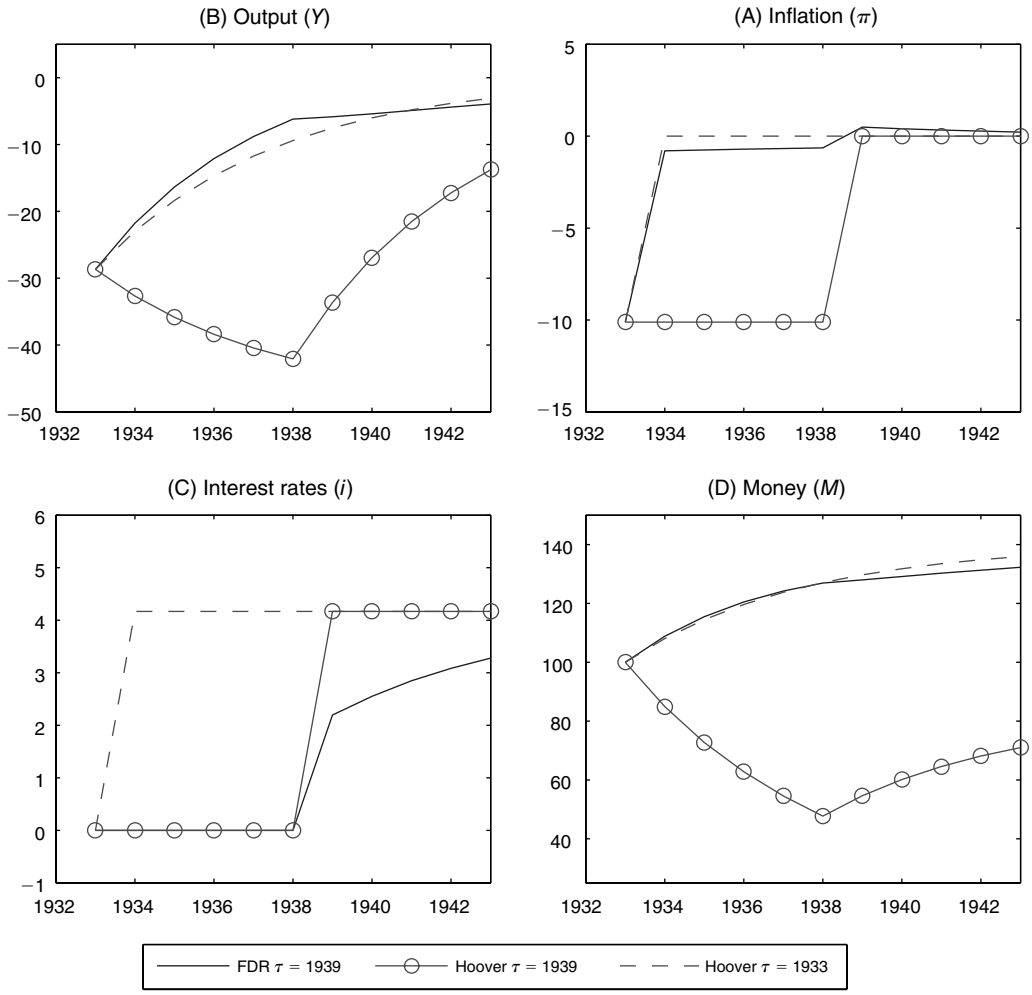

FIGURE 4

Notes: This figure contrasts the FDR regime to the Hoover regime under various assumption about when the shock reverts back to steady state (i.e., different dates for τ).

A. *The Elimination of Policy Dogmas under Roosevelt*

The first dogma attached to the Hoover regime was the perceived need for small government to foster a recovery. Roosevelt made clear that he would violate this dogma once he took office. In his inauguration address, he announced:

> Our greatest primary task is to put people to work. This is no unsolvable problem if we face it wisely and courageously. It can be accomplished in part by direct recruiting by the Government itself, treating the task as we would treat the emergency of a war, but at the same time, through this employment, accomplishing greatly needed projects to stimulate and reorganize the use of our natural resources.

Contrast this statement to Hoover's claim that "every additional" government expenditure would cause "intolerable pressures."

Hoover's second dogma was to balance the budget. Violating this dogma allows the government to issue "credit," defined as the sum of money and nominal debt. There is some narrative evidence that Roosevelt viewed government credit expansion as crucial to increase inflation. Interestingly, Roosevelt made no distinction between government debt and the monetary base, which is consistent with this interpretation. In one of his fireside chats in 1933,[58] for example, he stated, "In the first place, government credit and government currency are really one and the same thing." This statement is theoretically correct in the model, since interest rates were at zero at the time and so there was *no* economic difference between government debt and the monetary base. Furthermore, Roosevelt stated that government credit would be used to increase inflation. In the same speech, when firming up his commitment that prices would be inflated, he stated: "That is why powers are being given to the Administration to provide, if necessary, for an enlargement of credit [....] These powers will be used when, as, and if it may be necessary to accomplish the purpose [i.e., increasing inflation]."

Evidently, Roosevelt viewed credit expansion as crucial to fighting deflation.

B. *Characterizing the Roosevelt Regime*

We characterize again the solution by a first-order approximation around a steady state and using A1, A2, P1, and P2 to write out a linear approximation. Government policy satisfies the first-order conditions of the maximization problem (15) unconstrained by the dogmas, and the nonlinear first-order conditions are shown in Appendix B. The first-order conditions (with respect to π_t, w_t, T_t, F_t, Y_t, and i_t) can be linearized to yield

$$\pi_t - \frac{s'}{d''(1-s')} w_{t-1} - \phi_{3t} = 0, \tag{43}$$

$$\hat{\phi}_{1t} - E_t\hat{\phi}_{1t+1} - E_t(i_{t+1} - \bar{r}) + E_t\pi_{t+1} + \frac{1-s'}{s'}[\bar{f}^e_w \phi_{2t} - \beta \bar{S}^e_w \phi_{3t} - \gamma_{2t}] = 0, \tag{44}$$

$$\hat{\phi}_{1t} + \sigma^{-1}\delta_g^{-1}\hat{F}_t - \left(\frac{s''}{s'} + \sigma^{-1}\delta_g^{-1}s'\right)\hat{T}_t - \alpha^{-1}r^e_L + (i_t - \bar{r}) = 0, \tag{45}$$

$$-\tilde{Y}_t + (1 + \delta_c\delta_g^{-1})\hat{F}_t - \left(\delta_c\delta_g^{-1}s' - \sigma\delta_c\frac{s''}{1-s'}\right)\hat{T}_t + \phi_{2t} - \theta\phi_{3t} = 0, \tag{46}$$

$$-(\tilde{Y}_t - \beta\gamma E_t\tilde{Y}_{t+1}) + \psi(\hat{F}_t - \beta\gamma E_t\hat{F}_{t+1}) - \theta(\phi_{3t} - \beta\gamma E_t\phi_{3t+1}) + \psi(\phi_{2t} - \beta\gamma E_t\phi_{2t+1}) = 0, \tag{47}$$

$$-w_{t-1} - \hat{F}_t + \hat{T}_t + \frac{1-s'}{s'}[\beta\phi_{2t} + \gamma_{1t}] = 0, \tag{48}$$

and two complementary slackness conditions:

$$\gamma_{1t} \geq 0, \gamma_{1t} i_t = 0, \tag{49}$$

$$\gamma_{2t} \geq 0, \gamma_{2t}(w_t - w^b) = 0, \tag{50}$$

[58] Roosevelt (1933b).

where the variables $\hat{\phi}_{1t}$, ϕ_{2t}, ϕ_{3t}, γ_{1t}, and γ_{2t} are the Lagrangian multipliers with respect to (22), (24), (25), and the zero bound and the debt limit (see Appendix C for derivation). An approximate equilibrium under the Roosevelt regime is then defined as a collection of stochastic processes for the endogenous variables that satisfy (22)−(25) and (43)−(50) for a given path of $\{r_t^e\}$. Again, all the shocks are summarized by r_t^e. A complication arises because of the unknown expectation functions $\bar{f}_w^e$ and $\bar{S}_w^e$, and we cannot use the same argument as before (when discussing $\bar{f}_Y^e$ and $\bar{S}_Y^e$) to eliminate them because w_{t-1} is a state variable of the game.[59] One can approximate these functions by a method of undetermined coefficients, applied to the model without shocks. A Matlab routine was written which computes these functions numerically.[60]

The model can be solved in the same way as under the Hoover regime. First, we characterize the solution for $t > \tau$. In this case, all the variables are a function of the state variable w_t. We can write, for example, $\pi_t = \pi^w w_{t-1}$ for $t > \tau$ where π^w is a number. Using this to solve for expectations at time $t \leq \tau$[61], we can solve the model using standard solution methods for linear expectation models.[62]

C. *Numerical Characterization: The Recovery under Roosevelt*

To solve the model numerically and complement our previous calibration exercise, we need to take a stance on two fiscal parameters, the first and second derivative in the tax cost function $s(T)$, which plays a role only under the Roosevelt policy regime. The calibration is shown in Table 2 and discussed further in Appendix A. The next proposition summarizes the policy under Roosevelt in the baseline calibration. To facilitate comparison to the Hoover regime, the proposition specifies the response of taxes, spending, and interest rates in an analytic form. This form of policy held for all parameter values considered with minor exceptions.[63]

PROPOSITION 2: *Under the baseline calibration, policy is:*

(i) Fiscal policy:

$$\hat{F}_t = \eta_F^1 w_{t-1} < 0 \text{ for } t \geq \tau,$$

$$\hat{T}_t = \eta_T^1 w_{t-1} \geq 0 \text{ for } t \geq \tau,$$

$$\hat{F}_t = \eta_F^2 w_{t-1} + \phi_F^{FDR}(r_t^e - \bar{r}) > 0 \text{ for } t < \tau,$$

$$\hat{T}_t = \eta_T^2 w_{t-1} + \phi_T^{FDR}(r_t^e - \bar{r}) \leq 0 \text{ for } t < \tau, \tag{51}$$

where $(\eta_F^1, \eta_T^1, \eta_F^2, \eta_T^2, \phi_F^{FDR}, \phi_T^{FDR}) = (-0.0360, 0.1800, -0.0225, 0.1668, -0.8600, 1.9295)$.

[59] The functions $\bar{f}_y^e$ and $\bar{S}_y^e$ drop out here by the same argument as before.

[60] In all the numerical experiments, a unique value for $\bar{f}_w^e$ and $\bar{S}_w^e$ was found consistent with a bounded solution.

[61] Consider, for example, the solution for inflation expectations $E_t\pi_{t+1} = (1-\alpha)E_{t,L}\pi_{t+1} + \alpha E_{t,H}\pi_{t+1} = (1-\alpha)E_{t,L}\pi_{t+1} + \alpha\pi^w w_t$.

[62] The system will be of the form $\mathbf{AX}_{t+1} = \mathbf{BX}_t$, where the vector $\mathbf{X}_t$ contains $(\pi_t, \tilde{Y}_t, F_t, T_t, \phi_{1t}, \phi_{2t}, \phi_{3t}, \gamma_{1t}, w_{t-1}, r_L)$. A condition for a unique bounded solution is that the system has eight eigenvalues outside of the unit circle, a condition we confirm in our numerical simulation, in which case the system can be solved using the method of Olivier Blanchard and Charles Kahn (1980).

[63] The one exception is that if there is a very high level of debt w_{t-1} outstanding at the time of the regime change, there may be no need for additional deficit spending.

(ii) Monetary policy:

$$i_t < r_t^e \text{ so that } \pi_t = \eta_\pi^2 w_{t-1} > 0 \text{ when } t \geq \tau, \tag{52}$$

$$i_t = 0 \text{ when } 0 \leq t < \tau,$$

where $\eta_\pi^2 = 0.0081$

(iii) Outcomes:

$$\hat{Y}_t^{FDR} \geq \hat{Y}_t^H \text{ for all } t,$$

$$\pi_t^{FDR} \geq \pi_t^H \text{ for all } t.$$

The fiscal policy in Proposition 2 is countercyclical. The government responds to the contraction by expanding both real and deficit spending, much in the way as suggested by Roosevelt and in contrast to the Hoover regime. Interest rate setting is the same in the period $t < \tau$ because the nominal interest rate remains at zero. The key difference is that, under the Roosevelt regime, the short-term nominal interest rate will remain low even as the real disturbance reverts to steady state, i.e., $i_t < r_t^e$ for some time after the shock has returned to normal. Hence the Roosevelt policy regime implies a commitment to keep the nominal interest rate low for a considerably longer time than does the Hoover regime.

Figure 3 shows the quantitative consequence of the regime change in the model with a line marked Roosevelt regime.[64] Here, we take as initial values the level of output in 1933 and the level of real debt w_{t-1}, which was 35 percent as a fraction of 1929 output. The figure plots each of the variables under the assumption that the shock r_t^e remains in the negative state throughout the period, consistent with the observed low nominal interest rates in the data. We see that the regime change results in an increase in both prices and output, of a similar order as seen in the data and roughly mimicking the persistence of the two variables. The regime change explains 79 percent of the recovery in output in 1933–1937 and 67 percent of the recovery in inflation. Figure 3 also documents the change in the real interest rate according to the model in comparison with the estimate of the real interest rate in Hamilton (1992) and Cecchetti (1992).[65] Both estimates reveal a sharp drop in the real interest rate in 1933—on the order of 8–12 percent—and this is what we observe in the model as well. The policy instruments that drive the expansion are the aggressive increase in both deficits and real government spending, as can be seen in Figure 3.[66] Since the nominal interest rate was already zero in 1933, interest rate cuts play no role. Similarly, the money supply is indeterminate in the model due to the zero interest rates. Expectations about future interest rates and the money supply, however, are at central stage, as discussed in the next section.

D. *Discussion*

The most important aspect of the Roosevelt regime change is that it implies a commitment to lower future nominal interest rates relative to the Hoover regime, a higher future price level,

[64] Both data and the model for Y_t, F_t, and T_t are expressed as deviations from 1929, which, following Bordo, Erceg, and Evans (2000), is interpreted as steady state.

[65] The estimate in the figure is constructed by taking an average over each fiscal year.

[66] Here, real spending measures the deviation of F_t from steady state as a fraction of steady-state output, and the deficit measures the discrepancy between F_t and T_t as a fraction of steady-state output.

and hence a permanent increase in the money supply. This is clarified in Figure 4, which compares the solution under the Hoover regime to the Roosevelt regime from 1933 onward under the assumption that the shock r_L^e reverts to steady state in six periods (i.e., $\tau = 1939$), which is the expected duration of the shock in 1933. Under the Hoover regime, the government increases the interest rate and achieves zero inflation as soon as deflationary pressures have subsided at $\tau = 1939$, which, as explained in Section IIIE, leads to vicious deflationary dynamics and an output collapse in period $t < \tau$. Under the Roosevelt regime, however, the government keeps the nominal interest rate low for a substantial period of time and accommodates some inflation and some output expansion after the shock has subsided. Another way of stating this, loosely speaking, is that under the Roosevelt regime, the government commits to permanently increasing the money supply. The supply of money is uniquely defined when the shock has subsided (i.e. at dates $t \geq \tau$) [67] and the Roosevelt regime implies a money supply three times higher at $\tau = 1939$ than the Hoover regime.[68]

The Roosevelt regime change increases output through several channels, as can be seen by equation (42). First, the commitment to reflate the price level relative to the Hoover regime (panel B in Figure 4) implies lower real interest rates due to higher expected inflation, which stimulates spending, even at times when the nominal interest rate cannot be reduced. Second, the commitment to lower future nominal interest rates (panel C), at times at when people expected the central bank to raise interest rates under the Hoover regime (i.e., $t \geq \tau$), also stimulates spending. Observe that because equation (42) is forward looking, these expectations have a large effect, even if they apply to future economic developments. Third, the commitment to higher future output (panel A), relative to the Hoover regime, implies higher future income, thus stimulating spending through the permanent income hypothesis. Fourth, the increase in real government spending also directly increases output.

The expansion is almost exclusively due to expectations about future policy. A key question is *why* expectations coordinated on a reflationary regime when Roosevelt took office. One answer is that, as documented in Section I, Roosevelt *announced* that he would reflate the price level (implying a permanent increase in the money supply) and people believed him. This *simple* interpretation of the regime change is consistent with the main hypothesis of the paper, which is that the regime change caused the recovery.[69] Proposition 2, however, goes much *further* than this simple interpretation. It states *how* Roosevelt made people believe him because the maintained assumption of the MPE is that the government cannot commit to future policy, which makes a simple announcement of reflation not credible (as discussed in Section IIIE). The key to making the reflationary regime credible, according to Proposition 2, is the elimination of the policy dogmas, which shows up as an expansion in real government spending $\hat{F}_t$ and the deficit spending, i.e., the discrepancy between $\hat{F}_t$ and $\hat{T}_t$. Proposition 2, therefore, provides a formal explanation of why Roosevelt's reflationary regime was credible.

Consider, first, how violating the small government dogma supports the reflationary regime in the MPE. As can be seen by equation (42), a static increase in F_t moves output 1 to 1, holding expectations constant, and through equation (24) this reduces deflation. This relatively small static effect, however, is not the only effect because it neglects the dynamic consequence of real government spending. If people expect a fiscal expansion in all states of the world in which the zero bound is binding, this reduces expectations of future deflation and stimulates output in those

[67] The money supply plays no role in the period $t < \tau$ because then money and bonds are perfect substitutes. Hence, any money supply above the two lines in Figure 4 is consistent with equilibrium.

[68] The main reason for this large difference is that the reflation under FDR contains deflation and output contraction in all states $t < 1939$, which in turn has dramatic implications for the implied future money supply.

[69] See further discussion and alternative interpretations in Eggertsson (2007a).

future states, thus having a stimulative effect on current output. Observe that the fiscal expansion is fully credible by the MPE construction, and this is mostly explained by the fact that it involves a *direct* response to the current shock r_t^e. Because increases in government spending curb current and future deflation, they imply a higher money supply and price level *in the future*. The real government spending expansion was thus one *direct* way in which Roosevelt made his objective of inflating the price level *credible*. While real government spending is stimulative, it is not enough to explain the recovery in 1933–1937. In the baseline calibration, the increase in F_t can account for 18 percent of the recovery in output and 23 percent of the recovery in inflation.[70] We need to violate the balanced budget dogma for a full account of the recovery in the MPE.

Violating the balanced budget dogma provides even stronger support to the reflationary regime in the MPE. The key is that under the Roosevelt policy regime, inflation expectations are increasing in aggregate government credit, w_t, according to Proposition 2, while future interest rates are decreasing in w_t. Furthermore, equation (51) says that the government will issue government credit to generate expansionary expectations. Both these features of the Roosevelt policy regime are consistent with the narrative evidence cited in Section IVA. Roosevelt wanted reflation and announced that he would achieve this by issuing government credit "when, as, and if it may be necessary to accomplish the purpose." We can think of deficit spending as a "looming threat" Roosevelt held over the economy. If people did not believe his commitment to inflate, he would print government debt (money and/or bonds) until inflation rose. The MPE has a precise prediction about how much of this medicine was needed to create the right set of beliefs, as shown in Figure 3.

Government debt is inflationary in the MPE for the following reasons. An optimizing government wants to minimize the cost of taxation and hence dislikes tax increases. Government credit (base money and government bonds) is issued in nominal terms. The higher debt gives the government an *incentive* to inflate, because inflation reduces the real value of the debt and thus reduces the tax burden of the debt. Furthermore, government credit needs to be rolled over on a particular interest rate. This gives the government an *incentive* to keep the nominal interest rate low to reduce the interest rate burden of the debt, which also increases inflation.[71] As can be seen by equation (43), the inflation incentive is increasing in the cost of taxation s'.[72] Hence, a positive cost of taxation, together with the deficits, is important to understanding why Roosevelt's commitment to reflation was credible in 1933. Observe that by Proposition 2 the debt will not be paid

[70] To compute this number, I did the following experiment. Suppose that $\hat{F}_t = \hat{F}_L = 0.035$ when $r_t^e = r_L$ and $\pi_t = \hat{F}_t = 0$ for $t \geq \tau$ when $r_t^e = 1/\beta - 1$. The solution can be solved in closed form, yielding $\tilde{Y}_L = \{\sigma\delta_c/(\alpha - [\kappa\sigma\delta_c(1-\alpha)/(1-\beta(1-\alpha))])\} r_L^e + \{[\alpha - (\kappa\sigma\delta_c \psi(1-\alpha)/(1-\beta(1-\alpha)))]/[\alpha - (\kappa\sigma\delta_c(1-\alpha)/(1-\beta(1-\alpha)))]\} \hat{F}_L$, and the number for inflation can be computed using the AS equation. This number exaggerates the expansionary effect of real spending somewhat because $\hat{F}_t$ declines over time in the MPE, as can be seen by Figure 3. The number reported should therefore be interpreted as an upper bound.

[71] There is a relatively large literature, both empirical and theoretical, that studies the effect of fiscal variables on inflation. One of the early theoretical papers is Sargent and Neil Wallace (1981), but see also Hiroshi Fujiki (2001) for a recent survey of the empirical and theoretical literature. Goohoon Kwon, Laverne McFarlane, and Wayne Robinson (2006) provide a cross-sectional study and find that there is a strong correlation between growth in public debt and inflation. The paper suggests that the relationship between debt and inflation depends on the policy regime. This relationship is strong under the FDR regime, but completely absent under the Hoover regime. The institutional framework under FDR involved an effective elimination of the Federal Reserve independence, which corresponds more closely to the institutional framework in developing countries in recent years where the independence of the central bank is weak.

[72] If there is no cost of taxation, then $s' = 0$ and equation (43) reduces equation (28), which applies under the Hoover regime (so that inflation is zero at date $t > \tau$) and the only effect of the regime change is then due to the expansion in F_t (which explains only 18 percent of the recovery, as noted above). Observe that there are also other incentives to inflation in the model that we abstract from arising from the monopoly power of firms. Eggertsson (2006) extends the model to account for these incentives.

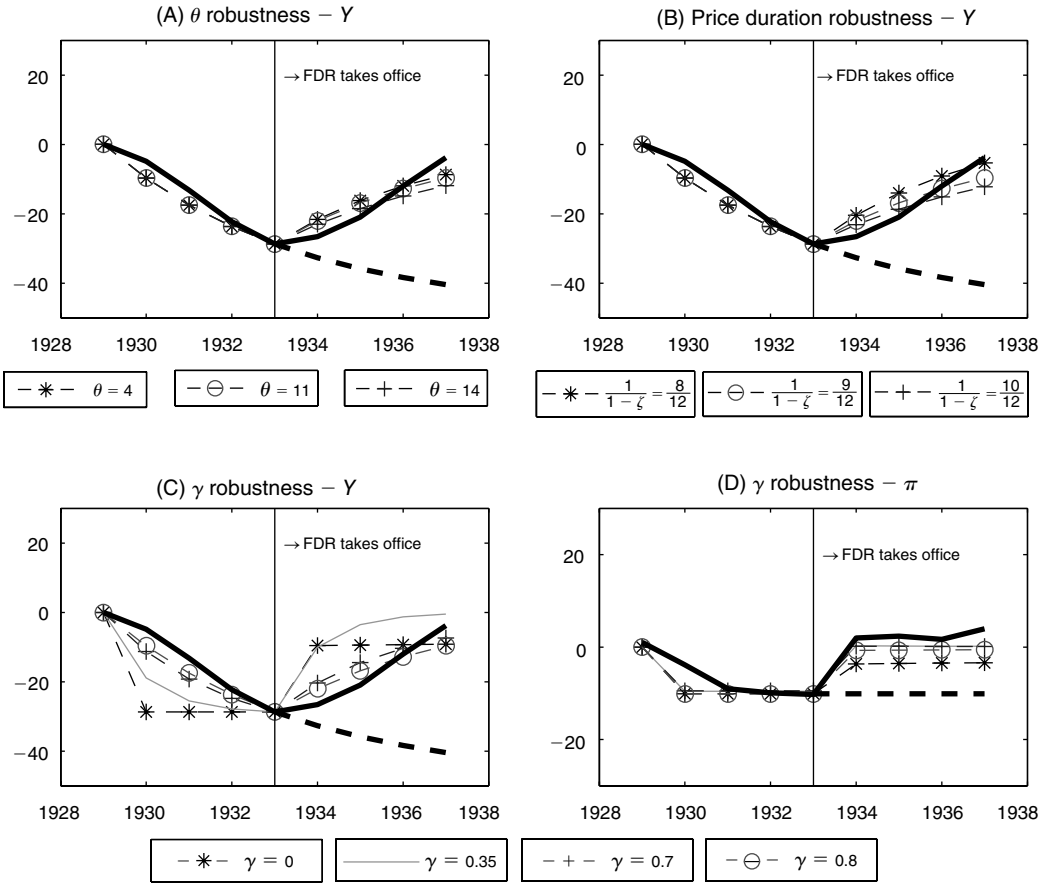

FIGURE 5

Notes: The thick solid line shows the data, while the thick dashed line shows the counterfactual if Hoover had remained in office according to the model. The other lines show the output of the model under different parameter configurations assuming a regime change in 1933.

off by inflation alone. The government runs deficits only as long as the shocks last, and then runs budget surpluses by raising taxes substantially at $t \geq \tau$ to pay down the debt.[73]

Figure 5 considers robustness of the numerical example by showing the effect of varying the paramenters $(\gamma, \theta, 1/(1-\zeta))$ one at a time. The figure considers other values that are common in the literature but remain within the boundaries of Table 3, as discussed further in the Appendix. For comparison, the figure also plots the counterfactual if Hoover would have remained in office. Recall from our discussion in Section IIID that the results under the Hoover regime are unchanged for any values in the parameter region in Table 3. We see from this figure that the effect on output is relatively modest under the Roosevelt regime for variations in θ and $1/(1-\zeta)$, as shown in panels A and B. (The same holds true for the response for inflation and for variations in σ and ω. See Eggertsson (2007a) for more extensive discussion and analysis.) The key reason

[73] This is consistent with FDR announcements at the time, but he said that the deficits were only temporary and would ultimately be reversed by tax increases once the economy returned to normal. I thank an anonymous referee for stressing this.

is that different values of the parameters will lead to a different value for the shocks (according to the criteria derived in the Appendix), while the main analytic mechanism of the model remains unchanged. The model solution for output is quite sensitive, however, to variations in the habit-persistence parameter γ. If there is no habit persistence, the fall in output is immediate, and the recovery is faster than in the data.[74] This is illustrated in panel C of Figure 5. The choice of the habit parameter 0.8 is made in order to match the gradual decline and recovery.[75] Inflation, however, is not very sensitive to variations in γ, as illustrated in panel D.

V. The Gold Standard Dogma

An important part of the Hoover policy regime not explicitly modeled thus far is the gold standard dogma. It is well documented that President Hoover was a strong defender of the gold standard, and many authors, such as Temin and Wigmore (1990) and Barry Eichengreen and Jeffrey Sachs (1985), put Roosevelt's elimination of the gold standard at the central stage of their analysis. Here, we extend the model explicitly to account for the gold standard, following Barro's (1979a) formulation. We find that eliminating the gold standard was a necessary but not sufficient condition for the regime change.

Following Barro (1979a), consider a gold standard of the form

$$M_t \leq \lambda_g p_G G_t^m, \tag{53}$$

where M_t is money, G_t^m is the reserve of gold, p_G is the dollar price of these reserves, and λ_g measures the gold backing of monetary issuance. This gold standard says that the government is committed to pay p_g units of gold for every dollar issued, and that it needs to keep reserves of gold to back up its outstanding monetary base. The rule for the gold backing is governed by λ_g. In the United States of the 1920s, the rule was that the US government needed to keep gold reserves corresponding to 40 percent of its base, while the price of gold was \$20.67 per ounce (hence the units of G_t^m is ounces). For simplicity, we assume that G_t^m is an exogenous stochastic process, but a more complete model would determine G_t^m as a result of international capital movements.

A key feature of this constraint is that it is asymmetric. This is in contrast to Barro (1979a), who assumes that it holds with equality at all times. The gold standard in (53) says that the Federal Reserve has to have *at least* G_t^m reserves to back up its base, but it can hold gold in excess of the money it supplies to the public. This is an important asymmetry because it means that if there is an inflow of gold in the model, which is an exogenous increase in G_t^m, the central bank does not need to increase the monetary base correspondingly, i.e., it can sterilize the inflows.[76] When there are outflows, and the inequality is close to binding, the central bank does not have this flexibility. The constraint holds with equality and the central bank needs to contract the money supply.

The definition of the Hoover regime can now be extended by adding to the government's maximization problem (15) the constraint (53). The solution is simple (see the Appendix for a formal statement of the policy problem in this case), at least for special assumptions for the sto-

[74] There are alternative mechanisms to habit persistence that can replicate the inertial response of output in DSGE models. Fabio Milani (2007) shows that a model with adaptive learning can, to a large extent, replicate the persistence implied by habit persistence, an alternative not explored here. Another well-known alternative is to add capital into the model and introduce investment adjustment costs.

[75] A choice of γ higher than 0.8 does not improve the fit much. See Eggertsson (2007a).

[76] The word "sterilization" of gold inflows is used when the Federal Reserve substituted gold inflows for interest-bearing bonds, leaving the supply of money unchanged.

chastic process for G_t^m. To see the solution, observe that we can approximate the objective of the government under the Hoover regime as

$$-E_t \sum_{T=t}^{\infty} \beta^{T-t}(\pi_T^2 + \lambda_Y \tilde{Y}_T^2), \tag{54}$$

and this objective is minimized by $\pi_t = \tilde{Y}_t = 0$. How does the solution change if there is a positive shock to G_t^m? To be specific, consider the following stochastic process for growth rate of G_t^m:

$$\Delta \hat{G}_t^m = \varepsilon_t, \tag{55}$$

where ε_t is i.i.d. First, suppose there is a positive innovation to $\Delta \hat{G}_t^m \equiv \hat{G}_t^m - \hat{G}_{t-1}^m$ and that $\hat{Y}_{t-1} = 0$. Consider now the consequences of the Federal Reserve accommodating this by printing money so that $\Delta \hat{G}_t^m = \Delta M_t$. Equation (12) can then be approximated to yield

$$\Delta \hat{G}_t^m = \Delta M_t = \Delta \hat{Y}_t + \pi_t, \tag{56}$$

which says that the gold flow will be reflected in a combination of higher inflation and output. However, recall that the objective of the government under the Hoover regime is (54), so this reduces the government's utility. Since the government is under no obligation to increase M_t in proportion to G_t^m, according to the inequality (53), the model suggests that the government would sterilize the gold inflow to neutralize the effect on the money supply.

Consider now the effect of a negative shock to G_t^m, and suppose that $M_t = \lambda_g P_G G_t^m$ when the shock hits, i.e., the constraint (53) is binding. The solution will then satisfy (55), (56), and the AS equation (24). A decrease in the reserve leads to a monetary contraction, deflation, and output losses, the size of each depending on the parameters of the model. Hence, a decline in G_t^m—at least at the boundary of the inequality (53)—leads to deflation and contraction, while an increase in G_t^m has no effect.

This asymmetry of the gold standard in the model accords relatively well with how the gold standard worked in the United States before the onset of the Great Depression. While not formally modeled, this asymmetry has been noted by several economists (see, for example, Friedman and Schwartz 1963, 279–87; Temin 1989, 20). During the 1920s, the Federal Reserve was accumulating gold in record quantities, driven mostly by gold inflows from Europe. The Fed did not, however, increase the monetary base to correspond to the increase in gold reserves. Instead, it sterilized the inflows so that $M_t < \lambda_g P_G G_t^m$ throughout the 1920s and during much of Hoover's term in office.[77] Interestingly, the reason the Federal Reserve gave for sterilization in the 1920s accords with the logic of our model, i.e., the Federal Reserve was unwilling to accept the inflationary consequences of increasing the monetary base in proportion to the gold inflow. The asymmetry of the gold standard suggests that the characterization of the Hoover regime remains unchanged if one introduces a constraint of the form (55) as long as $\hat{G}_t^m \geq 0$.[78]

[77] Consider February 1932. As Allan Meltzer (2003, 275) observes, gold was used as collateral for 71 percent of the total notes issued by the Federal Reserve at that time. Clearly, the 40 percent gold minimum for the backing of money in inequality (53) was not binding.

[78] The asymmetry is particularly important to understanding why the intertemporal shocks have such a negative effect on prices and output in the model. Consider Figure 4, which describes the solution under the Hoover regime. The path for the money supply suggests that the money supply in the future is expected to be lower than at the onset of the shock. Hence the model says that people expect the central bank to achieve zero inflation as soon as is possible, i.e., at $t > \tau$, and since the economy has experienced considerable deflation in period $t < \tau$, this says that the money supply will

While the supply of gold did not constrain open market operations during the Hoover regime, this does *not* suggest that eliminating it was not an essential part of the Roosevelt regime change. To see this, suppose that in 1933 $M_{1933} = \lambda_g P_G G^m_{1933}$, and assume that G^m_t is a constant. Under the Hoover regime, the money supply at any date $t \geq \tau$ is smaller than M_{1933} such that the gold standard constraint will not be binding in the future, as can be seen in Figure 4. Thus, as we have argued, the gold standard in (53) does not impose a constraint on policy under the Hoover regime because the constraint is becoming less and less binding with the fall in the price level. Under the Roosevelt regime, however, the money supply is *higher* at any date $\tau > 1933$, suggesting that the constraint will be binding in the future as long as M_{1933} is sufficiently close to $\lambda_g P_G G^m$. This indicates that eliminating the gold standard was a *necessary*—but *not a sufficient*—condition for the Roosevelt regime change, because it implies an upper bound on the money supply in the future.[79] Hence the analysis supports the conventional wisdom that going off the gold standard was crucial to sustain the recovery.

VI. Conclusion

This paper proposes that the recovery from the Great Depression was triggered by a shift in expectations. Of principal importance was the shift in expectations about the future money supply, although a shift in expectation about the government's real consumption of goods and services played a role as well. Yet, the proposition that the shift in expectations about the future money supply is the silver bullet leaves many loose ends. How, exactly, was this achieved, especially given that there was no change in either the short-term interest rate or the money supply around the turning point in March 1933? This paper addresses that question by modeling the determination of current and future money supply and government spending as a result of an infinitely repeated game between the government and the public, in the spirit of Kydland and Prescott (1977), such that the government maximizes utility in a discretionary way. What separates the regimes of Hoover and Roosevelt, and explained the large shift in expectations, is that Roosevelt eliminated several policy dogmas that Hoover had subscribed to: the gold standard, a balanced budget, and small government.[80] The analysis suggests that in a relatively standard DSGE model the elimination of these policy dogmas leads endogenously to a large shift in expectation that accounts for about 70–80 percent of the recovery of output and prices in the data from 1933 to 1937. In the absence of the regime change, however, the economy would have continued its free fall in 1933, and output would have been 30 percent lower in 1937 than in 1933, instead of increasing 39 percent in this period.

Appendix A: Robustness and Parameter Choices

Each period is a year. To pick the parameters in the baseline calibration, a relatively standard form for period utility is assumed (see, e.g., Christiano, Eichenbaum, and Evans 2005):

be contracted at that time. Hence the constraint (53) will then be expected to be more lax. If, instead, (53) holds with equality at all times, the gold standard would be equivalent to a price-level target (as long as G^m_t is fixed). As has been shown by several authors (see, for example, Eggertsson and Woodford 2003), a price-level target will largely eliminate the negative consequences of the intertemporal shocks and the zero bound (see also further discussion in Eggertsson 2007a).

[79] If we assume that G^m_t is a stochastic process that is affected by speculative attacks (e.g., due to expectations that the government will abandon the standard in the future), this will make this *constraint even tighter* thereby increasing the importance of eliminating the gold standard to curb deflationary expectations.

[80] It is worth noting that the policy dogmas of Hoover are not irrational under normal circumstances. They could, for example, be motivated as "commitment devices," i.e., a solution of the usual inflation bias of government debt during wartime, or could be due to political economy considerations. Those extensions are beyond the scope of this paper.

$$U_t = [\lambda_1 \log(C_t - H_t^c) + \lambda_2 \log G_t - \lambda_3 (L_t - H_t^l)^2] b_t, \tag{57}$$

so that $\sigma = \omega = 1$ (here λ_1, λ_2, and λ_3 are positive coefficients). In this example, the vector of shocks ξ_t appears as a single intertemporal disturbance, b_t, and this shock satisfies P1 and P2. The discount factor, β, is calibrated to be consistent with a 4 percent steady-state interest rate. We choose $\theta = 11$, implying average markups of 10 percent, which is another common value. There is no commonly agreed upon value for habits, and estimates vary depending on which features of the data the authors try to match.[81] As a consequence, we experimented with several values. We consider the value for $\gamma = 0.8$ in the baseline calibration , implying $\delta_l = 5$, and discuss below the considerations taken in this choice.

The cost of price adjustment, the second derivative d'', has to be determined in order to identify the parameter κ, which measures the sensitivity of inflation with respect to output movements. Since this parameter is hard to motivate by micro studies, we follow Schmitt-Grohe and Uribe (2004) by observing that the model is to a first-order identical to a model with staggered Calvo price adjustment. In a Calvo model calibrated in quarters, κ is expressed as

$$\kappa = \frac{(1-\zeta)(1-\zeta\beta)}{\zeta} \frac{\sigma^{-1}\delta_c^{-1} + \omega\delta_l}{1 + \omega\delta_l\theta}, \tag{58}$$

where ζ is the probability in each quarter that a firm leaves its price unchanged. We set $\zeta = 0.66$ to be consistent with an average duration of price adjustment of three quarters, a common value in the literature. To compute κ, we use (58) and then follow Stephanie Schmitt-Grohe and Martin Uribe (2004) by multiplying this by four to convert to annual frequency. This results in $\kappa = 0.1822$.

The government consumes 10 percent of output, so $\delta_c = 0.1$. While the tax costs play no role under the Hoover regime due to the fiscal dogmas, they are important in the MPE under Roosevelt because they determine the inflation incentives of the government. The tax cost function $s(T)$ is assumed to be quadratic and calibrated to match the level of deficit spending in 1933–1937. The criteria is that collection costs are chosen so that the peak in 1934 of deficit spending matches the maximum level in 1935 of 7.6 percent of 1929 GDP, yielding $s' = 0.1516$ and $s'' = 1.5160$. This means that in steady state for each dollar collected in taxes, 7.58 percent is wasted in collection costs.[82]

We now turn to the calibration of the shock r_t^e in terms of the size of the shock r_L^e and its persistence α. The shock r_L^e is chosen to match the nadir of the output contraction in 1933, assuming that output was at steady state in 1929. Consider first the implication for the value of $\tilde{Y}_t$, which by (34) remains constant in the low state $\tilde{Y}_L$. Since $\tilde{Y}_L = \hat{Y}_t - \gamma\hat{Y}_{t-1}$, we obtain

$$\tilde{Y}_L = \frac{1-\gamma}{1-\gamma^4}\hat{Y}_{1933}, \tag{59}$$

[81] Using quarterly data, Giannoni and Woodford (2005) estimate it as being close to one, while Christiano, Eichenbaum, and Evans (2005) place it at 0.65.

[82] Different choices for the tax function have little effect on the evolution of the endogenous variables (apart from taxes and debt) but imply that different levels of debt will be issued to make those paths for the endogenous variables incentive compatible.

where $\hat{Y}_{1933}$ represents output in 1933 in percentage deviation from the 1929 peak in output. Using this to substitute into (34), we obtain the implied value of the shock that brings this contraction about:

$$\hat{r}_L^e = \hat{Y}_{1933} \frac{1-\gamma}{1-\gamma^4} \frac{\alpha(1-\beta(1-\alpha)) - \sigma\delta_c\kappa(1-\alpha)}{1-\beta(1-\alpha)} \sigma^{-1}\delta_c^{-1}, \tag{60}$$

a number which depends on α.

We now choose α, which is the probability of leaving the deflationary state. We choose this parameter to match the level of deflation during 1931–1933 as closely as possible.[83] Observe by equation (33) that throughout the duration of the shock, we have

$$\pi_L = \frac{\kappa}{1-(1-\alpha)\beta} \tilde{Y}_L = \frac{\kappa}{1-(1-\alpha)\beta} \frac{1-\gamma}{1-\gamma^4} \hat{Y}_{1933}, \tag{61}$$

which says that the choice of α has an effect on the level of deflation in the "low" state. In particular, a lower value of α implies that agents expect to remain in the deflationary state for a longer period of time. Because inflation at time t depends on expected inflation in the future, a lower value of α implies a stronger deflation in reaction to the output contraction. We choose the parameter α to minimize

$$\min_{\alpha} \sum (\pi_L(\alpha) - \pi_t^{data})^2 \quad \text{s.t. } \alpha > \bar{\alpha} \text{ and } \alpha \in [0,1], \tag{62}$$

where the two constraints of the minimization problem are A2 and the probability has to be between zero and one. As long as this minimization has an interior solution, then

$$\pi_L = \frac{\sum \pi_t}{n} = \pi^*, \tag{63}$$

so that by (61) we obtain

$$\alpha = \kappa \frac{1-\gamma}{1-\gamma^4} \frac{\hat{Y}_{1933}}{\pi^*} - \frac{1-\beta}{\beta}, \tag{64}$$

which, under the baseline calibration, yields $\alpha = 0.1408$, so that the expected duration of the shock is $\alpha^{-1} = 7.1$ years.[84] Using this to substitute into (60), we obtain $r_L^e = -0.0497$.

Given the procedure described to pick r_L and α, the evolution of inflation and output in Figure 3 under the Hoover regime does not depend on the structural parameters, with the exception of γ (see further below), as long as the estimation of α is given by (64), i.e., the minimization problem (62) has an interior solution. To see this, observe that our procedure of picking the shocks is done so that π_L and $\tilde{Y}_L$ satisfy (59) and (63), and both these criteria depend only on the data and γ. Table 2 shows the range for the parameters (θ, β, σ^{-1}, $1/(1-\zeta)$, ω), which would lead to

[83] We could also choose to match deflation in the year up to the regime change, and this would lead to the same result because deflation stayed at -10 percent per annum in each of the years 1931–1933, as can be seen in Figure 6.

[84] Included are all the full fiscal years over which the contractionary phase of the Depression lasted: 1931, 1932, and 1933.

the same result as shown in Figure 3. Most estimates in the literature fall within these bounds. The range for β, for example, is between 0.9 to 1, and for θ it is between 1.8 to 14.8. Different values of the structural parameters do not change the paths for (π_t, Y_t, i_t) in the figure, but result in different estimates of the shocks. Consider, for example, if we choose whether $\theta = 4$ or $\theta = 14$ instead of $\theta = 11$. In this case, we obtain $\alpha^{-1} = 2.3$ and $r_L^e = -0.3755$ for $\theta = 4$ and $\alpha^{-1} = 9.8$ $r_L^e = -0.0084$ for $\theta = 14$. As we approach the upper bound of the region for θ, the shock needed to generate the contraction approaches zero as α reaches $\bar{\alpha}$. As we approach the lower part of the region, the size of the shock increases as α reaches one. If one imposes some prior on the shock, e.g., that only a shock in the range of -2 percent to -5 percent is "reasonable," with some prior on its duration, this would further narrow the range of permissible parameters in Table 2 (this approach is taken in Eggertsson 2007b). We do not impose such priors, but instead explore the robustness of the conclusions (i.e., if the Roosevelt regime change can explain the recovery) to perturbing the structural parameters in Table 2 within a wide range that corresponds to a wide range for the shocks. (There are even some extreme cases at the edge of the boundaries for α when the amplification of the model is very large or very small.) Eggertsson (2007a) discusses how the results are affected for parameters outside the range in Table 2.

The path for output, $\hat{Y}_t$, reported in Figure 3 is sensitive to the choice of γ since this parameter affects the ability of the model to explain a gradual downturn. With lower value of γ, the decline is much faster than observed in the data. This is the reason we have chosen a relatively high value for γ in the baseline calibration. Eggertsson (2007a) shows that the improvement in fit is marginal above $\gamma = 0.8$; the value 0.85 leads to only a slightly more gradual decline in output. Eggertsson (2007a) considers several other robustness exercises.

Appendix B: Deriving the Government Nonlinear First-Order Conditions and Steady States

Here, I write the most general form of a policy regime that includes all the policy regimes considered in the paper. Each policy dogma is added as a constraint. In the general formulation, each constraint is multiplied by a indicator function D^i, which takes the value one if the dogma applies, and zero otherwise. For completeness, I also include the gold standard constraint in the general formulation. The constraint (12) can be rewritten as[85]

$$\frac{M_t}{M_{t-1}} = \frac{Y_t}{Y_{t-1}} \Pi_t , \tag{65}$$

and observe that, rewritten in this way, the money supply is a state variable in the game. The maximization problem is

$$\begin{aligned} & V(Y_{t-1}, w_{t-1}, M_{t-1}; \xi_t, G_t^m) \\ = \quad & \max[u(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t) + g(G_t; \xi_t) - v(Y_t - \gamma Y_{t-1}; \xi_t) + \beta E_t V(Y_t, w_t, M_t; \xi_{t+1}, G_{t+1}^m)] \\ & \text{subject to} \\ & (2), (4), (6), (7), (8), (9), (10), (11), (13), (14) \text{ and } (65) \end{aligned}$$

[85] For simplicity, I write this constraint as an equality. This is without loss of generality since the inequality is slack only at zero interest rate where the money supply is indeterminate. In other words, I pick the lowest level of money supply consistent with equilibrium at zero interest rates.

and the policy dogmas

$D^1 \times$ (equation 16), $D^2 \times$ (equation 17), $D^3 \times$ (inequality 53).

The Lagrangian of this maximization problem can be written in the following form (with some substitutions of the constraints):

$$
\begin{aligned}
L_t = {} & u(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t) + g(F_t - s(T_t) - A_t; \xi_t) - v(Y_t - \gamma Y_{t-1}; \xi_t) + \beta E_t V(Y_t, w_t; \xi_{t+1}, G^m_{t+1}) \\
& + \phi_{1t}\{w_t - (1 + i_t)\,[w_{t-1}\,\Pi_t^{-1} + F_t - T_t]\} \\
& + \phi_{2t}\{\beta \bar{f}^{\,e}(Y_t, w_t; \xi_t, G^m_t)(1 + i_t) - u_{c,t}(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t))\} \\
& + \phi_{3t}\{\Pi_t d'(\Pi_t) u_c(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t)) \\
& \qquad - \theta[v_y(Y_t - \gamma Y_{t-1}) - u_c(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t))]\; Y_t - \beta \bar{S}^e(Y_t, w_t; \xi_t, G^m_t)\} \\
& + \phi_{4t}\left\{\frac{M_t}{M_{t-1}}\Pi_t^{-1} - \frac{Y_t}{Y_{t-1}}\right\} + \phi_{5t}\left\{\left(T_t - F_t - \left(\frac{1}{1+i_t} - \Pi_t^{-1}\right)\bar{w}\right)D^1\right\} + \phi_{6t}\{(F_t - \bar{F})\; D^2\} \\
& + \gamma_{1t}\, i_t + \gamma_{2t}(w^b - w_t) + \gamma_{3t}\{(\lambda_g P_G G^m_t - M_t)D^3\},
\end{aligned}
$$

and the first-order conditions can be found by taking partial derivatives with respect to each of the endogenous variables. The subsections below provide the nonlinear equations for the linearized first-order conditions (28)–(31) and (43)–(50) reported in the paper, simplifying the general problem a bit by taking account of the policy regime under study.

A. *The Hoover Regime*

Under the Hoover regime, we have $D^1 = D^2 = 1$ and abstract from the gold standard so that $D^3 = 0$. In this case, the value function is summarized by $V(Y_{t-1}, \xi_t)$. Observe that we can suppress the debt as a state because it is a constant $\bar{w}$. Similarly, we can suppress the money supply because the first-order condition with respect to the money supply yields $\phi_{4t} = 0$ such that the supply of money plays no role in determining the equilibrium because it enters only through that constraint. We can rewrite the Lagrangian as

$$
\begin{aligned}
L_t = {} & u(Y_t - \gamma Y_{t-1} - \bar{F} - d(\Pi_t); \xi_t) + g(\bar{G}; \xi_t) - v(Y_t - \gamma Y_{t-1}; \xi_t) + \beta E_t V(Y_t, \bar{w}; \xi_{t+1}) \\
& + \phi_{2t}\{\beta \bar{f}^{\,e}(Y_t, \bar{w}; \xi_t)\,(1 + i_t) - u_c(Y_t - \gamma Y_{t-1} - \bar{F} - d(\Pi_t); \xi_t)\} \\
& + \phi_{3t}\{\Pi_t\, d'(\Pi_t) u_c(Y_t - \gamma Y_{t-1} - \bar{F} - d(\Pi_t); \xi_t) \\
& \qquad - \theta[v_y(Y_t - \gamma Y_{t-1}; \xi_t) - u_c(Y_t - \gamma Y_{t-1} - \bar{F} - d(\Pi_t); \xi_t)]Y_t - \beta \bar{S}^e(Y_t, \bar{w}; \xi_t)\} \\
& + \gamma_{1t}\, i_t,
\end{aligned}
$$

giving rise to the first-order conditions

$$\frac{\partial L}{\partial \Pi_t} = -u_c d' + \phi_{2t} d' u_{cc} + \phi_{3t}[d' u_c + \Pi_t d'' u_c - \Pi_t d'^2 u_{cc} - \theta u_{cc} d' Y_t] = 0, \tag{66}$$

$$\begin{aligned}\frac{\partial L}{\partial Y_t} &= u_{c,t} - v_{y,t} + \beta E_t V_y(Y_t, \bar{w}; \xi_{t+1}) + \phi_{2t}[\beta \bar{f}^e_Y (1 + i_t) - u_{cc}] \\ &\quad + \phi_{3t}[\Pi_t d' u_{cc} - \theta v_{yy} + \theta Y_t u_{cc} - \theta(v_y - u_c)] - \phi_{3t} \beta \bar{S}^e_Y = 0,\end{aligned} \tag{67}$$

$$\frac{\partial L}{\partial i_t} = \phi_{2t} \beta \bar{f}^e(Y_t, \bar{w}; \xi_t) + \gamma_{1t}, \tag{68}$$

and the complementary slackness conditions

$$\gamma_{1t} i_t = 0, i_t \geq 0, \gamma_{1t} \geq 0, \tag{69}$$

and the envelope condition

$$V_Y(Y_{t-1}, \bar{w}; \xi_t) = -\gamma u_{c,t} + \gamma v_{y,t} + \phi_{2t} \gamma u_{cc} + \phi_{3t} \gamma[\theta v_{yy} Y_t - \Pi_t d' u_{cc} - \theta Y_t u_{cc}]. \tag{70}$$

Recalling that $d'(1) = 1$, it is easy to confirm using (2), (4), (7), (8), (9), (11), and (66)–(70) that there exists a steady state in which $\Pi_t = \bar{\Pi} = 1$ and $Y_t = \bar{Y}$ and $\phi_2 = \phi_3 = \gamma_1 = 0$. Equations (28)–(30) are obtained by linearizing (66)–(70) around this steady state (we use the normalization that $\bar{u}_c = 1$).

B. *The Roosevelt Regime*

Under the Roosevelt regime, we have $D^1 = D^2 = D^3 = 0$. In this case, the value function is summarized by $V(Y_{t-1}, w_{t-1}, \xi_t)$ because we can again suppress the money supply given that the first-order condition with respect to the money supply yields $\phi_{4t} = 0$. We can then rewrite the Lagrangian as

$$V(Y_{t-1}, w_{t-1}, \xi_t) = \max[u(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t) + g(G_t; \xi_t) - v(Y_t - \gamma Y_{t-1}; \xi_t)] + \beta E_t V(Y_t, w_t; \xi_{t+1});$$

$$\begin{aligned}L_t &= u(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t) + g(F_t - s(T_t) - A_t; \xi_t) - v(Y_t - \gamma Y_{t-1}; \xi_t) + \beta E_t V(Y_t, w_t; \xi_{t+1}) \\ &\quad + \phi_{1t}\{w_t - (1 + i_t)[w_{t-1} \Pi_t^{-1} + F_t - T_t]\} \\ &\quad + \phi_{2t}\{\beta \bar{f}^e(Y_t, w_t; \xi_t)(1 + i_t) - u_{c,t}(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t)\} \\ &\quad + \phi_{3t}\{\Pi_t d'(\Pi_t) u_c(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t) \\ &\qquad - \theta[v_y(Y_t - \gamma Y_{t-1}; \xi_t) - u_c(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t); \xi_t)] Y_t - \beta \bar{S}^e(Y_t, w_t, \xi_t)\} \\ &\quad + \gamma_{1t} i_t + \gamma_{2t}(w^b - w_t),\end{aligned}$$

yielding the first-order conditions:

$$\frac{\partial L}{\partial \Pi_t} = -u_c d' + \phi_{1t}(1+i_t)w_{t-1}\Pi_t^{-2} + \phi_{2t} d' u_{cc} + \phi_{3t}[d'u_c + \Pi_t d'' u_c - \Pi_t d'^2 u_{cc} - \theta u_{cc} d' Y_t], \tag{71}$$

$$\frac{\partial L}{\partial w_t} = \beta E_t V_w(Y_t, w_t; \xi_{t+1}) + \phi_{1t} + \phi_{2t}\beta \bar{f}_w^e(1+i_t) - \phi_{3t}\beta \bar{S}_w^e - \gamma_{2t} = 0, \tag{72}$$

$$\frac{\partial L}{\partial F_t} = -u_{c,t} + g_{G,t} - (1+i_t)\phi_{1t} + \phi_{2t} u_{cc} - \phi_{3t}\Pi_t d' u_{cc} - \phi_{3t}\theta u_{cc} Y_t, \tag{73}$$

$$\frac{\partial L}{\partial T_t} = -g_G s'(T_t) + \phi_{1t}(1+i_t), \tag{74}$$

$$\frac{\partial L}{\partial Y_t} = u_{c,t} - v_{y,t} + \beta E_t V_Y(Y_t, w_t; \xi_{t+1}) + \phi_{2t}[\beta \bar{f}_Y^e(1+i_t) - u_{cc}] + \frac{\phi_{3t}}{\bar{u}_c}[\Pi_t d' u_{cc} - \theta v_{yy} + \theta Y_t u_{cc} - \theta(v_y - u_c)] - \frac{\phi_{3t}}{\bar{u}_c}\beta \bar{S}_Y, \tag{75}$$

$$\frac{\partial L}{\partial i_t} = -\phi_{1t}[w_{t-1}\Pi_t^{-1} + F_t - T_t] + \phi_{2t}\beta f_t^e + \gamma_{1t}; \tag{76}$$

the two complementary slackness conditions:

$$\gamma_{1t} i_t = 0,\ i_t \geq 0,\ \gamma_{1t} \geq 0, \tag{77}$$

$$\gamma_{2t}(w^b - w_t) = 0,\ \bar{w} \geq w_t,\ \gamma_{2t} \geq 0; \tag{78}$$

and the envelope conditions:

$$V_Y(Y_{t-1}, w_{t-1}) = -\gamma u_{c,t} + \gamma v_{y,t} + \phi_{2t}\gamma u_{cc} + \phi_{3t}\gamma[\theta Y_t v_{yy} - \Pi_t d'(\Pi_t) u_{cc} - \theta Y_t u_{cc}], \tag{79}$$

$$V_w(Y_{t-1}, w_{t-1}, \xi_t) = -\phi_{1t}(1+i_t)\Pi_t^{-1}. \tag{80}$$

Recalling that $d'(1) = 1$, it is easy to confirm using (2), (4), (7), (8), (9), (11), and (71)–(80) that there exists a steady state in which $\Pi_t = \bar{\Pi} = 1$, $Y_t = \bar{Y}$ solving $u_c = v_y$, $F_t = \bar{F}$ solving $u_c = g_G(1 - s')$, and $\bar{G} = \bar{F} - s(\bar{F})$. Furthermore, $\bar{T} = \bar{F}$ and $\bar{w} = \phi_2 = \phi_3 = \gamma_1 = \gamma_1 = 0$ and $\phi_1 = \beta g_G s'(\bar{F})$. Equations (28)–(30) are obtained by linearizing (66)–(70) around this steady state (we use the normalization that $\bar{u}_c = 1$).

Appendix C: Data

Total federal expenditures along with revenues are published by the White House Office of Management and Budget (OMB). The gold purchases are taken as the change in the monetary

gold stock. This is found in Table 156 of the Federal Reserve's volume of Banking and Monetary Statistics 1914–1941 (BMS); it can also be downloaded as series m14076 from the NBER Macro History database (http://www.nber.org/databases/macrohistory/contests). The gold purchase series has been corrected for the $2.81 billion increase resulting from the decrease in the gold weight of the dollar.

It is important to take under consideration that much of the debt was held by the government itself. The Department of the Treasury, for example, bought a large part of the debt issued by the Reconstruction and Finance Corporation. Similarly, the Federal Reserve bought a large part of the debt issued by the Treasury. I take this into account in Table 1 by counting only public debt held by the private sector. It is the sum of all direct government debt and guaranteed securities (those issued as liabilities of government agencies with an explicit guarantee of the federal government) less any interagency holdings and debt held by the Federal Reserve system. These series are also found in BMS from Table 149 in Section 13. (This volume can be accessed online via the Federal Reserve Bank of St. Louis's FRASER system at http://fraser.stlouisfed.org/publications/bms/.)

The first two estimates of the deficit in Table 1 are computed by subtracting tax revenues from total government spending. The first estimate corresponds to the deficit reported by the OMB. This estimate does not, however, take account of the Treasury's gold purchases, which had a big impact on the government budget. The gold purchases are taken into account in the second estimate, also reported in Table 1, which is better than the OMB estimate because it is a better account of the difference between *all* government spending and taxes and therefore a better indicator of the increase in the government's inflation incentive. Even if one corrects the OMB deficit estimate for the gold purchases, however, it still does not reflect the true scale of the deficit spending in 1934. The OMB budget data mostly reflect direct inflows and outflows from the General Fund of the Treasury. Under the New Deal, however, several new government agencies were established and the mandate of others (such as the Reconstruction and Finance Corporation) was considerably extended. These agencies went on a spending spree that was only partially financed by the General Fund. To make up the difference, they issued their own debt (guaranteed by the Treasury). This extra spending is usually not factored into the standard estimate of the deficit. One can get a better measure by adding the spending programs of the various agencies into total expenditures in Table 1 before taking the difference between spending and tax revenues to estimate the deficit. This approach is beyond the scope of this paper.

Fortunately, a much simpler approach is possible, which takes account of all the factors above, and which is the one taken in the third estimate reported in the text. The government must issue debt (either directly or indirectly) or increase the base in order to pay for goods and services in excess of tax revenues. Thus one can consider the period-to-period increase in the government's total liabilities as an alternative and more complete measure of the deficit. The monetary base is measured as the end-of-year stock of currency held outside the Federal Reserve and Treasury, plus the amount of nonborrowed reserves held by member banks of the Federal Reserve. Both series are downloaded from the NBER Macro History database, m14135 and m14123, respectively. Total CPI and WPI are from the NBER Macro History database: series m04128 and m04048c, respectively. Commodity prices are taken from the NBER Macro History database: they are m04019b (Wheat Flour), m04006b (Cotton), m04005 (Corn), m04007 (Cattle), m04008 (Hogs), m04015b (Copper), and m04123b (Gasoline). They are normalized to 100 at Roosevelt's inauguration in March 1933. The short-term interest rate is the constant maturity yield on three-month Treasuries estimated by Cecchetti (1988). Ex post real interest rates are deflated using the three month ahead annualized percent change in the total CPI. The data on real interest rates are constructed from Cecchetti (1992) and Hamilton (1992). The monthly investment series is an index of new plant equipment orders from the 1937 Moody's Industrial Manual (a14). It is

also reported in Temin and Wigmore (1990). Gross domestic product on a fiscal year basis, as reported in Table 1, is published by the OMB (for the figures, it is deflated using the implicit deflator in Romer 1988). The federal government consumption and gross investment component of GDP is from the current NIPA tables. It is not available on a fiscal year basis for the time period under study, so it is reported in calendar years in the table.

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