Low Nominal Interest Rates: A Public Finance Perspective*

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This paper studies low-interest-rate policies from a public finance perspective. Two policy regimes are considered. In the first regime, the central bank is subordinate and its budget is integrated into the fiscal authority's budget constraint. In this case, monetary policy influences the revenue mainly through currency seigniorage. In the other regime, the central bank's budget is separated from that of the fiscal authority. Commitment to a low nominal interest rate forces the central bank to inject money when the primary deficit increases. Thus, even if the budgets are separated, the central bank's actions are constrained by the fiscal authority. Under a "passive" Taylor rule, a reduction in the nominal interest rate *lowers* the government revenue.

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Monetary policy is, conceptually, institutionally and practically, a small but significant part of intertemporal public finance—its liquid corner. (Buiter 2005, C1)

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1. Introduction

This paper studies low-interest-rate policies from a public finance perspective. It studies how changes in the nominal interest rate influence government revenue. In this paper, two policy regimes are considered. In the first regime, the central bank is subordinate in that its budget is integrated into the fiscal authority's budget constraint. In such a situation, monetary policy influences the government's revenue through seigniorage—the revenue from printing money. In the other regime, the central bank's budget is separated from that of the fiscal authority. Monetary policy continues to influence the fiscal authority's revenue through interest payment on the public debt.

Figure 1 (A–C) presents the evolution of public debt, interest obligations on public debt, and the nominal interest rate in Japan since 1980.[1] The figures indicate that, though the government was heavily in debt, especially in the 1990s, the interest obligations on the debt declined over time during this decade. Is this a consequence of the low-interest-rate policies implemented by the Bank of Japan?[2] Or is it simply part of the risk-free rate puzzle?[3]

Motivated by this observation, this paper explores how monetary policy influences government revenue. For this purpose, this paper exploits Laffer curves to highlight precisely how the nominal interest rate and the inflation rate affect government revenue. Laffer curves have proven to be useful in the field of public finance and monetary economics from two dimensions. One is that the peak of a Laffer curve tells us the maximum sustainable level of budget deficit. The other is that the slope of a Laffer curve indicates whether revenue is increasing or decreasing in the variable under consideration.

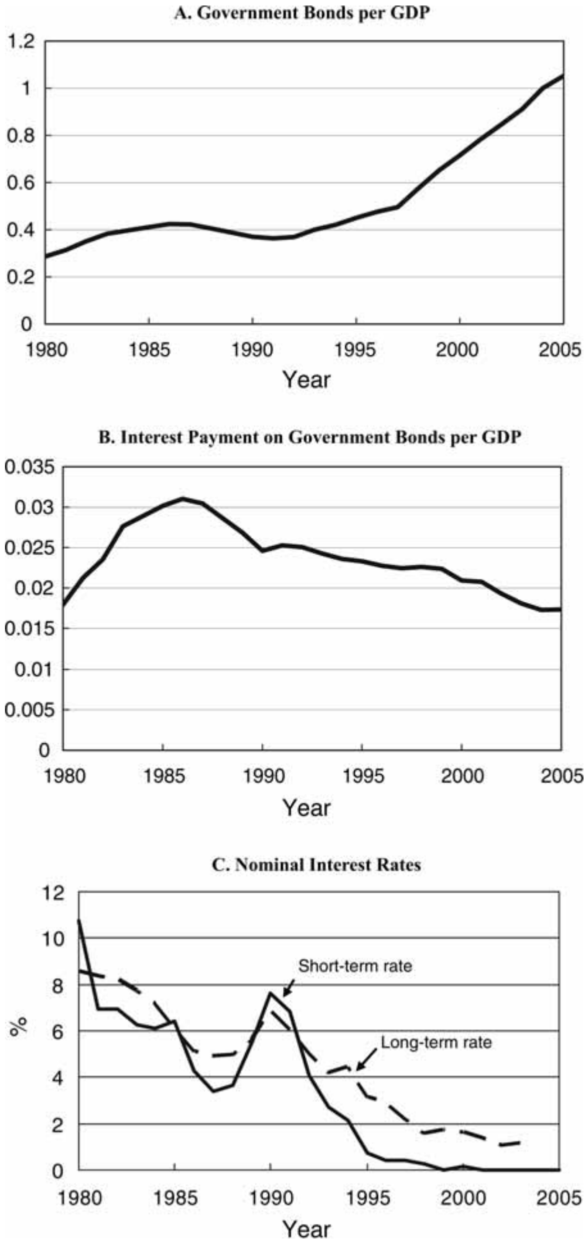
In monetary economics, the standard form of the Laffer curve relates the rate of inflation and total government revenue. I refer to it as the inflation Laffer curve. In addition to the standard Laffer curve, I introduce the nominal-interest-rate Laffer curve, which relates

[1] All data series, taken from the Ministry of Finance and the Bank of Japan, are annual data for the fiscal year.

[2] The zero-interest-rate policy in Japan ended on July 14, 2006. The Bank of Japan raised the target short-term rate to 0.25 percent.

[3] See Bullard and Russell (1999) for a discussion.

Figure 1. Evolution of Public Debt, Interest Obligations on Public Debt, and Nominal Interest Rate in Japan Since 1980



nominal interest rate and government revenue. It is downward sloping, suggesting that lower nominal interest rates are associated with higher total revenues for the government.

This paper also considers the Laffer curve when the central bank follows a Taylor rule, under which the nominal interest rate is an increasing function of the inflation rate. Generally, the Laffer curve under a Taylor rule is hump shaped. An interesting finding is that the slope of the Laffer curve at low nominal interest rates crucially depends on how "active" or "passive" monetary policy is. If monetary policy is sufficiently passive in the sense of Leeper (1991), then the Laffer curve slopes upward—higher inflation finances a larger deficit. If monetary policy is sufficiently active, then the Laffer curve slopes downward—a lower interest rate finances a larger deficit.

Sargent and Wallace (1981) made an important contribution by pointing out that the central bank loses one degree of freedom because its budget constraint is integrated into that of the fiscal authority. Since Sargent and Wallace (1981), the consolidated budget constraint has become the building block of monetary policy analysis. An important assumption of the analysis of Sargent and Wallace (1981) and their followers is that the central bank is subordinate to the fiscal authority in the sense that the central bank determines the growth rate of base money so as to ensure solvency of the government. However, contemporary central banking is best described as being independent, although the degree of independence differs across countries. As a result, the world economy appears to be in a state of low inflation.

Based on this observation, this paper considers, as an extension of the basic model, an environment in which the central bank is independent. Issues regarding central bank independence have gained much attention from many writers. The major theoretical approach to central bank independence is based on the model of time inconsistency, and it focuses on the inflationary bias that arises in various environments. A comprehensive study of this approach is found in Cukierman (1992), and a critical view is found in Blinder (1998).

The concept of central bank independence proposed in this paper is quite simple and easily integrated into any dynamic general equilibrium model. The key is that the budget constraint of the central bank is separated from that of the fiscal authority. Thus, the fiscal authority must finance its expenditures by tax and bonds. Money is injected directly into households via "helicopter drops." Interestingly, monetary policy continues to influence the fiscal authority's revenue through interest payment on the public debt. Under nominal-interest-rate targeting, an increase in the primary deficit raises the equilibrium inflation rate, because commitment to a particular bond price forces the central bank to inject more money into the economy. Under strict inflation targeting, the central bank does not need to maintain the bond price. However, there may be two steady states under inflation targeting. At the low-interest-rate equilibrium, low nominal interest rates are associated with *low* government revenues.

Intuitively, low-interest-rate policies raise government revenue by reducing interest obligations on past debt. In other words, the Laffer curve must be downward sloping. However, this paper finds that the slope of the Laffer curve under a passive Taylor rule may be *globally* upward sloping—a reduction in the nominal interest rate lowers government revenue by raising the real interest rate on bonds.

The organization of this paper is as follows. Section 2 provides a review of the literature. Section 3 describes the structure of the model. In sections 4, 5, and 6, I consider a policy regime in which the central bank's budget constraint is integrated into the government's budget. Section 4 assumes a nominal-interest-rate target, section 5 assumes a strict inflation target, and section 6 assumes a Taylor rule. Section 7 investigates an alternative policy regime in which the central bank's budget constraint is separated from that of the fiscal authority. That is, the central bank is "tough." Section 8 discusses the results and their implications for conducting monetary policy. Section 9 concludes. Appendices 1 and 2 present alternative versions of the model.

2. Related Literature

The traditional Laffer curve relates the tax rate and tax revenue. A tax Laffer curve appears in textbooks such as Barro (1997). Because they summarize how changes in a policy variable affect government revenue, Laffer curves are also useful in monetary policy analysis. An inflation Laffer curve relates the inflation rate and total seigniorage. Related papers are Sargent and Wallace (1981), Miller and Sargent (1984), Aiyagari and Gertler (1985), King and Plosser

(1985), Bhattacharya, Guzman, and Smith (1998), Espinosa-Vega and Russell (1998), Bhattacharya and Kudoh (2002), and Nikitin and Russell (2006). Review articles by Brunner (1986) and Sargent (1999) are also available. An interesting application of the Laffer curve analysis is found in Bhattacharya and Haslag (2003), who considered a "reserve-ratio Laffer curve" to study how the reserve requirement influences seigniorage. In addition to the standard inflation Laffer curve, this paper introduces the nominal-interest-rate Laffer curve, which relates the nominal interest rate and total revenue.

It is well known that the revenue from issuing bonds is positive if and only if the economy is dynamically inefficient, under which the output growth rate exceeds the real interest rate. The bond seigniorage is positive, because in such an economy, the government can roll over the debt forever—it enjoys a Ponzi game. Thus, whether or not an economy is dynamically efficient is an important issue. Darby (1984) argued that the U.S. economy is dynamically inefficient, while Abel et al. (1989) concluded that many OECD economies are dynamically efficient. Bullard and Russell (1999) argued that dynamically inefficient equilibria are empirically plausible. Chalk (2000) computed the maximum sustainable deficit, which is essentially finding the peak of the Laffer curve.

There is a large and growing body of literature on monetary policy rules. Clarida, Galí, and Gertler (1998, 2000) summarized recent results and presented some international estimates of monetary policy rules. Benhabib, Schmitt-Grohe, and Uribe (2001) and Carlstrom and Fuerst (2001) studied optimizing monetary models with Taylor-type feedback rules and clarified how monetary policy rules might cause self-fulfilling fluctuations. A contribution of this paper is to characterize the Laffer curve under a Taylor rule.

3. Subordinate Central Bank and Public Finance

3.1 Environment

Consider a pure exchange economy comprising an infinite sequence of two-period-lived overlapping generations, the initial old generation, and an infinitely lived government. Let $t = 1, 2, \ldots$ index time. At each date t, a new generation is born. The population is normalized to 1. Each young agent is endowed with y_t units of the consumption good, and the endowment grows at a gross rate of $n > 0$: $y_{t+1} = ny_t$. The price level of the consumption good at date t is p_t. Throughout this paper, I focus on steady-state equilibria, in which all per-output real variables are constant over time.

3.2 Consumers

In order to focus on the agents' portfolio choice, I assume that all individuals save their entire income. As a means of saving, agents may hold money M_t and government bonds B_t. In order to motivate the demand for money as a liquid asset, divide each period into two subperiods. The bonds are assumed to yield a gross nominal return of $I_{t+1} \geq 1$ in the next period. However, bonds cannot be liquidated until the second subperiod. Money, yielding no nominal interest rate, can be liquidated in the first subperiod. Related environments are found in Stiglitz (1970), Diamond and Dybvig (1983), and Dutta and Kapur (1998).

Each individual wishes to consume in both subperiods. Let c_{1t} and c_{2t} denote the consumption of the final good in the first and second subperiods by an old agent born at date t. The consumer's objective function is

$$\phi u(c_{1t}) + (1 - \phi)u(c_{2t}), \tag{1}$$

where ϕ captures the relative weight of utility between the two subperiods. Throughout, I use the following specification: $u(c) = [1 - \rho]^{-1}c^{1-\rho}$ with $\rho \neq 1$ and $\rho > 0$. Because the individual cannot liquidate bonds in the first subperiod, the agent faces a cash-in-advance constraint:

$$p_{t+1}c_{1t} \leq M_t, \tag{2}$$

which is binding for $I_{t+1} > 1$.

The budget constraint for each young individual is

$$M_t + B_t = p_t y_t - T_t, \tag{3}$$

where T_t is the amount of lump-sum tax. Similarly, the budget constraint for each old individual is

$$p_{t+1}c_{1t} + p_{t+1}c_{2t} = M_t + I_{t+1}B_t. \tag{4}$$

Thus, each young individual maximizes (1) subject to (2)–(4). It is easy to transform the problem into

$$\max_{M_t}\left\{\phi\frac{[M_t/p_{t+1}]^{1-\rho}}{1-\rho}+(1-\phi)\frac{[(p_ty_t-T_t-M_t)I_{t+1}/p_{t+1}]^{1-\rho}}{1-\rho}\right\}.$$

Using the first-order condition, obtain the money-demand function:

$$M_t=\gamma(I_{t+1})[p_ty_t-T_t], \tag{5}$$

$$\gamma(I_{t+1})\equiv\left[1+\left(\frac{1-\phi}{\phi}\right)^{1/\rho}I_{t+1}^{1/\rho-1}\right]^{-1}. \tag{6}$$

From (6),

$$\gamma'(I)=-\left[1+\left(\frac{1-\phi}{\phi}\right)^{1/\rho}I^{1/\rho-1}\right]^{-2}\times\frac{1-\rho}{\rho}\left(\frac{1-\phi}{\phi}\right)^{1/\rho}I^{1/\rho-2}.$$

Thus, it is easy to establish the following.

LEMMA 1. *(i)* $\gamma'(I)<0$ *holds for* $\rho\in(0,1)$*; (ii)* $\lim_{I\to\infty}\gamma(I)=0$ *for* $\rho\in(0,1)$*; (iii)* $\gamma(1)=[1+((1-\phi)/\phi)^{1/\rho}]^{-1}$*; (iv)* $\lim_{I\to1}\gamma'(I)=-[1+((1-\phi)/\phi)^{1/\rho}]^{-2}((1-\phi)/\phi)^{1/\rho}(1-\rho)/\rho$*; and (v) the interest elasticity of money demand satisfies*

$$-\frac{I\gamma'(I)}{\gamma(I)}=\frac{1-\rho}{\rho}[1-\gamma(I)]. \tag{7}$$

There are several other environments that induce this money-demand function. In Schreft and Smith (1997, 2000), for example, markets are spatially separated, and communication across the markets is limited. Thus, only money is universally accepted as a means of payment. “Relocation shock” similar to the liquidity preference shock of Diamond and Dybvig (1983) induces agents to hold a mix of money and interest-bearing assets. Financial intermediation arises to provide perfect risk sharing through demand-deposit contracts, and the deposit-demand function is of the form (5). It is also easy to verify that a class of money-in-the-utility function or cash-in-advance specification can generate the money-demand function (5).

The value of ρ captures the strength of the income effect of a change in I. Throughout, this paper focuses on the case in which $\rho \in (0,1)$—that is, when the income effect is relatively weak. Money demand is independent of the *real* interest rate because, by construction, the saving rate is constant and equal to 1. In general, the real interest rate influences the intertemporal allocation, while the nominal interest rate influences the composition of competing assets. In models such as Sargent and Wallace (1981), Bhattacharya, Guzman, and Smith (1998), Espinosa-Vega and Russell (1998), and Bhattacharya and Kudoh (2002), the rate of inflation affects the demand for money by influencing saving. The effect of inflation on money demand is important, especially when the focus of study is on *high* inflation. Because this paper is concerned mostly with *low* inflation, the absence of the channel does not seem very problematic. Appendix 1 presents an alternative environment in which aggregate money demand depends on the rate of inflation.

3.3 Government

This paper focuses on how the government finances its primary deficits. The consolidated government budget constraint is

$$G_t - T_t + I_t B_{t-1} = B_t + M_t - M_{t-1} \tag{8}$$

for $t \geq 2$ and $G_1 - T_1 = M_1 + B_1$ for $t = 1$, where it is assumed that $B_0 = 0$ and $M_0 \geq 0$. Money is supplied through the channel of open-market operations by the central bank. As is conventional, the fiscal authority determines the total government liability, while the central bank determines its composition. Throughout the paper, this policy regime is referred to as the SCB (subordinate central bank) regime. I assume that the government simply consumes G_t and that it does not affect the utility of any generation or production process at any date. Divide (8) by $p_t y_t$ to obtain

$$g_t - \tau_t = b_t - \frac{1}{\Pi_t n} I_t b_{t-1} + m_t - \frac{1}{\Pi_t n} m_{t-1}, \tag{9}$$

where $b_t = B_t/p_t y_t$, $\tau_t = T_t/p_t y_t$, $m_t = M_t/p_t y_t$, and $\Pi_t \equiv p_t/p_{t-1}$.

There is a recurrent theme regarding the monetary–fiscal policy regime. This paper assumes a Ricardian policy regime; that is, the government's budget constraint is satisfied at any price level. Thus, I consider (8) and (9) to be identities. In addition, this paper considers a policy regime called fiscal dominance, under which the fiscal authority "moves first" and commits to a level of primary deficit. In particular, I assume that g_t and τ_t are constant over time. Thus, $g - \tau$ is the permanent primary deficit that must be financed by money and bonds. Throughout, it is assumed that $g \in (0, 1)$ and $\tau \in (0, 1)$.

DEFINITION 1. *A monetary equilibrium in the SCB regime is a set of sequences for real allocations* $\{m_t, b_t\}$ *and relative prices* $\{I_t, \Pi_t\}$ *such that (i) each generation maximizes utility (1) subject to (2)–(4); (ii) the asset market clears; (iii) the government's budget constraint (9) is satisfied; (iv)* $g_t = g$ *and* $\tau_t = \tau$ *for all* t*; and (v) monetary policy determines* I_t*,* Π_t*, or a function that relates* I_t *and* Π_t*.*

In any equilibrium, $m_t = \gamma(I_{t+1})[1-\tau]$, $b_t = [1-\gamma(I_{t+1})][1-\tau]$, and

$$\delta = 1 - \frac{\mu(I_t)}{n\Pi_t} \tag{10}$$

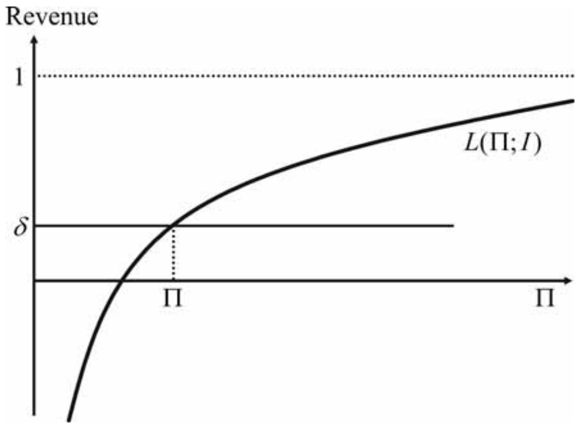
hold, where $\mu(I) \equiv I[1-\gamma(I)] + \gamma(I) > 1$ and $\delta \equiv (g-\tau)/(1-\tau)$. Under primary *surplus*, $\delta < 0$. Once monetary policy is specified, (10) determines the equilibrium.

4. Inflation Laffer Curve

4.1 Total Seigniorage, Currency Seigniorage, and Bond Seigniorage

Before investigating any equilibrium, I introduce Laffer curves to explore how government revenue is affected by inflation. First, consider a Laffer curve that relates inflation and total revenue. Suppose that the central bank targets the nominal interest rate such that $I_t = I$ for all t. The endogenous variable under nominal-interest-rate targeting is the rate of inflation. Because $M_{t+1}/M_t = \Pi n$ holds in the steady state, one could view that the central bank adjusts the base money growth rate in each period in order to maintain the target nominal interest rate.

Figure 2. Inflation Laffer Curve



Under nominal-interest-rate targeting, (10) reduces to

$$\delta = 1 - \frac{\mu(I)}{n\Pi_t} \equiv L(\Pi_t; I). \tag{11}$$

It is easy to verify that $\mu(1) = 1$ and $\mu'(I) = 1 - \gamma(I) - (I-1)\gamma'(I) > 0$. The right-hand side of (11) is referred to as the inflation Laffer curve, while equation (11) determines the equilibrium inflation rate. For a given I, the inflation Laffer curve $L(\Pi_t; I)$ is increasing in the rate of inflation, as shown in figure 2. The Laffer curve analysis is useful because it tells us the maximum possible level of revenue for the government. It is easy to verify that as $\Pi_t \to \infty$, $L(\Pi_t; I) \to 1$. It is important to note here that the upward-sloping Laffer curve depends crucially on the money-demand function that is independent of the inflation rate. As shown in appendix 1, the inflation Laffer curve becomes hump shaped if the money demand decreases with the inflation rate.

Because fiscal dominance is assumed, the primary deficit δ determines the need for seigniorage, thereby determining the equilibrium rate of inflation that finances the deficit. The equilibrium rate of inflation changes as the primary deficit changes. As is standard, an increase in δ raises the equilibrium inflation rate, because the upward-sloping Laffer curve implies that a higher inflation finances a greater deficit.

Total government revenue comprises currency seigniorage and bond seigniorage. I now investigate whether these two sources of revenue increase with inflation. First, consider the revenue from printing money. Under nominal-interest-rate pegging, the currency seigniorage is given by

$$m_t - \frac{1}{\Pi_t n} m_{t-1} = \left(1 - \frac{1}{\Pi_t n}\right) \gamma(I)[1-\tau] \equiv CS(\Pi_t; I). \qquad (12)$$

It is easy to verify that $\partial CS/\partial \Pi_t > 0$. The reason for this is as follows. For a given level of the nominal interest rate, the inflation tax base is invariant, because in this economy inflation does not influence money demand, and an increase in the inflation rate raises the inflation tax rate. Thus, the revenue is increasing in Π. It is important to note here that the currency seigniorage can be positive even under deflation as long as the output growth rate is positive ($n > 1$). The maximum possible currency seigniorage is $\lim_{\Pi \to \infty} CS(\Pi; I) = \gamma(I)[1-\tau]$.

Consider the revenue from issuing bonds. The bond seigniorage is given by

$$b_t - \frac{I}{\Pi_t n} b_{t-1} = \left(1 - \frac{I}{\Pi_t n}\right) [1-\gamma(I)][1-\tau] \equiv BS(\Pi_t; I). \qquad (13)$$

The bond seigniorage is increasing in Π. This is because an increase in the rate of inflation reduces the real interest on bonds. In other words, inflation reduces the interest payment on the government's outstanding debt. The maximum possible bond seigniorage is $\lim_{\Pi \to \infty} BS(\Pi; I) = [1-\gamma(I)][1-\tau]$.

4.2 Equilibrium

Under nominal-interest-rate pegging, the equilibrium inflation rate is determined by (11). Comparative statics exercises reveal that output growth is disinflationary, the primary deficit is inflationary, and nominal interest rates and inflation are positively related. These results are easily established by (11) with figure 2. First, (11) implies $\partial L/\partial n > 0$: an increase in n shifts the Laffer curve upward. From figure 2, this means that Π must be reduced. Figure 2 also implies that an increase in δ raises Π. Finally, because

$\partial L/\partial I = -\mu'(I)/n\Pi < 0$ holds, an increase in I shifts the Laffer curve downward and Π increases. At this point, it is important to note that total government revenue *in equilibrium* is $g - \tau$ by construction. Some other properties of the equilibrium are presented below.

LEMMA 2. *In any equilibrium, $\Pi_t > 1/(1-\delta)n$ must hold.*

Proof. From (11), it is easy to derive the equilibrium inflation rate as $\Pi_t = \mu(I)/(1-\delta)n$. Note that $\mu(I) > 1$. Thus, $\Pi_t = \mu(I)/(1-\delta)n > 1/(1-\delta)n$.

COROLLARY 1. *Necessary conditions for long-run deflation are (i) $n > (1-\delta)^{-1}$ and (ii) the nominal interest rate is sufficiently low.*

Proof. The equilibrium inflation rate is given by $\Pi_t = \mu(I)/(1-\delta)n$. Thus, $\Pi_t < 1 \Longleftrightarrow \mu(I) < (1-\delta)n$. Because μ is increasing, I must be sufficiently low.

Because the rates of inflation and nominal interest are positively related in equilibrium, low-interest-rate policies are associated with low inflation and perhaps deflation. Because the primary deficit is inflationary, it must be sufficiently small for a deflationary equilibrium.

PROPOSITION 1. *The equilibrium currency seigniorage is positive in the case of a budget deficit.*

Proof. From (11), $\Pi_t n = \mu(I)/(1-\delta)$ holds in equilibrium. Substitute it into (12) to obtain the currency seigniorage as $(1-(1-\delta)/\mu(I))\gamma(I)[1-\tau]$. Because $\mu(I) > 1$, CS is positive under $\delta \in (0,1)$.

LEMMA 3. *The equilibrium bond seigniorage is positive if $\delta > (I-1)/I$.*

Proof. From (13), the equilibrium bond seigniorage is given by $(1 - I/\Pi n)[1-\gamma(I)][1-\tau]$, which is positive if $I/\Pi n < 1$. From the equilibrium condition, it is easy to show that $I/\Pi n < 1$ holds if and only if $(1-\delta)I < \mu(I)$. Because $\mu(I) > 1$ holds for any $I \geq 1$, a sufficient condition for $(1-\delta)I < \mu(I)$ is $(1-\delta)I < 1$.

5. Nominal-Interest-Rate Laffer Curve

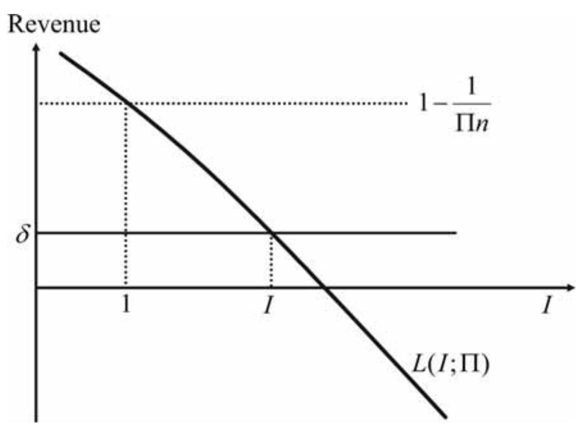
The primary purpose of this paper is to study whether and how low-interest-rate policies raise government revenue. For this purpose, this section studies another type of Laffer curve, which relates the nominal interest rate and total revenue, given the inflation rate.

Suppose that the central bank targets the rate of inflation by adjusting the nominal interest rate in each period. Such a policy rule is sometimes referred to as strict inflation targeting. Because $M_{t+1}/M_t = \Pi n$ holds in the steady state, strict inflation targeting is essentially the same as money growth targeting. Letting $\Pi_t = \Pi$, (11) can be rewritten as

$$\delta = 1 - \frac{\mu(I_t)}{n\Pi} \equiv L(I_t; \Pi), \tag{14}$$

where $L(.)$ is redefined. Because $\mu'(I) = 1 - \gamma(I) - (I-1)\gamma'(I) > 0$, it is evident that the nominal-interest-rate Laffer curve $L(I_t; \Pi)$ is a decreasing function of I. Thus, it is downward sloping, as shown in figure 3. In other words, a lower nominal interest rate can finance a greater deficit. The maximum possible revenue is given by $L(1; \Pi) = 1 - 1/\Pi n$. This implies that the target inflation rate must satisfy $\Pi n > 1$, or there is no equilibrium with budget

Figure 3. Nominal-Interest-Rate Laffer Curve



deficit. In other words, the target base money growth rate must be positive, or the government cannot run a permanent primary deficit.

Once the target inflation rate is set, equation (14) determines the equilibrium nominal interest rate. Given a level of inflation, a larger deficit raises the need for revenue. Because the nominal-interest-rate Laffer curve is downward sloping, the equilibrium nominal interest rate must be reduced in order to finance a larger deficit.

Consider the currency seigniorage, which satisfies $CS(I;\Pi) = (1 - 1/\Pi n)\gamma(I)[1 - \tau]$. It is easy to verify $\partial CS/\partial I < 0$ as long as $\Pi n > 1$. The reason for this is as follows. For a given level of inflation, an increase in the nominal interest rate reduces the demand for money, which reduces the inflation tax base. The maximum possible level of currency seigniorage is $(1 - 1/\Pi n)\gamma(1)[1 - \tau]$, at which the inflation tax base is maximized.

Consider the bond seigniorage, $BS(I;\Pi) = (1 - I/\Pi n)[1 - \gamma(I)][1 - \tau]$, from which

$$[1-\tau]^{-1}\frac{\partial BS}{\partial I} = -\left(1 - \frac{I}{\Pi n}\right)\gamma'(I) - \frac{1-\gamma(I)}{\Pi n}.$$

The first term is negative for $I > \Pi n$ or $R > n$, under which the *level* of bond seigniorage is negative. The bond Laffer curve is decreasing in the region in which the economy is dynamically efficient. For $I < \Pi n$, the bond seigniorage is positive because the economy is dynamically inefficient, so the government can roll over its debt forever. In this region, the slope of the bond Laffer curve is ambiguous. The determinant is the interest elasticity of the money-demand function. The slope at the lower bound is

$$\begin{aligned}[1-\tau]^{-1}\frac{\partial BS}{\partial I}\bigg|_{I=1} &= -\left(1 - \frac{1}{\Pi n}\right)\gamma'(1) - \frac{1-\gamma(1)}{\Pi n} \\ &= \frac{1-\gamma(1)}{\Pi n}\left[(\Pi n - 1)\frac{1-\rho}{\rho}\gamma(1) - 1\right],\end{aligned}$$

which is positive if and only if $(\Pi n - 1)(1-\rho)/\rho > 1 + [(1-\phi)/\phi]^{1/\rho}$. Because it is assumed that $\rho \in (0,1)$, this condition is rewritten as $\Pi n > 1 + \Phi$, where $\Phi \equiv \rho(1-\rho)^{-1}[1 + ((1-\phi)/\phi)^{1/\rho}] > 0$. Thus, the following result is obtained.

PROPOSITION 2. *The bond seigniorage increases with the nominal interest rate near the lower bound of the nominal interest rate if and only if the target inflation rate satisfies* $\Pi > (1 + \Phi)/n$.

6. Laffer Curve under Taylor Rules

There is a large body of recent research on Taylor rules. The theoretical literature mainly focuses on questions such as whether Taylor rules cause the indeterminacy of equilibrium. Indeterminacy implies that the economy is exposed to self-fulfilling fluctuations. Leading examples include Leeper (1991), Clarida, Galí, and Gertler (2000), and Carlstrom and Fuerst (2001). Although dynamic issues such as determinacy are quite important, these issues do not concern this paper, because many results are now established. A contribution of this paper is to perform Laffer curve analyses under a Taylor-type feedback rule.

Suppose that the central bank follows a Taylor-type feedback rule:

$$I_t = A\left(\frac{\Pi_t}{\Pi^*}\right)^{\beta}, \tag{15}$$

where $\Pi^* > 0$ is the implicit target level of the gross inflation rate, $A \geq 1$ is a scale parameter, and $\beta > 0$. According to Leeper (1991), monetary policy is said to be "active" if $\beta > 1$ and "passive" if $\beta < 1$. Solve (15) for Π_t to obtain $\Pi_t = \Pi^*(I_t/A)^{1/\beta} = \alpha\Pi^* I_t^{1/\beta}$, where $\alpha \equiv A^{-1/\beta}$. Substitute this into (10) to obtain

$$\delta = 1 - \frac{\mu(I)}{n\alpha\Pi^* I^{1/\beta}} \equiv L(I), \tag{16}$$

where $L(.)$ is redefined. The Laffer curve may be written in terms of I or Π. I describe total revenue as a function of I only for expositional reasons. The slope of the Laffer curve is given by

$$L'(I) = -\frac{\mu(I)}{n\alpha\Pi^* I^{1/\beta+1}}\left[\frac{\mu'(I)I}{\mu(I)} - \frac{1}{\beta}\right].$$

Thus, the Laffer curve slopes downward if and only if the interest elasticity of $\mu(I)$ is greater than $1/\beta$. Remember that $\mu(I) \equiv$

$I[1-\gamma(I)]+\gamma(I)$ and $\mu'(I) = 1-\gamma(I)-(I-1)\gamma'(I) > 0$. Thus, the slope is expressed as

$$L'(I) = \frac{\frac{1-\beta}{\beta}(1-\gamma(I)) + (I-1)\gamma'(I) + \frac{1}{\beta}\gamma(I)/I}{n\alpha\Pi^* I^{1/\beta}}. \tag{17}$$

Consider the slope near the lower bound. From (17),

$$\left.\frac{\partial L}{\partial I}\right|_{I=1} = \frac{1}{n\alpha\Pi^*}\left[\frac{1}{\beta} - (1-\gamma(1))\right].$$

It is now easy to verify that near the zero bound of the net nominal interest rate, the Laffer curve slopes downward if and only if $\beta > [1-\gamma(1)]^{-1}$. From (6), it is easy to establish the following.

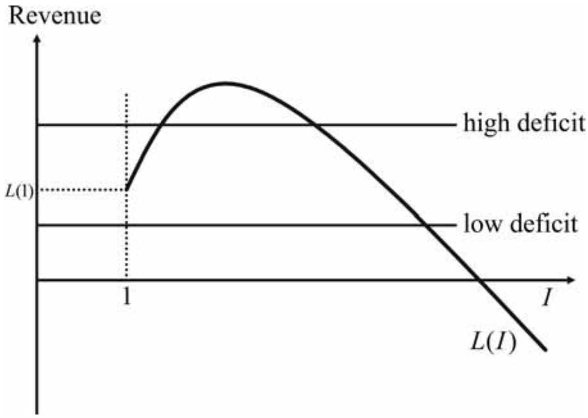
PROPOSITION 3. *The Laffer curve $L(I)$ slopes downward near the lower bound of the nominal interest rate if and only if $\beta > 1 + [(1-\phi)/\phi]^{-1/\rho}$.*

An important implication of proposition 8 is that low nominal interest rates are not necessarily helpful to the government's budget. The slope of the Laffer curve crucially depends on how "active" or "passive" the central bank is. In particular, for low nominal interest rates to be revenue increasing, the coefficient β must be sufficiently greater than unity: monetary policy must be sufficiently active.

Why is the activeness important in determining the slope of the Laffer curve? The key is the link between the nominal and real interest rates. Remember that $\Pi_t = \alpha\Pi^* I_t^{1/\beta}$ holds under the Taylor rule. Substitute this into the Fisher equation, $I_t = \Pi_t R_t$, to obtain $I_t^{1-1/\beta} = \alpha\Pi^* R_t$, from which it is easy to establish that $dR_t/dI_t > 0$ holds if and only if $\beta > 1$. In other words, a reduction in the nominal interest rate reduces the real interest rate if and only if monetary policy is active. Thus, a passive monetary policy ($\beta < 1$) is sufficient for the Laffer curve to be upward sloping near $I = 1$, because a reduction in the nominal interest rate *raises* the real interest rate on bonds. Thus, if a central bank follows a passive monetary policy in a disinflationary phase, the nominal interest rate is lowered, but the real interest rate rises and the government's revenue falls.

The Laffer curve suggests another issue regarding passive Taylor rules. Because the Laffer curve is generally hump shaped under a

Figure 4. Laffer Curve under a Passive Taylor Rule



Taylor rule, there arises a scope for multiple equilibria for a high primary deficit, as shown in figure 4. Many writers, such as Clarida, Galí, and Gertler (2000), have pointed out the self-fulfilling nature of passive Taylor rules. The Laffer curve suggests that, for a unique equilibrium, either (i) monetary policy is sufficiently active or (ii) the primary deficit δ is sufficiently small so that $L(1) > \delta$.

7. Central Bank Independence and Public Finance

7.1 Preliminaries

The preceding sections have investigated government revenue under a regime in which the central bank is subordinate to the fiscal authority in the sense that there is a single government budget constraint that integrates the central bank's budget. Thus, the fiscal authority determines the total government liability, while the central bank determines its composition. Although this modeling strategy is standard, it is not entirely consistent with modern, independent central banking. This section considers an alternative policy regime in which the central bank is independent in that its budget constraint is *separated* from that of the fiscal authority such that there is no direct interaction between monetary and fiscal policies.

Definition 2. *The central bank is independent if (i) the fiscal authority does not receive any revenue from it and (ii) it never purchases government bonds.*

Requirement (i) is insufficient for separating the monetary authority's budget from that of the fiscal authority, because if money is supplied by permanent open-market purchases of government bonds, then the two budget constraints are connected and only the consolidated budget constraint matters.

There exists a large body of literature, both theoretical and empirical, on central bank independence, and the definition of the term varies. According to Alesina and Summers (1993) and Fischer (1995), there are two important definitions: "political independence" and "economic independence." Political or goal independence is defined as the ability of central banks to set objectives such as price stability. Economic or instrument independence is defined as the ability to conduct monetary policy without restrictions. This paper defines central bank independence as the independence of the central bank's budget from that of the fiscal authority—this is a form of instrument independence.

Because open-market operations are ruled out, money in this economy is directly injected into the economy. The monetary authority's budget constraint is

$$H_t = M_t - M_{t-1}, \tag{18}$$

where H_t denotes the transfer to the household. This formulation implies that money is supplied via "helicopter drops." Divide (18) by $p_t y_t$ to obtain

$$h_t = m_t - \frac{1}{\Pi_t n} m_{t-1}, \tag{19}$$

where $h_t \equiv H_t / p_t y_t$. The steady-state money injection is positive if and only if $\Pi n > 1$.

Similarly, the fiscal authority's budget constraint is $G_t - T_t + I_t B_{t-1} = B_t$, from which

$$g - \tau = b_t - \frac{I_t}{\Pi_t n} b_{t-1}. \tag{20}$$

Note that under this policy regime, the fiscal authority must maintain its solvency on its own; there is no currency seigniorage available for the government. Thus, definition 9 specifies a "tough" central bank. In what follows, this policy regime is referred to as the CBI (central bank independence) regime.

Because money is injected directly into each household, the young individual's budget constraint is replaced with $M_t + B_t = p_t y_t - T_t + H_t$. Thus, the demands for money and bonds are given by $m_t = \gamma(I_{t+1})(1-\tau+h_t)$ and $b_t = [1-\gamma(I_{t+1})](1-\tau+h_t)$, respectively. Appendix 2 presents a brief sketch of an alternative version of the model in which the old generation receives the transfer.

Definition 3. *A monetary equilibrium in the CBI regime is a set of sequences for real allocations $\{m_t, b_t\}$ and relative prices $\{I_t, \Pi_t\}$ such that (i) each generation maximizes utility (1) subject to (2)–(4); (ii) the asset market clears; (iii) the government's budget constraints (19) and (20) are satisfied; (iv) $g_t = g$ and $\tau_t = \tau$ for all t; and (v) monetary policy determines I_t, Π_t, or a function that relates I_t and Π_t.*

7.2 Inflation Laffer Curve

Consider the case in which the central bank targets the nominal interest rate. From (20),

$$g - \tau = \left(1 - \frac{I}{\Pi n}\right)[1 - \gamma(I)](1 - \tau + h) \tag{21}$$

holds in a steady state. Solve (19) and $m = \gamma(I)(1-\tau+h)$ for h as

$$h = \frac{\left(1 - \frac{1}{\Pi n}\right)\gamma(I)(1-\tau)}{1 - \left(1 - \frac{1}{\Pi n}\right)\gamma(I)}.$$

Substitute it into (21) to obtain

$$\delta = \frac{(1 - I/\Pi n)[1 - \gamma(I)]}{1 - (1 - 1/\Pi n)\gamma(I)} = \frac{\Pi n - I}{\Pi n + \Gamma(I)} \equiv \Omega(\Pi; I), \tag{22}$$

where $\Gamma(I) \equiv \gamma(I)/(1 - \gamma(I))$. If the nominal interest rate is the policy parameter, then $\Omega(\Pi; I)$ defines the inflation Laffer curve. In contrast to the model considered in the preceding sections, the primary deficit must equal the bond seigniorage. It is evident that total revenue is positive if and only if $I < \Pi n$ or, equivalently, if $R < n$. Thus, in the CBI regime, the government can run a permanent primary deficit if and only if the economy is dynamically inefficient, under which the fiscal authority is able to roll over the debt forever.

Consider the shape of the inflation Laffer curve. It is easy to verify that the inflation Laffer curve slopes upward, because $\partial\Omega/\partial\Pi > 0$ for any Π. This is because for a given nominal interest rate, an increase in inflation reduces the real interest rate. Therefore, the interest payment on the government's outstanding debt is reduced. In addition, $\lim_{\Pi\to\infty} \Omega(\Pi; I) = 1$. It is now evident that the shape of the inflation Laffer curve should be similar to the one shown in figure 2.

The upward-sloping Laffer curve implies that there is a unique equilibrium. The level of the primary deficit determines the need for bond seigniorage, and the equilibrium rate of inflation is determined. As $\delta \equiv (g - \tau)/(1 - \tau)$ increases, the equilibrium inflation rate goes up. Although the analysis focuses on the case in which the bond seigniorage is positive, it is not necessary to rule out equilibria with $\delta < 0$, in which case the economy is dynamically efficient.

The effect of a change in the target nominal interest rate is more subtle. Rewrite (22) as $[\Pi n + \Gamma(I)]\delta = \Pi n - I$. Totally differentiate this expression to yield $d\Pi/dI = [\delta\Gamma'(I) + 1]/(1 - \delta)n$, where $\Gamma'(I) = \gamma'(I)/(1 - \gamma(I))^2 < 0$. Thus, $d\Pi/dI > 0$ holds if $\delta\Gamma'(I) + 1 > 0$. Using (7), rewrite this condition as

$$\frac{1 - \gamma(I)}{\gamma(I)} I > \frac{1 - \rho}{\rho} \delta, \tag{23}$$

which holds for sufficiently small values of δ and sufficiently large values of ρ. Thus, an increase in the target nominal interest rate raises the inflation rate if (23) is satisfied. The left-hand side of (23) increases with I, implying that the condition is more likely to be satisfied for large values of I. In other words, this condition becomes tighter when the central bank follows a low-interest-rate policy. Consider the case in which the nominal interest rate is near the lower bound. Use (6) to rewrite (23) to obtain the following.

Proposition 4. *The target nominal interest rate and the equilibrium inflation rate are positively related near $I = 1$ if*

$$\left(\frac{1-\phi}{\phi}\right)^{1/\rho} > \frac{1-\rho}{\rho}\delta. \tag{24}$$

Remember that in the SCB regime, the target nominal interest rate and the equilibrium inflation rate are always positively related under nominal-interest-rate targeting. In the CBI regime, if the central bank follows a low-interest-rate policy, then the target nominal interest rate and equilibrium inflation rate are *negatively* related if δ is large, ρ is small, and ϕ is large. A large ϕ implies that households face greater liquidity needs.

7.3 Nominal-Interest-Rate Laffer Curve

Consider an economy in which the central bank targets inflation. From (22), redefine Ω as

$$\delta = \frac{\Pi n - I}{\Pi n + \Gamma(I)} \equiv \Omega(I; \Pi), \tag{25}$$

which is the nominal-interest-rate Laffer curve, given a target inflation rate. At $I = 1$, $\Omega(1; \Pi) = (\Pi n - 1)[\Pi n + (\phi/(1-\phi))^{1/\rho}]^{-1}$. The revenue is positive if and only if $I < \Pi n$ or, equivalently, if $R < n$. Thus, it is positive in the region $I \in [1, \Pi n)$. Consider the slope of the Laffer curve. From (25),

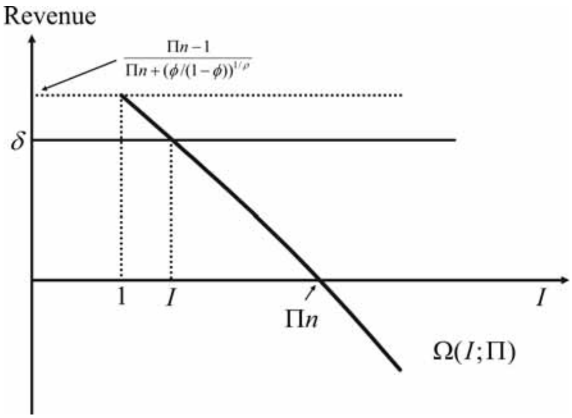
$$\left[1 + \frac{\Gamma(I)}{\Pi n}\right]^2 \Pi n \times \frac{\partial \Omega}{\partial I} = -\left[1 + \frac{\Gamma(I)}{\Pi n}\right] - \left[1 - \frac{I}{\Pi n}\right]\Gamma'(I). \tag{26}$$

Make use of (7) to rewrite the right-hand side of (26) as

$$-1 + \Gamma(I)\left\{\left(1 - \frac{I}{\Pi n}\right)\frac{1-\rho}{\rho I} - \frac{1}{\Pi n}\right\}. \tag{27}$$

The Laffer curve slopes downward if and only if this expression is negative. The question here is whether the Laffer curve slopes downward near the lower bound of the nominal interest rate. Let $I = 1$ in (27) to obtain the following.

Figure 5. Nominal-Interest-Rate Laffer Curve in the CBI Regime



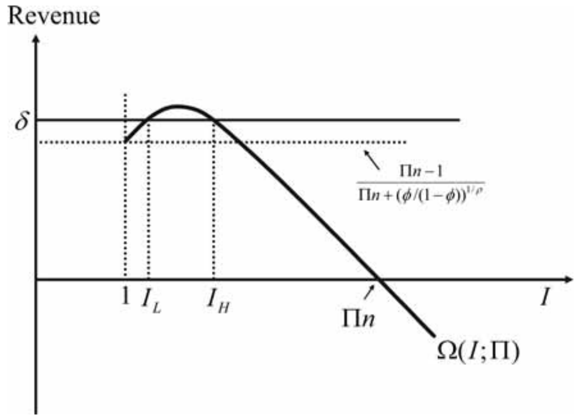
Proposition 5. *The nominal-interest-rate Laffer curve slopes downward near $I = 1$ if and only if*

$$1 - \frac{1}{\Pi n} < \rho + \rho\left(\frac{1-\phi}{\phi}\right)^{1/\rho}. \tag{28}$$

This condition is satisfied if (i) the target inflation rate is sufficiently low (i.e., the money injection is sufficiently small), (ii) the interest elasticity of money demand is high (i.e., ρ is sufficiently high), and (iii) the households' liquidity need is small (i.e., ϕ is sufficiently small). If these conditions are satisfied, then the Laffer curve is decreasing for all $I \geq 1$. In such a case, a unique equilibrium is obtained for each level of the primary deficit, as shown in figure 5. Because the Laffer curve attains its maximum at $\Omega(1;\Pi)$, equilibrium exists for $\delta \leq \Omega(1;\Pi)$.

On the other hand, if (28) is not satisfied, then the Laffer curve slopes upward near $I = 1$, as shown in figure 6. Such a case occurs if the target inflation rate is high, the interest elasticity of money demand is low, and the household's liquidity need is large. In this case, lower nominal interest rates are associated with *smaller* government revenues. In addition, if the primary deficit satisfies $\delta > \Omega(1;\Pi)$, then there arise *two* steady-state equilibria.

Figure 6. Multiple Equilibria in the CBI Regime



EXAMPLE 1. *Let the parameter values be* $\phi = 0.6$*,* $\rho = 0.1$*,* $n = 1.05$*, and* $\Pi = 1.08$*. The maximum total revenue is* 0.002309*. For* $\delta = 0.0023$*, there are two steady-state equilibria,* $I = 1.008601$ *and* $I = 1.027440$*.*

Remember that there is a unique equilibrium under strict inflation targeting if the central bank is subordinate to the fiscal authority. With a tough central bank that follows a strict inflation target, there is scope for multiple equilibria if the primary deficit is sufficiently large. Keeping the primary deficit low can ensure the uniqueness of equilibrium and a positive relation between the nominal interest rate and revenue.

7.4 Taylor Rules

Consider the feedback rule specified in (15) under the CBI regime. In this case, (22) is replaced with

$$\delta = \frac{n\alpha\Pi^* I^{1/\beta} - I}{n\alpha\Pi^* I^{1/\beta} + \Gamma(I)} \equiv \Omega(I), \tag{29}$$

where $\Omega(.)$ is redefined. At the lower bound of the nominal interest rate, $\Omega(1) = (n\alpha\Pi^* - 1)[n\alpha\Pi^* + (\phi/(1-\phi))^{1/\rho}]^{-1}$, which is positive as long as $n\alpha\Pi^* > 1$. The slope of the Laffer curve satisfies

$$\Omega'(I) = \frac{(\beta^{-1}-1)n\alpha\Pi^* I^{1/\beta} - (n\alpha\Pi^* I^{1/\beta} - I)\Gamma'(I) + (\beta^{-1}n\alpha\Pi^* I^{1/\beta-1} - 1)\Gamma(I)}{[n\alpha\Pi^* I^{1/\beta} + \Gamma(I)]^2}.$$

Thus, it is easy to verify that $\Omega'(I) > 0$ holds if $\beta < 1$, $n\alpha\Pi^* > I^{1-1/\beta}$, and $n\alpha\Pi^* > \beta I^{1-1/\beta}$ are satisfied. The third condition is redundant under $\beta < 1$. Because $I^{1-1/\beta}$ is decreasing in I under $\beta < 1$, its maximum is 1. Thus, $\Omega'(I) > 0$ holds for all $I \geq 1$ if the implicit target Π^* satisfies $n\alpha\Pi^* > 1$. Similarly, $\Omega'(I) < 0$ holds if $\beta > 1$, $n\alpha\Pi^* < I^{1-1/\beta}$, and $n\alpha\Pi^* < \beta I^{1-1/\beta}$ are satisfied. With $\beta > 1$, the third condition is redundant. Because $I^{1-1/\beta}$ is increasing in I under $\beta > 1$, its minimum is 1. Thus, $\Omega'(I) < 0$ holds for all $I \geq 1$ if the implicit target Π^* satisfies $n\alpha\Pi^* < 1$. The following summarizes.

PROPOSITION 6. *Consider the CBI regime. Under a passive Taylor rule, the Laffer curve slopes upward for all* $I \geq 1$ *if the implicit target* Π^* *is sufficiently high; under an active Taylor rule, the Laffer curve slopes downward for all* $I \geq 1$ *if the implicit target* Π^* *is sufficiently low.*

Two comments are worth making. First, the implicit target level of the inflation rate Π^* influences the slope of the Laffer curve in the CBI regime; this is not true in the SCB regime, in which the slope of the Laffer curve depends on the shape of the money-demand function. Second, in the SCB regime, the Laffer curve under a Taylor rule can slope upward only near the zero bound of the nominal interest rate, while in the CBI regime the Laffer curve can be *globally* upward sloping.

The slope near the lower bound of the nominal interest rate is positive if and only if

$$\frac{1-\beta}{\beta} - \frac{n\alpha\Pi^* - 1}{n\alpha\Pi^*}\Gamma'(1) + \left(\frac{1}{\beta} - \frac{1}{n\alpha\Pi^*}\right)\Gamma(1) > 0. \tag{30}$$

Because $\Gamma'(I) < 0$, it is easy to verify that Ω slopes upward near $I = 1$ if $\beta < 1$. Applying (7), rewrite (30) to establish the following.

Proposition 7. *The Laffer curve slopes upward near the lower bound of the nominal interest rate if and only if*

$$\left(\frac{1-\phi}{\phi}\right)^{-1/\rho}\left[\frac{n\alpha\Pi^{*}-1}{n\alpha\Pi^{*}}\frac{1}{\rho}+\frac{1-\beta}{\beta}\right]+\frac{1-\beta}{\beta}>0.$$

Notice that this condition is satisfied for any $\beta \in (0,1)$. A passive monetary policy is sufficient for the Laffer curve to slope upward near the lower bound of the nominal interest rate. Under a passive monetary policy, a lower nominal interest rate is associated with a higher real interest rate on bonds. Thus, the Laffer curve slopes downward near the lower bound only when monetary policy is considerably active.

8. Discussion of the Results

In the SCB regime, the primary deficit is financed by bonds and money. The Laffer curve under nominal-interest-rate targeting is increasing in the inflation rate. This suggests that as the primary deficit increases, the central bank is forced to increase money growth, a standard result. Under strict inflation targeting, the Laffer curve is decreasing in the nominal interest rate, suggesting that the central bank is forced to cut the nominal interest rate if the primary deficit increases. Finally, under a Taylor rule, the Laffer curve is not necessarily decreasing in the nominal interest rate. In particular, the Laffer curve is increasing in the nominal interest rate near the lower bound of the nominal interest rate under a passive Taylor rule, because a reduction in the nominal interest rate raises the real interest rate on government bonds.

In the CBI regime, the central bank is “tough,” and the deficit must be financed only by bonds. Under nominal-interest-rate targeting, the government’s revenue continues to be increasing in inflation. As the primary deficit increases, the central bank *must* inject money into the economy in order to maintain the level of the nominal interest rate. In other words, the central bank must offset the increased demand for money by greater money injection. In this sense, the central bank is not fully independent of the fiscal policy when it has to peg the bond price.

Under strict inflation targeting in the CBI regime, the central bank has no obligation to raise revenue or maintain the bond price. In this case, the nominal-interest-rate Laffer curve is not always downward sloping. This contrasts with the Laffer curve under the SCB regime, which is unambiguously downward sloping. The slope of the nominal-interest-rate Laffer curve under the CBI regime is strongly influenced by the money-demand function. Near the lower bound of the nominal interest rate, the Laffer curve slopes upward if the interest elasticity of money demand is sufficiently small. Then, cutting the nominal interest rate *reduces* government revenue. In such a situation, the government must reduce the primary deficit if it wishes to lower the equilibrium nominal interest rate further.

Finally, consider the case in which the central bank follows a Taylor rule in the CBI regime. The key finding is that the slope of the Laffer curve crucially depends on how active or passive the central bank is. If the central bank follows a passive Taylor rule and the implicit target level of the inflation rate is sufficiently high, then cutting the nominal interest rate *lowers* government revenue for all nominal interest rates. In contrast, the Laffer curve under a passive Taylor rule in the SCB regime slopes upward only near the zero lower bound of the nominal interest rate. Under an active Taylor rule in the CBI regime, the central bank can ensure a downward-sloping Laffer curve by setting the implicit target to a sufficiently low level.

There are several findings regarding the link between targets and uniqueness of (long-run) equilibrium. In the SCB regime, unique equilibrium results under nominal-interest-rate targeting and strict inflation targeting.[4] Under Taylor rules, uniqueness is obtained if the monetary policy is sufficiently active. Uniqueness results even under a passive Taylor rule if the primary deficit is sufficiently small. In the CBI regime, unique equilibrium is obtained under nominal-interest-rate targeting. There may be two steady states under inflation targeting if the target inflation rate is high, the interest elasticity of money demand is low, and the household's liquidity need is large. Uniqueness prevails even in such an environment if the primary deficit is small enough. Finally, equilibrium is likely to be unique

[4]The results depend on the money-demand function that is independent of the inflation rate.

under Taylor rules in the CBI regime, because in many situations the Laffer curve is either upward sloping or downward sloping.

There are two main reasons why central banks around the globe follow low-interest-rate policies when the economy is in a state of stagnation. One is obviously to stimulate the economy by influencing the cost of funds for private firms. The other is to reduce the cost of funds for the fiscal authority that faces a greater need to spend and a smaller tax revenue. This suggests an interesting measure of central bank independence—the degree of central bank independence is low if a central bank hesitates to raise the nominal interest rate when the fiscal authority has accumulated a large public debt. Because monetary policy has a strong impact on the bond seigniorage even under the CBI regime, the fact that the central bank's budget is separated from the fiscal authority's budget is not enough to ensure instrument independence of a central bank. The key is whether a central bank can raise the nominal interest rate when it must.

9. Conclusion

This paper has studied various types of Laffer curves in order to clarify the link between monetary policy instruments and government revenue under different fiscal–monetary policy arrangements. Two aspects are particularly new. One is that Laffer curves are studied under a Taylor-type feedback rule. The other analysis that is new in this paper is that it has studied Laffer curves in which there is no currency seigniorage. Interestingly, monetary policy continues to influence government revenue through changing the interest obligation on the public debt.

There are several important cases that are left unexplored. One possible extension of the analysis is to consider a production economy, in which a change in the real interest rate influences output. Another possible extension is to consider nonindexed bonds. Studying the bond seigniorage with nonindexed bonds is important, because an unexpected change in monetary policy may have a greater impact on the bond seigniorage. Finally, it is certainly interesting to investigate the political pressure on the central bank to follow low-interest-rate policies. Politicians dislike high interest rates for the same reason that they dislike high tax rates. Such a direction of research may enhance our understanding of central bank independence.

Appendix 1. Inflation and Money Demand

Consider an alternative environment in which there are two types of households, type 1 and type 2. A type 1 household is the same as the one described in section 3.2. A type 2 household is assumed to consume both when young and when old. It is also assumed that a type 2 cannot participate in the bond market. These households are closely related to "poor" households in Sargent and Wallace (1981). Alternatively, one could assume that type 2 consumers are "early diers," in the context of Diamond and Dybvig (1983), who *must* consume in the first subperiod. In any case, a type 2 individual wishes to hold money as a means of saving. A type 2's problem is to choose the amount of saving s_t to maximize the lifetime utility. Thus,

$$\max_{s_t} U\left(\frac{p_t y_t - T_t - s_t}{p_t}, \frac{s_t}{p_{t+1}}\right),$$

where it is assumed that the utility function U is homothetic. Assuming interior solution, the maximization problem gives the standard real saving function: $S(p_t/p_{t+1}, y_t - T_t/p_t) = \eta(p_t/p_{t+1})[y_t - T_t/p_t]$. Note that homotheticity ensures that the saving rate η is a function of the real interest rate and independent of income.

Suppose that the fraction of type 2 household is θ. Then, the money-market clearing condition is $M_t = (1-\theta)\gamma(I_{t+1})[p_t y_t - T_t] + \theta\eta(p_t/p_{t+1})[p_t y_t - T_t]$. Divide this equation by $p_t y_t$ to obtain

$$m_t = [(1-\theta)\gamma(I_{t+1}) + \theta\eta(\Pi_{t+1}^{-1})](1-\tau). \tag{31}$$

An important implication of (31) is that aggregate money demand now depends on both the nominal interest rate and the inflation rate.

Substitute (31) and $b_t = (1-\theta)[1-\gamma(I_{t+1})][1-\tau]$ into (9) to obtain

$$\delta = (1-\theta)\left\{1 - \frac{\mu(I)}{\Pi n}\right\} + \theta\left\{1 - \frac{1}{\Pi n}\right\}\eta(\Pi^{-1}), \tag{32}$$

which implies that the inflation Laffer curve may have a downward-sloping region for high rates of inflation if $\eta' > 0$. As inflation increases, the real interest rate on money decreases, which in turn decreases real money demand by type 2 households.

Appendix 2. Transfer to the Old

Consider the CBI regime. The quantity of base money newly injected into the economy in period t is denoted by H_t. In section 7, it is assumed that the entire H_t is in the form of transfer to the young. The purpose of this section is to present an alternative environment in which a fraction of H_t is given to the old. In particular, let φH_t be the quantity of money transferred to the old, while $(1-\varphi)H_t$ is transferred to the young. Then, the household's budget constraints are replaced with $M_t+B_t = p_t y_t - T_t + (1-\varphi)H_t$ and $p_{t+1}c_{1t}+p_{t+1}c_{2t} = M_t + I_{t+1}B_t + \varphi H_{t+1}$. Then, the demands for money and bonds are $M_t = \gamma(I_{t+1})[p_t y_t - T_t + (1-\varphi)H_t] + \varphi H_{t+1}\gamma(I_{t+1})/I_{t+1}$ and $B_t = [1-\gamma(I_{t+1})][p_t y_t - T_t + (1-\varphi)H_t] - \varphi H_{t+1}\gamma(I_{t+1})/I_{t+1}$, respectively. Divide these expressions by $p_t y_t$ to obtain

$$m_t = \gamma(I_{t+1})[1-\tau+(1-\varphi)h_t] + \frac{\gamma(I_{t+1})}{I_{t+1}}\varphi h_{t+1}\Pi_{t+1}n, \tag{33}$$

$$b_t = [1-\gamma(I_{t+1})][1-\tau+(1-\varphi)h_t] - \frac{\gamma(I_{t+1})}{I_{t+1}}\varphi h_{t+1}\Pi_{t+1}n. \tag{34}$$

It is important to note here that real money demand now depends on the inflation rate if $\varphi > 0$. In particular, a higher inflation rate expands the demand for money, which is precisely the opposite of the model considered in appendix 1.

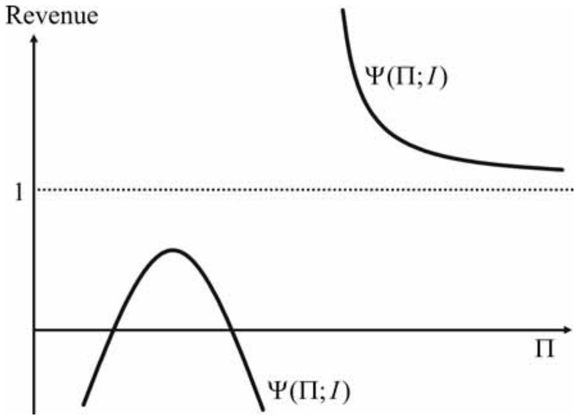
Focus on the steady state. Solve (33) and (19) for h as

$$h = \frac{(1-1/\Pi n)\gamma(I)[1-\tau]}{1-(1-1/\Pi n)\gamma(I)[(1-\varphi)+\varphi\Pi n/I]}.$$

Substitute it and (34) into (20) to obtain

$$\delta = \left(1-\frac{I}{\Pi n}\right)[1-\gamma(I)] + \frac{1-\varphi-\gamma(I)[(1-\varphi)+\varphi\Pi n/I]}{1-(1-1/\Pi n)\gamma(I)[(1-\varphi)+\varphi\Pi n/I]}$$
$$\times\left(1-\frac{I}{\Pi n}\right)\left(1-\frac{1}{\Pi n}\right)\gamma(I).$$

Figure 7. Transfer to the Old



This coincides with (22) when $\varphi = 0$. Consider the case with $\varphi = 1$. Then,

$$\delta = \left(1 - \frac{I}{\Pi n}\right)[1 - \gamma(I)] - \frac{\gamma(I)(1 - I/\Pi n)(1 - 1/\Pi n)\gamma(I)\Pi n}{I - (1 - 1/\Pi n)\gamma(I)\Pi n}.$$

Simplify this expression to obtain

$$\delta = \left(1 - \frac{I}{\Pi n}\right)\left\{1 - \frac{\gamma(I)}{1 - (\Pi n - 1)\gamma(I)/I}\right\} \equiv \Psi(\Pi; I), \tag{35}$$

which defines the inflation Laffer curve. The typical configuration of the inflation Laffer curve is depicted in figure 7. For relatively low levels of the inflation rate, the Laffer curve is hump shaped, and therefore there may be two equilibria. Beyond this region, there is no equilibrium with $\delta < 1$.

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