Fiscal Multipliers and Policy Coordination

Gauti B. Eggertsson
Federal Reserve Bank of New York

It is important to recognize that the role of an independent central bank is different in inflationary and deflationary environments. In the face of inflation, which is often associated with excessive monetization of government debt, the virtue of an independent central bank is its ability to say "no" to the government. With protracted deflation, however, excessive monetary creation is unlikely to be the problem, and a more cooperative stance on the part of the central bank may be called for.

—Ben Bernanke, (2003)

This paper is about an economy in a liquidity trap, that is, an environment with a zero nominal interest rate, deflationary pressures, and subpar growth. The paper shows two fiscal policy multipliers in a relatively standard New Keynesian liquidity trap economy with taxation costs. It computes real government spending multiplier and the deficit spending multiplier. In line with recent literature, it shows that the real government spending multiplier can be quite big. The deficit spending multiplier, however, can be either big or zero, depending on the institutional arrangement. That is the main point of the paper.

It is perhaps a bit misleading to talk about a deficit spending multiplier, but I do this to sharpen the distinction between this mechanism relative to real government spending. The deficit spending multiplier in this paper refers to the effect that increasing nominal debt has on output. In a Ricardian environment, where the choice between

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debt and taxes is irrelevant, this multiplier is zero. Things change, however, if there are costs of taxation. In this case, a high nominal debt can trigger expectations of higher future inflation because the discretionary government optimally trades off between costly taxation and some inflation. Expectation of some future inflation is exactly what is needed in an economy with a zero short-term nominal interest rate and deflationary pressures, because with the interest rate stuck at zero, higher inflation expectations reduce the real rate of interest and thus stimulate demand. Hence, higher debt leads to higher inflation expectations, lowering the real interest rate, which in turn leads to an output expansion. One interesting aspect of this is that while standard budget deficits lead to higher debt, that is not the only way nominal debt can be increased. Any policy action that increases debt, such as printing money (or bonds) and buying privately held assets like foreign exchange or stocks, also does the trick, as does dropping money (or bonds) from helicopters. The deficit spending multiplier is therefore a catchphrase for things that increase government debt and thus affect the inflation incentive of the government.

The main focus in this paper is on optimal policy when the government cannot commit to future policy (that is, optimal policy under discretion), which puts relatively strong restrictions on what sort of taxes the government can levy. The problem of the liquidity trap can largely be eliminated in most general equilibrium models if the government can commit to higher future money supply or, equivalently, a higher future price level.[1] The optimal monetary policy commitment in Eggertsson and Woodford (2003), for example, makes the problem of the zero bound pretty trivial. One way to understand how bad things can happen in these models at a zero interest rate, therefore, is to say that this commitment cannot be achieved due to credibility problems (see Eggertsson, 2006b). If the monetary authorities increase the money supply today, the problem boils down to this: how can they commit to not reducing the money supply back to its original level in the future? This puts a certain perspective on monetary and fiscal cooperation. Monetary-fuelled fiscal expansion is a way of credibly committing the government to a higher future money supply.

1. See, for example, Krugman (1998); Eggertsson and Woodford (2003); Eggertsson (2006b); Auerbach and Obstfeld (2006). The problem can similarly be eliminated if the government has access to a sufficiently rich number of fiscal instruments; see Eggertsson and Woodford (2003).

While the mechanism through which deficits and debt can increase inflation is relatively obvious, its existence relies on a key assumption. Not only does it require some cost of taxation, but it will also only work to the extent that monetary authorities react to the inflation incentives this nominal debt creates. If the monetary authority does not react to this inflation incentive, then the deficit multiplier spending is also zero. In some respects, modern independent central banks have been developed precisely to eliminate inflationary incentives. Hence, under modern institutional arrangements, it is not all that clear that this multiplier is all that big, if it exists at all. That is one motivation for monetary and fiscal policy coordination, and one goal of this paper is to try to clarify what coordiation means both in theory and practice.

In this paper, an independent central bank is defined as a bank that has an objective other than optimizing social welfare and whose policy choices are not influenced by the government budget constraint or borrowing limits. Coordinated monetary and fiscal policy, on the other hand, is when policymakers jointly set monetary and fiscal policy to maximize social welfare and are both responsible for satisfying the government's budget constraint and debt limit. Under coordination, deficit spending increases output and the price level when the interest rate is zero because it credibly increases expectations about the future money supply, since this has fiscal benefits.[2] Without coordination, this link is broken because the central bank does not internalize the fiscal consequences of its actions. Therefore, deficit spending and other actions that affect the government balance sheet (such as foreign exchange interventions and purchases of real assets) have no effect on nominal output and the price level if the central bank is goal independent.

This perspective on coordinated monetary and fiscal policy provides an interesting interpretation of several proposals that are common in the literature, which often implicitly (or explicitly) assume some form of coordination. Caballero (2010), for example, recommends a "helicopter drop" of money from the Federal Reserve to the Treasury.[3] This paper's framework clarifies that such an action only has an effect if the Federal Reserve cares about the fiscal consequences of its action or, more precisely, that its own budget

2. See Calvo (1978); Barro and Gordon (1983); Lucas and Stokey (1983); Eggertsson (2006b, 2008); Auerbach and Obstfeld (2005).

3. Bernanke (2003) and Auerbach and Obstfeld (2005) make similar proposals.

constraint or that of the Treasury plays a role in the Federal Reserve's policymaking. In the absence of fiscal considerations, there is nothing to prevent the Fed from undoing the helicopter drop as soon as the economy improves (that is, when the nominal interest rate rises), rendering the policy irrelevant.

While the main point of the paper is positive, the normative implications are a topic in itself. The results indicate that some cooperation between the treasury and the central bank can be helpful to combat a deflationary shock, as argued by Ben Bernanke, then Governor of the Federal Reserve, in Japan in 2003, as cited above. Such cooperation may not be necessary, however, to the extent that the central bank can make credible commitments about future policy. One way to think about coordination, then, is as an escalation plan that is implemented if monetary policy reflation lacks credibility.

The importance of fiscal policy emphasized here relates to the recent literature on the fiscal theory of the price level.[4] The key difference between my model and these contributions is that I model the government as a maximizing agent subject to certain constraints while the fiscal theory characterizes policy by exogenous policy rules. This alternative modeling strategy allows me to clarify the role of central bank independence and a richer interpretation of the role of coordination.

1. A Tale of Two Countries

The way in which I specify the institutional setup, that is, the interaction between the Treasury and the central bank, is guided by a certain objective, because the paper also has a complementary goal. That goal, which is somewhat lofty, is to use the theory sketched out to think about the very different results observed during the Great Depression in the United States and the Great Recession in Japan in response to relatively similar policy actions. This part of the paper is quite speculative, and it is based on the simple theoretical structure proposed and some broad patterns in the data. The thought experiments are quite helpful, however, for casting some light on these episodes, and the largely speculative component of the exercise is justified given how high the stakes are for understanding these events.

4. See, for example, Sargent and Wallace (1981); Sims (1994); Woodford (1996); Benhabib, Schmitt-Grohé, and Uribe (2002).

The episodes I have in mind are the United States during the Great Depression of 1929–41 and Japan during the Great Recession of 1992–2006.[5] Both countries implemented unusually large policy actions as measured by interest rate cuts, increases in the money supply, expansion in fiscal variables, and exchange market interventions. Nevertheless, the outcomes were very different: while demand responded strongly during the Great Depression in the United States during the recovery phase (1933–37 and 1938–41), it responded little—if at all—during the Great Recession in Japan. I suggest that the different outcomes are explained by the greater independence of the Bank of Japan relative to the Federal Reserve during the respective crises. Illustrating how economic outcomes, as a function of policy actions, depend on the institutional framework underpins a novel interpretation of the Great Depression relative to the Great Recession. More generally, one takeaway from this paper is that the consequences of certain policy actions cannot be understood independently from the institutional framework. The modeling exercise provides one way of thinking about this, but the narrative accounts in the paper do, as well.

While the Great Depression in the United States and the Great Recession in Japan were very different along several dimensions, there are some important similarities. Both events started with a big decline in the stock market. In the aftermath of these large shocks, both central banks cut the interest rate down to zero, albeit somewhat gradually, to counteract an economic slowdown. Table 1 shows that by 1996, the overnight interest rate had declined to close to zero in Japan. While there is no comparable data for the United States during the Great Depression, the closest proxy is the interest paid on three-month Treasury bills. Table 2 shows that according to this measure, the short-term interest rate had also declined close to zero in the United States by the end of 1932. Another similarity is that both countries experienced deflation and contraction in their nominal gross domestic product (GDP). During the entire Great Recession in Japan, nominal GDP stagnated and there was mild deflation, while the Unted States experienced sharp and violent declines in prices and nominal GDP during the first and second phases of the Great Depression in 1929–33 and 1937–38.

5. I am coining the period 1992–2006 as the Great Recession in Japan, since in 2006 the Bank of Japan raised interest rates based on the expectation that the growth observed at the time and modest inflation would signal the end of the long contractionary phase. In 2008, however, the world economy entered financial crisis, and Japan once again found itself in a similar situation as during 1992–2006.

Table 1. Fiscal Multipliers for coordinated policy
United States during the Great Depression

	$i = 0$	$i > 0$
Real Spending Multiplier	2.20	0.33
Deficit Spending Multiplier	4.20	0.50

Source: Author's computations

Table 2. Fiscal Multipliers for uncoordinated policy
Japan during the Great Recession

	$i = 0$	$i > 0$
Real Spending Multiplier	1.20	0.33
Deficit Spending Multiplier	0.00	0.00

Source: Author's computations

Another striking similarity is the response of the Japanese and American policymakers. In both countries, after the nominal interest rate reached zero, the central banks expanded the monetary base much beyond what was required to keep the interest rate at zero. The Federal Reserve almost doubled the nominal monetary base in 1933–37 (the initial phase of the recovery). Similarly, the Bank of Japan more than doubled the base beetween 1996, when the interest rate first approached zero, and 2006. The Bank of Japan was especially aggressive in the period of quantitative easing that started in May 2001 and ended in the spring of 2006, when it expanded the base by 70 percent in nominal terms. A similar picture emerges on the fiscal front. In the United States, the government spent 70 percent more dollars in 1937 than in 1933. The expansion of government expenditures was of the magnitude of 6 percent of GDP in 1933. The growth rate of government spending in Japan was smaller. The Japanese government spent 20 percent more yen in 2005 than in 1992. However, if the increase is measured as a fraction of 1992 GDP, it is about the same as in the United States, at 6 percent (table 1).[6]

6. The government in Japan was much bigger in 1992 in relative terms than the United States. government in 1933. Although deficits and government expenditures have increased in Japan, government consumption of final goods and services has, by various measures, not been increased substantially since 1996 (Broda and Weinstein, 2005). Similar points, however, have been made about the government expansion in the United States during the Great Depression (Brown, 1956), so this fact hardly explains the difference in outcomes.

Neither country financed these spending increases with tax hikes. Instead, both governments ran large deficits. The annual deficits were 4–9 percent of GDP in the United States from 1933–37, and they were of a similar magnitude throughout the Great Recession in Japan. In fact, net government debt was 94.7 percent of GDP in Japan as of 2006, up from 14.3 percent in 1992 before the onset of the Great Recession. Finally, both countries intervened in the foreign exchange markets. The Japanese Ministry of Finance bought foreign exchange on several occasions. In 2003, for example, the interventions corresponded to about 5.7 percent of GDP and 37.0 percent of the monetary base (Lipscomb and Tille, 2005). One can to some extent interpret United States purchases of gold as corresponding to foreign exchange interventions. The scope of these interventions were of a similar order, for example, in 1933–34 (Eggertsson, 2008).[7]

Despite the similarities in policy actions, the outcomes were radically different. One sensible measure of outcomes is nominal GDP. A real-business-cycle theorist expects a nominal demand stimulus to mainly increase the price level, whereas a Keynesian or a monetarist would expect some combination of real output and price increases. All theories, however, suggest that nominal GDP will increase. Consider the reaction of nominal GDP in the United States after President Franklin D. Roosevelt started expansionary policies in earnest. In 1933–37, nominal GDP expanded by 52 percent, of which about 80 percent is explained by growth in real GDP and 20 percent by inflation (table 2). In contrast, nominal GDP contracted or stagnated throughout the Great Recession in Japan due to ongoing mild deflation and modest or no real growth (table 1). The nominal GDP in 2005 was only 5 percent higher than it was in 1992 and 2 percent lower than in 1997. What is the reason for these radically different outcomes?

The reigning hypothesis for United States growth in 1933–37 attributes it to the monetary expansion. Leading proponents include Friedman and Schwartz (1963) and Bordo, Erceg, and Evans (2000). All authors point toward the increase of the monetary base (or usually M1). However, if a 70 percent increase in the nominal stock of money increased nominal GDP by 52 percent in the United

7. The United States went off the gold standard in 1933. The dollar value of gold was again fixed in 1934 only to be changed in the 1970's but it is generally argued that the United States was off the gold standard for all practical purposes from 1933 onward.

States, why did the larger increase in Japan not lead to a robust recovery in nominal GDP? The leading alternative hypothesis relates to fiscal expansion. Here again, if increasing government spending by 6 percent of GDP and running deficits of 4–9 percent increased nominal GDP by 52 percent in the United States, why did the larger and more sustained increase in Japan not lead to a robust recovery in nominal GDP?

The hypothesis for the United States recovery submitted in this paper relies on an earlier work (Eggertsson, 2008), which argues that the recovery was driven by a shift in expectations. This shift was triggered by President Roosevelt's policy choices. In particular, Roosevelt announced an explicit target to raise prices. A large body of recent literature on the liquidity trap shows that when the short-term interest rate is zero, as it was in 1933 when Roosevelt came into office, it is crucial to raise expectations about the future money supply in order to stimulate demand.[8] The problem is how to generate these expectations. Eggertsson (2008) argues that beyond making an explicit verbal commitment to inflate, Roosevelt achieved this objective with fiscal expansion and other actions that affected the government's balance sheet (such as foreign exchange interventions), thereby making the commitment to inflate credible. Printing money in the future became crucial to finance fiscal actions and prevent future balance sheet losses. This paper adds to the story in Eggertsson (2008) by emphasizing that for this channel to work, monetary and fiscal policy need to be coordinated. I use this insight to contrast the economy's response to policy in the Great Recession with its response in the Great Depression.

Why did the public's expectations about the future money supply not increase as dramatically in Japan in the Great Recession as they did during 1933–37 in the United States, even though the fiscal and monetary policy actions taken by the Japanese government were just as dramatic? The most obvious difference is that in addition to his various expansionary actions, Roosevelt announced an explicit objective to inflate the price level to pre-Depression level (Eggertsson, 2008). In Japan, by contrast, policymakers undertook various expansionary actions, but they never made an explicit commitment to future inflation. This explanation is unsettling,

8. See, for example, Krugman (1998); Auerbach and Obstfeld (2005); Eggertsson (2006b, 2008); Eggertsson and Woodford (2003); Svensson (2001, 2003); and Jeanne and Svensson (2007); Adam and Billi (2006, 2007); Jung, Teranishi, and Watanabe (2006).

however. Is the lesson that policy actions are irrelevant, and all that matters is what policymakers say? And why did Roosevelt's words have such tremendous power in 1933? President Hoover repeatedly announced in 1929–33 that a recovery in prices and output was just around the corner (even if he did not specify pre-Depression levels for prices), and Japanese policymakers made similar predictions at various points in the crisis. Why did these words not carry the same weight?

In this paper, I explain the strong reaction of nominal demand in the United States versus the weak response in Japan with differences in the monetary and fiscal institutions in the two countries. In particular, I assume that the Bank of Japan is independent, while in the United States monetary and fiscal policy were coordinated. I document how this coordination was achieved through legislation in the United States Congress in section 7. This explanation does not rely on policymakers' words. In fact, I assume words have no power in this paper.[9] While extreme and arguably unrealistic, the assumption that words carry no weight is useful for isolating the importance of different institutions and for identifying why some actions had a big effect in the United States in the 1930s and little or no effect in Japan in the 1990s, even if we abstract from differences in announced policy commitments. This approach also highlights what types of action are likely to help make various communication strategies credible and which institutional reforms may facilitate this objective. This is why I consider an equilibrium in which the government is purely discretionary so that it cannot commit to any future actions (as in Kydland and Prescott, 1977; Barro and Gordon, 1983) apart from repaying any debt issued (as in Lucas and Stokey, 1983).

While coordination of monetary and fiscal policy can explain the recovery in the United States in 1933–37—and the lack thereof during the prolonged recession in Japan—there are some alternative explanations. One alternative is that the United States recovery was

9. This is surely an extreme assumption that does not hold exactly. There is some evidence, for example, that Bank of Japan's announcements (for example, in the fall of 2003) were helpful in stimulating demand. At that time, and on a few other occasions, the bank announced that the short-term interest rates would be zero until the changes in the consumer price index (CPI) moved back into positive territory, which helped lower real rates and stimulate spending. Similar announcements by the Federal Reserve in 2003 most likely also stimulated demand (but the Federal funds rate was then at 1 percent, and there were concerns over deflation).

due to the resolution of the banking crisis in the spring of 1933, an explanation emphasized by many authors. Given the difficulties in the Japanese banking system, one could speculate that what was missing in Japan was not coordination of monetary and fiscal policy, but a cleanup of the banking system. While solving the banking crisis was certainly a contributing factor in the recovery in 1933–37, this hypothesis does not explain the second contractionary phase of the Great Depression in 1937–38 and the recovery starting in 1938, as there were no banking crises in thesecond phase. As I argue in section 7, however, the recession in 1937 can be interpreted through the lens of the same theory we apply here, namely, that the Federal Reserve was reasserting its independence (mostly by raising reserve requirements) and the private sector expected it to renege on the administration commitment to reinflate prices to pre-Depression levels. Hence, Roosevelt's commitment to permanently increase the money supply was no longer credible in 1937. Similarly, as I argue in section 7, the recovery in 1938 can be interpreted as a renewed commitment to inflating the price level by a coordination of monetary and fiscal policy.[10]

2. The Model

Here I outline a simplified version of a relatively standard New Keynesian model, assuming reduced-form money demand and special functional forms.[11] I assume there is a representative household that maximizes expected utility over an infinite horizon:

$$E_t\left[\sum_{T=t}^{\infty}\beta^{T-t}b_T\left(\log C_T+\chi\log G_T-\psi\frac{h_T^{1+\omega}}{1+\omega}\right)\right], \qquad (1)$$

where b_t is an intertemporal shock; C_t is a Dixit-Stiglitz aggregate of consumption of each of a continuum of differentiated goods,

10. An alternative hypothesis is that abolishing the gold standard explains the recovery in 1933, in exclusion of the channel proposed. As I argue in Eggertsson (2008), going off gold was a necessary condition for the recovery, but it was not a sufficient condition. Some countries that abolished the gold standard (such as Great Britain) did not experience fast growth during the Great Depression. Furthermore, the price of gold was fixed from 1934 to the 1970's, so focusing on the government-mandated price of gold in dollar terms cannot explain the recession in 1937–38 and the recovery in 1938.

11. See Eggertsson (2006b) for a more detailed version with a money-in-utility function and general functional forms.

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

with elasticity of substitution equal to $\theta > 1$; G_t is a Dixit-Stiglitz aggregate of government consumption defined in a similar 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 h_t is hours worked. E_t denotes mathematical expectation conditional on information available in period t. For simplicity, I assume as cashless economy where only one-period riskless government bonds are traded. The household thus faces the following budget constraint:

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

where Z_t is the profit earned by a representative firm, T_t taxes, B_t one-period riskless bonds, i_t the one-period nominal riskfree interest rate, and n_t wages. The household maximizes its utility subject to the budget constraint by choosing its asset holdings, labor, and consumption. There is a continuum of firms on the unit interval that maximize expected discounted profits. Firms produce using a production function that is linear in labor, and I abstract from capital dynamics. As in Rotemberg (1982), I assume that firms face a resource cost of price changes, $(\delta/2)[(p_t(i))/(p_{t-1}(i)) - 1]$. For algebraic simplicity, I follow Rotemberg and Woodford (1997) by assuming a subsidy of $(1 + s) = \theta / (1 - \theta)$ for each unit produced, so that production is at its efficient level in the steady state and there is no inflation bias (see Eggertsson, 2006b, for the general case).

The first-order conditions of the household and firm maximization problems can be summarized by two Euler equations. The household consumption decisions satisfy the Euler equation often referred to as the IS equation:

$$C_t^{-1} = (1 + i_t) f_t^e, \tag{2}$$

where $f_t^e = E_t C_{t+1}^{-1} \prod_{t+1}^{-1} \beta((b_{t+1})/b_t))$ is an expectation variable and $\prod_t \equiv p_t/(p_{t-1})$. This equation says that consumption demand depends on expected future consumption, the nominal interest rate, expected inflation, and the intertemporal shocks. The firm optimal pricing decisions, on the one hand, and the household optimal labor supply decisions, on the other, also satisfy a Euler equation, often referred to as the AS equation:

$$\Pi_t(\Pi_t - 1) = \frac{\theta}{\delta}(\psi C_t Y_t^{\omega} - 1)Y_t + \beta C_t S_t^e \tag{3}$$

where $S_t^e = E_t \Pi_{t+1}(\Pi_{t+1} - 1)C_{t+1}^{-1}\beta[(b_{t+1})/b_t)]$ is an expectations variable. 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.

There is an output cost of taxation (for example, due to tax collection costs as in Barro, 1979) captured by the function $(\gamma/2)\, T_t^2$. For every dollar collected in taxes, $(\gamma/2)\, T_t^2$ units of output are wasted without contributing anything to utility. Total government real spending, F_t, is then given by

$$F_t = G_t + \frac{\gamma}{2} T_t^2.$$

In the remainder of the paper, all expressions are written in terms of F_t instead of G_t, using the equation above. Abstracting from seigniorage revenues, the government budget constraint can be written as[12]

$$w_t = (1 + i_t)[w_{t-1}\Pi_t^{-1} + F_t - T_t] \tag{4}$$

where I have defined the variable $w_t \equiv [(B_t(1 + i_t)) + M_t]/P_t$ as the real value of the end-of-period government debt inclusive of interest payments. To ensure solvency, I assume that the government needs to satisfy a debt limit:

12. For simplicity, I drop the term $[i_t / (1 + i_t)]\, M_t / P_t$ in the budget constraint. See Eggertsson (2006b) for the extension.

$$w_t \leq \bar{w} \tag{5}$$

which excludes Ponzi schemes. Market clearing implies that

$$Y_t = C_t + F_t + (\delta/2)(\Pi_t - 1)^2. \tag{6}$$

Space considerations preclude entering into the details of the means by which the central bank controls the nominal interest rate. However, as long as the government is committed to supplying a nominal claim (that is, money) with zero return, there is a zero bound on the short-term nominal interest rate:

$$i_t \geq 0 \tag{7}$$

An equilibrium is a collection of stochastic processes for $\{T_t, F_t, i_t, C_t, Y_t, \pi_t, w_t\}$ that satisfy equations (2) through (7) for a given path for the exogenous shock $\{b_t\}$.

An equilibrium can be defined without any reference to the money supply. A money demand equation can be appended to the model, for example, by having money supply enter additively separately in utility (Eggertsson, 2006b). This will have no effect on the equilibrium, provided I abstract from seigniorage revenues in the government budget constraint, which in any event is relatively small in most industrialized countries. The money demand equation only has a role in determining money demand given the interest rate and consumption. It is useful, however, to keep track of a money supply since much of the earlier literature is cast in terms of money. I assume (as do Krugman, 1998, and King and Wolman, 2004) that a certain fraction of production needs to be held in money balances, so the following inequality has to be satisfied:

$$(M_t/P_t) \geq vY_t. \tag{8}$$

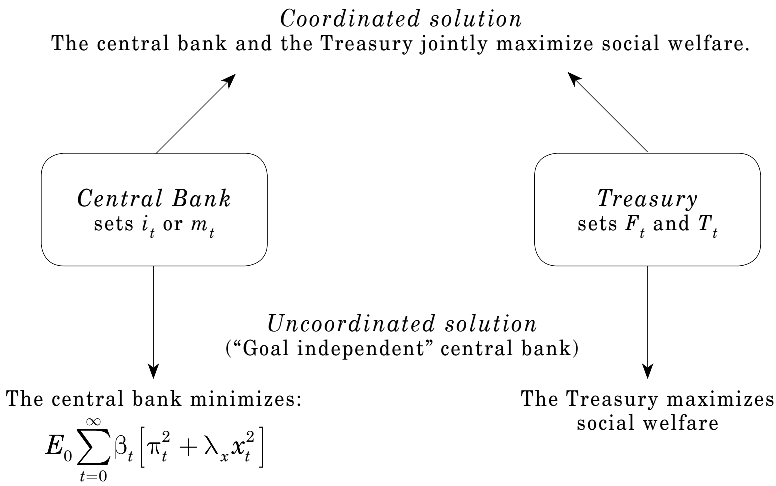
I abstract from any effect money balances have on utility or welfare. At a zero interest rate, this inequality can be slack because the households can be indifferent to holding money versus bonds.

3. Institutions

I assume that monetary and fiscal policy were coordinated in the United States in 1933–37 and 1938–41 during the first and second recovery phases of the Great Depression and that they were uncoordinated in Japan in 1992–2006 during the Great Recession. Figure 1 illustrates what coordination means in this paper. There are two government agencies: the central bank and the Treasury. The central bank sets the interest rate, i_i (or alternatively the money supply, M_i). The Treasury decides spending, F_i, and taxes, T_i. Policy is coordinated when the Treasury and the central bank join forces to maximize social welfare; policy is uncoordinated when each agency pursues its own objectives. The example I consider for uncoordinated policy is when the Treasury maximizes social welfare, but the central bank pursues a narrower objective. I refer to this institutional arrangement as a case in which the central bank is independent. I assume that the independent central bank minimizes the quadratic deviation of inflation and output from a target (a relatively standard objective in the literature), but other specifications for the bank's preferences do not change the central results. An important additional assumption I make is that the independent central bank is not responsible for satisfying the Treasury's budget constraint or borrowing limit. If this assumption is not made, the treasury can force the central bank's hand by accumulating debt up to the limit and then cutting taxes further (in which case the central bank would have to inflate in order to make the budget constraint and borrowing limit hold). The key difference between the coordinated and uncoordinated solutions is that in the uncoordinated case, the independent central bank does not take into account the fiscal consequences of its actions. This institutional arrangement is somewhat special, and my definition of coordination does not encompass all the different cases that various authors have in mind when discussing the coordiation of monetary and fiscal policy (although it corresponds quite closely to some of the previous literature).[13] This is not a major weakness in my view. What is important for my purposes is that the two

13. Observe that this definition, that is, the goal independent central bank, is consistent with Rogoff's (1985) conservative central banker and is identical to Dixit and Lambertini's (2003) institutional framework.

Figure 1. Coordinated versus Uncoordinated Policy Actions of the Central Bank and the Treasury



Source: Author's elaboration.

cases (coordinated versus uncoordinated policy) capture a basic difference between the monetary and fiscal policy arrangements in Great Depression and the Great Recession. This may be even more clear in section 7, where I explicitly discuss how this particular institutional arrangement can be used to interpret these two events in light of the narrative record. Hence, the paper primarliy outlines a positive analysis, whereas a normative analysis may require a more detailed and flexible institutional description.

4. Discretionary Equilibrium under Coordinated Policy

4.1 Definition

This section defines optimal policy under discretion when monetary and fiscal policy are coordinated. Under discretion, the government cannot commit to future policy. Optimal policy under discretion is sometimes referred to as a Markov perfect equilibrium. The timing of events in the game is as follows. At the beginning of each period t, w_{t-1} is a predetermined state variable, and the shock b_t is realized and observed by the private sector and the government. The monetary and fiscal authorities choose policy for period t given the current state (b_t, w_{t-1}), and the private sector forms expectations f_t^e and S_t^e. I assume that the private sector may condition its expectation at time t on the policy actions of the government. In other words, it observes the policy actions of the government in that period so that expectations are determined jointly with the other endogenous variables. The only endogenous state variable in the model at time $t+1$ is w_t. This implies that the expectation variables f_t^e and S_t^e are a function of w_t and b_t:

$$f_t^e = \bar{f}^e(w_t, b_t), \tag{9}$$

and

$$S_t^e = \bar{S}^e(w_t, b_t), \tag{10}$$

so that the IS and AS equations can be written as

$$C_t^{-1} = (1 + i_t)\,\bar{f}^e(w_t, b_t), \tag{11}$$

and

$$\Pi_t(\Pi_t - 1)^2 = (\theta/\delta)[(\psi\, C_t Y_t^{\omega} - 1)Y_t + C_t \bar{S}^e(w_t, b_t)]. \tag{12}$$

Under discretion, the government maximizes the value function $J(w_{t-1}, b_t)$ by its choice of the policy instruments, taking the expectation functions $\bar{f}^e(w_t, b_t)$, $\bar{S}^e(w_t, b_t)$ as given because it cannot commit to future policy. It thus solves

$$J(w_{t-1}, b_t) = \max_{F_t, T_t, i_t} \left\{ \begin{array}{l} [\log C_t + \chi \log(F_t - \frac{\gamma}{2} T_t^2) - \psi \frac{h_t^{\omega}}{1+\omega}] b_t \\ +\beta E_t J(w_t, b_{t+1}) \end{array} \right\} \tag{13}$$

subject to equations (4), (5), (6), (7), (11), and (12). The first-order conditions for the maximization problem are derived by writing the right-hand side as a Lagrangian problem and setting the partial derivatives with respect to each of the variables $(\Pi_t, C_t, Y_t, w_t, i_t, F_t, T_t)$ to zero. Because the government is a large strategic player and moves simultaneously with the private sector, it can choose a value for all these variables as long as they satisfy the private sector optimality conditions and the resource constraint.[14] The model has a well-defined steady state with zero inflation and debt. The model is approximated around this steady state so that the solution is only accurate to the first order. The next section characterizes this approximate solution.

4.2 Results

Below I show the linear approximation of the equilibrium. To express this solution, I first need to define two concepts: the natural level of output and the natural rate of interest. The natural level of output is the output that would be produced if prices were flexible, that is, $\delta = 0$ in equation (3). Using this equation in conjunction with (6) yields

$$\hat{Y}_t^n = \frac{\sigma^{-1}}{\sigma^{-1} + \omega} \hat{F}_t \tag{14}$$

where $\sigma \equiv (C/Y)$, $\hat{F}_t = \log F_t/\overline{Y}$, and the natural level is expressed in log deviation from steady-state output. Output under flexible prices does not depend on the shock b_t, but increases with $\hat{F}_t$ for familiar reasons from the real business cycle (RBC) literature: a higher level of government consumption increases the marginal utility of consumption and thereby increases the labor supply.

The natural rate of interest is the real interest rate when prices are flexible, that is,:

$$\begin{aligned} r_t^n &= \overline{r} + \hat{b}_t - E_t \hat{b}_{t+1} + \frac{\sigma^{-1}\omega}{\sigma^{-1} + \omega}(\hat{F}_t - E_t \hat{F}_{t+1}) \\ &= r_t^e + \frac{\sigma^{-1}\omega}{\sigma^{-1} + \omega}(\hat{F}_t - E_t \hat{F}_{t+1}) \end{aligned} \tag{15}$$

14. Some recent examples in the literature assume that the government moves before the private sector within each period (see, for example, King and Wolman, 2004; Albanesi, Chari, and Christiano, 2003). In those cases, there can be multiple point-in-time equilibria. I do not prove the global uniqueness of equilibria, only local uniqueness. Proving global uniqueness is hard except in simpler models. The timing assumption here is the same as in the linear-quadratic literature on discretion, such as Clarida, Galí, and Gertler (1999) and Woodford (2003).

where $\bar{r} \equiv \log\beta^{-1}$, $\hat{b}_t \equiv \log b_t/\bar{b}$. The natural interest rate depends both on the intertemporal shock and fiscal spending. I summarize the exogenous component of the natural rate by r_t^e.

A linear approximation of the private sector first-order conditions can be written in terms of deviations from these variables. The consumption Euler equation (2) is

$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^n), \tag{16}$$

where $\pi_t = \log\Pi_t$ is inflation and x_t is the output gap $x_t \equiv \hat{Y}_t - \hat{Y}_t^n$ where $\hat{Y}_t \equiv \log Y_t - \log \bar{Y}$. The term i_i now refers to $\log(1 + i_i)$ in the notation of the previous section so that the zero bound in the form (7) can still be expressed. This equation can be forwarded to yield

$$x_t = E_t x_T - E_t \sum_{s=t}^{T-1} \sigma(i_s - \pi_{s+1} - r_s^n)$$

which illustrates that the output gap depends not only on the current nominal interest rate and expected inflation, but on the entire expected path of future interest rates and inflation. Equation (3) can be approximated as

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1}, \tag{17}$$

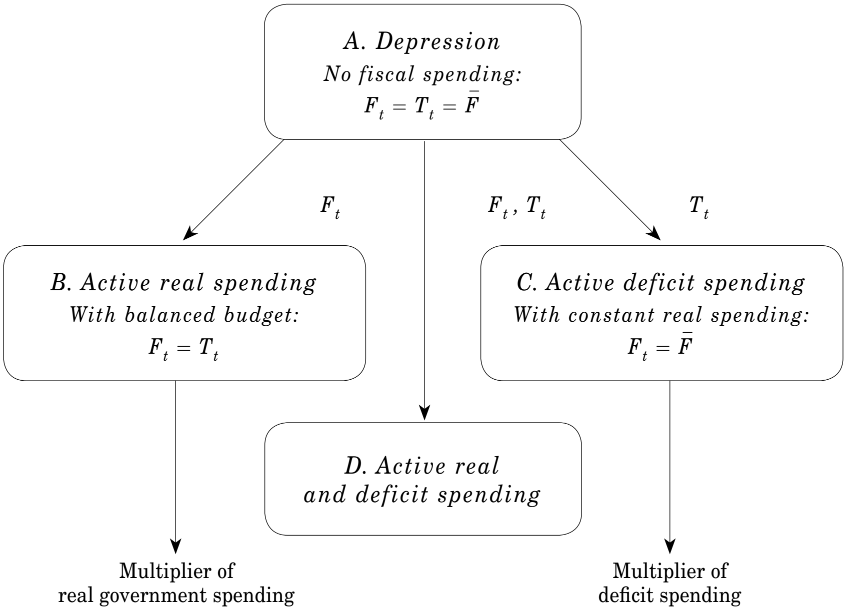
where $\kappa_t \equiv (\theta/\delta)(\sigma^{-1} + \omega)$. If this equation is forwarded, it says that inflation depends on the expected path of future output gaps.

Finally, the budget constraint of the government is approximated by

$$w_t - \bar{w} i_t = \beta^{-1} w_{t-1} - \beta^{-1} \bar{w} \pi_t + \beta^{-1} \hat{F}_t - \beta^{-1} \hat{T}_t, \tag{18}$$

where $\hat{T}_t = \log T_t/\bar{Y}$ and where I have linearized around a given level for outstanding debt $\bar{w}$. The budget constraint says that for *a given* level of debt, monetary policy can improve 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 (namely, nominal bonds and the money supply). Equations (14)

Figure 2. Roadmap for Results under Coordination[a]



Source: Author's elaboration.
a. The presentation of the results when the central bank is goal independent has the same structure.

through (18) summarize the private sector equilibrium constraints. I now turn to government policy.

This paper is about government policy when sufficiently large deflationary shocks cause the nominal interest rate to decline to zero. I assume that r_t^e is temporarily negative at time 0, while $r_L^e < 0$ and returns to steady state with a probability α in each period. To ensure a bounded solution, I impose the restriction on α that $\alpha[1 - \beta(1 - \alpha)] - \sigma\kappa(1 - \alpha) > 0$. I call the date that r_t^e returns to steady state τ. Once it returns to steady state, it stays there forever.

To clarify the organization of the results, figure 2 provides a road map for the remainder of this section. I analyze the results in four steps. I first show the equilibrium when fiscal policy is inactive ($\hat{F}_t = \hat{T}_t = 0$), which is equilibrium A in figure 2. I then analyze the consequences of optimally increasing real government spending, $\hat{F}_t$, but holding the budget balanced (so that $\hat{T}_t = \hat{F}_t$) which is equilibrium B. In equilibrium C, the government optimally uses deficit spending,

$\hat{T}_t$, to stimulate demand, but real government spending is kept constant at its steady state ($\hat{F}_t = 0$). Finally, equilibrium D considers the effect of using both deficit and real spending optimally.

Applied to the Great Depression, equilibrium A corresponds to the policies of President Hoover because he aimed at both keeping the government small and balancing the budget (Eggertsson, 2008). In that model, this Hoover regime represents optimal discretion under the constraint of "balanced budget dogma" and "small government dogma." Roosevelt, in contrast, broke both these dogmas. His policy regime corresponded to equilibrium D, which is unconstrained discretion.

The policy rule the government follows under discretion is found by approximating the first-order conditions of the maximization problem (13). These conditions are shown in appendix A. Since there are seven first-order conditions and two complementary slackness conditions, it is cumbersome to write them out in the main text. Fortunately, however, one can infer the form of the solution—and even obtain some closed-form solutions—using almost no algebra by considering a second-order approximation of the household utility:

$$U_t = -\frac{1}{2}\sum_{T=t}^{\infty}\beta^{T-t}\left\{\pi_T^2 + \lambda_x x_T^2 + \lambda_F \hat{F}_T^2 + \lambda_T \hat{T}_T^2\right\}. \tag{19}$$

where the lambdas are derived in the appendix A as a function of the structural parameters. Consider first the solution in equilibrium A from the perspective of $t > \tau$, when the deflationary shock has subsided (recall that I impose $\hat{F}_t = \hat{T}_t = 0$). Under discretion, the government seeks to maximize this objective regardless of its actions in the past. The best possible equilibrium is thus when

$$\pi_t = x_t = 0 \text{ for } t \geq \tau. \tag{20}$$

which can be achieved at that time and is dynamically consistent.

Consider now the solution in period $t < \tau$. Ideally, the government would wish to achieve zero inflation and a zero output gap. The assumption that the shock r_t^e is negative makes this infeasible, however, since it would imply a negative nominal interest rate by equation (16). The government therefore tries to achieve maximum accommodation by setting the interest rate to zero. Because the shock is the same in all $t < \tau$, the solution for π_t and x_t solves the two equations

$$x_t = (1 - \alpha)x_t + \sigma(1 - \alpha)\pi_t + \sigma r_L^e \tag{21}$$

and

$$\pi_t = \kappa x_t + \beta(1 - \alpha)\pi_t \tag{22}$$

yielding

$$x_t = \frac{1-\beta(1-\alpha)}{\alpha(1-\beta(1-\alpha))-\sigma\kappa(1-\alpha)}\sigma r_L^e \text{ for } t < \tau \tag{23}$$

and

$$\pi_t = \frac{1}{\alpha(1-\beta(1-\alpha))-\sigma\kappa(1-\alpha)}\kappa\sigma r_L^e \text{ for } t < \tau \tag{24}$$

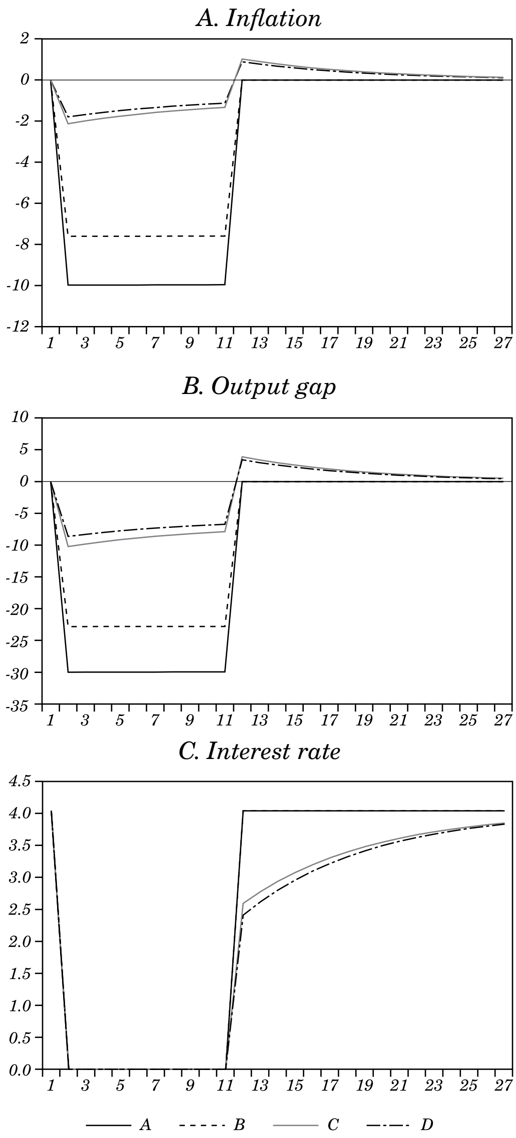
Figure 3 shows a numerical solution of the model that is calibrated to illustrate some basic qualitative features of the Great Depression in the United States. Each period is a quarter. The parameter $\beta = 0.99$ is set to match the 4 percent real interest rate, and $\sigma = 0.90$ is set to match 10 percent government spending in steady state. The parameter α is set at 0.1, so that the shock is expected to last for ten quarters. The parameter κ governs how much inflation reacts to movements in output. It is chosen to match data from 1932, when the average nominal interest rate was close to zero, and there was 10 percent deflation. There are no reliable data on the output gap at that time, but a reasonable lower bound for the output gap is that output had declined by about a third from its peak in 1929. Given the calibrated value of α, I can use equation (22) to pick a κ that matches these facts:

$$\kappa \equiv (1 - \beta(1 - \alpha))(\pi/x) = 0.0091$$

Finally, I use equation (23) to choose the value of the shock r_L^e to match a 30 percent output gap, which results in $r_L^e = -3$ percent.

The figure shows the case in which the natural interest rate returns to steady state in period $\tau = 10$ (which is the expected duration of the shock). Recall from equations (23) and (24) that these lines would look the same for any other contingency, but with a different breaking point corresponding to $t = \tau$ (that is, the lines would jump up at different times). Because of the choice of r_L^e the

Figure 3. Inflation, the Output Gap, and Interest Rates under the Optimal Policy under Discretion in Equilibria A, B, C, and D: Great Depression Calibration



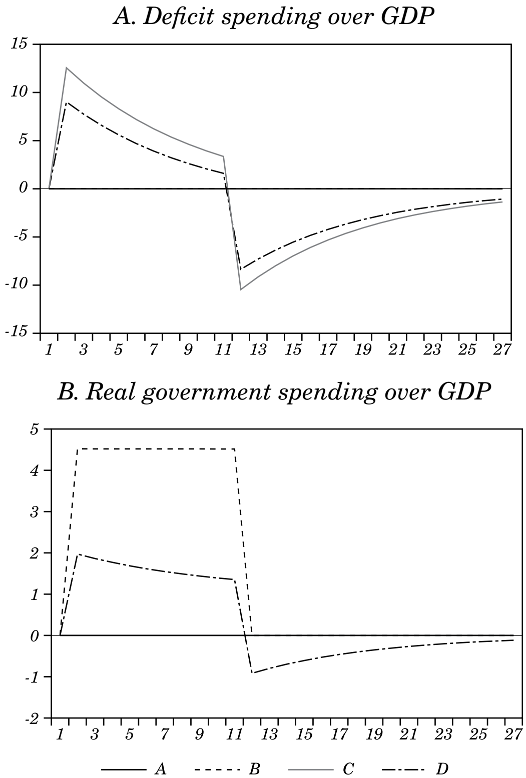
Source: Author's computations.

model generates a 30 percent collapse in output and a 10 percent deflation, and the contraction lasts as long as the duration of the shock (which is stochastic). The contraction at any time t is created by a combination of the deflationary shock in period $t < \tau$ and—more importantly—the *expectation* that there will be price and output contraction in future periods $t + j < \tau$ for $j > 0$. The contraction in period $t + j$, in turn, depends on expectations of 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 is satisfied. The overall effect is an output and price collapse.

The contraction in the model is entirely driven by monetary forces and the zero bound. If the central bank were able to accommodate the shock by setting a negative nominal interest rate of –3 percent, there would be no output contraction and no deflation. The contraction is caused by a discrepancy between the long-term real interest rate and the long-term natural interest rate. Due to the zero bound and the expectation that inflation will be set at zero at $t > \tau$, this difference cannot be reduced by nominal interest rate cuts. The difference increases with expectations about future deflation, since expected deflation increases the short- and long-term real interest rates. Real interest rates can be particularly high when there are expectations of a deflation. During the contractionary phase of the Great Depression in the United States, the real rates were of the order of 10 percent (see table 2), and the Federal Reserve was unable to lower these rates in 1933 because the nominal interest rate was close to zero.

Printing money has no effect in this equilibrium. Because expectations are pinned down by equation (20), any increase in the money supply in periods $t < \tau$ will be expected to be reversed in period τ. Moreover, money and bonds are perfect substitutes in periods $t < \tau$ (so that equation 8 is slack), and printing money thus has no meaningful implication at the time the money is printed: households simply replace government bonds in their portfolio with money. It is impossible for a discretionary central bank to change expectations in period $t < \tau$ under the assumption of discretion. Even if it would be beneficial in period $t < \tau$ to create expectations of lower future interest rates and inflation in period $t \geq \tau$, the bank has an incentive to renege on this promise once the shock has subsided in period τ (because from that time on the government can achieve $\pi_t = x_i = 0$, which maximizes its objective). This problem of discretionary policy is coined the deflation bias in Eggertsson (2006b). While the classic inflation bias of Kydland and Prescott (1977) and Barro and Gordon

Figure 4. Deficit and Real Goverment Spending under Optimal Policy under Discretion in Equilibria A, B, C, and D: Great Depression Calibration



Source: Author's elaboration.

(1983) is a steady-state inefficiency, the deflation bias arises due to temporary deflationary shocks.

The dotted line in figures 3 and 4 shows equilibrium B in the diagram in figure 2. In this case the government is no longer constrained to keep real government spending constant. In addition to the parameters I have already specified, I need to calibrate the parameter ω, which is the inverse of the Frisch elasticity of labor supply. I calibrated it at $\omega = 2$, which strikes a middle ground between microeconomic studies (which are usually much higher than 2) and parameters often used in the RBC literature (which are usually around 0.5). The form of the solution can once again be inferred by inspecting equation (19). In periods $t > \tau$, the government can once again maximize its objective by setting $\pi_t = x_t = \hat{F}_t = 0$. In periods $t < \tau$, however, temporarily increasing $\hat{F}_t$ can improve the outcome. To see this, recall that the cause of the contraction is that the real interest rate is higher than the natural interest rate. The natural rate of interest, however, depends in fiscal spending, as seen in equation (15), so that increasing $\hat{F}_t$ in periods of the shocks increases the natural interest rate and thus reduces the output gap and deflation in periods $t < \tau$. The cost of doing this is that in these period there is an oversupply of public goods, causing the level of $\hat{F}_t$ to rise above what would be optimal in the absence of the demand-driven depression. A discretionary policymaker trades off the costs and benefits, and the resulting government expansion is shown in the figure.

Output increases more than the corresponding improvement in the output gap reported in the figure. The output effect of the fiscal expansion can be decomposed into an RBC channel and a New Keynesian channel. Output can be written as

$$\hat{Y}_t = x_t + \hat{Y}_t^n$$

so that the increase in output, by definition, is due to an improvement in the output gap and an increase in the natural rate of output. As shown in the RBC literature, an increase in government spending increases the natural level of output, and this effect can be seen by equation (14).

A multiplier of government spending answers the question of how much each dollar of real spending increases output, moving from the equilibrium in which $\hat{F}_t = 0$ (equilibrium A in figure 2) to the one in which $\hat{F}_t$ is optimally set (equilibrium B in figure 2). I measure each variable in net present value. This statistic can be analytically derived, yielding the following result:

$$MP_{A,B} \equiv \frac{E_0 \sum_{t=0}^{\infty} \beta^t (\hat{Y}_t^A - \hat{Y}_t^B)}{E_0 \sum_{t=0}^{\infty} \beta^t (\hat{F}_t^A - \hat{F}_t^B)} = \frac{\left[\frac{1}{1-\alpha} - \beta\right]\sigma^{-1} - \alpha^{-1}\kappa \frac{\sigma^{-1}}{\sigma^{-1} + \omega}}{\left[\frac{1}{1-\alpha} - \beta\right]\sigma^{-1} - \alpha^{-1}\kappa} > 1$$

This multiplier is 2.2 under the baseline calibration outlined above. The Keynesian channel, that is, the improvement in output due to the improvement in the output gap, accounts for 80 percent of the size of the multiplier.

In both equilibrium A and equilibrium B, the private sector expects zero inflation after the deflationary shocks have subsided. Even if the government expands the money supply, the private sector expects it to be reversed once deflationary pressures subside. Can a permanent increase in the money supply be credible? There is a straightforward policy tool for increasing inflation expectations in the model, even when the government is discretionary, as assumed. One way of making inflation policy credible is to expand government liabilities, that is, the sum of the monetary base and the government debt, given by the variable w_t in equation (18). This is what I call deficit spending or credit expansion; it is shown in the third line in figure 3, called equilibrium C. In this case, the government is no longer constrained to keep deficit spending constant, and instead I hold real spending constant. As the figure reveals, the government chooses to increase deficit spending in period $t < \tau$ and then runs surpluses when the deflationary shocks have subsided. This, in turn, has a large positive effect on both inflation and output.

The reason for the big impact of deficit spending on prices and output is that it changes expectation about future inflation, output, and nominal interest rates. As can be seen in figure 4, the deficit spending implies that the central bank will keep the nominal interest rate low for a substantially longer time than the duration of the shock and accommodate an output expansion and inflation in period $t > \tau$. These expectations feed into a large stimulus in period $t < T$ through several channels. The expectation of future inflation lowers the real interest rate, even if the nominal interest rate cannot be reduced further, thus stimulating spending. A commitment to a lower future nominal interest rate (once the deflationary pressures have subsided) stimulates demand for the same reason. Finally, the expectation of higher future income, as manifested by the expected output boom, stimulates current spending, in accordance with the permanent income hypothesis.

The reason why expansionary policy in periods $t > \tau$ is credible for the discretionary policymaker in equilibrium C but not in equilibrium A or B can be seen by inspecting equation (19) and the government budget constraint (18). The government accumulates additional debt in periods $t < \tau$. Because there is a cost of taxation, the government wishes to reduce the real value of its debt in periods $t > \tau$ by accommodating inflation (and I assume it only issues nominal bonds and money). It also wants to keep the real interest rate low because it is rolling its debt over from period to period. Both considerations give the government an incentive to keep the nominal interest rate low and accommodate inflation and output expansion in periods $t > \tau$ even if it could, in principle, stabilize prices and output at that time.

For the calculation reported in figure 3, I need to choose the cost of tax collection in the function,

$$\frac{\gamma}{2} T_T^2.$$

This parameter is chosen so that this cost corresponds to 10 percent of government spending to match the level of deficit spending once Roosevelt took power in 1933 (which was about 9 percent of GDP). A lower value for γ would have little effect on the results and only change the scale of the deficit spending. Since there was already some debt outstanding in 1933 (once Roosevelt embarked on an inflationary program), one could set this value much smaller and still match the evolution for deficit spending.

To usefully summarize the effect of the deficit spending or credit expansion on output through the multiplier, I need to make some adjustment to the definition of the multiplier. What I consider instead is a variable, $\tilde{T}_t$, defined as $\tilde{T}_t = \hat{T}_t$ if $\tilde{r}_t^n = r_t^L$ and $\tilde{T}_t = 0$ if $\tilde{r}_t^n = 0$. (The results derived for $\hat{F}_t$ would have been unchanged if I had defined $\tilde{F}_t$ in this way, because $\hat{F}_t = 0$ if $\tilde{r}_t^n = 0$). This variable captures the deficit spending used in the depression state. The value of this multiplier answers the following question: by how much does each dollar spent on deficit spending or credit expansion in a liquidity trap increase output? In the baseline calibration, the answer is 4. One can decompose the size of the multiplier into the RBC channel and the New Keynesian channel. No part of the multiplier can be explained by the RBC channel. The effectiveness of deficit spending comes entirely through increasing inflation expectations, and this is only valuable if one assumes sticky prices. Since prices are flexible in an RBC model, this channel has no role in that model.

4.2 Extensions: Exchange Interventions, Unconventional Open Market Operations, Bank Bailouts, Helicopter Money, and Long-Term Bonds

The last section emphasized cutting taxes relative to spending (deficit spending) in order to shift expectations about policy in periods $t \geq \tau$. Several other policy actions can also be described through the same mechanism. Government debt is the driving force for shifting expectations, not the tax cuts in themselves. Government debt can be increased in a variety of other ways, however, such as printing money (or bonds) or buying some private assets such as foreign exchange. As shown in Eggertsson (2003), these actions have the same implication for future government policy. Bailing out domestic banks by money printing or, even more exotically, dropping money from helicopters would have exactly the same effect. While Roosevelt did not drop money from helicopters in 1933, he took a variety of actions beyond deficit spending that expanded government credit, such as purchasing gold and refinancing private banks. These actions also had a large effect on the government balance sheet and should thus have fed into expectations about the future money supply.

It is sometimes suggested that monetary injection at a zero interest rate is somehow different from government debt because money does not have to repaid. Given our assumption that policy is discretionary in the future (that is, when the zero bound is no longer binding), this distinction is not valid. The reason for this is that the optimal future policy pins down the future price level and the future money supply from that date onwards, that is, at dates $t \geq \tau$. Hence, even if money is printed in period $t < \tau$ instead of issuing bonds (the distinction at that time is irrelevant, since both carry a zero interest rate), it will need to be "repaid" in the future once $t \geq \tau$ because the money supply at that time is uniquely determined by optimal policy.

It is often suggested that if long-term bonds have yields above zero, purchases of such bonds by the central bank should lower long-term interest rates and therefore increase spending.[15] As stressed by Eggertsson and Woodford (2003), however, the

15. The discussion in this paragraph is taken from Eggersson (2001). However, the results with respect to long-term debt are still "preliminary".

expectation theory of the term structure implies that this should not be possible, unless such actions are taken to signal a change in the bank's commitments regarding future monetary policy. Under coordination, if the central bank buys long-term bonds with money in a liquidity trap under cooperation, it is in effect changing the maturity structure of outstanding government debt (if the monetary base is considered a government liability). Since money and short-term bonds are perfect substitutes in a liquidity trap, replacing long-term bonds with money is equivalent to replacing long-term bonds with short-term bonds. The question of whether open market operations in long-term bonds is effective in a liquidity trap can thus be rephrased as follows: does changing the maturity structure of government debt increase inflation expectations? Preliminary results from work in progress suggest that the answer is yes. The logic behind this is straight forward. If the government holds long-term bonds, it reduces its incentives to lower the short-term real rate of return, as those returns will not apply to debt already issued. One of the two inflation incentives discussed earlier (for the case when all debt is short term) is thus reduced with a longer maturity. Since open market operations in long-term bonds shortens the maturity of outstanding debt, my preliminary results suggest that it may be effective to increase inflation expectations. An important caveat is that this channel will only be effective if the central bank is not independent.

5. Discretionary Equilibrium when the Central Bank is Independent

The preceding section assumes that monetary and fiscal policy are coordinated to maximize social welfare. This assumption may be questionable, however, given that many central banks have more narrow goals than social welfare. I now analyze the consequence of this alternative assumption, supposing the central bank is independent in the way defined in section 3.

The timing of events in the game is as follows. At the beginning of each period t, w_{t-1} is a predetermined state variable, and the exogenous disturbance b_t is realized and observed by the private sector, the treasury, and the central bank. The monetary and fiscal authorities simultaneously choose policy at time t given the state, and the private sector forms expectations:

$$\begin{bmatrix} F_t \\ T_t \end{bmatrix} = \begin{bmatrix} \bar{F}(w_{t-1}, b_t) \\ \bar{T}(w_{t-1}, b_t) \end{bmatrix} = \bar{T}r(w_{t-1}, b_t) \tag{25}$$

and

$$i_t = i(w_{t-1}, b_t) \tag{26}$$

Under discretion, the treasury maximizes the value function $J^{TR}(w_{t-1}, b_t)$ by its choice of policy instruments, taking the expectation functions $\bar{f}^e(w_t, b_t)$ and $\bar{S}^e(w_t, b_t)$ as given because it cannot commit to future policy. It solves

$$J^{Tr}(w_{t-1}, b_t) = \max_{T_t, F_t} \left\{ [\log C_t + \log G_t + \psi \frac{h_t^{1+\omega}}{1+\omega})]b_t + \beta E_t J^{Tr}(w_t, b_{t+1}) \right\} \tag{27}$$

subject to equations (4), (5), (6), (7), (11), (12), and (26). The central bank solves

$$J^{Cb}(w_{t-1}, b_t) = \max_{i_t} [-(\Pi_t - 1)^2 - \lambda \frac{Y^t}{Y_t^n} - 1)^2 + \beta E_t J^{Cb}(w_t, b_{t+1})] \tag{28}$$

subject to equations (6), (7), (11), (12), and (25).

The conditions that constrain the actions of the treasury and the central bank in equations (27) and (28) are the private sector equilibrium conditions and the strategy functions of the other government agency.[16] The debt is a state variable in the central bank's problem only because it enters in the strategy function of the treasury. Apart from the other players' strategy functions, these constraints are the same for both the treasury and the central bank, but with one important exception: the borrowing and budget constraint of the treasury is *only a restriction on the treasury taxing and borrowing strategies*; it does not impose any constraints on the central bank. To see why this is important,

16. Note that the government budget constraint can equivalently be interpreted as the budget constraint of the household and it thus belong in both maximization problems as a private sector equilibrium constraint.

suppose the contrary was true. This would create a much more complicated strategic game between the treasury and the central bank. The treasury could, for example, accumulate large amounts of debt up to its debt limit, $\bar{w}$, and then cut taxes further. In this case, in order not to violate the borrowing constraint, the central bank would need to inflate away some of the existing debt. The definition of an independent central bank proposed here is therefore that the central bank has its own objective and also carries no responsibility for government finances.

5.1 Results

I first consider the power of real government spending when the central bank is goal independent. To isolate the effect of real government spending, I constrain the budget to be balanced at all times so thatt $\hat{F}_t = \hat{T}_t$ (corresponding to equilibrium B in figure 2, when the central bank is goal independent). The solution does not depend on whether the central bank is goal independent. This can be proved in two steps. Observe first that the solution when the natural interest rate becomes positive (and the zero bound is no longer binding) is the same under either coordination or goal independence because the central bank will target zero inflation and a zero output gap at that time (and the Treasury will then set $\hat{F}_t = 0$). Consider now the solution when the zero bound is binding. Since monetary policy is constrained by the zero bound at this time, its different objective is irrelevant during this period as long as it implies a zero interest rate. The central bank interest rate policy, therefore, only matters in period $t \geq \tau$, and I have just argued that its policy will be the same in those periods as under coordination. The Treasury, in turn, maximizes social welfare, and the path for government spending will therefore be exactly the same as analyzed in last section when $t < \tau$. It follows that the solution is the same under coordination and goal independence. A formal way of verifying this is to write out the first-order conditions of the two maximization problems and verify that they are identical to the one implied by the joint maximization problem analyzed in the last section.[17]

Consider now the case of deficit spending when the central bank is goal independent and suppose that now real spending

17. See an earlier version of this paper (Eggertsson, 2006a).

is held constant, so that $\hat{F}_t = 0$. In this case, the power of deficit spending depends dramatically on whether the central bank is goal independent: If the central bank is goal independent, deficit spending has *no effect* on inflation or output.

Proposition 1: *If the central bank is goal independent and if $\hat{F}_t = 0$, then deficit spending has no effect on output and prices.*

A formal proof can be obtained by writing out the first-order conditions of each of the maximization problems of the treasury and the central bank.[18] The logic of the result is as follows. For a given path of F_t, Ricardian equivalence holds in the model, so that debt does not enter into any of the equilibrium conditions of the private sector apart from its budget constraint. Monetary policy is set to minimize $(\Pi_t - 1)^2 + \lambda_x x_t^2$. Government debt or deficits do not enter this objective or the constraints that limit the actions of the central bank. It follows that debt has no effect on the equilibrium determination of inflation, output, and interest rates, which are determined by exactly the same set of equations as if fiscal policy was completely inactive (that is, in equilibrium C in figure 2). It follows that if I set $\hat{F}_t = 0$ to be exogenously given, deficit spending has no effect on the equilibrium outcome when the central bank is goal independent. The central bank will determine inflation and the output gap without any reference to deficits or debt.[19] The effect of fiscal policy when coordinated with monetary policy is thus fundamentally different depending on whether or not monetary and fiscal policy are coordinated. When the central bank is goal independent, the deficit spending multiplier is zero.

5.2 Extensions: Irrelevant Policies such as Exchange Interventions, Unconventional Open Market Operations, Bank Bailouts, Helicopter Money, and Long-Term Bonds

In the context of the current crisis in the United States and the previous crisis in Japan, many commentators and researchers

18. See an earlier version of this paper (Eggertsson, 2006a).

19. If the treasury chooses F_t in each period, deficit spending can, in principle, have an effect by influencing the expectations about future spending, F_{t+j}. This is only a second-order effect in this model, however.

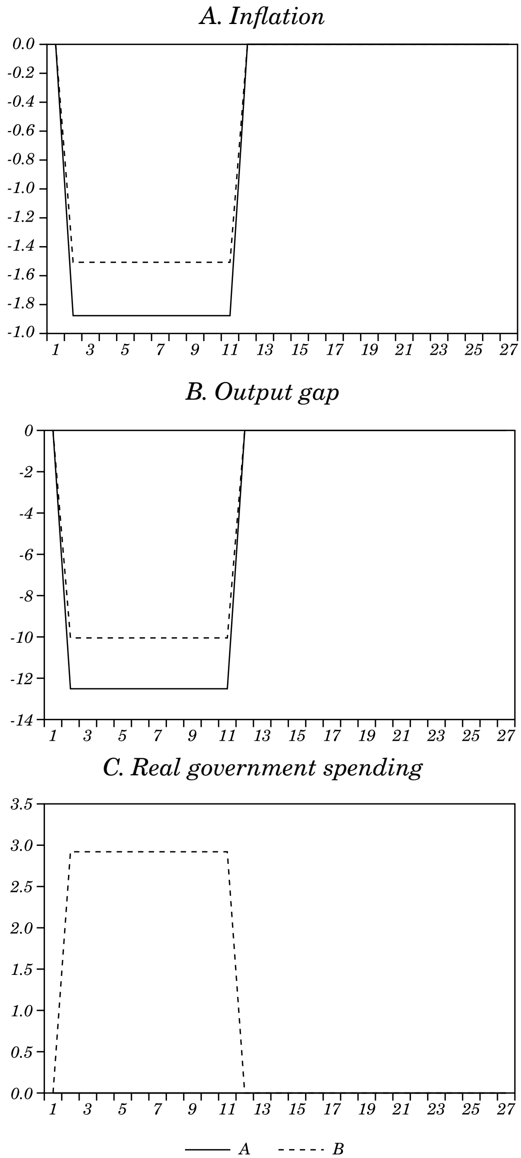
have suggested various policy options to stimulate demand, such as unconventional open market operations, helicopter money, purchases of long-term debt, and so on. None of these policies will have any effect, however, given an independent central bank, as described above. Their effect relies entirely on policy coordination and the extent to which a current fiscal burden implies an inflation incentive in the future. The theory laid out in this paper leaves no room for channels such as a portfolio effect or the different degrees of liquidity of various assets. While this is arguably unrealistic, the current setup clarifies that the signalling effect that many of those who suggest these policies rely on hinges critically on monetary and fiscal coordination.

Another mechanism may be important, even for an independent central bank. If the central bank cares about its own balance sheet, these operations may well operate under "independence" in a similar fashion as the "coordinated" solution implies. One can even argue that the balance sheet consideration may be so strong, that it would preclude a central bank from taking sufficiently strong actions.

6. Fiscal Multipliers and Policy Coordination: The United States during the Great Depression and Japan in the Great Recession

A possible reconciliation of the different outcomes in the United States during the Great Depression in 1933–37 and 1938–41 and Japan today is the different policy multipliers under coordination and central bank independence. To make the comparison more concrete, I recalibrate the model to match some basic features of the Great Recession in Japan. This calibration is not based on a estimation using Japanese data and is made purely for illustrative purposes. It should be interpreted in this light. I assume the same values for β and α as in the previous section, but I set $= 0.8$ to match the size of the Japanese government of 20 percent of steady state (recall the assumption of a log-utility function). I again pick the value of κ using equation (16). To do this, I need to take a stance on the size of the output contraction, or the output gap, in the Great Recession,as there is no reliable measure of this variable (the numerical example here is preliminary). In a recent study, Kamada (2005) reviews several measures of the output gap used at the Bank of Japan, which are in

Figure 5. Policy under Discretion under Central Bank Independence: Great Recession



Source: Author's computations.

Table 3. Coordination of Fiscal and Monetary Policy in the Great Depression in Japan
(in percent)

Year	*Change in GNP deflator*	*Change in CPI*	*Change in WPI*	*Change in GNP*	*Goverment surplus over GNP*
1929	–	–2.3	–2.8	0.5	–1.0
1930	–	–10.2	–17.7	1.1	2.0
1931	–12.6	–11.5	–15.5	0.4	0.4
1932	3.3	1.1	11.0	4.4	–3.5
1933	5.4	3.1	14.6	10.1	–3.0
1934	–1.0	1.4	2.0	8.7	–3.5
1935	4.1	2.5	2.5	5.4	–3.3
1936	3.0	2.3	4.2	2.2	–2.0

Source: Author's elaboration.

the range of 5–15 percent in this period. Using 10 percent as a value for the output gap and –1.5 percent for deflation, I obtain

$$\kappa \equiv (1-\beta(1-\alpha))\frac{\pi}{x} = 0.0041,$$

which is a lower number than I used for the United States during the Great Depression. This indicates that a higher degree of price rigidity is needed in Japan to account for the features I match. I assume a shock of $r_L^e = -4.5$ percent to match this output gap. In contrast to the other exercise, I assume that the central bank is goal independent, but that the treasury uses fiscal spending to stimulate demand.

Figure 5 shows the response of the output gap, inflation, and government spending policy to the shock r_L^e, given goal independence and discretionary government spending. The optimal response of the ministry of finance is to increase government spending by 3 percent of GDP. An interesting counterfactual is to ask what would have happened in the absence of the expansion of real government spending. The solid line shows that in this case, the Great Recession in Japan would have resulted in additional 2.5 percent decrease in the output gap (or 3.5 percent in output).

Table 3 compares the multiplier of real spending across the Great Depression in the United States and the Great Recession in Japan in our illustrative calibration examples. The multiplier is higher in the calibrated example for the United States, which is driven by the different parameter values assumed for κ and σ. I do not wish to dwell on whether these different result reflect important differences in the structure of the United States economy during the Great Depression versus Japan in the Great Recession, since the parameters picked to generate the results are only intended for illustration and were backed out to match the basic features of the data outlined above. If those parameters were assumed to be the same in the two calibrations, the real spending multiplier would be the same in the two countries. A formal estimation strategy may yield quite different results, and these calibrations simply show that the model can replicate certain features of the data.[20] The main point I wish to stress is the dramatic difference in the deficit spending multiplier in the two examples, and this is true regardless of the parameter values assumed. While the deficit spending multiplier is substantial for the United States during the Depression in 1933–37, it is zero in Japan during the Great Recession.

The result in the table illustrates that deficit spending, foreign exchange interventions, or any other actions by the treasury that affect the government balance sheet are completely irrelevant if the central bank is independent. This can explain the difference between the responses of the Japanese and the American economies to the various stimulative actions.

For comparison, the table also shows the multipliers for the scenario in which interest rates are positive. This scenario reflects the response of output when there are no deflationary pressures, but (counterfactually) the path for both the deficit and real spending is the same as if the shocks had occurred. In this case, the multipliers are much smaller, because the central bank counteracts the positive pressure on inflation and the output gap by raising interest rates. When the deflationary shock actually occurs, however, the central bank does not react in this way since both the output gap and inflation are below the level the central bank would wish them to be. This indicates that fiscal policy is mainly effective when the interest rate is zero.

The multipliers under coordination are much bigger than in the traditional Keynesian literature. The most cited paper on fiscal policy during the Great Depression, for example, is Brown (1956).

20. For an exercise that is closer to that spirit, see Denes and Eggertsson (2009).

In his baseline calibration the real spending multiplier is 0.5 and the deficit spending multiplier is 2.0.[21] The reason for this large difference is that the old models ignore the expectation channel. Modeling expectations is the key to understanding the large effect of government spending.

6.1 The Evolution of the Money Supply

So far I have not discussed the implied path of the money supply for the different policy regimes. As mentioned in section 2, the equilibrium can be fully characterized without any direct reference to the money supply. For a given path of output, prices, and interest rates, the money supply is given by equation (8), which I list again here:

$$M_t \geq \nu P_t Y_t. \qquad (29)$$

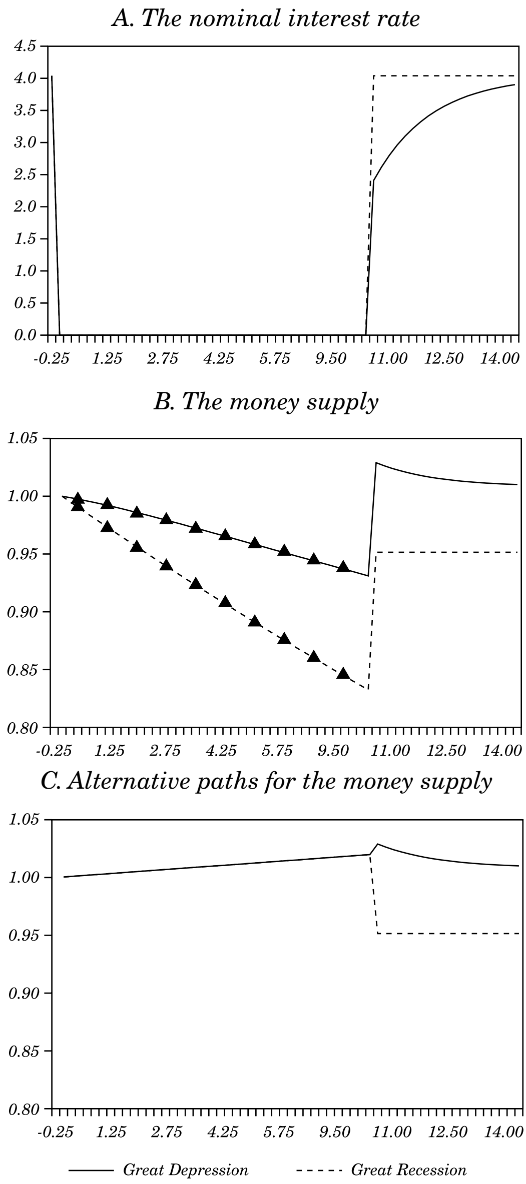
This inequality has to hold with equality at all times when the nominal interest rate is greater than zero. The reason is that at a positive interest rate, the household would prefer to aqcuire interest on its assets. At zero interest rate, however, the household is indifferent between holding money or government bonds as assets, so the money supply is indeterminate.[22] This has strong implications for the evolution of money supply during the Great Depression and the Great Recession.

Figure 6 shows the evolution of the nominal interest rate and the money supply for a scenario in which the natural interest rate stays negative for ten years for each of calibration examples (but interest rates remained close to zero in 1933–41 in Great Depression and in 1996–2006 in the Great Recession). Consider panel A in figure 6. For periods 0–10, the interest rates is zero in both policy regimes. In panel B, any money supply is consistent with the equilibrium in

21. See Brown (1956, table 1). Column 14 is his baseline calibration where he assumes "that the marginal propensity to spend disposable income and profits (a)" is 0.8 and " the marginal propensity to spend, national product (b)" is 0.6. The real spending multiplier in his model is $(1 - a) / (1 - b)$ and the deficit spending multiplier is $a / (1 - b)$, which give the numbers cited above.

22. A more detailed money demand specification would define velocity, ν, as a function of the nominal interest rate, but this is not required for the basic point I wish to make in this section. Additionally, with productivity growth, the implied money supply would be increasing at the phase of productivity.

Figure 6. Implied Money Supply and Nominal Interest Rate during the Great Depresson and the Great Recession



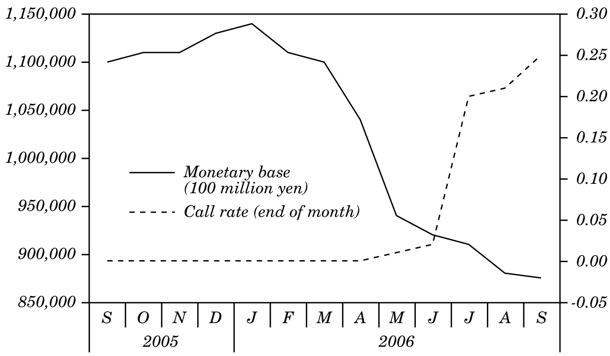
Source: Author's computations.

periods 0–10 (which is denoted by triangles) as long as it is above the triangulated lines, because during those periods the interest rate is zero and inequality (29) is therefore not binding. In other words, the *velocity of money* is indeterminate in periods 0 to 10. What is uniquely determined, however, is the money supply from period 10 onward, when the natural interest rate is positive again, in which case the nominal interest rate is no longer zero, as can be seen in panel A. What this means is that increases in the money supply in periods before 10 have no effect unless they change the expectations about the money supply in period 10 onward. Hence, according to the model, the fact that the Bank of Japan and the Federal Reserve both more than doubled the money supply in the periods in which interest rates were zero (roughly speaking 1996–2006 and 1933–41) had no effect unless it changed expectations about the money supply from 2006 onward, on the one hand, or 1941 onward, on the other. The expansionary stance of monetary policy in 1996–2006 versus 1933–41, therefore, cannot be gauged by the level of the money supply alone. Rather, what separates the two policy regimes is that the policy regime during the Great Depression implied a permanent increase in the money supply (post-1941), while policy during the Great Recession (post-2006) did not.

To illustrate this point, panel C in figure 6 shows a possible path for the money supply for the Great Recession and the Great Depression. This hypothetical evolution of the money supply is the same in the periods when the interest rate is zero. The only difference between the two regimes is that policy during the Great Recession implies that the money supply is lower in period 10 onward, so as soon as the deflationary pressure subsides, the central bank contracts the money supply aggressively.

A monetary contraction was, in fact, observed in Japan as soon as deflationary pressures started to wane in 2006. In the spring of 2006, as the deflationary pressures subsided, the Bank of Japan ended its period of quantitative easing. The Bank of Japan subsequently contracted the monetary base by about 30 percent, as shown in figure 7. No such contraction was observed during the Great Depression, apart from in a short period in 1937 through an increase in reserve requirements—a policy that was then reversed, as I discuss in the next section.

Figure 7. Contraction of the Money Supply in Japan in the Spring of 2006



Source: Federal Reserve Board and NBER Macrohistory Database.

7. The Role of Central Bank Independence during the Great Depression in the United States

The paper's model can be used to interpret the recovery from the Great Depression from the perspective of the independence of the Federal Reserve. If one takes the institutional arrangement described here literally, the model indicates that when the short-term nominal interest rate is zero, a move that coordinates monetary and fiscal policy would increase output and prices. This gives an interesting perspective on the recovery in 1933–37 in the United States, the recession in 1937–38, and the recovery from 1938 onward.

Roosevelt was inaugurated in March 1933. The following month, Congress passed a law, the Thomas Amendment, whose two most prominent features were that the president could reduce the gold value of the dollar and issue US$3 billion in currency. The US$3 billion corresponded to 30 percent of the monetary base at the time and more than half the currency in circulation.[23] While both provisions were only authorizations rather than required actions, they effectively ended the independence of the Federal Reserve for

23. The monetary base is defined as the sum of currency in circulation and nonborrowed reserves.

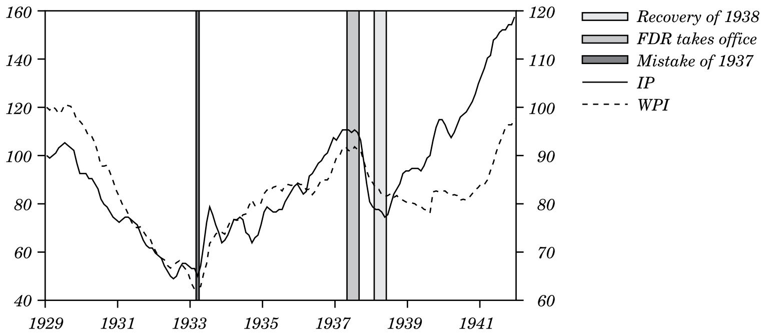
the time being. Roosevelt used this power to go off the gold standard. In addition, he said on several occasions that he wished to inflate the price level to pre-Depression levels. On 1 May of 1933, for example, Roosevelt was quoted in the *Wall Street Journal* as saying that "We are agreed in that our 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."

Figure 8 shows that prices and output immediately responded to these announcements. In addition, the administration embarked on various spending programs that increased the budget deficit. Were these expansionary programs related to making inflation more credible? When the market seemed to doubt the administration's commitment to inflation in the fall of 1933, Roosevelt said in a radio address that "If we cannot do this [reflation] one way, we will do it another. Do it, we will [...] 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 [increasing inflation]".

The administration saw deficit spending—that is, the enlargement of government credit—as crucial to increase inflation. Newspaper articles from this era provide anecdotal support for this claim. The violation of what Eggertsson (2008) calls the balanced budget dogma created widespread anger among some commentators in the press who believed the government would embark on a path of uncontrolled inflation, citing experiences of deficit spending in some countries in the aftermath of World War I (such as Germany).

Perhaps even more interesting, from a theoretical perspective, is the cause of the 1937 recession. Eggertsson and Pugsley (2006) argue that this recession was caused by the administration's abandonment of the commitment to inflate the price level to predepression levels. Specifically, the administration—especially the Federal Reserve—started warning that inflation was too high in the early months of 1937, even though prices had not reached predepression levels. This resulted in a shift in expectations and a contraction, as can be seen in figure 8. Eggertsson and Pugsley (2006) do not explain why the Federal Reserve started warning against high inflation. However, the argument laid out here suggests that the Federal Reserve reneged on the administration's commitment to inflation because it saw its objective as that of an independent bank. In other words, the Federal Reserve wanted to avoid inflation because it thought output had reached potential, and in that scenario an independent bank should have raised interest rates.

Figure 8. Monthly Whole Sale Prices and Industrial Production during the Great Depression



Source: Federal Reserve Board and NBER Macrohistory Database.

This interpretation seems to be consistent with some narrative evidence. Given the high level of outstanding government debt in 1937, the Federal Reserve's warning that inflation was too high would, according to my theory, be consistent with itas objective (since it thought the depression was essentially over at that time; see Eggertsson and Pugsley, 2006), but inconsistent with the Treasury's objective that is, the agency responsible for financing the budget deficits and outstanding debt payments. Historical evidence indicates that the Treasury reacted strongly to the Federal Reserve's actions in 1937, which included implementing higher reserve requirements that raised short-term interest rates, precisely because it was inconsistent with the policy regime of coordinated monetary and fiscal policy. Marriner Eccles, the governor of the Federal Reserve, described the reaction of the Secretary of Treasury, Henry Morgenthau, to the increase in interest rates in May 1937 triggered by an increase in reserve requirements:

> I was out of Washington when this happened. After hurrying back to do what I could to correct the situation, I found Secretary Morgenthau understandably disturbed about the fall in government bond prices [that is, the increase in the short-term interest rate]. He insisted that the Federal Reserve Board rescind its order for the second part of the [reserve requirement] increase, which was to go into effect on May 1. In a tense meeting at his home on Saturday night, he let it be known that if the Board failed to do what he urged,

> he would release a substantial amount of sterilized gold and thereby create new reserves that could be used to bolster the government bond market (Eccles, 1951, p. 292).

What this quote illustrates is that the Secretary of the Treasury threatened to take monetary policy away from the Federal Reserve unless it kept interest rates low. As Eccles notes, the Secretary's threat "would indicate that the Secretary of the Treasury had taken over control of monetary and credit policy" because a release of sterilized gold would have led to a corresponding increase in the monetary base. This narrative evidence indicates that the Treasury wanted inflationary policies to protect the low interest rate it was paying on its outstanding debt, consistent with the coordinated solution.

The Federal Reserve did not budge in 1937. In 1938, however, the country had experienced another deep recession, as can be seen in figure 8, and a tumble in the price level. In early 1938, Roosevelt restored an inflationary policy by overriding the Federal Reserve, giving them explicit directions on how to conduct policy. The first announcement of considerable importance was made at a press conference on 15 February, where Roosevelt said that he believed, as he had announced in 1933, that prices should be inflated back to their predepression levels (Eggertsson and Pugsley, 2006).

Three days later Roosevelt called another press conference to illustrate overall coordination of monetary and fiscal policy. On that occasion, he read a statement prepared jointly by Federal Reserve Chairman Eccles, Treasury Secretary Henry Morgenthau, and several other senior government officials. Flanked by senior administration officials, Roosevelt announced that "it is clear that in the present situation a moderate rise in the general price level is desirable." Later that spring, the administration took several steps to support an inflationary program, such as lowering the reserve requirement back to its 1936 level, increasing deficit spending, and desterilizing government gold stocks. The 1938–42 recovery was even stronger than the 1933–37 recovery, and by most measures the economy had fully recovered by 1942.

It is often argued that it was wartime spending that finally lifted the United States economy out of the Great Depression. This "conventional wisdom" is probably colored by the Keynesian view that monetary policy was impotent during this period. There is no doubt that wartime spending helped stimulate demand. According to the current hypothesis, however, the turnaround from 1937–38 is more appropriately traced back to Roosevelt's recommitment to inflation and coordinated monetary and fiscal policy in the early months of 1938.

8. Coordination during the Great Depression in Japan

The main objective of this paper is to compare the United States during the Great Depression and Japan during the Great Recession. The choice of these specific episodes was primarily motivated by the fact that they are relatively well known by economists. It is impossible, however, to leave the topic of coordination without mentioning another historical episode, which, while less known, is of great interest to the analysis.[24]

Despite the experience of the 1990s and 2000s, Japan has an interesting historical precedent of a cooperative solution. In the late 1920s, Japan was slipping into a depression. Growth had slowed down considerably: GNP rose by only 0.5 percent in 1929, 1.1 percent in 1930, and 0.4 percent in 1931. At the same time, deflation was crippling the economy. This was registered by several macroeconomic indicators, as illustrated in table 4. In December 1931, Korekiyo Takahashi was appointed the Finance Minister of Japan. Takahashi took three immediate actions. First, he abolished the gold standard. Second, he subordinated monetary policy to fiscal policy by having the Bank of Japan underwrite government bonds. Third, he ran large budget deficits. These actions had dramatic effects (see table 3). All the macroeconomic indicators changed in the direction predicted by the model. As the budget deficit increased, GNP rose and deflation was halted. During the same period, interest rates were at a historical low. I do not have a good measure of the short-term riskfree nominal rate, but the commercial rate, while low, was not zero, and it declined even further with Takahashi's actions. In addition to the nominal interest rate cuts, the model indicates that the other actions taken—that is, aggressive deficit spending that was financed by underwriting of government bounds—could have had considerable effects on the real rate of return by increasing expected inflation. This channel may

24. See, for example, Patrick (1971), Nakamura (1971), and Nanto and Takagi (1985) for a discussion of this period in Japan.

be important for explaining the success of these policy measures in Japan during the Great Depression. In 1936, Takahashi was assassinated, and the government finances were subjugated to military objectives. The subsequent military expansion eventually led to excessive government debt and hyperinflation. Until Takahasi was assassinated, however, the economic policies in Japan in the 1930s were remarkably successful, as the table reveals. The resulting hyperinflation that followed in later years, however, reflects the dangers associated with coordination of this kind.

9. Conclusions

Inflation has been considered the main threat to monetary stability for several decades. In the aftermath of the double digit inflation of the 1970s, there was a movement to separate monetary policy from fiscal policy and assign it to independent central bankers whose primary responsibility was to prevent inflation. This development was reinforced by important contributions on the theoretical level, most notably by Kydland and Prescott (1977) and Barro and Gordon (1983) , who illustrated the inflation bias of a discretionary government. It is easy to forget that in the aftermath of the Great Depression, when deflation was the norm, the discussion at the political and theoretical level was quite the opposite. Paul Samuelson claimed that the Federal Reserve was “the prisoner of its own independence” during the Great Depression, exaggerating the slump by its inability to fight deflation.[25] Similarly, Milton Friedman argued that “monetary policy is much too serious a matter to be left to the central bankers.”[26] This paper explains the different reactions of nominal demand during the Great Recession versus the Great Depression by illustrating the importance of central bank independence. Working out the normative implications of this is a hard task, which I do not attempt to address here. There are obvious and large benefits of central bank independence under regular circumstances, but there is a case for coordination when the economy is in dire straits. The case for coordination is weaker to the extent that the central

25. See Mayer (1990, p. 6).

26. However, he suggested rules to solve the problem, rather than coordinated discretion as I do here. See Friedman and Friedman (1980).

bank has high degree of credibility and is able to effectively use it to steer away from Depression-style contraction.

As I have stressed in this paper, the two key differences between policymaking in the Great Recession and the Great Depression are that monetary and fiscal policy were coordinated during the Great Depression and that the government made an explicit commitment to reflate the price level. What was the contribution of each of these channels? In the model analysis, I make a strong assumption that words had no weight so that the second channel played no role, which is essentially equivalent to assuming that the government had no credibility. One cannot, however, infer whether this assumption is correct in the data because words and actions went together (that is, the publicly communicated commitment to inflation in the United States was concurrent with the reduction in central bank independence). Is it possible that the change in the institutional arrangement was irrelevant and that all that mattered was the commitment of the government to price-level targeting? This is a question for future research.

APPENDIX A
Computation Method

I start by defining the following notation:

$$\Lambda_t \equiv \left[\Pi_t \;\; Y_t \;\; i_t \;\; F_t \;\; T_t\right], \text{ and } e_t \equiv \begin{bmatrix} f_t^e \\ S_t^e \end{bmatrix}.$$

I summarize conditions (2), (3), and (4) by the vector function Γ, so that

$$\Gamma(\Lambda_t, w_t, w_{t-1}, b_t) = 0 \tag{A1}$$

and the inequalities (5) and (7) by Υ, so that

$$\Upsilon\,(\Lambda_t, w_t, b_t) \geq 0 \tag{A2}$$

I summarize the utility as $U(\Lambda_t,b_t)$, so that the maximization problem can be written compactly as

$$J(w_{t-1}, \xi_t) = \max_{i_t,F_t,T_t}\left[U(\Lambda_t,b_t) + E_t\beta J(w_t,b_{t+1})\right] \tag{A3}$$

subject to equations (30) and (31).

I obtain the necessary conditions for a Markov perfect equilibrium by differentiating the Lagrangian:

$$L_t = U(\Lambda_t, \xi_t) + E_t\beta J(w_t, \xi_{t+1}) + \phi_t'\Gamma(e_t, \Lambda_t, w_t, w_{t-1}, \xi_t) + \delta_t'\Upsilon(\Lambda_t, w_t, \xi_t),$$

where ϕ_t is a (5×1) vector and γ_t is (2×1). The first-order conditions for $t \geq 0$ (where each derivative of L is equated to zero) are

$$\frac{dL}{d\Lambda_t} = \frac{dU(\Lambda_t,\xi_t)}{d\Lambda_t} + \phi_t' \frac{E_t d\Gamma(\Lambda_t,w_t,w_{t-1},\xi_t)}{d\Lambda_t} + \delta_t' \frac{d\Upsilon(\Lambda_t,\xi_t)}{d\Lambda_t}; \tag{A4}$$

$$\frac{dL}{dw_t} = E_t \frac{d\beta J(w_t,\xi_{+1})}{dw_t} + \phi_t' \frac{E_t d\Gamma(\Lambda_t,w_t,w_{t-1},\xi_t)}{dw_t} + \delta_t' \frac{d\Upsilon(\Lambda_t,w_t,\xi_t)}{dw_t};$$

$$\gamma_t \geq 0, \quad \Upsilon(\Lambda_t, w_t, \xi_t) \geq, 0 \quad \delta_t' \Upsilon(\Lambda_t, w_t, \xi_t). \tag{A5}$$

Here, $dL \,/\, d\Lambda_t$ is a (1×5) Jacobian. I use the following notation:

$$\frac{dL}{d\Lambda_t} \equiv \left[\frac{\partial L}{\partial \Pi_t}, \frac{\partial L}{\partial Y_t}, \frac{\partial L}{\partial i_t}, \frac{\partial L}{\partial F_t}, \frac{\partial L}{\partial T_t} \right],$$

so that equation (33) is a vector of six first-order conditions. The Markov equilibrium must also satisfy an envelope condition:

$$J_w(w_{t-1}, \xi_t) = \phi_t' \frac{d\Gamma(e_t, \Lambda_t, w_t, w_{t-1}, \xi_t)}{dw_{t-1}}, \tag{A6}$$

In addtion, the derivative of $J(.)$ with respect to all other elements of Λ_t is zero.

As proved in Eggertsson (2006b), this system has a steady state with $\Pi = 1$, $Y = \bar{Y}$, $1 + i = \beta^{-1}$, $F = \bar{F} = T = \bar{T}$ and $w = 0$ and $\phi_1 = (\gamma \bar{F} \beta)/(\bar{F}(1 - \gamma))$, while all the other elements of the vectors ϕ and δ are zero. The system is linearized around this steady state for each set of equalities that have to hold when the zero bound is binding and when it is not, and the resulting solution is accurate to the first order (Eggertsson, 2006b). I wrote a Matlab file to numerically approximate the linearized system. The numerical solution obtained is then found using the solution method in Eggertsson and Woodford (2003) and Eggertsson (2006b). This solution is shown in the Matlab files available online at www.ny.frb.org/research/economists/eggertsson/index.html.

Appendix B
Derivation of Objective

Here I do a linear quadratic approximation of the utility of the representative household to verify the statement in the text. The utility function of the household is:

$$E_t \sum_{t=0}^{\infty} \beta^t \{u(Y_t - F_t - d(\pi_t), \xi_t) + g(F_t - s(T_t), \xi_t) - v(Y_t, \xi_t)\},$$

using a slightly more general notation than in the text. In steady state,

$$u_c = C^{-\sigma^{-1}} u^{\sigma^{-1}} = 1;$$
$$u_{c\xi} = \sigma^{-1} C^{-\sigma^{-1}} u^{\sigma^{-1}-1} = C^{-1}\sigma^{-1};$$
$$u_{cc} = -\sigma^{-1} C^{-\sigma^{-1}-1} u^{\sigma^{-1}} = -C^{-1}\sigma^{-1};$$
$$v_y = \lambda_1 Y^{\omega} q^{-\omega} = 1;$$
$$v_{yy} = \omega\lambda_1 Y^{\omega-1} q^{-\omega} = \omega;$$
$$v_{y\xi} = -\lambda_1 \omega Y^{\omega} q^{-\omega} = -\omega;$$
$$g_G = \chi G^{-\sigma^{-1}} g^{\sigma^{-1}} = \chi;$$
$$g_{GG} = -\sigma^{-1}\chi G^{-\sigma^{-1}-1} g^{\sigma^{-1}} = -\chi G^{-1}\sigma^{-1};$$
$$g_{G\xi} = \sigma^{-1}\chi G^{-\sigma^{-1}} g^{\sigma^{-1}-1} = \chi G^{-1}\sigma^{-1};$$
$$(1 - s')\chi = 1.$$

Also recall that in steady state I normalize $Y = 1$. The first piece of the utility is

$$
\begin{aligned}
u\left[Y_t - F_t - d\left(\pi_t\right), \xi_t\right] &= u + u_c dY_t - u_c dF_t + u_c d' dp_t + u_\xi d\xi_t \\
&\quad - \frac{1}{2} c_{cc} dY_t^2 + u_{c\xi} d\xi_t dY_t - u_{c\xi} d\xi_t dF_t \\
&\quad - u_{c\xi} d\xi_t d' d\pi_t - u_{cc} dY_t dF_t + u_{cc} d' dY_t d\pi_t \\
&\quad + u_{cc} d' dF_t d\pi_t + \frac{1}{2} u_{cc} dF_t^2 - \frac{1}{2} u_c d'' d\pi_t^2 \\
&\quad + \frac{1}{2} u_{cc} \left(d'\right)^2 d\pi_t^2 + \frac{1}{2} \xi_t' u_{\xi\xi} \xi_t \\
&= \hat{Y}_t - \hat{F}_t + \begin{bmatrix} -\frac{1}{2} \sigma^{-1} C^{-1} \hat{Y}_t^2 + \sigma^{-1} C^{-1} \hat{Y}_t \hat{F}_t \\ + \sigma^{-1} C^{-1} \hat{Y}_t \hat{u}_t - \sigma^{-1} C_t^{-1} \hat{F}_t \hat{u}_t \\ -\frac{1}{2} d'' d\pi_t^2 - \frac{1}{2} \sigma^{-1} C^{-1} \hat{F}_t^2 \end{bmatrix} \\
&\quad + \text{TIP},
\end{aligned}
$$

where TIP stands for terms independent of policy. The second piece is

$$
\begin{aligned}
g\left[F_t - s\left(T_t\right), \xi_t\right] &= \bar{g} + g_G dF_t - g_G s' dT_t + g_\xi d\xi_t + \frac{1}{2} g_{GG} dF_t^2 \\
&\quad + \frac{1}{2} g_{GG} \left(s'\right)^2 dT_t^2 - \frac{1}{2} g_G s'' dT_t^2 + g_{G\xi} d\xi_t dF_t \\
&\quad - g_{G\xi} d\xi_t s' dT_t + \frac{1}{2} \xi_t{}' g_{\xi\xi} \xi_t \\
&= \chi \hat{F}_t - s' \chi \hat{T}_t - \frac{1}{2} \chi \sigma^{-1} G^{-1} \hat{F}_t^2 - \frac{1}{2} \chi \sigma^{-1} G^{-1} \left(s'\right)^2 \hat{T}_t^2 \\
&\quad - \frac{1}{2} s'' \chi dT_t^2 + \chi G^{-1} \sigma^{-1} \hat{F}_t \hat{g}_t - \chi G^{-1} \sigma^{-1} s' \hat{T}_t \hat{g}_t + \text{TIP}.
\end{aligned}
$$

Combine period utility to yield

$$\begin{aligned}
&\hat{Y}_t - \hat{F}_t - \frac{1}{2}\sigma^{-1}C^{-1}\hat{Y}_t^2 - \sigma^{-1}C^{-1}\hat{Y}_t\hat{F}_t + \sigma^{-1}C^{-1}\hat{Y}_t\hat{u}_t - \sigma^{-1}C^{-1}\hat{F}_t\hat{c}_t - \frac{1}{2}d''d\pi_t^2 \\
&\quad - \frac{1}{2}\sigma^{-1}C^{-1}\hat{F}_t^2 + \chi\hat{F}_t - s'\chi\sigma^{-1}G^{-1}\hat{F}_t^2 - \frac{1}{2}\chi\sigma^{-1}G^{-1}\left(s'\right)^2\hat{T}_t^2 \\
&\quad + \chi G^{-1}\sigma^{-1}\hat{F}_t\hat{g}_t - \chi G^{-1}\sigma^{-1}s'\hat{T}_t\hat{g}_t - \hat{Y}_t - \frac{1}{2}\omega\hat{Y}_t^2 + \omega\hat{Y}_t\hat{q}_t \\
&\quad = \left(\chi - 1\right)\hat{F}_t - s'\chi\hat{T}_t - \frac{1}{2}d''\pi_t^2 \\
&\quad + \left[-\frac{1}{2}\left(\sigma^{-1}C^{-1} + \omega\right)\hat{Y}_t^2 + \sigma^{-1}C^{-1}\hat{Y}_t\hat{F}_t + \sigma^{-1}C^{-1}\hat{Y}_t\hat{u}_t + \omega\hat{Y}_t\hat{q}_t\right] \\
&\quad + \left[-\frac{1}{2}\sigma^{-1}\left(C^{-1} + \chi G^{-1}\right)\hat{F}_t^2 + \chi G^{-1}\sigma^{-1}\hat{F}_t\hat{g}_t - \sigma^{-1}C_t^{-1}\hat{F}_t\hat{u}_t\right] \\
&\quad + \left\{-\frac{1}{2}\chi\left[\sigma^{-1}G^{-1}\left(s'\right)^2 + s''\right]\hat{T}_t^2 - \chi G^{-1}\sigma^{-1}s'\hat{T}_t\hat{g}_t\right\}
\end{aligned}$$

Welfare criterion can now be written as

$$\sum_{t=0}^{\infty}\beta^t\left\{\begin{array}{l}
-\frac{1}{2}d''\pi_t^2 - \frac{1}{2}(\sigma^{-1}C^{-1} + \omega)(\hat{Y}_t - \hat{Y}_t^n)^2 \\
-\frac{1}{2}\sigma^{-1}(C^{-1} + \chi G^{-1})(\hat{F}_t - \hat{F}_t^n)^2 \\
-\frac{1}{2}\chi[\sigma^{-1}G^{-1}(s')^2 + s'')(\hat{T}_t - \hat{T}_t^n)^2]
\end{array}\right\},$$

where:

$$\hat{Y}_t^n \equiv \frac{\sigma^{-1}C^{-1}}{\sigma^{-1}C^{-1} + \omega}\hat{F}_t + \frac{\sigma^{-1}C^{-1}}{\sigma^{-1}C^{-1} + \omega}\hat{u}_t + \frac{\omega}{\sigma^{-1}C^{-1} + \omega},$$

$$\hat{F}_t^n \equiv \frac{\chi G^{-1}}{C^{-1} + \chi G^{-1}}\hat{g}_t - \frac{C^{-1}}{C^{-1} + \chi G^{-1}}\hat{u}_t,$$

and

$$\hat{T}_t^n \equiv -\frac{G^{-1}\sigma^{-1}s'}{\sigma^{-1}G^{-1}(s')^2 + s''}g_t,$$

because

$$\sum_{t=0}^{\infty}\beta^t\left(\chi-1\right)dF_t - s'\chi dT = w_{-1} + \sum_{t=0}^{\infty}\beta^t\left[-1+\chi\left(1-s'\right)\right]dF_t = w_{-1} = 0.$$

Table B1. Japan 1990-2006
(in ten billion Japanese yen)

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Nominal GDP	4,401.67	4,682.91	4,805.14	4,841.42	4,865.23	4,931.40	5,028.72	5,125.67
Government expenditure	1,395.65	1,474.95	1,559.29	1,657.46	1,693.06	1,763.92	1,823.40	1,797.02
Percent of GDP	31.71	31.50	32.45	34.24	34.80	35.77	36.26	35.06
Deficit (-) / Surplus (+)	90.24	84.83	37.90	−115.10	−182.70	−232.45	−254.81	−194.44
Percent of GDP	2.05	1.81	0.79	−2.38	−3.76	−4.71	−5.07	−3.79
Nominal monetary base	3,922.01	3,981.29	3,892.81	4,024.69	4,209.61	4,415.16	4,778.78	5,144.47
Short-term interest rates (percent)	8.25	5.50	3.84	2.38	2.22	0.40	0.38	0.44
Real GDP	100.00	105.81	109.97	112	109.17	111.22	114.16	115.74
Percent change	5.26	3.33	0.95	0.20	−2.52	1.87	2.65	1.39
Real monetary base	100.00	98.26	94.31	96.33	100.05	105.22	113.93	121.05
GDP deflator	100.00	100.55	99.27	98.20	101.24	100.74	100.08	100.61
Percent change	−3 .00	0.55	−1.28	−1.07	3.09	−0.50	−0.65	0.53
CPI	100.00	103.31	105.25	106.53	107.28	106.99	106.95	108.36
Percent change	3.10	3.31	1.88	1.22	0.71	−0.27	−0.04	1.32

Table B1. (continued)

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Nominal GDP	5,027.52	4,956.31	5,013.39	4,968.74	4,897.47	4,907.74	4,961.24	5,026.07
Government expenditure	1,815.90	1,659.28	1,789.89	1,810.81	1,845.99	1,830.20	1,812.10	1,867.69
Percent of GDP	36.12	37.70	38.22	37.68	38.13	36.75	36.75	37.16
Deficit (-) / Surplus (+)	277.27	−318.13	−350.11	−294.35	−381.73	−373.36	−321.50	−322.99
Percent of GDP	−5.51	−7.23	−7.48	−6.13	−7.88	−7.67	−6.52	−6.42
Nominal monetary base	5,585.80	5,993.81	6,450.79	6,930.20	8,711.11	10,142.94	10,865.43	11,079.76
Short-term interest rates (percent)	0.34	0.01	0.22	0.00	0.00	0.00	0.00	0.00
Real GDP	1,13.59	113.47	116.76	117.19	117.35	119.49	122.20	125.40
Percent change	−1.86	−0.11	2.9	0.37	0.14	1.82	2.27	2.62
Real monetary base	130.35	140.46	152.67	165.89	210.65	246.23	264.04	270.69
GDP deflator	100.55	99.24	97.55	96.33	94.81	93.31	92.24	91.06
Percent change	−0.06	−1.31	−1.7	−1.25	−1.57	−1.58	−1.15	−1.28
CPI	109.27	108.80	107.74	106.52	105.44	105.03	104.92	104.36
Percent change	0.84	−0.42	−0.98	−1.13	−1.01	−0.39	−0.10	−0.53

Source: Federal Reserve Board.

Table B2. United States 1930-1941
(in millions of US dollars)

	1930	*1931*	*1932*	*1933*	*1934*	*1935*
Nominal GDP	97,400.00	83,800.00	67,600.00	57,600.00	61,200.00	69,600.00
Government expenditure	3,545.90	4,300.30	4,572.30	5,115.60	5,216.00	6,843.80
Percent of GDP	3.64	5.13	6.76	8.88	8.52	9.83
Deficit (-) / Surplus (+)		−1,402.00	−1,520	−3,305	−5,502.50	−5,440.00
Percent of GDP		−1.67	−2.25	−5.74	−8.99	−7.82
Nominal monetary base	6,393.00	6,426.00	7,364.00	7,821.00	9,402.00	11,405.00
Short-term interest rates (per cent)	1.25	2.75	0.05	0.50	0.20	0.15
Real GDP	100.00	93.60	81.43	80.37	89.05	96.98
Percent change	−8.60	−6.40	−13.00	−1.30	10.80	8.90
Real monetary base	100.00	110.53	141.10	158.22	183.77	217.25
GDP Deflator	100.00	89.60	79.03	76.95	81.20	82.84
Percent change	−3.67	−10.38	−11.76	−2.70	5.57	2.01
CPI	100.00	90.94	81.63	77.33	80.03	82.12
Percent change	−2.55	−9.06	−10.23	−5.28	3.50	2.61

Table B2. (continued)

	1936	*1937*	*1938*	*1939*	*1940*	*1941*
Nominal GDP	78,500.00	87,800.00	89,000.00	89,100.00	96,800.00	114,100.00
Government expenditure	8,532.80	8,835	8,453.34	9,319.80	9,794.45	19,052.80
Percent of GDP	10.87	9.38	9.50	10.46	10.12	16.70
Deficit (-) / Surplus (+)	−6,659.00	−3,158.00	−738.00	−5,558.00	−5,735.00	−7,038.00
Percent of GDP	−8.48	−3.60	−0.83	−6.24	−5.92	−6.17
Nominal monetary base	13,014.00	13,283.00	15,428.00	18,883.00	22,539.00	23,597.00
Short-term interest rates (per cent)	0.20	0.12	0.05	0.05	0.06	0.35
Real GDP	109.59	115.18	111.26	120.27	130.86	153.23
Percent change	13.00	5.10	−3.40	8.10	8.80	17.10
Real monetary base	245.42	241.61	286.20	354.88	420.55	419.24
GDP Deflator	83.80	87.35	84.84	84.06	85.01	90.73
Percent change	1.12	4.32	−2.91	−0.97	1.17	6.70
CPI	82.95	86.00	84.33	83.24	83.84	88.05
Percent change	1.01	3.68	−1.95	−1.29	0.72	5.02

Source: Federal Reserve Board.

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