

Great Expectations and the End of the Depression

July 2007

Gauti B. Eggertsson, Federal Reserve Bank of New York

<http://www.ny.frb.org/research/economists/eggertsson/index.html>

Gauti.Eggertsson@ny.frb.org

Abstract

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 (FDR) policy actions. On the monetary policy side, FDR 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, FDR expanded real and deficit spending. This made his policy objective *credible*. These actions violated prevailing *policy dogmas* and involved a *policy regime change* as in Sargent (1983) and Temin and Wigmore (1990). The economic consequences of FDR are evaluated in a dynamic stochastic general equilibrium model with nominal frictions.

I thank Stephen Cecchetti, Helima Croft, Stefano Eusepi, Mark Gertler, Bart Hobjin, Nobu Kiyotaki, Friedrich Mishkin, Emi Nakamura, Maurice Obstfeld, Hugh Rockoff, Thomas Sargent, Jón Steinsson, Scott Sumner, Eric Swanson, Andrea Tambalotti, Alan D. Viard and especially Michael Woodford for helpful discussions. I also thank seminar participants at the NY Fed, Board of Governors, Federal Reserve System Conference in San Francisco and NBER ME 2005 fall meeting (especially I thank Anna Schwartz for insightful comments), the NBER Summer Institute 2006. I also thank Benjamin W. Pugsley, Krishna Rao, Erick Sager, for excellent research assistance and many helpful discussions and comments, and Stephen Cecchetti for data. The views expressed here are those of the authors, and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

If we cannot do this [reflation] one way we will do it another. Do it, we will.

President Franklin Delano Roosevelt, October 22th, 1933¹

1 Introduction

What ended the Great Depression in the United States? This paper suggest 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, FDR abolished the gold standard and announced an explicit policy objective of inflating the price level to pre-depression levels. On the fiscal policy side, FDR expanded government real and deficit spending (i.e. government credit expansion) which helped making his policy objective *credible*. The key to the recovery was the successful management of expectations about *future policy*.

In this paper FDR's rise to power is modeled as a *policy regime change*, as in Sargent (1983) and Temin and Wigmore (1990) and the paper explores whether the regime change can account for the recovery from the Great Depression. The results should be interpreted as a formalization of Temin and Wigmore's paper in a dynamic stochastic general equilibrium (DSGE) framework where the regime change is modelled in a repeated game setting. In the model a regime change means the elimination of certain "policy dogmas" which constrain the actions of the government. The elimination of the policy dogmas generates an endogenous shift in expectations due to a coordination of monetary and fiscal policy. Coordinated monetary and fiscal policy 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 the real rate of interest, thus stimulating demand, while the expectation of higher future income stimulated demand by raising permanent income.

FDR was elected President in November 1932 and inaugurated in March 1933, succeeding President Herbert Hoover. This was at the height of the Great Depression, when the short-term nominal interest rate was close to zero and deflation ran at double digits (output contracted by 13.4 percent in 1932 and the CPI by 10.2 percent). FDR immediately implemented several radical policies, including an aggressive fiscal expansion and a change in monetary policy. These policies violated three policy dogmas of the time: (i) the gold standard, (ii) a balanced budget and (iii) that the government should be small. It is hard to overstate how radical the regime change was. "This is the end of Western civilization," declared Lewis Douglas, Director of the Budget.² During FDR's first year in office several senior government officials resigned in protest.³ Interestingly, the end of the gold standard and the monetary and fiscal expansion

¹See Roosevelt (1933c).

²Cited in Davis (1986), p. 107.

³These included Lewis Douglas. The 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.

were largely unexpected since these policies violated the Democratic presidential platform.

The effects of the FDR regime change is clearly evident in the data. Figures 1 and 2 show several measures of prices and economic activity with a vertical line denoting the month of FDR's inauguration. Figure 1 (a)-(c) show a one year window for commodity prices, the stockmarket, and a monthly investment index, all of which are highly volatile and should respond strongly to a change in expectations. There is a strong rebound by all indicators once FDR takes office. The stock market, for example, increased by 66 percent in FDR's first 100 days and commodity prices skyrocketed. Similarly investment nearly doubled in 1933 with the turnaround in March that year. Figure 2 takes a broader view and shows that FDR inauguration reversed the persistent deflation in the Wholesale and the Consumer Price Indexes from 1929 to March 1933 into modest inflation from March 1933 to 1937. Similarly FDR's inauguration reversed the same trend in monthly industrial production which bottoms out in March 1933 after falling for three consecutive years. Overall the comparison between FDR's first term in office (1933-37) and President Herbert Hoover's last (1929-33) is striking. Hoover's last term resulted in 26 percent deflation, while FDR's first registered 13 percent inflation. Similarly, output declined by 30 percent from 1929-1933. 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 war. This dramatic turning point, the defining moment of the recovery, requires a careful description. That is the main goal of this paper.

The turning point cannot be explained by contemporaneous changes of the money supply, as stressed by Temin and Wigmore (1990). As shown in the panel (d) of figure 1, the money supply did not change around the turning point (there was a temporary increase in currency in circulation due to the banking crisis but this was offset by a drop in non-borrowed reserves leaving the monetary base virtually unchanged). The nominal value of the monetary base was lower, in fact, in the fall of 1933 than in the beginning of that year.⁴ Similarly the turning point cannot be explained by interest rate cuts. The short-term interest rate was already close to zero in the beginning of 1933, as can be seen in panel (a) in figure 2. The yield on three month Treasuries, for example, was only 0.05 percent in January 1933.

Yet, despite the fact that neither the nominal interest rate nor the money supply changed much at the turning point, this paper argues that the change in the *systematic* part of monetary policy, i.e. the framework that governed the policy setting, was largely responsible for the recovery. 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 study short-term real interest rates, the difference between the nominal interest rate and expected inflation. Figure 3 shows the evolution of several measures of real interest rates. Panel (b) shows the ex post real rate, panel (c) the ex ante real rate with 95 percent confidence intervals estimated by Cecchetti (1992) using term structure data, and panel (d) shows the ex ante real rate estimated by Hamilton (1992) based on commodity futures

⁴Temin and Wigmore (1990) document that the real value of some broader monetary aggregates such as M2 declined considerably in 1933.

data. According to all measures the short term real interest rates collapsed in 1933, going from a high level during 1929-33 to modestly negative in 1933-37 despite small contemporaneous changes in the money supply and interest rates around the turning point.

The FDR regime change is modeled in a DSGE model with nominal frictions. The government and the private sector play an infinitely repeated game without commitment, referred to as a Markov Perfect Equilibrium (MPE). A policy regime is defined by a policy objective and a set of constraints that limits the government's ability to achieve it. Both President Hoover and FDR maximize social welfare in the model and the only difference between the "Hoover regime" and the "FDR regime" is that the Hoover regime is constrained by the policy dogmas. The FDR *regime change* is defined as an unexpected elimination of the dogmas.⁵

The Great Depression is triggered by deflationary shocks in the model. For large enough shocks the Hoover regime generates an output collapse and deflation of the same order as observed in the Great Depression. Under the Hoover regime neither government spending nor the money supply are expanded in response to the shocks. The reason for the collapse is that the central bank does not lower interest rates enough to accommodate the shocks and is unable to change expectations about future policy. The zero bound on the short-term interest rate is important because it implies that the central bank cannot contain the deflationary shocks even with maximum interest rate cuts. Since the short-term nominal interest rate had collapsed to zero by 1933, a theory of the turning point has to take the zero bound into account.

Further interest rate reductions were clearly not feasible in 1933. This suggests that open market operations, in isolation, had no effect, since money and government bonds were perfect substitutes.⁶ Despite this, however, monetary policy was far from powerless. While increasing the money supply at zero interest rate has no effect, increasing expectations about the *future* money supply (once deflationary pressures have subsided and interest rates are positive again) has a large effects because it changes expectations about the future price level, thus reducing real interest rates. The shift in expectations about the future money supply is the most important element of the FDR regime change.

The FDR policy regime, in contrast to the Hoover regime, counteracts the deflationary shocks. The elimination of the policy dogmas is the focal point of the regime change and generates expectations of a sustained increase in the money supply and government spending. By any measure the violation of the small government dogma was dramatic. The federal government's consumption and investment almost doubled if one compares FDR's first full calendar year in office to Hoover's last as documented in section 2. This counteracted the deflationary shocks directly through higher spending on goods and services, and the expectation of similar policy in the future changed expectations about future inflation and output

⁵The results in the paper, however, do not depend on the dogmas being permanently abandoned. It is enough that the public believes them to be temporarily abandoned so their abandonment can be blamed on an "emergency" and that they will be reimposed with some probability.

⁶To the extent open market operation signalled a higher money supply in the future, however, they would have been effective, see discussion in section 5.5.

which stimulated demand even further. The spending spree was not financed by tax increases but through the violation of the balanced budget dogma. The deficit during FDR's first fiscal year is the highest in the US history outside of war as discussed in section 2. This helped making a permanent increase in the money supply *credible*, thus firming up inflation expectations, because it was a crucial strategy to finance the government's debt payments. While the gold standard dogma is not essential to explain the contraction in the model, eliminating it is crucial to sustain the recovery because maintaining the gold standard would have implied an upper bound on the supply of money *in the future*, thus greatly limiting the expectation effect of the regime change. Taken together, the elimination of the policy dogmas generates a large quantitative effect in the model.

While the main results of the paper are analytical, the paper 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 1933-37. This suggests that additional reflationary policies such as the National Industrial Recovery Act (NIRA) are needed to explain the remaining fifth of the recovery (see Eggertsson (2006) who shows that these policies were expansionary in this model). Some counterfactual experiments show the outcome if the Hoover regime had remained in place in 1933-37. The model suggests that output would have continued to decline and been about 30 percent lower in 1937 than in 1933, and 49 percent below the 1929 peak.

The most important assumption in the paper is the presence of intertemporal shocks that imply that 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. Other common shocks in the business cycle literature (e.g. technology, markup and money demand shocks) cannot generate this pattern in the MPE. Since the intertemporal shocks are exogenous, the paper does not provide a complete characterization of the Great Depression or address the difficult question of the origin of the deflationary shocks. These deflationary shocks are most likely due to a host of factors, including the stock market crash (see e.g. Romer (1992)) and banking problems (see e.g. Bernanke (1983)). The paper shows that a reversal of the intertemporal shocks cannot explain the recovery, because that would imply counterfactual increase in the short-term nominal interest rate (which remained at zero throughout the recovery). The main focus of the paper is the regime change at the turning point of 1933 in order to offer an explanation of why the contraction turned into a robust recovery, without a change in the intertemporal disturbances.

Friedman and Schwartz (1963) also suggest that the recovery from 1933-37 was driven 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 only increases demand 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 only be achieved 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, mainly by influencing expectations about the future money supply. There are several papers that study the Great Depression in DSGE models.⁷ The current paper shares many elements with these papers. The main difference is the focus on the regime shift associated with FDR's rise to the presidency and its implication on output and prices. While many of these papers recognize the importance of expectations they do not model *why* and *how* they changed in 1933 with FDR's election.⁸ The focus on regime change is also what separates this paper from the large theoretical literature on the zero bound.⁹ Eggertsson and Pugsley (2006) study the recession of 1937-38 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 the recession in 1937-38 can be explained by people's expectations that policy would revert back to a Hoover style deflationary regime.¹⁰

2 The Turning Point: A brief historical narrative

FDR 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 FDR, 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 FDR declared would be "subservient" to domestic recovery. FDR's goal was to increase prices to their pre-Depression levels within 1-3 years. He stated this objective on several occasions. At a press conference on April 19th, for example, FDR stated the "definitive objective" of raising commodity prices. This press conference was called after Congress had passed the Thomas Amendment, a bill that gave FDR broad powers to inflate and effectively eliminated the independence of the Federal Reserve.¹¹ Similarly,

⁷There are numerous examples, see e.g. Lucas and Rapping (1967), Bordo, Erceg and Evans (2000), Christiano, Motto and Rostagno (2003), and Cole and Ohanian (2005).

⁸The emphasis on expectations is complementary to Harrison and Weder (2005). The key difference is that Harrison and Weder assume that expectations fluctuations are due to exogenous nonfundamental sunspot shocks while here they endogenous due to policy changes.

⁹See e.g. Krugman (1998), Eggertsson and Woodford (2003,2005), Eggertsson (2006), Jeanne and Svensson (2004), Auerbach and Obstfeld (2005), and Adam and Billi (2005). Furthermore the paper analyzes a Markov Perfect Equilibrium (MPE), while Eggertsson and Woodford (2003,5) study optimal policy under commitment. The assumption of MPE is important because it implies that the policy regime change is *credible*. Jeanne and Svensson (2004), Eggertsson (2005) and Adam and Billi (2005) also study optimal policy without commitment but do not model regime changes. For other work on the zero bound see e.g. Svensson (2004) for a survey.

¹⁰Eggertsson 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 explained by the recession 1937-38.

¹¹See FDR (1933a) on p. 156-158 Volume 1: "Here is a team that has a perfectly definite objective, which is to make a touchdown, so far as commodity prices go. The basis of the whole thing really comes down to commodity prices. And, this

Roosevelt said in the *Wall Street Journal* on the 1st of May of 1933:¹²

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.

FDR reiterated this in a radio address to the nation in one of his "fireside chats" on May 7th.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*. Apart from the elimination of the gold standard the most important action was an aggressive and visible fiscal expansion. Table 1 shows several policy measures that made an increase in the price level credible (this point will be formalized in the model in coming sections).

On the real spending side, the data indicate a substantial expansion as reported in Table 1. The federal government's consumption and investment, for example, was 90 percent higher in 1934 (FDR'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 These spending increases were not financed by new taxes. Instead FDR ran significant budget deficits.

Deficit spending plays a key role in the paper because it measures the change in the inflation incentive of the government. The deficit is defined as the difference between the governments expenditures and tax revenues. Table 1 shows three estimates of the deficit. The estimate that corresponds most closely to the deficit in the model of the paper is the third one.¹⁶ The deficit, according to this estimate, increased by

is entirely off the record, the general thought is that we have got to bring commodity prices back to a recent level."

¹²After a joint meeting with the Prime Minister of Canada.

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

¹⁴Data 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. To the extent that these reductions were not caused by the federal spending increases this has no effect on the analysis since we are interested in the effect of the regime change at a federal level and its interaction with monetary policy. See Brown (1956) for discussion of local government spending.

¹⁵The gold inflows to the US 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 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 non-borrowed 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 non-borrowed 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. The same point is made in Sumner (2004) who states that "the gold-buying program has been unfairly maligned by both contemporaneous critics and modern historians." See Eggertsson (2003) for a formal analysis of the effect of buying real asset on the inflation incentive of the government.

¹⁶This estimate takes account of that as a matter of accounting, 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

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. (The reason for the differences is discussed in the Data Appendix). Leaving measurement issues aside, however, there is even stronger evidence for the regime change than reported in Table 1.

The most convincing evidence of the regime change is found by investigating the primary sources on how fiscal policy was *decided*. The deficits during Hoover's presidency were almost entirely due to a collapse in output and the inability of the Treasury to predict the associated fall in revenues (total tax revenues are reported in Table 1). 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 FDR, in contrast, was *deliberate* and a part of the reflation program that was expected to endure until the economy recovered. One piece of evidence is 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 next two years.¹⁸ Despite the projected decline, the Secretary 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 dollars, 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 campaign in US history. As for the deficit for the fiscal year 1934, he projected it to be even higher, or 6.6 billion dollars, more than double the deficit in 1933. This suggests a key difference in the policy regime. Whereas the deficits were Hoover's miscalculation, they were FDR's strategy (see also quotes in section 5). FDR'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 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 one of the foundations of the balanced budget dogma of the time. Many commentators at the time, especially in the conservative press were worried that FDR's deficit spending would in fact be

in the government's nominal liabilities in a given fiscal year – i.e. the government credit expansion – with government liabilities as sum of government bonds and the monetary base. This way of estimating the deficit is also appealing for the model because government liabilities are the relevant "state variable" in the model of the paper.

¹⁷President 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).

¹⁸This is slightly different from the OMP estimate reported in Table 1. This number is the actual number he gave in his report to Congress and has undoubtedly gone through several revisions in later publications.

too inflationary.¹⁹ As proof, many "sound money men" pointed towards the deficits of several European countries after WWI and the resulting hyperinflation.²⁰

3 The Model and the Equilibrium Concept

This section outlines a simple variation of a relatively standard DSGE model, as for example in Clarida, Gali and 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:

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

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

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

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,

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

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. 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 4.2). The terms H_t^c and H_t^l denote external consumption and work habits.²¹

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 taxes, M_t money, B_t one period riskless bonds, i_t one period nominal risk-free interest rate and n_t 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

¹⁹See e.g. and opinion piece in the Wall Street Journal on the 2cond of November 1933, p. 6 under the heading "Unconvincing Reassurance". See also Davis (1986) p. 107 who writes that Lewis Douglas, the Director of the Budget, "scoffed at the notion that there could ever be a "mild" or "controlled" inflation; public knowledge that greenback issuance was an available executive option would of itself alone set off wild inflation, leading to "complete chaos".

²⁰See e.g. Davis (1986) p. 107.

²¹The 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 e.g. Smets and Wouters (2003) and Christiano et al (2005)). Labor habits have similarly a long track record in business cycle analysis, dating at least back to Kydland and Prescott (1982).

to a production function that is linear in labor and the model abstracts from capital dynamics.²² As Rotemberg (1983), 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 .²³

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

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

where

$$f_t^e = E_t u_{c,t+1} \Pi_{t+1}^{-1} \quad (3)$$

is an expectation variable, $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ and the marginal utility of consumption at date t is $u_{c,t}$. This equation says that consumption demand depends on expected future consumption, the nominal interest rate and expected inflation. 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"

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

where

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

is an expectation variable and the marginal disutility of working is $v_{y,t}$.²⁴ This equation is a standard "New Keynesian Phillips curve" that says that inflation depends on the marginal cost of production and expected inflation deflated by the stochastic discount factor.²⁵

The government pays an output cost of taxation (e.g. due to tax collection costs as in Calvo (1977) and Barro (1979)) 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

$$F_t = G_t + s(T_t) + R_t \quad (6)$$

²² Complementary notes, available on the authors website, were written that show how the model can be extended to include capital with convex adjustment costs. Those notes only consider this extension in the most simple case, i.e. without external habits, and show that the result do not change much for the contractionary phase of the depression. This is in line with what Woodford (2005) finds, i.e. that the model with fixed capital stock (as in the main text) provides a reasonable good approximation to the endogenous capital stock extension. The reason capital is not included in the main text is that it introduces new state variables into the model that complicates the analysis considerably, thus precluding closed form solutions, without changing the main channel for policy.

²³ 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 i.e. $(1 + s) = \frac{\theta}{\theta - 1}$ (see Eggertsson (2006) for the general case).

²⁴ Here I have used 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 I refer to the derivative v_L and v_{LL} as v_y and v_{yy} in the remainder of the paper.

²⁵ To a first order an equivalent Phillips curve can be derived assuming Calvo-Yun 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.

where R_t denotes residual government spending that does not contribute to utility.²⁶ The government budget constraint can be written as

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

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

$$w_t \leq w^b \quad (8)$$

which excludes Ponzi schemes. Market clearing implies

$$Y_t = C_t + F_t + d(\Pi_t). \quad (9)$$

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

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

This form of habits 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, $\tilde{Y}_t \equiv Y_t - \gamma Y_{t-1}$, which corresponds to output in a model without habit.

Without entering into the details of by what means the central bank controls the nominal interest rate, 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

$$i_t \geq 0 \quad (11)$$

An equilibrium can be defined without any reference to the money supply, an abstraction used in much of the paper.²⁷

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 6. A certain fraction

²⁶We will need this residual for technical reasons when we define the Hoover Regime, see footnote 33.

²⁷A money demand equation can be appended to the model for example by having money supply enter additively separately in utility (Eggertsson (2006)). The money demand equation only has a role in determining money demand given the interest rate and consumption.

of production needs to be held in money balances so the following inequality is satisfied²⁸

$$\frac{M_t}{P_t} \geq \chi_t Y_t. \quad (12)$$

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 money balances have on utility or welfare. At zero interest rate this inequality is slack because the households 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, for example, President Hoover 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 (see e.g. Klein, Krusell and Rios-Rull (2003)). The timing of events in the game is: 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

$$f_t^e = \bar{f}^e(w_t, Y_t, \xi_t) \quad (13)$$

$$S_t^e = \bar{S}^e(w_t, Y_t, \xi_t) \quad (14)$$

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 $\bar{f}^e(w_t, Y_t, \xi_t)$, $\bar{S}^e(w_t, Y_t, \xi_t)$ as given because it cannot commit to future policy.³⁰

We can now define the government maximization problem for arbitrary policy dogmas, but we will be

²⁸As in Krugman (1998) and King and Wolman (2004).

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

³⁰Because the government is a large strategic player and moves simultaneously with the private sector it can choose a value for all the endogenous variables $(\Pi_t, C_t, Y_t, F_t, G_t, R_t, T_t, i_t, w_t)$ 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 than 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 (see e.g. King and Wolman (2004), Albanesi, Chari, 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 and stable. Proving global uniqueness is hard but possible in simpler models (see Eggertsson and Swanson (2007) who prove it analytically in a somewhat simplified model). The timing assumption here is the same as in the linear-quadratic literature on discretion such as for example Clarida, Gali and Gertler (1999) and Woodford (2003). See Ortigueira (2006) and Eggertsson and Swanson (2007) for a more detailed discussion about timing assumptions in MPE.

more specific in the next section. The government policy problem can be written as³¹

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

s.t. i) equations (2),(4),(6),(7),(8),(9),(10),(11),(13),(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 (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}) .

4 An Output Collapse and Excessive Deflation under the Hoover policy regime

This section outlines a policy regime, coined 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.

4.1 The Policy Dogmas

First, there is a "no additional spending dogma" or "small government dogma" so that real government spending is constant at all times, i.e.

$$F_t = \bar{F} = \bar{G} + s(T_t) + R_t \quad (16)$$

This viewpoint or dogma captures Hoover's views on fiscal policy, that the government should be kept "small" at its current level. We read, for example, in his address to the American Legion on 21st of September 1931 (Hoover (1934)):

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.

³¹Observe that in this definition of the policy regime it is assumed that i_t is the instrument of monetary policy. Appendix 3 defines the game with M_t being the governments choice variable in which case M_{t-1} becomes a state. This is necessary once the gold standard is a policy dogma because it specifies a relationship between M_t and gold reserves.

³²One 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} .

Second, there is a "balanced budget dogma" so 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

$$w_t = w_{t-1} = \bar{w} \quad (17)$$

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

$$T_t = \bar{F} + \left(\frac{1}{1 + i_t} - \Pi_t^{-1} \right) \bar{w} \quad (18)$$

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.³³ This dogma represents Presidents Hoover's views at the time. In a press statement at the early stages of the Depression on July 18th 1930, for example, he stated (Hoover (1934)):

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 as documented in section 2. These dogmas form the foundations of the Hoover policy regime.

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

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 that this constraint was not binding. Section 6 extends the Hoover regime to include the gold standard.

4.2 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 1929-33 is that the short term nominal interest rate collapsed to zero together with a decline in output and prices. Motivated by this fact we follow Eggertsson and Woodford (2003) and Auerbach and Obstfeld (2004) by assuming that *purely intertemporal*

³³In writing the two dogmas in this way we abstract from any welfare effects the variations in taxes have by setting $G_t = \bar{G}$ and assumed the residual spending R_t in (16) adjust to counteract any changes in tax collection costs. This simplifies our characterization of the Hoover Regime considerably.

disturbances were responsible for the contraction in the model 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 or markups shocks (i.e. intratemporal shocks) do not have this property. Consider a productivity shock which 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 a MPE (see e.g. Woodford (2003)). An exogenous increase in markups (i.e. intratemporal shocks), which can be modeled as time varying θ , will also reduce output in a MPE. At the same time, however, it *increases* the nominal interest rate and inflation in a MPE (see e.g. Clarida, Gali and Gertler (1999)). Finally consider a money demand shock as represented by variations in χ_t in equation (12). In a MPE equilibrium the central bank will completely offset this shock with no effect on inflation, output or interest rates.

Intertemporal shocks have been used to explain the Great Depression at least since Hicks' (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 that a lower real interest rate is required for demand to remain unchanged and explore the consequences of different policies taking this as given. This theory of the Great Depression was later advocated by Temin (1976) who argued that shocks to the IS equation were the key to understanding the Great Depression, rather than monetary policy shocks, since they imply that the short-term nominal interest rate declines while a monetary policy disturbance would require the nominal interest rate to increase. In our dynamic model, however, it will be the interaction between the *intertemporal shocks* and the *systematic component* of monetary policy that causes the Great Depression. In this sense one may argue that monetary policy was responsible for the downturn, as in Friedman and Schwartz (1963), even if the impulse was IS shocks, as suggested by Temin (1976).³⁴

At the most general level it is useful to define a purely intertemporal disturbance as one that reduces the efficient rate of interest while leaving other variables in the efficient allocation unchanged (i.e. the efficient level of output, hours and public and private consumption).³⁵ Any decline in output due to the intertemporal disturbance, therefore, is *inefficient*. This imposes some discipline on the quantitative analysis of the contraction. It means that the fall in output is explained *entirely* by the interaction of the intertemporal shocks, the policy regime, and the assumed frictions.³⁶ The *efficient* allocation is defined as the optimal or first best solution under flexible prices, i.e. the solution once the fiscal instrument have been set at their optimal level. Each variable in the efficient allocation is denoted by a superscript e .³⁷

³⁴Romer (1990) argues that shocks that increased uncertainty lead to lower demand during the Great Depression. These shocks, while not explicitly captured by our linearized model, will also have the property that the nominal interest rate has to decline to stabilize demand.

³⁵Observe that this assumption implies that any increase in government spending in an optimal allocation is second best. See Eggertsson (2006) for a discussion of second best problem in a similar model.

³⁶As opposed to output dropping exclusively due to the exogenous shocks, e.g. through negative productivity disturbances. Those disturbances would reduce the ability of firms to produce directly, while in the current setup there is no reason for output to drop if policy is conducted appropriately, since the production possibilities of the firms and the willingness of household to work remain unchanged.

³⁷This concept is relatively well known in the literature, and is for example formally defined in a similar model in Eggertsson

Formally, we assume that time 0 the efficient level of interest is negative so that

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

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 so 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

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

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 only valid as long as this bound is satisfied.³⁸ A *purely intertemporal shock* requires that other variables in the efficient allocation remain unchanged. This imposes the following two restrictions on how the shock enters the model

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

where $C_t^e = \bar{C}$ and $Y_t^e = \bar{Y}$

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

where $Y_t^e = \bar{Y}$, $C_t^e = \bar{C}$ and $G_t^e = \bar{G}$. Both (20) and (21) can be derived from a social planners 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 (2005) so that the utility function can be written as:

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

where β_T is a stochastic disturbance.³⁹

We consider the simple stochastic process for R_t^e that has only a "low" and "high" state 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 FDR regime

(2006).

³⁸In the baseline calibration the expected duration of the shock can be no longer than 9 years for the approximation to remain valid.

³⁹This 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 authors website.

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 the entire recovery period (and this assumption is consistent with the data because the nominal interest rate stayed at zero throughout the recovery in 1933-37). All the dynamics of the model, then, will be driven by internal dynamics of the model and the regime change, and we only have the freedom to pick the level of the shock R_L^e and its persistence α at the beginning of the Great Depression in 1929. This puts some discipline on the quantitative exercise. The next section shows that A1-A2, together with P1-P2, are sufficient to characterize who the shocks enter the linear approximation of the model.

4.3 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 3 as the solution under the Hoover regime in the absence of shocks. The IS equation (2), together with (9), can be approximated to yield

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

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

$$i_t \geq 0. \quad (23)$$

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

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

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

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

⁴⁰The 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 $\hat{Y}_t$ refers to output (because $\gamma = 0$). This makes clear that none of the analytical results derived depends on the particular form of habit persistence, they are only introduced to improve the fit of the model. The same would not hold if we introduce internal habits which would imply some additional dynamics.

Finally the budget constraint of the government is approximated by

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

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 hand side 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 hand side 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). Equations (22)-(25) summarize the private sector equilibrium constraints.

Government policy satisfies the first order conditions of the maximization problem (15) and the non-linear first order conditions are shown in Appendix 3. The policy dogmas can be approximated as

$$\hat{w}_t = \hat{F}_t = \hat{G}_t = 0 \quad (26)$$

$$\hat{T}_t = -\frac{1}{s'}\hat{R}_t = \bar{w}\beta^2(i_t - \bar{r}) - \bar{w}\pi_t. \quad (27)$$

These equations say that the 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

$$\pi_t - \phi_{3t} = 0 \quad (28)$$

$$-(\tilde{Y}_t - E_t\tilde{Y}_{t+1}) - \theta(\phi_{3t} - \beta\gamma E_t\phi_{3t+1}) + \psi(\phi_{2t} - \beta\gamma E_t\phi_{2t+1}) + \sigma\delta_c\psi(f_Y\phi_{2t} - \beta S_Y\phi_{3t}) \quad (29)$$

$$\phi_{2t} + \beta^{-1}\gamma_{1t} = 0 \quad (30)$$

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

$$\gamma_{1t}i_t = 0, \quad i_t \geq 0, \quad \gamma_{1t} \geq 0. \quad (31)$$

where the variables $\phi_{2t}, \phi_{3t}, \gamma_{1t}$ are the Lagrangian multipliers associated with (22),(24) and the zero bound respectively (see Appendix 3 for derivation).

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 f_Y^e and 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 $f_Y = S_Y = 0$.⁴¹ Another complication is

⁴¹This 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.

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 $Y_t = \pi_t = 0$ for $t \geq \tau$.⁴² 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):

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

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

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 so 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 $t < \tau$

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

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

To summarize:

Proposition 1 *Equilibrium policy and outcomes under the Hoover Regime. If A1 and A2 then equilibrium policy under the Hoover regime is: (i) Fiscal policy:*

$$\hat{F}_t = \hat{G}_t = \hat{w}_t = 0 \quad \forall t. \quad (36)$$

$$\hat{T}_t = -\frac{1}{s'}\hat{R}_t = -\bar{w}\beta^2(i_t - \bar{r}) + \bar{w}\pi_t \quad \forall t \quad (37)$$

(ii) Monetary policy:

$$i_t = r_t^n \text{ so that } \pi_t = 0 \text{ when } t \geq \tau \quad (38)$$

⁴²In this case the zero bound is no longer binding, $i_t > 0$, and from (30) and (31) we see that $\gamma_1 = \phi_{2t} = 0$. 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 $\tilde{Y}_t = (\frac{\beta}{1+\theta\kappa})^j E_t\tilde{Y}_{t+j}$ 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 $\theta, \kappa > 0$.

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

⁴⁴Observe 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 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 $\lambda^2 - \left(\frac{1}{\beta(1-\alpha)} + \frac{1}{1-\alpha} \left(\kappa\frac{\sigma}{\beta} + 1\right)\right)\lambda + \left(\frac{1}{\beta(1-\alpha)^2} \left(\kappa\frac{\sigma}{\beta} + 1\right) - \kappa\frac{\sigma}{\beta^2(1-\alpha)^2}\right)$

$$i_t = 0 \text{ when } 0 \leq t < \tau \quad (39)$$

iii) *Outcomes*

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

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

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

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).

The policy characterization implies that the Federal Reserve behaves as if it follows a strict zero inflation target with the twist that it may not be able to achieve it if the efficient rate of interest is negative. In this case the Fed lowers the 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.

The pursue of low inflation appears to accords well to 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 6). 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 start recovering, consistent with (38) and (39). The view of the Federal Reserve appears to have been that the deflation was a necessary consequences of the speculative excesses of the past that had to be "purged".⁴⁵ 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 economist, this concern is puzzling because the price level fell slowly from 1927-29, then more rapidly."⁴⁶ The current paper suggest an interpretation of this behavior: It was a consequence of a purely discretionary behavior by the Federal Reserve, treating "bygones as bygones", as further discussed in section 4.5 (especially footnote 53).

⁴⁵ See Meltzer (2003) p. 280.

⁴⁶ See Meltzer (2003) p. 728. Meltzer also has expensive discussion on this in chapter 5, see especially p. 273-80. The recession in 1937-38 provides further evidence of this behavior but then the Federal Reserve moved to tighten despite that the price level had not recovered to its pre-depression levels and regardless of FDR's commitment to reflate the price-level to pre-depression levels (see Eggertsson and Pugsley (2006)).

4.4 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 1933-37, *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 is annual. Table 1 shows the values for the parameters $(\sigma, \omega, \beta, \theta, \kappa, \gamma)$. The first five are relatively standard values from the literature (discussed in Appendix 1). For κ the model is mapped into a model with stochastic price adjustment as in Calvo (1982), denoted ζ in the table, and it is assumed that prices are adjusted on average once every 9 months (see Appendix 1). There is no common agreement on the value for γ , the habit persistence parameter. Some authors assume no habit persistence while others (such as Giannoni and Woodford (2005)) estimate a consumption habit close to 1. We experiment with several values for γ .⁴⁷

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 in the contractionary phase of the Great Depression. Appendix 1 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.⁴⁸ Figure 4 shows the response of output, inflation, interest rates to an intertemporal shock of this size and compares to the data. The output of the model is plotted under the contingency that r_t^e stays in the low state for the entire period. The data is annual GDP (in fiscal year so that the year 1933 is the fiscal year ending in June 1933), year on year changes in CPI and the short-term interest rate is measured as the yield on three month Treasuries in June of each year (see further discussion in the data Appendix).⁴⁹

As can be seen from the figure the model can replicate the data relatively well for the period 1929-1933. The figure shows by a vertical line the regime change when Hoover lost power and FDR came to office. This is where the model and the data diverge. Output continues to decline in the model under the Hoover regime, reaching a nadir of -49 percent from steady state, but the data shows a strong recovery. Section 5 analyses whether the regime change can explain the recovery in the data, taking the shocks as given.

Figure 4 is insensitive to variations in the structural parameters $(\sigma, \omega, \beta, \theta, \kappa)$ as long as they remain in

⁴⁷See section 5.3 and Appendix 1.

⁴⁸This 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 in the data. Several authors have attempted to estimating the frequency of contractions due to the zero bound if the government targets zero inflation, which is equivalent to the Hoover regime in this paper. An early example is Summers (1991) but see also Rotemberg and Woodford (1997), Reifschneider and Williams (2000) and Christiano (2003). 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 bank's tend to accommodate higher levels of inflation on average. Observe that a symmetric gold standard is akin to a price level target (see discussion in section 6) which also tends to minimize the distortions associated with the zero bound.

⁴⁹To 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 et al (2000) none of the data is detrended but output is expressed in deviations from the 1929 peak.

the region in Table 2, 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 1.⁵⁰ The figure is sensitive to variations in γ but this parameter helps account for the gradual decline in output as discussed further in section 5.3.

4.5 Discussion

The contraction at any time t in figure 4 is created by a combination of the deflationary shock in period $t < \tau$ – but more importantly – the *expectation* that there will be deflation and output contraction in future periods $t+j < \tau$ for $j > 0$. The deflation in period $t+j$ in turn depends on expectations of deflation and output contraction in periods $t+j+i < \tau$ for $i > 0$. This creates a vicious cycle that does not even converge unless the restriction on α in A2 is satisfied.

The output collapse is mostly driven by the IS equation (22)

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

The expectation hypothesis says that the long-term interest rate is the sum of current and expected future short-term rates. Hence this equation indicates that demand depends on long-term real interest rates and the output gap at time T . The contraction is caused by a discrepancy between long-term real interest rate and the efficient rate of interest. Due to the zero bound this difference cannot be reduced by nominal interest rate cuts. This difference increases with expectations about future deflation.⁵¹

Increasing the money supply has no effect in the model unless it changes expectations. The reason is that money supply works through the short-term interest rate and by 1933 they were already close to zero, so that money and bonds were perfect substitutes. Any money supply above $\chi Y_t P_t$ (see inequality (12)) during the period of zero interest rates is thus consistent with the equilibrium. Furthermore open market operations do not change expectations under the Hoover policy regime.⁵² 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 (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).

Why does the government not simply commit to increasing the money supply *in the future* under

⁵⁰ This suggests that while the choice of the parameters within the range in table 1 has no effect on figure 4 it has strong effect on the amplification of the model, i.e. the ability of the model to generate the deflation and output collapse for "small shocks", see further discussion in Appendix 1.

⁵¹ 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 Tobin (1975) and De Long and Summers (1986).

⁵² One can of course imagine a policy regime in which this is not the case, see e.g. Auerbach and Obstfeld (2005), see further discussion in section 5.5.

the Hoover regime since this increases inflation expectations which in turn stimulates demand (according (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) coins the deflation bias of discretionary policy in a liquidity trap.⁵³

While figure 4 shows the solution assuming that r_L stays low for the entire period, figure 5 shows the solution under 3 other contingencies, i.e. when the exogenous shock reverts to normal in 1931, 1934 or 1937 respectively (the contingency $\tau > 1937$ is the one we have previously considered). If the shock reverts to normal there is a recovery in both prices and output and this is an alternative hypothesis for the recovery in 1933-37. Under this alternative hypothesis it was a coincidence that the regime change and the turning point coincided.⁵⁴ The panel for the interest rate in figure 4 shows that this alternative hypothesis is inconsistent with the data. If the intertemporal disturbances dissipated in 1933, the model implies an increase in the nominal interest rate. Instead, the nominal interest rate stayed low throughout the recovery period, without strong inflationary pressures.

Figure 4 shows that the model replicates the collapse in the short-term nominal interest rate observed in 1929-33. The model, however, suggest a slightly faster decline than observed in the data. While the model suggest that interest rates should have declined from steady state in 1929 to zero in 1930 we see that the interest rate went from 5 percent in 1929 to 1.78 percent in June 1930, reaching 0.6 in 1931, 0.25 in 1932 and then 0.15 in 1933 where it stayed throughout the episode. What were the consequences of the Fed not cutting the interest to zero immediately? To answer this we calculate the path for output and inflation under the assumption that the government follows a simple Taylor rule

$$i_t = \max(0, \phi_\pi \pi_t + \epsilon_t) \quad (43)$$

where $\phi_\pi > 1$. Observe that if $\epsilon_t = 0 \forall t$ this policy rule is equivalent to the policy under the Hoover regime.⁵⁵ The policy rule therefore allows for a stochastic deviation from the baseline Hoover regime by including the term ϵ_t which means that even if there is deflation, the interest rate may still be higher than zero. By choosing the right ϵ_t we can explore the quantitative consequence of a random deviation from the baseline MPE to match the data (see Appendix 2 for derivation). The solution is shown in figure 4 as a dashed line and suggests that this deviation had a trivial quantitative effect under the baseline calibration. This means that even if the government had cut the interest rate to zero in 1930, the outcome would not

⁵³To 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 $-\sum_{T=t}^{\infty} \beta^T (\pi_T^2 + \lambda_y \tilde{Y}_T^2)$. 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.

⁵⁴Or perhaps there were other elements of the regime change that we are not modelled here that were responsible and worked through the efficient rate of interest.

⁵⁵Because $\pi_t = 0$ when $t > \tau$ and $i_t = 0$ when this cannot be achieved

change much and that the Hoover regime captures policy relatively well (at least compared to a Taylor rule (43) that matches the evolution of interest rates exactly). The reason is helpful to understand the logic of the model. What is mostly driving the output collapse and deflation is not the interest rate setting in each period but the policy regime, i.e. expectations about how interest rates, inflation and output will evolve in the future. Most importantly, expectations are formed under the assumption that the Hoover Regime will be maintained in the future and that the policy authority *will be unable to contain deflation and output contraction as long as the intertemporal shocks lasts*. It is not of principal importance that the zero bound did not become binding until 1932 (or even if the interest rate could have been lowered below 0.14 from 1933 onwards).⁵⁶ Instead what matters is that people expect that the government will be unable to contain deflation and output contraction in future states of the world which creates the vicious deflationary dynamics described in subsection 4.5. The FDR policy regime breaks these vicious dynamics.

5 An Economic Expansion under the FDR 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 modelled as follows:

Hoover Regime $\longrightarrow$ (Unexpected) Elimination of Policy Dogmas $\longrightarrow$ FDR Regime

Both FDR 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 FDR Regime *The government solves (15) free from policy dogmas.*

5.1 The elimination of policy dogmas under FDR

The first dogma attached to the Hoover regime was the small government dogma. FDR made clear that he would violate this dogma once he assumed power. 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.

⁵⁶ A similar comment applies to that fact that interest rates were slightly positive during the period or around 0.14 as measured by 3 month Treasuries. Going from 0.14 (to the extent this was even possible) to 0 has relatively small quantitative effects in the model. This can be seen formally by analyzing policy rule $i_t = \max(i^n, \phi_\pi \pi_t + \epsilon_t)$ where $i^n > 0$ and show that the effect of increasing i^n from zero to 0.14 is small in the baseline calibration (hence there is no discontinuity with respect to the effect of the regime change at $i^n = 0$ as long as $r_L^e < 0$).

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 FDR made no distinction between government debt and the monetary base, which is consistent with this interpretation. In one of his fireside chats in 1933 (Roosevelt (1933b)), 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 so there was *no* economic difference between government debt and the monetary base. Furthermore FDR 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 FDR viewed credit expansion as crucial to fight deflation. Section 6 discusses the gold standard dogma.

5.2 Characterizing the FDR 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 the Appendix. The first order conditions (with respect to $\pi_t, w_t, T_t, F_t, Y_t, i_t$) can be linearized to yield:

$$\pi_t - \frac{s'}{d''(1-s')}w_{t-1} - \phi_{3t} = 0 \quad (44)$$

$$\hat{\phi}_{1t} - E_t\hat{\phi}_{1t+1} - E_t(i_{t+1} - \bar{r}) + E_t\pi_{t+1} + \frac{1-s'}{s'}[f_w\phi_{2t} - \beta S_w^e\phi_{3t} - \gamma_{2t}] = 0 \quad (45)$$

$$\hat{\phi}_{1t} + \sigma^{-1}\delta_g^{-1}\hat{F}_t - (\frac{s''}{s'} + \sigma^{-1}\delta_g^{-1}s')\hat{T}_t - \alpha^{-1}r_L^e + (i_t - \bar{r}) = 0 \quad (46)$$

$$-\tilde{Y}_t + (1 + \delta_c\delta_g^{-1})\hat{F}_t - (\delta_c\delta_g^{-1}s' - \sigma\delta_c\frac{s''}{1-s'})\hat{T}_t + \phi_{2t} - \theta\phi_{3t} = 0 \quad (47)$$

$$-(\tilde{Y}_t - \beta\gamma E_t\tilde{Y}_{t+1}) + \psi(\hat{F}_t - \beta\gamma E_t\hat{F}_{t+1}) - \theta(\phi_{3t} - \beta\gamma E_t\phi_{3t+1}) + \psi(\phi_{2t} - \beta\gamma E_t\phi_{2t+1}) = 0 \quad (48)$$

$$-w_{t-1} - F_t + T_t + \frac{1-s'}{s'}[\beta\phi_{2t} + \gamma_{1t}] = 0 \quad (49)$$

and two complementary slackness conditions

$$\gamma_{1t} \geq 0, \gamma_{1t}i_t = 0 \quad (50)$$

$$\gamma_{2t} \geq 0, \gamma_{2t}(w_t - w^b) = 0 \quad (51)$$

where the variables $\hat{\phi}_{1t}, \phi_{2t}, \phi_{3t}, \gamma_{1t}, \gamma_{2t}$ are the Lagrangian multipliers with respect to (22), (24), (25) and the zero bound and the debt limit respectively (see Appendix 3 for derivation). An approximate equilibrium under the FDR regime is then defined as a collection of stochastic processes for the endogenous variables that satisfy (22)-(25) and (44)-(51) for a given path of $\{r_t^e\}$ and again all the shocks are summarized by r_t^e . A complication arises because of the unknown expectation functions f_w^e and S_w^e and we cannot use the same argument as before (when discussing f_Y and S_Y) to eliminate them, because w_{t-1} is a state variable of the game.⁵⁷ One can approximate these functions by method of undetermined coefficients, applied to the model without shocks, and a Matlab routine was written that computes these functions numerically.⁵⁸

Several interesting properties of the solution emerge from these first order conditions. Unlike under the Hoover regime, there is an endogenous state variable, w_t , that is under the control of the government. We see from equation (44) that a higher value of debt will increase the incentive of the government to inflate. This term is not present under the Hoover regime because the balanced budget dogma implies that the government ignores the fiscal consequences of monetary policy. This state variable plays a key role, because it means that the regime change increases inflationary expectations, thus helping to curb deflation. The first order conditions (45) and (46) say how the government uses debt and taxes to exploit this channel. The first order condition (47) arises because the government can violate the small government dogma. There is a tendency to increase government spending, F_t , according to this condition, in response to a low value of $\tilde{Y}_t$.⁵⁹

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 , for example, we can write $\pi_t = \pi^w w_{t-1}$ for $t > \tau$ where π^w is a number. Using this to solve for expectations at time $t \leq \tau$ ⁶⁰ we can solve the model using standard solution methods for linear expectation models.⁶¹

5.3 Numerical Characterization: The Recovery under FDR

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 only plays a role under the FDR policy regime. The calibration is shown in table 2 and discussed further in Appendix 1. The next proposition summarizes the policy under FDR under the baseline calibration. To facilitate comparison to the Hoover Regime, the proposition specifies the response of taxes, spending and interest rates in an

⁵⁷The function f_Y and S_Y drop out here by the same argument as before.

⁵⁸In all the numerical experiments a unique value for f_w^e and S_w^e was found consistent with a bounded solution.

⁵⁹Also observe that in addition to the complementary slackness condition with respect to the interest rate, there is one with respect to debt. We will assume that the bound w^b is sufficiently large so that this condition never binds.

⁶⁰Consider, for example, the solution for inflation expectations $E_t \pi_{t+1} = (1-\alpha)E_{t,L} \pi_{t+1} + \alpha E_{t,H} \pi_{t+1} = (1-\alpha)E_{t,L} \pi_{t+1} + \alpha \pi^w w_t$

⁶¹The system will be of the form $AX_{t+1} = BX_t$ where the vector 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 8 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 Blanchard and Kahn (1980).

analytic form – this form of policy held for all parameter values considered with minor exceptions.⁶²

Proposition 2 *Under the baseline calibration, policy is*

(i) Fiscal policy:

$$\begin{aligned}\hat{F}_t &= \eta_F^1 w_{t-1} < 0 \text{ for } t \geq \tau \\ T_t &= \eta_T^1 w_{t-1} \geq 0 \text{ for } t \geq \tau \\ \hat{F}_t &= \eta_F^2 w_{t-1} + \phi_F^{FDR}(r_t^e - \bar{r}) > 0 \text{ for } t < \tau \\ T_t &= \eta_T^2 w_{t-1} + \phi_T^{FDR}(r_t^e - \bar{r}) \leq 0 \text{ for } t < \tau\end{aligned}\tag{52}$$

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

(ii) Monetary policy:

$$i_t < r_t^e \text{ so that } \pi_t = \eta_\pi^2 w_{t-1} > 0 \text{ when } t \geq \tau\tag{53}$$

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

where $\eta_\pi^2 = 0.0081$

iii) Outcomes

$$\begin{aligned}\hat{Y}_t^{FDR} &\geq Y_t^H \text{ for all } t \\ \pi_t^{FDR} &\geq Y_t^H \text{ for all } t\end{aligned}$$

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 FDR 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 FDR 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 FDR policy regime implies a commitment to keep the nominal interest rate low for a considerably longer time than the Hoover regime.

Figures 6 and 7 show the quantitative consequence of the regime change in the model.⁶³ 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 figures 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 immediate increase in both prices and output, of a similar order as seen in the data and roughly mimicking the persistence in the two variables. The regime change explains 79 percent of the recovery in output in 1933-37 and 67 percent of the recovery in inflation.

⁶²The one exception is that if there is 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.

⁶³Both data and model for Y_t , F_t and T_t are expressed as deviation from 1929 steady state output.

Figure 6 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).⁶⁴ 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 the figure. Since the nominal interest rate was already zero in 1933, the 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.

5.4 Discussion

In the Markov Perfect Equilibrium the regime change is supported by the expansion in real government spending, F_t , and deficit spending, i.e. discrepancy between F_t and T_t . Consider first the consequence of the increase in F_t . This has an effect through two channels. On the one hand the increase in F_t increases the flexible price output, or natural level of output (see e.g. Woodford (2003)). This channel has been extensively documented in the RBC literature (see e.g. Baxter and King (1993) and references therein).⁶⁵ On the other hand government spending increases the flexible price interest or natural level of interest. Due to the sticky price assumption, this also has an expansionary effect. Observe that both of these channels are operative holding expectations constant but their effect is relatively small. As can be seen by equation (42) the sum of these effects moves output 1 to 1 with fiscal spending. This static effect, however, is not the only effect because it neglects the dynamic consequence of real government spending. If people expect there to be 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 *future* states, thus having stimulative effect on current output.

While real government spending is stimulative, it is not enough to explain the recovery in 1933-37. In the baseline calibration the increase in F_t , due to both channels explained above can account for 18 percent of the recovery in output and 23 percent of the recovery in inflation.⁶⁶ We need the interactions of deficits, public debt and expectations about a future monetary expansion to explain the recovery.

While there is some "direct effect" of real government spending on output, deficit spending works

⁶⁴The estimate in the figure is constructed by taking an average over each fiscal year.

⁶⁵In the context of our model, just as in Baxter and King, the natural rate of output increases if government expenditures increase as can be. This increase is due to a higher willingness of people to work. Higher government spending increases the marginal utility of consumption (for given level of consumption) which induces people to work more to equate the marginal utility of private consumption and the disutility of working.

⁶⁶To compute this number I did the following experiment: Suppose that $F_t = F_L = 0.035$ when $r_t^e = r_L$ and $\pi_t = F_t = 0$ for $t \geq \tau$ when $r_t^e = 1/\beta - 1$. The solution can be solved in closed form yielding $Y_L = \frac{\sigma\delta_\pi}{\alpha - \frac{\kappa\sigma\delta_\pi(1-\alpha)}{1-\beta(1-\alpha)}} r_L^e + \frac{\alpha - \frac{\kappa\sigma\delta_\pi(1-\alpha)}{1-\beta(1-\alpha)}}{\alpha - \frac{\kappa\sigma\delta_\pi(1-\alpha)}{1-\beta(1-\alpha)}} F_L$ and the number for inflation can be computed using the AS equation. This number exaggerates the expansionary effect of real spending somewhat because F_t declines over time in the MPE as can be seen by figure 7. The number reported should therefore be interpreted as an upper bound.

entirely through expectations in the model. The key to understanding the effect of deficit spending is that inflation and output expectations are increasing in aggregate government credit, w_t , according to Proposition 2, while future interest rates are decreasing in aggregate credit. Furthermore equation (52) indicates that the government will issue government credit to generate expansionary expectations. Both these features of the FDR policy regime are consistent with the narrative evidence cited in section 5.1. FDR wanted reflation and announced that he would achieve this by issuing government credit. This has a large quantitative effects in the model. The mechanism for why government credit increases demand is as follows: The government wants to minimize the cost of taxation because taxation is costly in the model. 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 in turn has an expansionary effect on both inflation and output. This suggest that inflation and output are increasing in government debt, and the nominal interest rate is decreasing. Since the key problem in period $t < \tau$ is contractionary expectations (in both output and inflation), this has a large effect in the model.⁶⁷

Figure (6)-(7) show the quantitative effect of the regime change under the assumption that r_L remains negative throughout the recovery period. While this is a plausible assumption – because the nominal interest rate stayed at zero throughout the recovery – it is helpful to see the evolution of each of the variables for a different scenario since this will make the effect of expectations clearer. Figure (8) shows the case in which the shock r_L reverts to steady state in 6 periods (i.e. $\tau = 1939$) which is the expected duration of the shock at the time of the regime change in 1933, comparing the evolution under the Hoover and FDR policy regimes. Under the Hoover regime the government increases the interest rate when the shock is over and achieves zero inflation as soon as deflationary pressures have subsided. Under the FDR regime, however, the government keeps the nominal interest rate low for a substantial period of time and accommodates some inflation and some output expansion as can be seen in the figure. An alternative way of stating this is that under the FDR regime the government commits to permanently increasing the

⁶⁷ 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 include Sargent and Wallace (1982) but see e.g. Fujiki (2001) for a recent survey of the empirical and theoretical literature. Kwon et al (2006) provide a cross sectional study and find that there is a strong correlation between growth in public debt and inflation. An important finding in that paper is that this relationship is weaker in industrial countries.

Observe 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. In the aftermath of WWII steps were taken with the Treasury Accord (see e.g. Meltzer (2003)) to weaken the control of the administration and the Treasury over the Federal Reserve so that in post war US data we should not expect a strong correlation between debt (as it was under the Hoover) since central bank independence may substitute for the discipline of the gold standard and the fiscal policy dogmas under Hoover (see Fujiki (2001) who also draws on this connection). In the run up of the deficits under Ronald Reagan, for example, inflation was brought down at the same time, an similarly the recent experience of large deficit have had a limited noticeable impact on inflation expectations in the US (I thank an anonymous referee for stressing this).

money supply as can be seen in the figure. 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 8 is consistent with equilibrium. The supply of money, however, is uniquely defined at date $t \geq \tau$ and the FDR regime implies a much higher supply of money in the future than the Hoover regime. Observe that the difference in the money supply between the Hoover regime and the FDR regime is large, more than 50 percent in $\tau = 1939$. The reason for this large difference is not the small degree of inflation and output expansion in $t > \tau$ under FDR relative to Hoover. Instead, it is the fact that the reflationary commitment contains deflation and output contraction in all states $t < \tau$ which in turn has dramatic implications for the implied commitment of the money supply comparing the two regime (because under the Hoover regime any deflation will be accommodated and the money supply contracted correspondingly). Finally it is of interest to observe in figure 8 that the debt will not only be paid off by inflation. The government only runs deficits as long as the shocks lasts and then runs budget surpluses by raising taxes substantially at $t \geq \tau$ to pay down the debt.⁶⁸

Figures 9 and 10 shows the effect of varying $(\theta, \beta, \sigma^{-1}, \frac{1}{1-\zeta}, \omega, \gamma)$ one at the time. The figure considers other values in the literature that are common in the literature, further discussed in the Appendix 1, but remain within the boundaries of Table 3. For comparison the figure also plots the counterfactual if Hoover would have remained in office. Recall from our discussion in section 4.4 that the results under the Hoover regime are unchanged for any values in the parameter region in Table 2. We see from this figure that the effect on output and inflation is relatively small for each of the parameters, even if we allow for considerable variations. The main difference is when we change the habit persistence parameter. If there is no habit persistence the fall in output is immediate, and also the recovery is faster than in the data.⁶⁹ Table 4-5 show that for each of the different combination of the structural parameter the criteria for the shocks implies a different value for the shocks so as to match the output contraction in 1933 and the deflation observed. Appendix 1 discusses further sensitivity analysis, including values for the structural parameters outside of the range in Table 2.

5.5 Alternative interpretations of the FDR policy regime

Proposition 2 is only one way of representing the FDR policy regime. Because we assume no commitment in Proposition 2, deficits and public debt play a key role by helping the government to commit to a higher future money supply/price level. If we assume instead that the government *can commit* to future policy, then we can determine output, inflation and interest rates independently of deficits and debt by conditioning directly on the future money supply or the price level. Here we consider two such alternative

⁶⁸This is consistent with FDR announcements at the time but he said that the deficit were only temporary and would ultimately be reversed by tax increases once the economy turned to normal. I thank an anonymous referee for stressing this.

⁶⁹The are alternative mechanism to habit persistence that can replicate the inertial response of output in DSGE models. 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.

characterization. These alternative ways of describing the FDR policy regime have some strengths and weaknesses as discussed below. It is worth stressing, however, that they are both consistent with central hypothesis of the paper that the recovery was explained by a shift in expectations.

Consider first a government that can commit to policy and that this commitment takes the following form

$$\hat{F}_t = F^* \text{ for } t < \tau \text{ and } \hat{F}_t = 0 \text{ for } t \geq \tau \quad (54)$$

$$i_t = 0 \text{ for } t < \tau \text{ and } (p_t - p^*)i_t = 0 \text{ for } t \geq \tau \quad (55)$$

In (54) we assume that the government will expand government spending in period $t < \tau$ to counteract the deflationary shocks. In (55) we assume that the government commits to keeping the interest rate at zero until the price level reaches a target level p^* . It can be shown that this policy regime approximates the FDR regime in Proposition 2 relatively well, at least for the evolution of output and inflation, for appropriately chosen p^* and F^* . This commitment is sufficient to close the model independently of deficits and debt.⁷⁰ The FDR policy regime can therefore alternatively be interpreted at a more basic level as 1) an expansion in real government spending F_t and 2) a credible commitment to a higher future price level (relative to the one implied by the Hoover regime).

Another way of stating the FDR regime, which is better consistent with the previous literature, is to replace (55) with commitment to a statistical representation of the money supply (i.e. a money supply rule)

$$M_t = M_{t-1} + \epsilon_t \quad (56)$$

where ϵ_t is *iid* and represents open market operations at time t (or some other actions) that increase the money supply. This policy commitment, usually in slightly more general form, is used by several authors such as Bordo et al (2000), Christiano et al (2004) and Auerbach and Obstfeld (2005). Under this assumption a monetary expansion at date t , will automatically increase expectations about future money supply by the assumed policy commitment (56). It follows that a contemporaneous monetary expansion increases output and inflation.⁷¹ It can be shown that by appropriately choosing ϵ_t , this policy rule is equivalent to (55) because according to (12) the price level in the future p^* is proportional to the future money supply M^* . Hence, if the government can commit directly to a future money supply, e.g. through a statical relationship (56), deficits and debt play no role. This alternative characterization is somewhat less appealing to describe the turning point in 1933 than the price level target rule (55) for two reasons. First, as we documented in the introduction, the money supply did not increase around the turning point in 1933 so even if the government committed to a policy rule like (56) it cannot explain the turning point.

⁷⁰ A similar point is made in Eggertsson and Woodford (2003) in comparison to a Ramsey equilibrium. The Ramsey equilibrium and the MPE are very close under the FDR regime.

⁷¹ As documented by many authors (e.g. Auerbach and Obstfeld (2005)) observe that the monetary expansion in these papers does not arise through a "direct" effect of the money infusion but through the expectation of a higher future money supply. Monetary policy is thus only affecting spending through real interest rates.

Second, FDR usually made his commitments in terms of the future price level instead of the future money supply as we have documented in section 2.

Both the price level and the money supply rules are helpful as complementary descriptions of the FDR policy regime and are not competing hypothesis. The analysis of the MPE adds to these descriptions by explaining *how* the government changed expectation and *why* expectations coordinated on some particular statistical description of the money supply or the price level. As we have already documented in section 5.1 FDR first declared his objective to raise prices (consistent with (55)), and then that he would *increase government credit until this objective was achieved* (consistent with the MPE). The appeal of the MPE analysis is particularly clear if we consider (56) as representing the government's policy commitment. According to this policy rule a possible description of the regime change is that the Federal Reserve increased the supply of money so that according to policy commitment (56) the public expected this to represent a permanent increase. Yet, this description raises a fundamental question: Why didn't the public expect the Federal Reserve to contract the money supply as soon as deflationary pressures subsided in order to prevent inflation at that time, in which case the monetary expansion would have had no effect due to the zero bound?⁷² As we have already discussed in section 4.5 that would be consistent with a discretionary behavior under the Hoover regime and the expectations supporting this equilibrium are reasonable: "People expect that the Federal Reserve will act to prevent inflation as soon as deflationary pressures have subsided".⁷³

The MPE provides an explicit theory of how a commitment to increase the future monetary base/price level can be achieved in a rational expectation model and thus an explanation of *why expectations coordinated on a permanent increase in the money supply in 1933* instead of coordinating on that the Federal Reserve would try to prevent future inflation as the economy recovered (an expectation that would have been consistent with the behavior of the Federal Reserve over the preceding decade as we document in section 4.3)). The elimination of the policy dogmas achieve this and make a permanent increase in the monetary base "credible" or "incentive compatible", thus formalizing Temin and Wigmore's (1990) hypothesis of a regime change. Yet, this description of the events in 1933 does not preclude the possibility that several other forces played complementary role. While eliminating the policy dogmas was important, it is also quite plausible that FDR's statements about his objectives about future prices and the observed

⁷²In the case of open market operations this expectation seems particularly natural because a future contraction would have happened mechanically and in the absence of further actions. With open market operation the central bank gives the government money in exchange for government bonds. The government bonds is a contract that stipulates that the government pays the central bank the money back at a future date, and thus at a mechanical level the open market operations will leave the future money supply unchanged. The Bank of Japan, in fact, contracted the monetary base in 2006 by close to 50 percent when transiting from zero to positive interest rates by making bonds they were holding "expire", i.e. without conducting any direct open market operations to contract the monetary base.

⁷³Recent history documents behavior of this kind. When the Bank of Japan was transitioning from zero to positive interest rate in 2006 it contracted the monetary base by 50 percent in a period of a few months in order to soak up "excess liquidity" that might cause too high inflation. These actions appear to have been largely *expected* by the market at the time and did not have a large impact on inflation expectations in Japan in 2006 (suggesting that people did not expect that the previous open market operations by the Bank of Japan represented a permanent increase in the monetary base. suggesting that expectations did to coordinate on a policy commitment like (56)).

increase in the money supply in 1933-37 also played a role in shaping expectations. Eggertsson (2006) also emphasizes the importance of the National Industrial Recovery Act which further increased inflation expectations and supported the recovery.

6 The Gold Standard Dogma

An important feature of the Hoover policy regime which has not been explicitly modeled in the paper so 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 Eichengreen and Sachs (1985), put FDR'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 (1979) formulation. We find that eliminating the gold standard was a necessary but not sufficient condition for the regime change.

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

$$M_t \leq \lambda_g p_G G_t^m \quad (57)$$

where M_t is money, G_t^m is the reserve of gold and 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 in the 1920's the rule was that US government needed to keep gold reserve corresponding to 40 percent of it's base, while the price of gold in dollars 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 (1979) that assumes that it holds with equality at all times. The gold standard in (57) says that the Fed has to have *at least* G_t^m reserves to back up its base but 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.⁷⁴ 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 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 (57). The solution is simple (see Appendix for a formal statement of the policy problem in this case), at least for special assumptions for the stochastic process for G_t^m . To see the solution

⁷⁴The word "sterilization" of gold inflows is used when the Federal Reserve substituted gold inflows for interest-bearing bonds, leaving the supply of money unchanged.

observe that we can approximate the objective of the government under the Hoover regime as

$$-\sum_{t=0}^{\infty} \beta^t (\pi_t^2 + \lambda_Y \tilde{Y}_t^2) \quad (58)$$

and this objective can be minimized by setting $\pi_t = \tilde{Y}_t = 0$. 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 .

$$\Delta \hat{G}_t^m = \epsilon_t \quad (59)$$

where ϵ_t is iid. 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

$$\Delta \hat{G}_t^m = \Delta M_t = \Delta \hat{Y}_t + \pi_t \quad (60)$$

which says that the gold flows will be reflected in a combination of higher inflation and output. However, recall that the objective of the government under the Hoover regime is (58) 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 (57), 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 (57) is binding. The solution will then satisfy (59), (60) 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 (57) – leads to deflation and contraction while an increase in G_t^m has no effect.

This asymmetric nature of the gold standard in the model accords relatively well with the how the gold standard worked in the US 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), p. 279-287, Temin (1989), p. 20). During the 1920's the Federal Reserve was accumulating gold in record quantities, mostly driven 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 1920's and during much of Hoover's term in office.⁷⁵ Interestingly, the reason the Federal Reserve gave for sterilization in the 1920's 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

⁷⁵ Consider February 1932. As Meltzer (2003, p. 275) observes, gold was used as collateral for 71 percent of the total note issued by the Federal Reserve at that time. Clearly the 40 percent gold minimum for the backing of money in inequality (57) was not binding.

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 (59) as long as $\hat{G}_t^m \geq 0$.⁷⁶

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 FDR regime change. To see this suppose that in 1933 $M_{1933} = \lambda_g P_G G_{1933}^m$ and assume that G_t^m is a constant. Under the Hoover regime the money supply at any date $t \geq \tau$ is smaller than M_{1933} so that gold standard constraint will not be binding in the future as can be seen in figure 8. Thus, as we have argued, the gold standard in (57) 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 FDR 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 FDR regime change, because it implies an upper bound on the money supply in the future. If we assume that G_t^m 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.⁷⁷ Hence the analysis supports the conventional wisdom that going off the gold standard was crucial to sustain the recovery.

7 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 governments 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 neither the short-term interest rate nor the money supply around the turning point in March 1933? This paper addresses this

⁷⁶The asymmetry is particularly important to understand why the intertemporal shocks have such a negative effect on prices and output in the model. Consider figure 8 that 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 this 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 be contracted at that time. Hence the constraint (57) will then be expected to be more lax. If instead (57) holds with equality at all times the gold standard would be equivalent to a price level target (as long as G_t^m is fixed). As has been shown by several authors (see e.g. Eggertsson and Woodford (2003)) a price level target will largely eliminate the negative consequences of the intertemporal shocks and the zero bound and this was also illustrated by our characterization of the approximate FDR policy regime. Hence the failure of the US to play by the "rules of the game" in the 1920 by sterilizing gold inflows – effectively creating an asymmetric gold standard – is key to understand the vicious propagation of the deflationary shocks in the 1930's. By the "rules of the game" I mean that they did not expand the money supply in the 1920's as they should have if they had conducted the gold standard with the inequality (57) holding with the equality sign.

⁷⁷Observe that a stochastic G_t^m can also make the Hoover regime even more contractionary because it may imply states of the world in which there is a speculative attacks that drain gold out of the system and cause a monetary contraction on top of the intertemporal shocks that cause the contraction in our model. Even if no such attacks occur, the expectation that they may occur, is enough to cause expectations to be even more deflationary. Britain going off gold in 1931 may have had some effects of this kind.

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 (1978), so that the government maximizes utility in a discretionary way. What separates the regime of President Hoover and FDR and explained the large shift in expectations was that FDR eliminated several policy dogmas which Hoover subscribed to, i.e. the gold standard, a balance budget dogma and a small government dogma. The paper attempts to motivate the policy dogmas, and their ultimate removal, in some detail from historical records.⁷⁸ 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 1933-37. In the absence of the regime change, however, the economy would have continued in free fall in 1933 and output would have been 30 percent lower in 1937 than in 1933, instead of registering the 39 percent output increase in this period.

⁷⁸It is worth noting that the policy dogmas of Hoover are not irrational. They could, for example, be motivated as "commitment devices", i.e. a solution of the usual inflation bias of government debt during wartime, or being due to political economy considerations. Those extensions are beyond the scope of the paper.

8 References

1. Auerbach, Allan, and Maury Obstfeld (2005) "The Case for Open Market Operations," American Economic Review, Volume 95, No. 1.
2. Barro, Robert J. (1979), "On the Determination of the Public Debt," The Journal of Political Economy, Volume 87, Issue 5, 940-971.
3. Barro, Robert (1979), "Money and the Price Level Under the Gold Standard," The Economic Journal. Vol. 89, No. 353, pp. 13-33
4. Barro, Robert J., and David B. Gordon. (1983) "A Positive Theory of Monetary Policy in a Natural Rate Model," The Journal of Political Economy, Volume 91, Issue 4, 589-610.
5. Baxter, Marianne and Robert G. King. (1993) "Fiscal Policy in General Equilibrium," The American Economic Review, Vol. 83, No. 3, June, p. 315-334.
6. Bernanke, Ben (1983), "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression," American Economic Review 73, pp. 257-276.
7. Black, Conrad (2003), "Franklin D. Roosevelt: Champion of Freedom," PublicAffairs, Perseus Books Group.
8. Blanchard Olivier and Charles M. Kahn (1980) – "The Solution of Linear Difference Models under Rational Expectations", Econometrica 48, pp. 1305-1313.
9. Bordo, M., Evans, C. and C. Erceg (2000), "Money, Sticky Wages, and the Great Depression" (with Michael Bordo and Charles Evans), American Economic Review, vol. 90, pp. 1447-63.
10. Bordo, Michael, Ehsan Choudhri, and Anna Schwartz (2000), "Was Expansionary Monetary Policy Feasible during the Great Contraction: An Examination of the Gold Standard Constant." Explorations in Economic History 39, 1-28.
11. Blinder, Alan S. (1998), "Central Banking in Theory and Practice", MIT University Press.
12. Brown, E. Cary, "Fiscal Policy in the 'Thirties: A Reappraisal," American Economic Review, Vol. 46, No.3, p. 857-879.
13. Bureau of Economic Analysis (1986), The National Income and Product Accounts, 1929-1982. Washington D.C.
14. Calvo, Guillermo. (1978) "On the Time Consistency of Optimal Policy in a Monetary Economy," Econometrica, November 1978.

15. Calvo, Guillermo. (1983) "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics*, 12: 383-98.
16. Clarida, Richard, Jordi Gali and Mark Gertler (1999), "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature* 37: 1661-1707.
17. Cole, H, and L. Ohanian (2004), "New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis," *Journal of Political Economy*, Volume 112, Number 4.
18. Cecchetti, S. (1988), "The Case of the Negative Nominal Interest Rates: New Estimates of the Term Structure of Interest Rates During the Great Depression," *Journal of Political Economy*, December, 96, p. 1111-41.
19. Cecchetti, S. (1992), "Prices during the Great Depression," *American Economic Review*, Vol 82, No. 1, March, p. 141-156.
20. Christiano, L., Motto, R. and M. Rostagno (2004), "The Great Depression and the Friedman-Schwartz Hypothesis," *Journal of Money, Credit and Banking*.
21. Christiano, L, Eichenbaum, M, and C. Evans (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, volume 113, pages 1-45.
22. Davis, Kenneth, S. (1986) "FDR The New Deal Years 1933-37," New York: Random House.
23. De Long, J.B., and Summers, (1986), "Is Increased Price Flexibility Stabilizing?" *American Economic Review* 76, 1031-1044.
24. Eccles, Marriner S. (1935). Testimony. House Committee on Banking and Currency. Hearings on the Banking Act of 1935. 74th Congress., 1st sess. Washington DC: Government Printing Office.
25. Eccles, Marriner S. (1951) "Beconing Frontiers," New York: Alfred A. Knopf Inc.
26. Eichengreen, B. and J. Sachs (1985), "Exchange Rates and Economic Recovery in the 1930s," *Journal of Economic History*, Vol. XLV, No. 4.
27. Eggertsson, Gauti (2003), "Fighting Deflation at Zero Interest Rates: Committing to Being Irresponsible," IMF Working Paper WP/03/64.
28. Eggertsson, Gauti. (2006), "The Deflation Bias and Committing to Being Irresponsible," *Journal of Money, Credit, and Banking*, 36 (2), p. 283-322
29. Eggertsson, Gauti and Jonathan Ostry (2005) , "Does Excess Liquidity Pose a Threat in Japan," *Federal Reserve Bank of New York Economic Policy Review*, forthcoming.

30. Eggertsson, Gauti and Eric Swanson (2007), "Optimal Time-Consistent Monetary Policy in the New Keynesian Model with Repeated Simultaneous Play," SF Fed, mimeo. Available at <http://www.ericswanson.us/>
31. Eggertsson, Gauti and Woodford, Michael (2003a), "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity* 1, 212-219.
32. Eggertsson, Gauti and Woodford, Michael (2003b), "Optimal Monetary Policy in a Liquidity Trap," NBER Working Paper no. 9968.
33. Eggertsson, Gauti and Michael Woodford. (2004), "Optimal Monetary and Fiscal Policy in a Liquidity Trap," ISOM conference volume, forthcoming.
34. Federal Reserve Board (1943), *Banking and Monetary Statistics*. Washington D.C. Available via FRASER at <http://fraser.stlouisfed.org/publications/bms/>.
35. Friedman, Milton. (1969), "The Optimum Quantity of Money," in *The Optimum Quantity of Money and Other Essays*, Chicago: Aldine, 1969.
36. Friedman, Milton and Anna Schwartz. (1963), "A Monetary History of the United States," Princeton University Press.
37. Giannoni, Marc, and Michael Woodford (2004), "Optimal Inflation Targeting Rules," in B. Bernanke and M. Woodford (eds.) *The Inflation Targeting Debate*, University of Chicago Press, Chap. 3: 93-162, 2004.
38. Goodfriend, M. and Robert King (1997), "The New Neoclassical Synthesis and the Role of Monetary Policy," *National Bureau of Economic Research 1997 Macroeconomics Annual*, pp.231-95.
39. Hamilton, James D. (1992), "Was the Deflation During the Great Depression Anticipated? Evidence from the Commodity Futures Market," *American Economic Review*, March, 82, p.157-82.
40. Harrison, Sharon G and Weder, Mark (2002), "Did Sunspot Forces Cause the Great Depression?," *Journal of Monetary Economics*, forthcoming.
41. Hicks J.R. (1937). "Mr. Keynes And the Classics." *Econometrica* 5, 1471-159.
42. Hsieh, C.T., and Christina Romer (2001), "Was the Federal Reserve Fettered? Devaluation Expectations and the 1932 Monetary Expansion," NBER Working Paper No. 8113.
43. Hoover, Herbert, (1934): "The state papers and other public writings of Herbert Hoover". edited by William Starr Myers. Doubleday, Doran & Co. Available at http://www.geocities.com/mb_williams/hooverpapers/.
44. Jeanne, O., and Svensson, L. (2004) "Credible Commitment to Optimal Escape from a Liquidity Trap: The Role of the Balance Sheet of an Independent Central Bank," mimeo, Princeton University.

45. Klein, Paul, Krussel, Per and Victor Rios-Rull. (2003), "Time-Consistent Public Expenditures," mimeo.
46. Keynes, John Maynard. (1936) "The General Theory of Employment Interest and Money", London: Macmillan.
47. Kinderlberger, C.P. (1986), "The World in Depression, 1929-1939", Berkeley: California University Press.
48. Krugman, Paul. (1998), "It's Baaack! Japan's Slump and the return of the Liquidity Trap," Brookings Papers on Economic Activity 2:1998.
49. Kwon, G., McFarlane, L, and Robinson, W.(2006), "Public Debt, Money Supply, and Inflation: A Cross-Country Study" IMF Working Paper, WP/06/121.
50. Kydland, Finn E. and Edward C. Prescott. (1977): "Rules Rather than Discretion: The Inconsistency of Optimal Plans." J.P.E. (85): pp. 473-91.
51. Kydland, Finn E. and Edward C. Prescott. (1982): "Time to Build and Aggregate Fluctuations." *Econometrica* Vol. 50, No. 6, pp. 1345-1370.
52. Lucas, Robert and Stokey, Nancy. (1983), "Optimal Fiscal and Monetary Policy in an Economy without Capital," *Journal of Monetary Economics* 12, p55-93.
53. Maskin, Eric. and Jean Tirole. (2001) "Markov Perfect Equilibrium: Observable Actions", *Journal of Economic Theory*.
54. Meltzer, Allan H. (2003): "A History of the Federal Reserve. Volume 1: 1913-1951", University of Chicago Press.
55. Nakamura, E, and Jon Steinsson (2006), "Five Facts About Prices: A Reevaluation of Menu Cost Models," mimeo, Harvard University.
56. The New York Times (1935),"Caution Discerned in Reserve Policy," pg.F1, December 21.
57. Ortigueira, Salvador (2006). "Markov-Perfect Optimal Taxation," *Review of Economic Dynamics* 9, 153–78
58. Romer, Christina D. (1988), "World War I and the Postwar Depression: A Reinterpretation Based on Alternative Estimates of GNP," *Journal of Monetary Economics* 22, pp 91-115.
59. Romer, Christina D. (1990), "The Great Crash and the Onset of the Great Depression." *Quarterly Journal of Economics* 105: 597-624.

60. Romer, Christina D. (1992), "What Ended the Great Depression?" *Journal of Economic History* 52, December : 757-784.
61. Roosevelt, Franklin D (1933a), "Presidential Press Conference on April 19th 1933," in "Complete presidential press conferences of Franklin D. Roosevelt," volume 1 p. 152-161. Da Capo Press. New York: 1972.
62. Roosevelt, Franklin D. (1933b), "Radio Address of the President on the 7th of May 1933", in *The Public Papers and Addresses of Franklin D. Roosevelt*. Random House. New York: 1938.
63. Roosevelt, Franklin D. (1933c), "Radio Address of the President on October 22nd 1933", in *The Public Papers and Addresses of Franklin D. Roosevelt*. Random House. New York: 1938.
64. Rotemberg, Julio. (1982), "Sticky prices in the United States", *Journal of Political Economy* 90, p. 1187-1211.
65. Sargent, Thomas and Neil Wallace. (1981) "Some Unpleasant Monetarist Arithmetic," *Federal Reserve Bank of Minneapolis Quarterly Review*, 5:3, 1-17.
66. Sargent, Thomas (1983), "The Ends of Four Big Inflations," in Robert Hall (Ed.), *Inflation: Causes and Effects*. University of Chicago Press.
67. Schmitt-Grohe, S and Martin Uribe. (2004) "Optimal Fiscal and Monetary Policy Under Sticky Prices," *Journal of Economic Theory*, vol 114, 198-230.
68. Smets, F. and R. Wouters, 2003. An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association*, vol. 1, 1124-1175.
69. Summers, Lawrence. (1991), "Panel Discussion: Price Stability. how Should Long-Term Monetary Policy Be Determined?" *Journal of Money, Credit and Banking*, 23(3), 625-631.
70. Sumner, Scott (1996), "Bold and Persistent Experimentation: Macroeconomic Policy during 1933," Bentley College, working paper
71. Sumner, Scott (1997), "News, Financial Markets, and the Collapse of the Gold Standard, 1931-32," *Research in Economic History*, 17, p. 39-89.
72. Sumner, Scott (2004), "Roosevelt, Warren, and the Gold-Buying Program of 1933", in *Exchange Rates and Economic Policy in the 20th Century*, eds. Catterall, R. and Aldcroft, D., Ashgate Publishing Group.
73. Svensson, Lars (2003), "Escaping from a Liquidity Trap and Deflation: The Foolproof Way and Others," *Journal of Economic Perspectives* 17-4, p. 145-166.

74. Temin, Peter, and Barrie Wigmore (1990), "The End of One Big Deflation," *Explorations in Economic History*, 27: p. 483-502. October.
75. Tobin, James (1975), "Keynesian Models of Recession and Depression," *American Economic Review Papers and Proceedings*, May, 65, pg. 195-202.
76. The Wall Street Journal (1933a), "Unconvincing Reassurance," pg. 5, November 2.
77. The Wall Street Journal (1933b), "Higher Commodity Prices Held Needed," pg. 11, May 1.
78. United States Department of the Treasury.(1932), "Annual Report of the Secretary of the Treasury, 1934," Government Printing Office.
79. United States Department of the Treasury.(1933), "Annual Report of the Secretary of the Treasury, 1934," Government Printing Office.
80. Woodford, Michael. (2003), "Interest and Prices: Foundations of a Theory of Monetary Policy", Princeton University.

9 Appendix 1: 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 et al (2005))

$$U_t = [\lambda_1 \log(C_t - H_t^c) + \lambda_2 \log G_t - \lambda_3 (L_t - H_t^l)^2] b_t \quad (61)$$

so that that $\sigma = \omega = 1$ (here $\lambda_1, \lambda_2, \lambda_3$ 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 four 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 authors try to match.⁷⁹ As a consequence we experiment 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

$$\kappa = \frac{(1 - \zeta)(1 - \zeta\beta)}{\zeta} \frac{\sigma^{-1}\delta_c^{-1} + \omega\delta_l}{1 + \omega\delta_l\theta} \quad (62)$$

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 3 quarters, a common value in the literature. To compute κ , we use (62) and then follow Schmitt-Grohe and Uribe (2004) by multiplying this by 4 to convert to annual frequency. This results in $\kappa = 0.1822$.

The government consumes 10 percent of output, so that $\delta_c = 0.1$. While the tax costs play no role under the Hoover regime due to the fiscal dogmas, they are important in the MPE under FDR 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 1933-37. The criteria is that collection cost 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.⁸⁰

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

⁷⁹Using quarterly data Giannoni and Woodford (2004) estimate it as being close to 1 while Christiano et al (2005) place it at 0.65.

⁸⁰Different choices for the tax function have little effect on the evolution of the endogenous variables (apart from taxes and debt) but imply that different level of debt will be issued to make those paths for the endogenous variables incentive compatible.

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 $\tilde{Y}_L = \hat{Y}_t - \gamma\tilde{Y}_{t-1}$ we obtain

$$\tilde{Y}_L = \frac{1-\gamma}{1-\gamma^4} \hat{Y}_{1933} \quad (63)$$

where $\hat{Y}_{1933}$ represent 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

$$\hat{r}_L^e = \hat{Y}_{1933} \frac{1-\gamma}{1-\gamma^4} \frac{\alpha(1-\beta(1-\alpha)) - \sigma\delta_c\kappa(1-\alpha)}{1-\beta(1-\alpha)} \sigma^{-1} \delta_c^{-1} \quad (64)$$

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 1931-33 as closely as possible.⁸¹ Observe by equation (33) that throughout the duration of the shock we have

$$\pi_L = \frac{\kappa}{1-(1-\alpha)\beta} \tilde{Y}_L = \frac{\kappa}{1-(1-\alpha)\beta} \frac{1-\gamma}{1-\gamma^4} \hat{Y}_{1933} \quad (65)$$

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

$$\begin{aligned} \min_{\alpha} \quad & \sum (\pi_L(\alpha) - \pi_t^{data})^2 \\ \text{s.t.} \quad & \alpha > \bar{\alpha} \text{ and } \alpha \in [0, 1] \end{aligned} \quad (66)$$

where the two constraints of the minimization problem are A2 and that the probability has to be between 0 and 1. As long as this minimization has an interior solution then

$$\pi_L = \frac{\sum \pi_t}{n} = \pi^* \quad (67)$$

so that by (65) we obtain

$$\alpha = \kappa \frac{1-\gamma}{1-\gamma^4} \frac{\hat{Y}_{1933}}{\pi^*} - \frac{1-\beta}{\beta} \quad (68)$$

which under the baseline calibration yields $\alpha = 0.1408$ so that the expected duration of the shock is

⁸¹We 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 1931-33 as can be seen in figure 6.

$\alpha^{-1} = 7.1$ years.⁸² Using this to substitute into (64) 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 4 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 (68), i.e. the minimization problem (66) has an interior solution. To see this observe that our procedure of picking the shocks is done so that π_L and $\hat{Y}_L$ satisfy (63) and (67), and both of these criteria only depend on the data and γ . Table 2 shows the range for the parameters $(\theta, \beta, \sigma^{-1}, \frac{1}{1-\zeta}, \omega)$ which would lead to the same result as shown in figure 4. Most estimates in the literature fall within these bounds, for example the range for β 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 wither $\theta = 4$ 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 can be seen in Table 4 (Table 4 and 5 report values for the shocks corresponding to several parameter variations). 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 1. If one imposes some prior on the shock, e.g. that only a shock in the range of -2% to -5% is "reasonable", with some prior on its duration, this would further narrow the range of permissible parameters in table 2. We do not impose such priors, but instead explore the robustness of the conclusions (i.e. if the FDR regime change can explain the recovery) to perturbing the structural parameters in table 2 within a wide range which 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). The footnote discusses how the results are affected for parameters outside the bounds in Table 2.⁸³

⁸²Included are all the full fiscal years that the Depression lasted, i.e. 1931, 1932 and 1933.

⁸³To study the issue of robustness further let us now consider values of the parameters that are outside the bounds in table 2 when either constraint $\alpha > \bar{\alpha}$ or $\alpha \in [0, 1]$ in (66) become binding. In this case either the criteria (63) or the interior solution (65) cannot be satisfied and one would need to decide how to trade them off.

Consider the following example: The range of parameters for ζ in table 2 imply an average duration between 1.7 and 3.4 quarters. Consider value the value $\zeta = 0.8$ so the average duration of price adjustment is 5 quarters. This implies a lower value for κ . Recall from equation (65) that a lower value of κ suggests that there will be less deflation associated with the output decline. A lower value of α can counteract this, since if the firms expect the low demand to persist, they will tend to lower their prices more. At some point, however, the bound $\alpha > \bar{\alpha}$ becomes binding. Under the assumption of $\zeta = 0.8$ then $\bar{\alpha} = 0.0561$ so the expected duration of the shock can be no longer than 17 years. An interior solution given by formula (68) requires $\alpha = 0.0196$ or an expected duration of 70 years. Figure 12 shows inflation when α is set slightly above $\bar{\alpha}$ (output is unchanged). The model can only generate a deflation of 6 percent under this calibration even when α is close to $\bar{\alpha}$. We also consider a case when $\zeta = 0.33$ i.e. prices are very flexible (with an expected duration 1.5 quarters). In this case a higher value of α counteracts the fall in prices but this parameter is bounded above by 1. Figure 12 shows that then the model over predicts the degree of deflation associated with the drop in output. Choosing a values for $\beta, \theta, \sigma, \omega$ outside the boundary in table 2 has the same effect, i.e. while the evolution of output is unchanged the model will over or under predicts the amount of deflation associated with the output drop. Observe that rather than under or over predice deflation, we could also choose to violate criterion (63) and let the model under or over predict the output decline. For values outside the boundaries given in the table one would need to pick some metric to make those trade-offs.

If the model represents the truth, the most reasonable interpretation for this finding is that the ranges of parameters reported in table 2 are the most plausible ones to consider, since once we move away from these values the model either over or under predicts the deflation relative to the data. The data from 1930-33 on inflation, output, and interest rates, however, cannot discriminate between the values of $\beta, \theta, \sigma, \omega$ that lie inside the ranges in table 2. This makes it a reasonable approach to "calibrate" these parameters using outside information, while keeping in mind that the exact values chosen are not crucial for the results under the Hoover regime. Once we explore the consequence of the regime change we consider how robust our

The path for output, $\hat{Y}_t$, reported in figure 4 is sensitive to the choice of γ since this parameter affects the ability of the model to explain a gradual downturn. Figure 11 shows output under several different choices of γ using (63). We observe that for a lower value of γ the decline is much faster than observed in the data. This is the reason for why we have chosen a relatively high value for γ in the baseline calibration. Observe that the improvement in fit is marginal above $\gamma = 0.8$, the value 0.85 only leads to a slightly more gradual decline in output.

The main question of the quantitative analysis addresses is if the regime change can explain the recovery, taking the values of the shocks as given by the criterion 64 and 68. The sensitivity analysis in figures 9 and 10 consider how the results change with reasonable variations in the structural parameters. As is clear from criterion 64 and 68, changing the structural parameters will alter the amplification properties of the model, so a different shock is needed to account for the Great Depression. The shocks corresponding to the different calibrations in the figure 9 and 10 are reported in table 4-5. It is worth briefly commenting on these variations. The business cycle literature typically considers values of θ around 8-12. The figure considers relatively large deviation for these standard values, considering a value as low as 4 and as high as 14. The value of β is chosen to match steady state real interest rate. Common estimates center around 4 percent which is the value we chose. We allow for large deviations from this number going from a steady state value of 2 percent to a steady state value of 8 percent. The functional form for the disutility of labor follows a common functional form in the literature (as in Christiano et al (2005)). Another common specification is to assume that disutility of working is in log form (see e.g. Cole and Ohanian (2004)) so we can write 61 as

$$\lambda_1 \log(C_t - H_t^c) + \lambda_2 \log G_t + \lambda_3 \log(1 - (L_t - H_t^l))$$

Using this specification and assuming that the representative household spend quarter of time in the workplace as Cole and Ohanian (2004) results in $\omega = 0.5$ in their model. To explore sensitivity for higher value of ω we assumed equal distance in the other direction, resulting in $\omega = 1.5$. Recent estimates on the frequency of prices (see e.g. Nakamura and Steinsson (2006)) suggest a frequency of price adjustment of between 8-11 months. Our baseline specification is close to the middle of this range, and corresponds to the most commonly used parameter used in the literature (see e.g. Rotemberg and Woodford (1997)). In the sensitivity analysis we consider a value in the lower range of their estimate. For the higher degree of price rigidities we consider 10 months which is at the upper boundary of the permissible values for ζ listed in table 2. For higher value of ζ we would need to compromise on the fit of the model, as explained in footnote 83, because if the model is calibrated with such rigid prices it has difficulty explaining the large fall in the price level in the data. We also consider variations in the parameter σ . By far the most common value in the literature is the log specification, although it is sometimes assumed that relative risk aversion

conclusions are by conducting robust checks allowing all of the parameters to vary within the bounds set in table 2. Of course we could also consider robustness for values outside the bounds, but in this case the model is not as successful in replicating the deflation prior to the regime change.

is higher. We consider a couple of higher values for this parameter, $1/2$ and $1/3$. Finally we consider variations in the habit persistence parameter γ . The results are most sensitive to this variations, as already discussed in the context of figure 11, but a higher value of γ explains a more gradual downturn. The same hold for the recovery, the lower the value of γ the more rapid the recovery. To illustrate this we plot results for the entire range from 0 to 0.8 in figures 9 and 10.

10 Appendix 2: Random deviations from the MPE

To obtain this solution we solve backwards. In 1933 the solution is the same as under the Hoover Regime. Taking the equilibrium in 1933 as given output and inflation in 1932 solves

$$\pi_{1932} = \kappa \tilde{Y}_{1932} + \beta(1 - \alpha)\pi_{1932}$$

$$\tilde{Y}_{1932} = (1 - \alpha)\tilde{Y}_{1933} - \sigma\delta_c i_{1932} + \sigma\delta_c(1 - \alpha)\pi_{1933} + \sigma\delta_c r_L^e$$

where we now use actual data for interest rates on the right hand side. We then can similarly solve for 1931 and 1930 using the solution above for 1932. As the dashed line illustrates, the quantitative consequence of this policy mistake is small and barely visible in the graph, since it reduces output only by approximately one percentage point and increases deflation by about 0.2 of a percentage point.

11 Appendix 3: Deriving the government non-linear first order conditions and steady states

Here I write the most general form of a policy regime which includes all the policy regimes considered in the paper. Each of the policy dogmas is added as a constraint. In the general formulation each constraint is multiplied by a indicator function D^i which takes the value 1 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 as⁸⁴

$$\frac{M_t}{M_{t-1}} = \frac{Y_t}{Y_{t-1}}\Pi_t \quad (69)$$

⁸⁴For simplicity I write this constraint as an equality. This is without loss of generality since the inequality is only slack at zero interest rate where the money supply is indeterminate. What this means is that I pick the lowest level of money supply consistent with equilibrium at zero interest rates.

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

$$\begin{aligned}
V(Y_{t-1}, w_{t-1}, M_{t-1}, \xi_t, G_t^m) &= \max[u(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t), \xi_t) + g(G_t, \xi_t) - v(Y_t, \xi_t)] + \beta E_t V(Y_t, w_t, M_t, \xi_{t+1}, G_{t+1}^m) \\
&\text{subject to} \\
&(2), (4), (6), (7), (8), (9), (10), (11), (13), (14) \text{ and } (69) \\
&\text{and the policy dogmas:} \\
&D^1 * (\text{equation 16}), D^2 * (\text{equation 17}), D^3 * (\text{inequality 57})
\end{aligned}$$

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

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

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 non-linear equations for the linearized first order conditions (28)-(31) and (44)-(51) reported in the paper, simplifying the general problem a bit by taking account of the policy regime under study.

11.1 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 $\phi_{4t} = 0$ so 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:

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

giving rise to the first order conditions

$$\frac{\partial L}{\partial \Pi_t} = -u_c d' + \phi_{2t} d' u_{cc} + \phi_{3t} [d' u_c + \Pi_t d'' u_c - \Pi_t d'^2 u_{cc} - \theta u_{cc} d' Y_t] = 0 \quad (70)$$

$$\begin{aligned}
\frac{\partial L}{\partial Y_t} = & u_{c,t} - v_{y,t} + \beta E_t V_y(Y_t, w_t, \xi_{t+1}) + \phi_{2t} [\beta f_Y^e(1 + i_t) - u_{cc}] \\
& + \phi_{3t} [\Pi_t d' u_{cc} - \theta v_{yy} + \theta Y_t u_{cc} - \theta(v_y - u_c)] - \phi_{3t} \beta S_Y = 0
\end{aligned} \quad (71)$$

$$\frac{\partial L}{\partial i_t} = \phi_{2t} \beta f^e(Y_t, w_t) + \gamma_{1t} \quad (72)$$

and the complementary slackness conditions

$$\gamma_{1t} i_t = 0, \quad i_t \geq 0, \gamma_{1t} \geq 0 \quad (73)$$

and the envelope condition

$$V_Y(Y_{t-1}, w_{t-1}) = -\gamma u_{c,t} + \gamma v_{y,t} + \phi_{2t} \gamma u_{cc} + \phi_{3t} \gamma [\theta v_{yy} Y_t - \Pi_t d' u_{cc} - \theta Y_t u_{cc}] \quad (74)$$

Recalling that $d'(1) = 1$ it is easy to confirm using (2),(4),(7),(8),(9),(11) and (70)-(74) 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 (70)-(74) around this steady state (we use the normalization that $\bar{u}_c = 1$).

11.2 The FDR Regime

Under the FDR 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 because the first order condition with respect to the money supply yield $\phi_{4t} = 0$. We can then rewrite the Lagrangian as:

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

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

yielding the first order conditions:

$$\begin{aligned}
\frac{\partial L}{\partial \Pi_t} = & -u_c d' + \phi_{1t} (1 + i_t) w_{t-1} \Pi_t^{-2} \\
& + \phi_{2t} d' u_{cc} + \phi_{3t} [d' u_c + \Pi_t d'' u_c - \Pi_t d'^2 u_{cc} - \theta u_{cc} d' Y_t]
\end{aligned} \tag{75}$$

$$\frac{\partial L}{\partial w_t} = \beta E_t V_w(Y_t, w_t, \xi_{t+1}) + \phi_{1t} + \phi_{2t} \beta f_w^e (1 + i_t) - \phi_{3t} \beta S_w^e - \gamma_{2t} = 0 \tag{76}$$

$$\begin{aligned}
\frac{\partial L}{\partial F_t} = & -u_c(Y_t - \gamma Y_{t-1} - F_t - d(\Pi_t), \xi_t) + g(F_t - s(T_t) - R_t, \xi_t) \\
& - (1 + i_t) \phi_{1t} + \phi_{2t} u_{cc} - \phi_{3t} \Pi_t d' u_{cc} - \phi_{3t} \theta u_{cc} Y_t
\end{aligned} \tag{77}$$

$$\frac{\partial L}{\partial T_t} = -g_s'(T_t) + \phi_{1t} (1 + i_t) \tag{78}$$

$$\begin{aligned}
\frac{\partial L}{\partial Y_t} = & u_{c,t} - v_{y,t} + \beta E_t V_Y(Y_t, w_t, \xi_{t+1}) + \phi_{2t} [\beta f_Y^e (1 + i_t) - u_{cc}] \\
& + \frac{\phi_{3t}}{\bar{u}_c} [\Pi_t d' u_{cc} - \theta v_{yy} + \theta Y_t u_{cc} - \theta (v_y - u_c)] - \frac{\phi_{3t}}{\bar{u}_c} \beta S_Y
\end{aligned} \tag{79}$$

$$\frac{\partial L}{\partial i_t} = -\phi_{1t} [w_{t-1} \Pi_t^{-1} + F_t - T_t] + \phi_{2t} \beta f^e(Y_t, w_t) + \gamma_{1t} \tag{80}$$

the two complementary slackness conditions:

$$\gamma_{1t} i_t = 0, \quad i_t \geq 0, \quad \gamma_{1t} \geq 0 \tag{81}$$

$$\gamma_{2t} (\bar{w} - w_t) = 0, \quad \bar{w} \geq w_t, \quad \gamma_{2t} \geq 0 \tag{82}$$

and the envelope conditions:

$$V_Y(Y_{t-1}, w_{t-1}) = -\gamma u_{c,t} + \gamma v_{y,t} + \phi_{2t} \gamma u_{cc} + \phi_{3t} \gamma [\theta Y_t v_{yy} - \Pi_t d'(\Pi_t) u_{cc} - \theta Y_t u_{cc}] \tag{83}$$

$$V_w(Y_{t-1}, w_{t-1}, \xi_t) = -\phi_{1t} (1 + i_t) \Pi_t^{-1} \tag{84}$$

Recalling that $d'(1) = 1$ it is easy to confirm using (2),(4),(7),(8),(9),(11) and (75)-(84) 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 (70)-(74) around this steady state (we use the normalization that $\bar{u}_c = 1$).

12 Appendix 4: Data

Total federal expenditures along with revenues are published by the White House 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. 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 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 only counting 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' 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 Office of Management and Budget. 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 one because it is a better account of the difference between *all* government spending and taxes and is 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 '34. The OMB budget data mostly reflect direct inflows and outflow 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 funds from the General Fund. To make up for 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 that 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 non-borrowed 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 FDR's inauguration in March of 1933. The short-term interest rate is the constant maturity yield on 3 month Treasuries estimated by Cecchetti (1988). Ex-post real interest rates are deflated using the 3 month ahead annualized percent change in the Total CPI. The data on real interest rate 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 White House Office of Management and Budget (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.

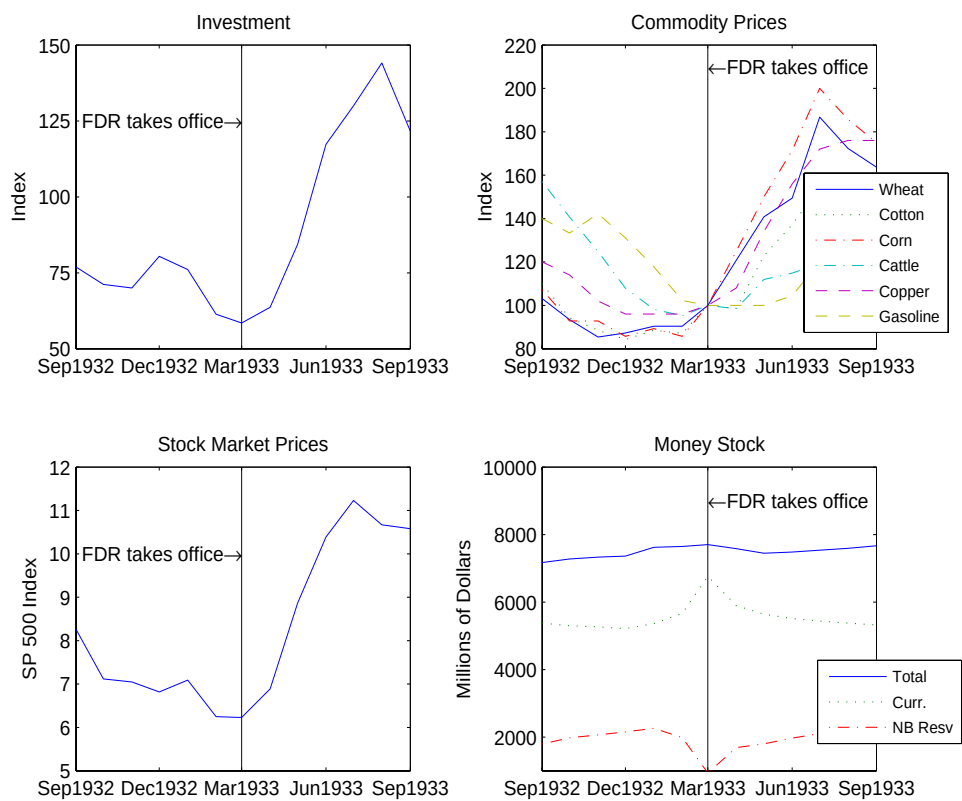
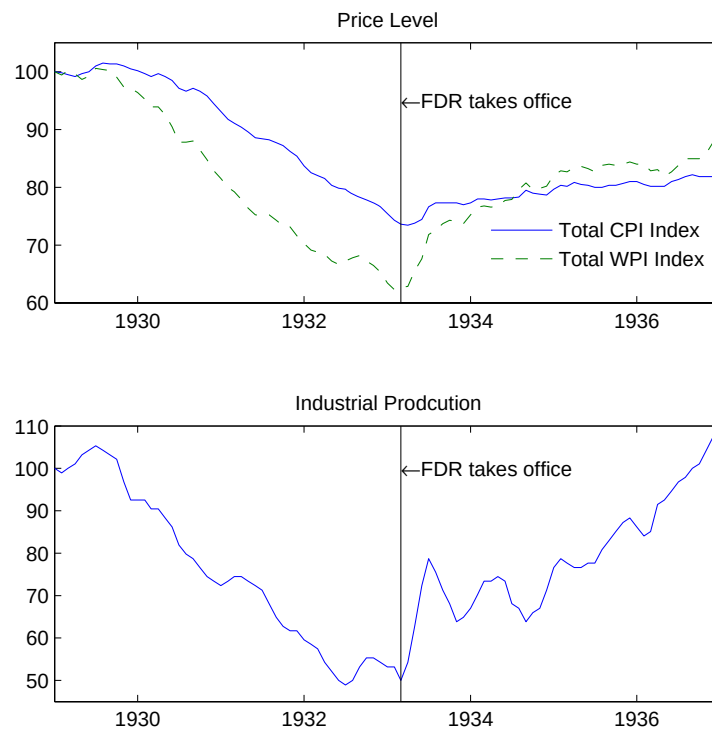


Figure 1: Investment, commodity prices and the stockmarket rebounded once FDR took office. This large change in these forward looking variables cannot be explained by contemporaneous changes in the money supply, that did not change around the turning point.



Source: Bureau of Labor Statistics

Figure 2: The Consumer Price Index, Wholesale Price Index and Industrial Production started recovering in March 1933 after a long an contraction.

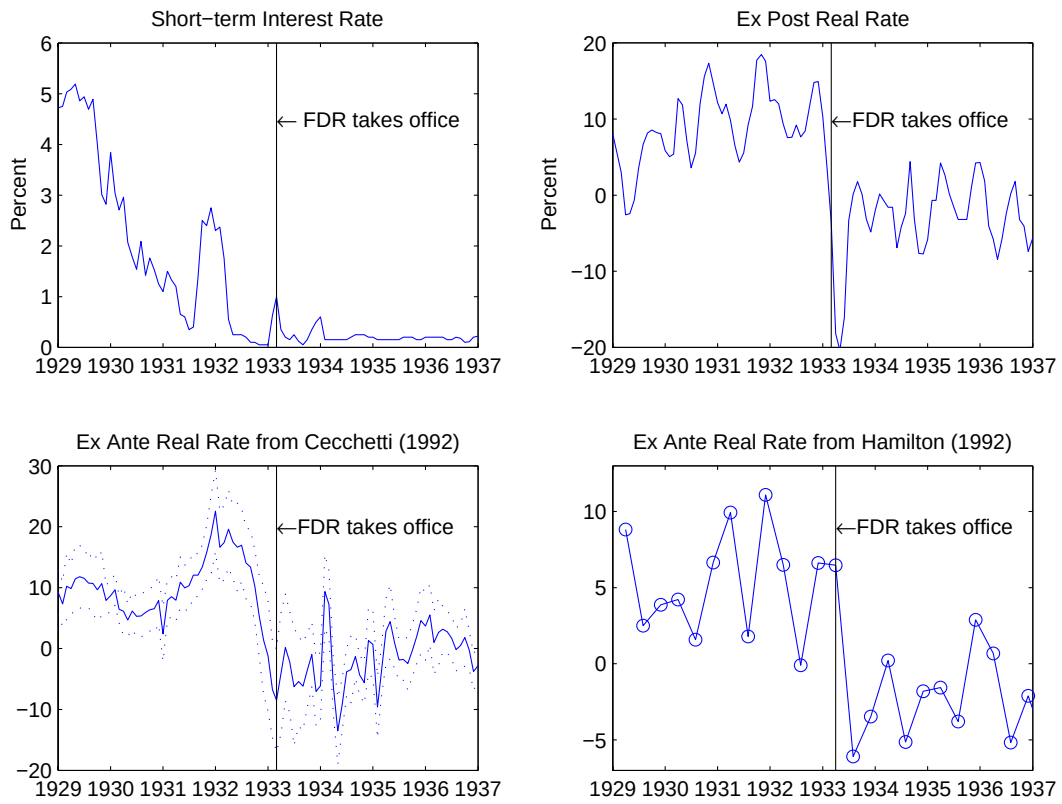


Figure 3: Real interest rate collapsed around the turning point, even if the short term nominal interest rate did not change much. This suggest a large change in inflation expectations.

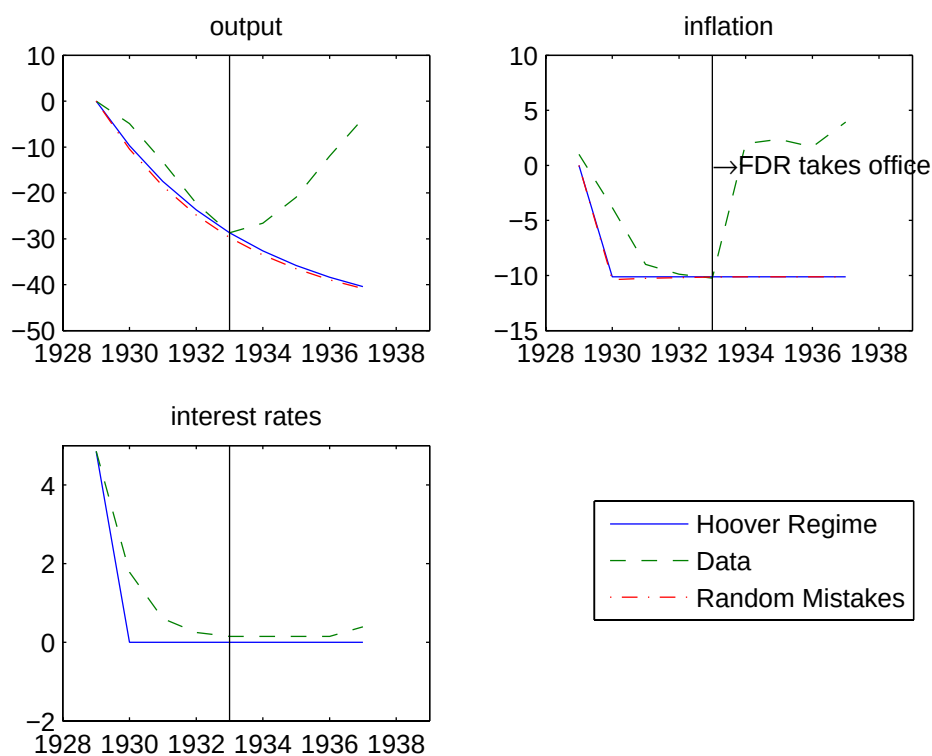


Figure 4: The Hoover Regime can account for a large decline in output and prices during 1929-1933. In 1933-37 a Hoover regime would have suggested a continuing collapse in output and prices while the data registers strong recovery. The paper tries to explain this recovery by modeling a regime change. The somewhat more gradual decline in the short-term nominal interest rate than observed in the data – corresponding to non-systematic policy errors in the model – have trivial quantitative consequences under the baseline calibration as shown by the dashed line labelled as "Random Mistakes".

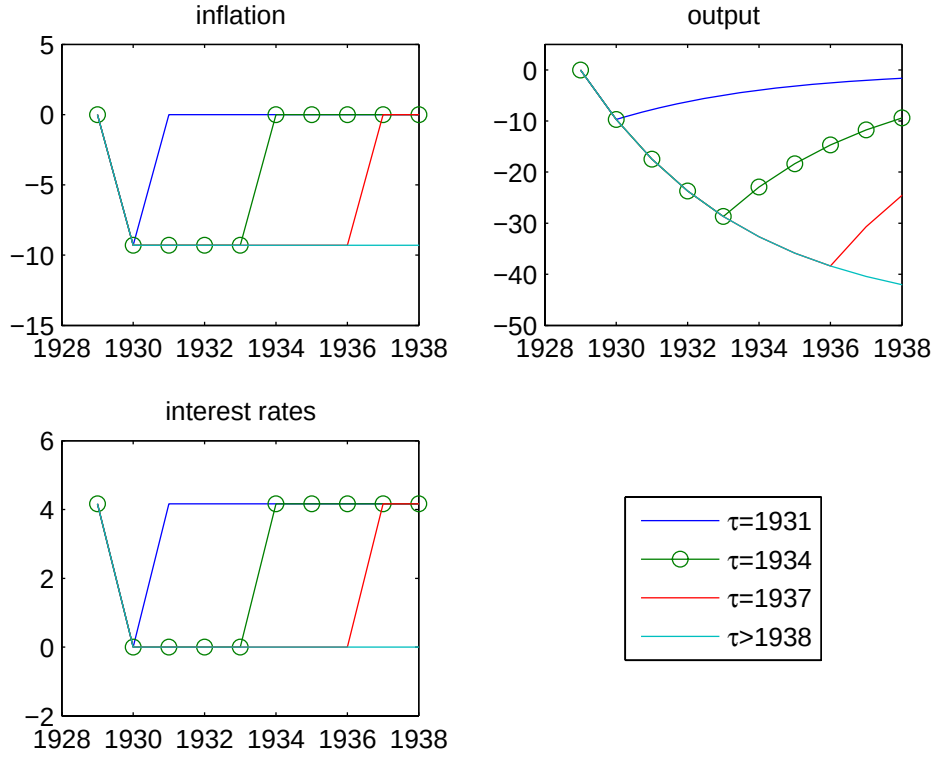


Figure 5: This figure shows the evolution of output, inflation and interest rate under several different assumption about when the shock reverts r_L^e back to steady state. The maintained assumption in the paper is that the shock stays in the "low" state throughout the recovery period 1933-37. This is consistent with the data which shows that the short term nominal interest rate stayed at zero throughout this period.

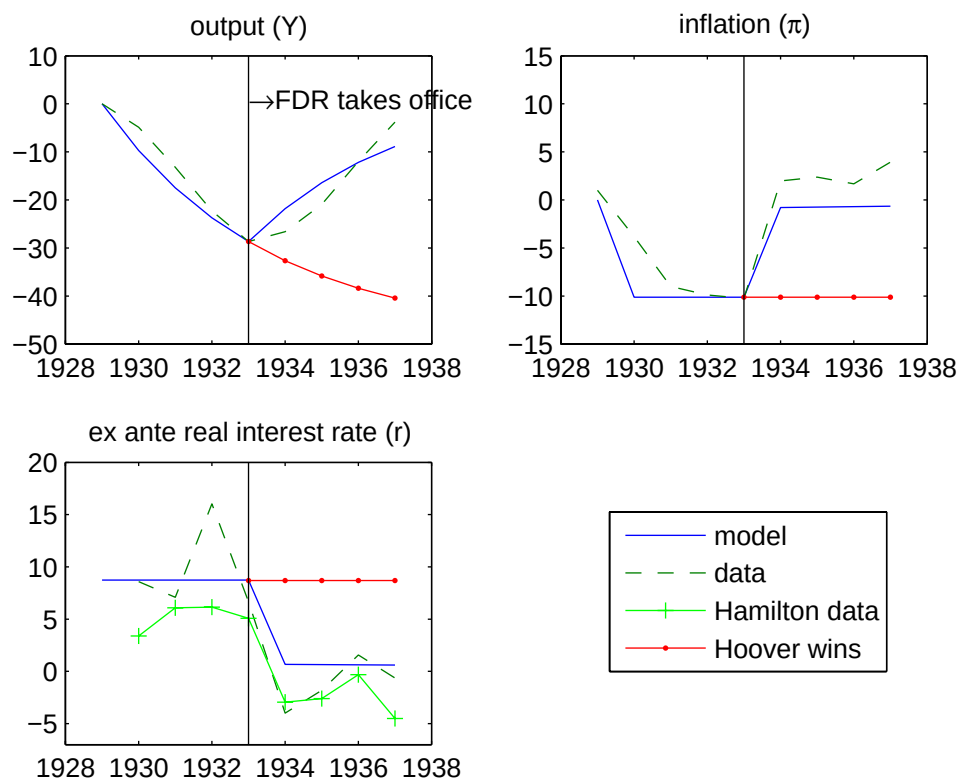


Figure 6: The FDR regime change implies a collapse in real interest rate and a robust recovery in prices and output. The regime change can account for 67 percent of the recovery in prices and 79 percent of the recovery in output in the period 1933-37. The dashed line contrast the FDR regime change with the counterfactual Hoover regime.

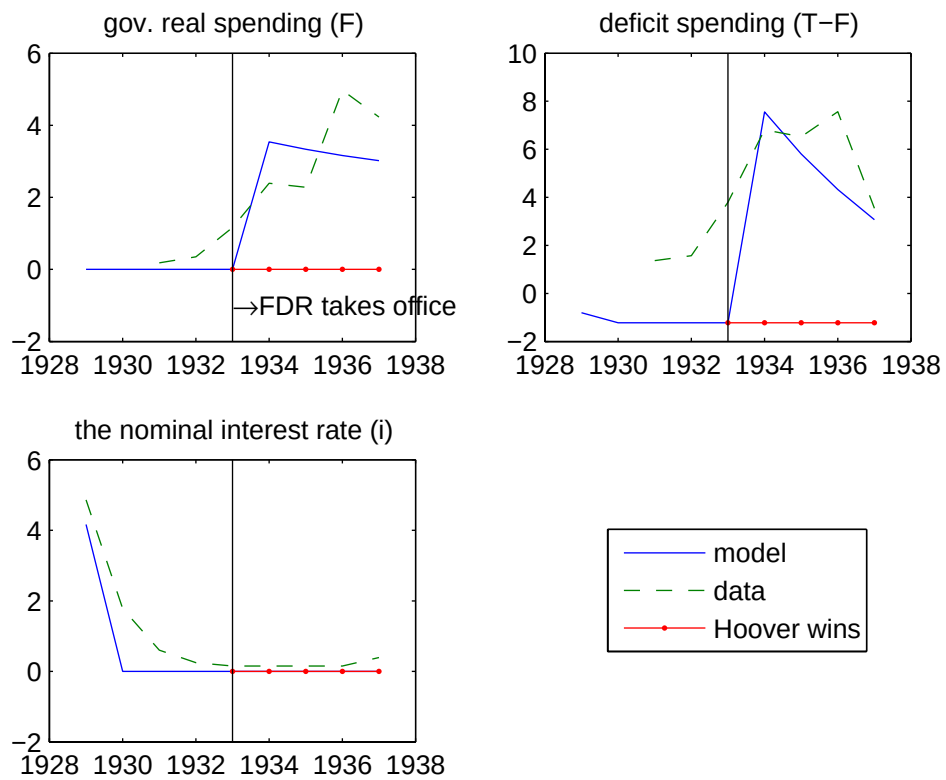


Figure 7: The FDR regime change implies a large increase in real government spending and in deficits, while the interest rate remain at zero.

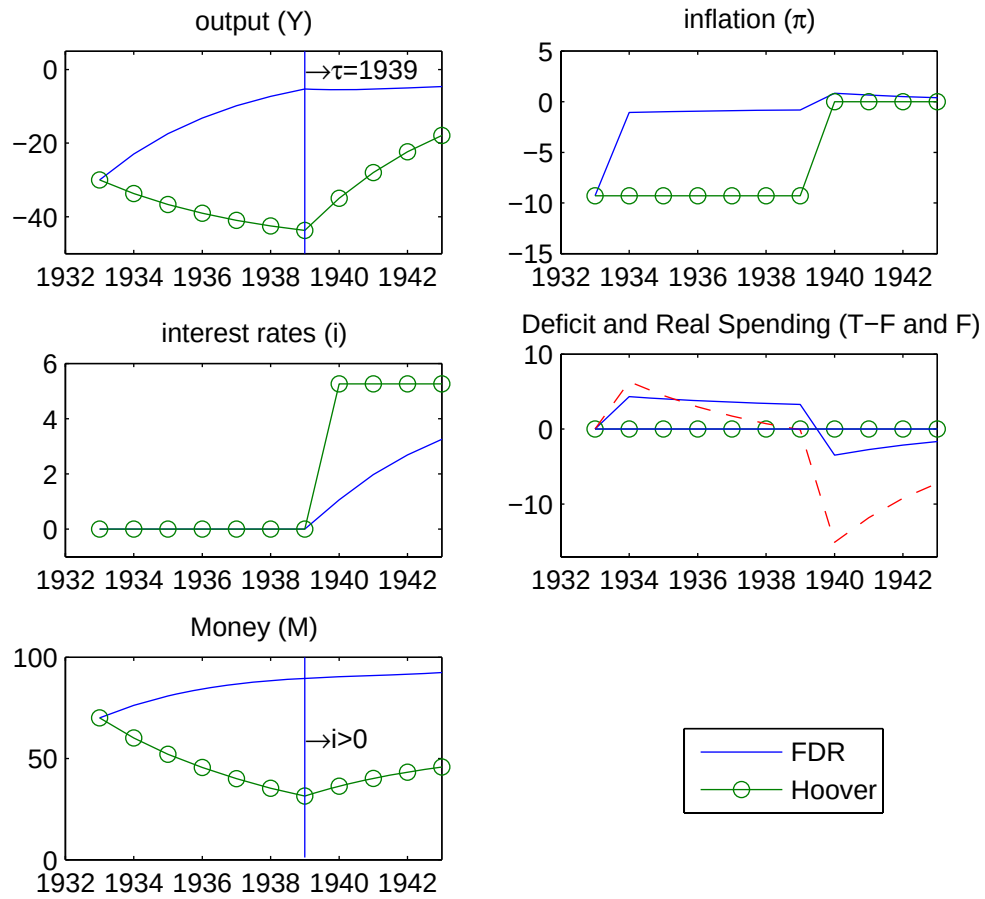


Figure 8: This figure contrast the FDR regime to the counter factual Hoover regime under the assumption that the structural shock revert to steady state in 1939. The figure reveals that the FDR regime implies a commitment to low future nominal interest rate and a substantial increase in the monetary base relative to the Hoover regime. The money supply is about 50 percent higher under the FDR regime than under the Hoover regime under this contingency.

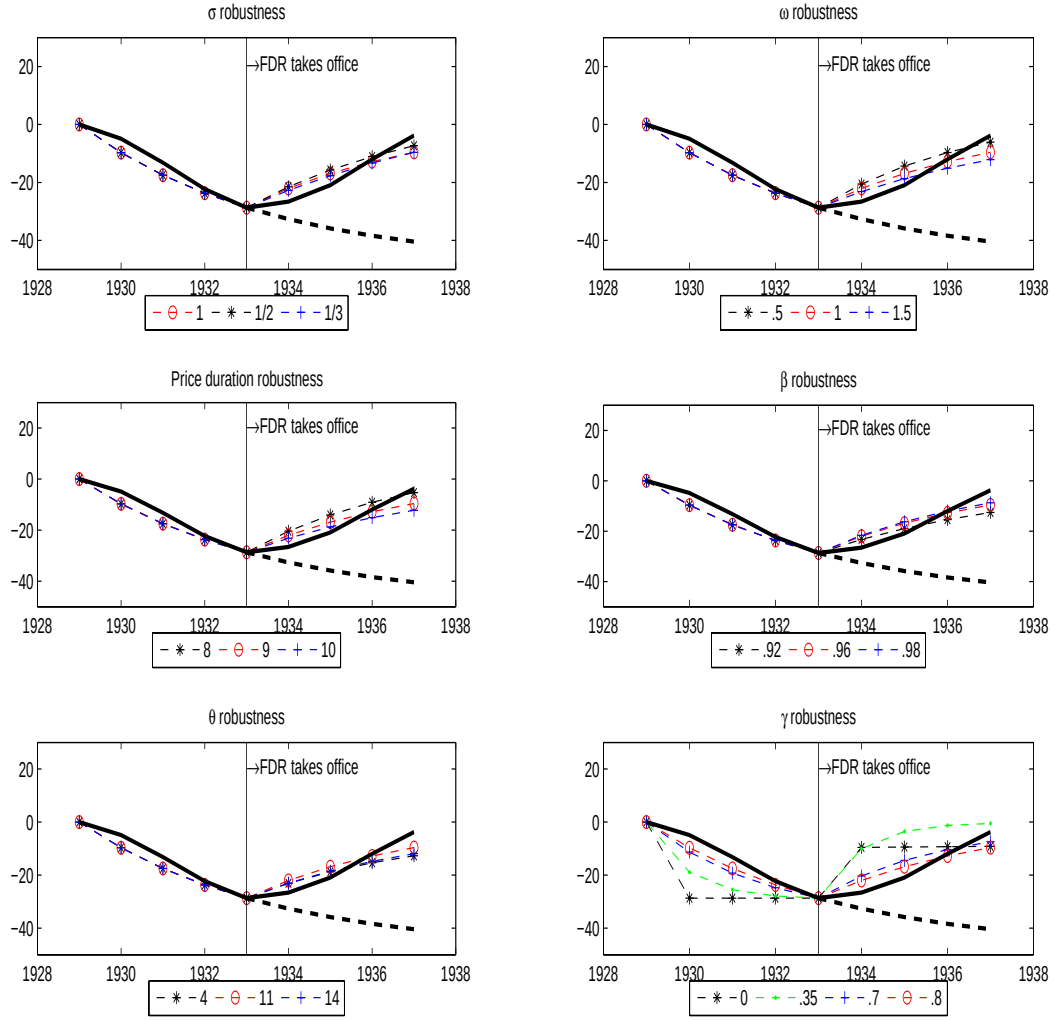


Figure 9: This figure shows the sensitivity of the results for output with respect to different choices of the structural parameters. Observe that different choice of the parameters will lead to different choice for the shocks according to the criterion in Appendix 1 as shown in Table 4-5.

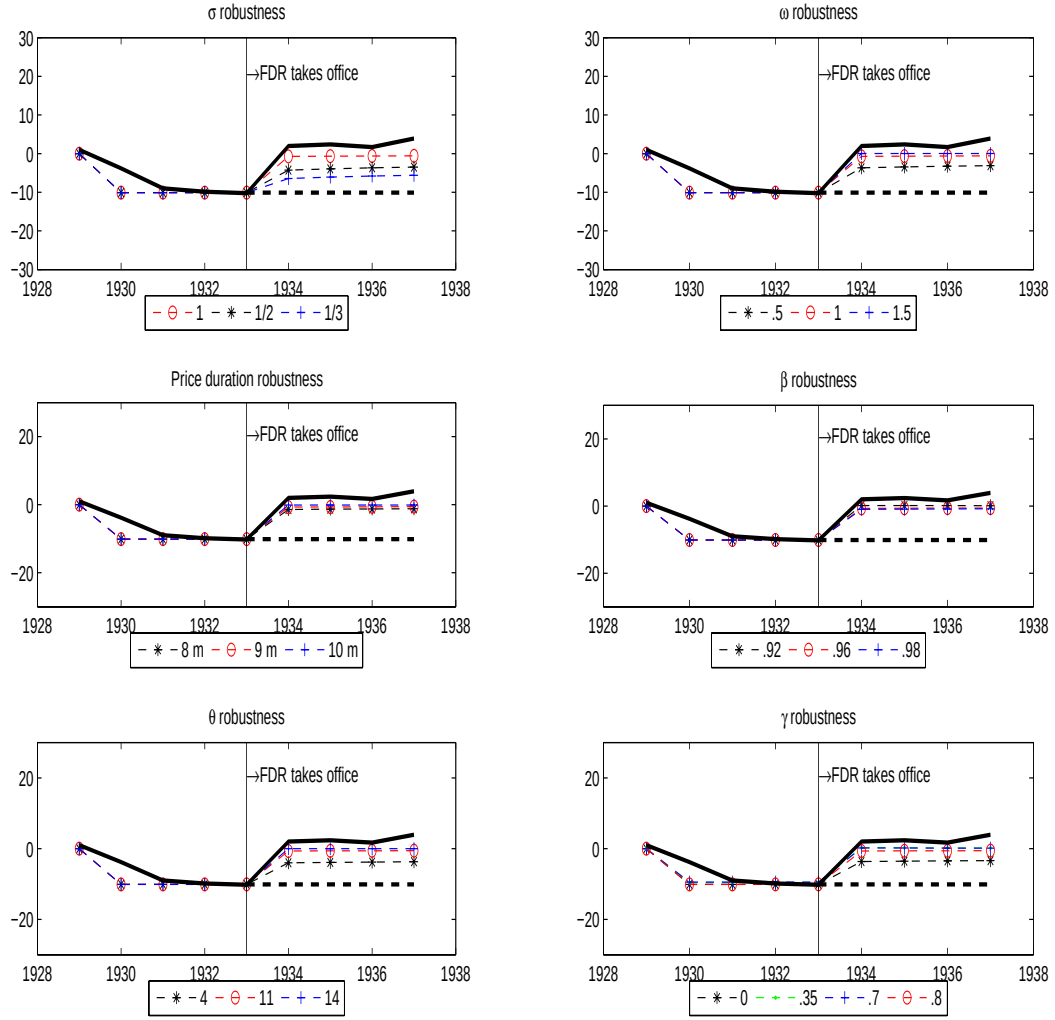


Figure 10: This figure shows the sensitivity of the results for inflation with respect to different choices of the structural parameters. Observe that different choice of the parameters will lead to different choice for the shocks according to the criterion in Appendix 1 as shown in Table 4-5.

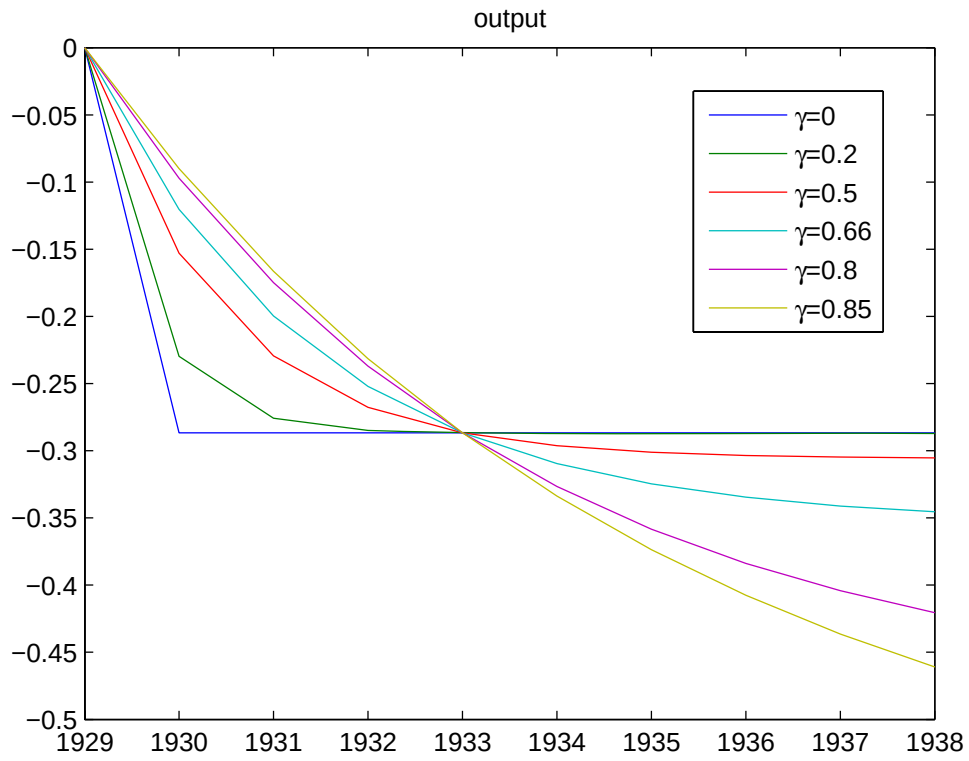


Figure 11: This figure is associated with the sensitivity analysis in the appendix. It shows that the choice of the habit persistence parameter γ has strong effect on the ability of the model to generate a gradual downturn.

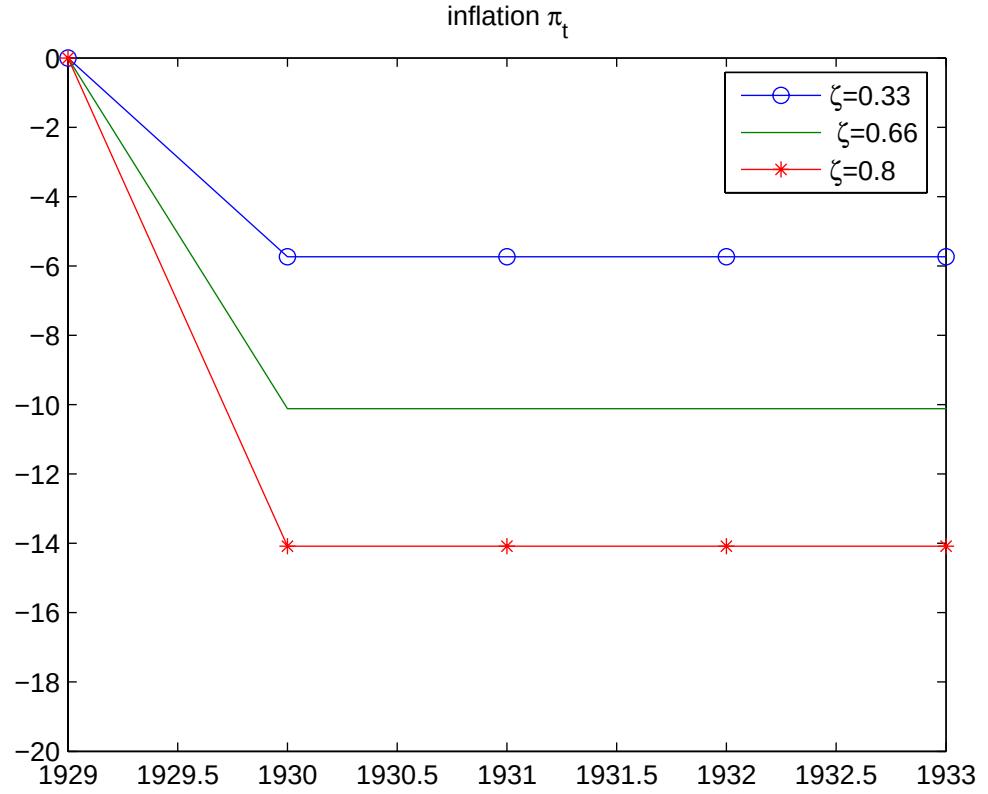


Figure 12: This figure is associated with the sensitivity analysis in the Appendix. It illustrates that if we choose parameter configurations for the structural parameters outside of Table 2 we are faced with trading off if we want to matching the output contraction in 1933 observed in the data versus the decline in prices during the period. This figure shows that if we assume very rigid prices (and ask the model to match the output contraction) the model cannot account for the strong collapse in prices seen in the data. If we assume very flexible prices, on the other hand, the model would require stronger collapse in prices than predicted by the data. This suggest that there is no reason to constrain oneself to the parameter range in table 2, as long as one is willing to compromise on the fit of the model as defined by the criteria for output and inflation defined in the Appendix.

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	1,829	2,286	3,278	3,374	5,565	5,092	5,719	6,018	6,472	17,973
Total Expenditures	3,540	3,917	3,749	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
Non-borrowed 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 - revenues	-738	461	2,735	2,601	3,586	2,803	4,305	2,193	89	2,846	2,920	4,941
Total expenditures - 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 Federal Reserve Board publication *Banking and Monetary Statistics 1914-1941*

¹ Reported in calendar years

² Gold Purchases are corrected for a 2.81 billion increase in 1934 after the revaluation of gold against the dollar

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

Figure 13: Key monetary and fiscal statistics from the Great Depression

Table 2

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
κ	0.1822
shocks	
r_L^e	-0.0497
α	0.1406

Table 3

	min	max
Expected duration of price changes ($\frac{1}{1-\zeta}$)	1.7	3.44
θ	1.8	14.8
ω	0.125	1.95
σ^{-1}	0.74	7.14
β	0.9040	1

Table 4

	<i>Baseline</i>	$\theta = 4$	$\theta = 14$	$\beta = 0.92$	$\beta = 0.98$	$\sigma = 1/2$	$\sigma = 1/3$
r_L	-0.0497	-0.3755	-0.0084	-0.0012	-0.0938	-0.4347	-1.0557
α^{-1} (expected duration in years)	7.1	2.3	9.8	10.1	5.6	3.8	2.6
$\bar{\alpha}^{-1}$	9	5.5	10.3	10.2	8	10	10.4

Table 5

	<i>Baseline</i>	$\omega = 0.5$	$\omega = 1.5$	$\frac{1}{1-\zeta} = 2.667$ (8 months)	$\frac{1}{1-\zeta} = 3.33$ (10 months)
r_L	-0.0497	-0.1743	-0.0071	-0.1171	-0.0055
α^{-1} (expected duration in years)	7.1	3.9	9.9	4.9	10
$\bar{\alpha}^{-1}$	9	7	10.3	7.7	10.4