Seigniorage Revenue and Monetary Policy

Joseph H. Haslag
Senior Economist and Policy Advisor
Federal Reserve Bank of Dallas

The resource costs to the U.S. Treasury [to print a $100 bill] are more than offset by the value of the goods that could be purchased with the $100 bill.

Money creation is one potential source of revenue for a government. Seigniorage—government revenue received through creating money—is a relatively inexpensive means of raising funds. Take the United States as an example. It costs just a few pennies to print a $100 bill. The resource costs to the U.S. Treasury are more than offset by the value of the goods that could be purchased with the $100 bill. It is even less expensive for the Federal Reserve to electronically purchase large quantities of Treasury bonds, notes, and bills from traders in New York. It is important to note that the Federal Reserve returns the interest payments on its security holdings (less its expenses) to the U.S. Treasury. Consequently, when the Federal Reserve increases its bond holdings, for example, the U.S. Treasury realizes an effective reduction to its debt expenses.[1] The present value of the reduction in Treasury expenses is equal to the amount of money injected by the Federal Reserve's open market purchase.

The problem is that although money may be cheap to produce, the social costs of money creation are almost certainly greater than what the Federal Reserve pays to create it. Indeed, a large body of empirical evidence suggests that the rate of money creation is closely correlated with inflation. Thus, faster money creation costs society by eroding the purchasing power of money already in circulation, which is the inflation tax. Though tempted by low production costs, governments must balance the benefits with social costs when deciding how much to rely on seigniorage.

The article addresses two questions. First, how much do countries rely on money creation as a source of revenue? The answer to this question gives some idea of the size of the seigniorage revenue "problem." For most of the countries, money creation accounts for less than 2 percent of real GDP. The evidence indicates that seigniorage revenue is not the primary source of revenue for a government, but neither is it quantitatively insignificant.

Second, are monetary policy settings systematically related to a government's reliance on real seigniorage revenue, and, if so, what is the relationship? Such evidence should be a useful guide for economic theories—that is, a good theory should be able to account for a government's reliance on seigniorage revenue versus, say, its reliance on income taxes.

Sargent (1986) presents some evidence that very rapid money growth does not translate into greater reliance on real seigniorage revenue. He studies monetary policy during four hyperinflation episodes that occurred immediately following World War I. For two countries, Austria and Hungary, Sargent reports data on money growth and the fraction of government spending earned through seigniorage revenue. Austria raised about 67 percent of government expenditures through money creation in the first half of 1919. However, the ratio of money creation to government expenditures fell to about 40 percent of government expenditures by 1922. Between 1919 and 1922, Austrian crowns in circulation went from roughly 4.7 billion to nearly 4.1 *trillion.* For Hungary, money creation accounted for more than 45 percent of its government expenditures in 1921–22, falling to about 33 percent in 1924–25. Between February 1921 and April 1925, Hungary saw its notes in circulation rise from 15 billion kronen to 4.5 trillion kronen.[2] For these two case studies, the evidence suggests that reliance on money creation decreases as the rate of money growth increases. Hyperinflations are rare and probably not good laboratories for studying the relationship between monetary policy and seigniorage revenue. Still, the Austrian and Hungarian data show that dramatic increases in the rate of money growth do not necessarily translate into a government's increased reliance on seigniorage revenue.

In this article, I use data from different countries to identify whether a systematic relationship exists between monetary policy and a country's reliance on seigniorage revenue. Rather than focus on year-to-year realizations, the approach taken in this article is to study the correlation between monetary policy and seigniorage over a longer horizon; specifically, the sample mean is computed from a 30-year period. Both economic theory and problems with statistical inference point to using a sufficient statistic to measure monetary policy. (A sufficient statistic captures changes in the variable that the researcher is studying.) Here, the monetary policy measure is a combination of the money growth rate and the reserve ratio. As such, the evidence bears on whether countries with a high money growth rate–reserve ratio combination also tend, on average, to rely more heavily on seigniorage revenue over these longer horizons than countries with a low money growth rate–reserve ratio combination.

The cross-country evidence indicates a positive association between the monetary policy measure and a country's reliance on seigniorage revenue. Thus, countries with high monetary policy settings tend to rely more on seigniorage revenue than countries with low monetary policy settings. An additional implication follows from the way in which the measure of monetary policy is constructed; specifically, one can infer that the relationship between the reserve ratio, which holds the money growth rate constant, and a country's reliance on seigniorage revenue is concave. The concave relationship also holds between the money growth rate and seigniorage reliance when the reserve ratio is constant. The implied concavity complements Sargent's findings for Austria and Hungary.

It is useful to begin with a brief overview of seigniorage revenue that shows how it fits into a broader picture of government finance.

SEIGNIORAGE REVENUE—AN OVERVIEW

Suppose the government prints new pieces of currency and uses these newly created bills to buy goods and services, such as missiles or computers, or pay workers' salaries.[3] For simplicity, I assume that the economy has a composite commodity (hereafter, the consumption good). The government can buy units of this consumption good with the newly printed money, which is

$$(1) \qquad (M_t - M_{t-1})v_t\,,$$

where M denotes the total quantity of high-powered money in the economy (t denotes time), and v denotes the money's value in terms of the units of the consumption good that can be acquired with one unit of money (that is, the inverse of the price level). Thus, Equation 1 represents the units of the consumption good that can be purchased with newly printed money—in other words, real seigniorage revenue.

Seigniorage revenue is just one part of a larger picture. To see the complete picture, it is necessary to give the government's income statement, or budget constraint. To keep things simple, assume that the government issues only one-period, fully indexed bonds.[4] For this simple economy, the government's budget constraint can be written as

$$(2) \qquad g_t + r_t b_{t-1} = \tau_t y_t + b_t + (M_t - M_{t-1})v_t.$$

In Equation 2, g is the total quantity of goods purchased by the government; the product, rb, is the principal and interest payments, measured in units of the good, that the government owes for one-period bonds issued at date $t - 1$; r is the real gross return (principal plus net interest) on government securities worth b goods. Thus, the left-hand side of Equation 2 represents the total expenditures by the government. The right-hand side characterizes the government's total receipts. The product, τy, represents the income tax revenue earned by the government at rate τ, and y is the aggregate level of real income.

Note that in Equation 2 the government has access to an income tax. Representing tax revenue this way is not necessary. However, there is a useful analogy between seigniorage revenue and income tax revenue. The relationship between the income tax rate and tax revenue has been popularized in the Laffer curve. Suppose that income, y, is negatively related to the tax rate. With an increase in the tax rate, for example, people would report less income.[5] The basic supply-side question, therefore, is whether higher tax rates are offset by a lower tax base. Since tax revenues are the product of these two factors, it is impossible to say, *a priori*, whether income tax revenues rise or fall in response to an increase in tax rates.

Seigniorage Revenue and Money Growth

An increase in the money growth rate has an effect on seigniorage that is analogous to the effect that an increase in the tax rate has on income tax revenue. To illustrate this point, I modify the expression for seigniorage revenue to identify a tax rate and tax base. The date t quantity of money in circulation is equal to the product of a growth rate and date $t-1$ stock. Thus,

$$M_t = \theta_t M_{t-1}, \tag{3}$$

where θ is the gross rate of money supply expansion. With $\theta > 0$, the percentage change in the money supply is $\theta - 1$. Use Equation 3 to substitute for M_{t-1} in Equation 1. The resulting government budget constraint is given by

$$g_t + r_t b_{t-1} = \tau_t y_t + b_t + v_t M_t\,(1 - 1/\theta_t). \tag{2'}$$

The analog to income tax revenue is now more accessible. In Equation 2′, the total revenue from money creation is now the product of a tax base, $v_t M_t$, and a tax rate, $(1 - 1/\theta)$, that is positively related to the rate of money growth.

To complete the analogy to the tax revenue setting, linking the seigniorage tax base to the seigniorage tax rate is necessary. One way to do this is to assume that the real quantity of money—which for seigniorage revenue is the tax base—is a function of its real rate of return. More specifically, let real money balances be positively related to the real return on money. It is straightforward to show that the real rate of return on money is the inverse of the inflation rate; that is, $1/\pi$, where $\pi = p_t/p_{t-1}$.[6] Other things being equal, the rate of inflation is positively related to the rate of money growth. Hence, faster money growth means that the real return on money falls. It follows that faster money growth results in a smaller tax base for real seigniorage revenue.

Overall, faster money growth can lead to either more or less real seigniorage revenue, depending on whether the change in the tax rate or the change in the tax base is quantitatively larger.

Reserve Requirements and the Tax Base

There is another monetary policy tool that could potentially influence real seigniorage revenue. The reserve requirement stipulates that money balances cannot be less than γ percent of bank deposits, where γ denotes the reserve requirement ratio. Consequently, for a given level of deposits, a higher reserve requirement implies that the quantity of real money balances increases; that is, a larger tax base. However, holding the level of deposits constant is unlikely. An increase in the reserve requirement ratio may induce people to decrease their total savings and hence their bank deposits. As a result, people may avoid the inflation tax by reducing their bank deposits.

To illustrate this point, people have two means of saving: government bonds and money. For simplicity, I assume that the real return on the government bonds, r, is constant and that these bonds dominate money in terms of offering a higher rate of return—that is, $1/\pi < r$.

In this economy, banks serve a very simple function. I assume that government bonds are issued in denominations that are too large for any one saver to acquire. The bank costlessly pools the funds to acquire these government bonds. Because the bank maximizes profits in a perfectly competitive market, the rate of return on deposits will also be r. Each person takes the rate of return on deposits as given. The reserve requirement stipulates that the person hold a fraction of these deposits as money balances.[7] Because money is rate of return dominated by government bonds, the person will not hold any fiat money in excess of this reserve requirement. The equilibrium return on a person's savings is

$$q = \frac{\gamma}{1+\gamma} \bullet \frac{1}{\pi} + \frac{r}{1+\gamma}, \tag{4}$$

where q is the gross real return on savings. Note that q is a weighted average of the rate of return on real money balances and on government bonds. With $1/\pi < r$, Equation 4 implies that $q < r$. In other words, the reserve requirement ratio drives a wedge between the return on bonds and the return to savings.

Suppose there is an increase in the reserve requirement ratio. The quantity of real money balances held by people is γd, where d is the quantity of goods deposited with banks. For a given level of deposits, people will hold more money and the tax base rises. Equation 4, however, implies that the real return on savings falls as the reserve requirement ratio increases. It seems reasonable to assume that people's savings are positively related to the real return on savings. Therefore, it follows that a higher reserve requirement ratio will result in a decline in a person's savings. A decline in savings implies a decline in the quantity of bank deposits. As such, γ is increasing and d is falling so that the product—the seigniorage tax base—could either increase or decrease.

The thrust of this section is twofold. First, real seigniorage revenue is formally defined. Second, economic theory offers an ambiguous picture regarding the effects that monetary policy settings have on the size of this revenue. The gist of the economic argument is that people try to avoid taxes, so with higher tax rates, whether it be inflation or income, they have an incentive to reduce the quantity of the good being taxed. The remainder of this article seeks to establish some preliminary observations on the correlation between a country's reliance on seigniorage revenue and its monetary policy settings.

THE DATA

I obtain the data in this article from International Financial Statistics. I use annual observations, spanning the period 1965–94. For each of the variables I examine over this 30-year period, I use the sample mean to measure each country's central tendency. Unfortunately, observations are not available for each country for each year. Each country in the sample has at least fifteen annual observations. The result is a sample of sixty-seven countries.[8]

Following Fischer (1982), I compute the ratio of seigniorage revenue to output, hereafter S/Y, for each country.[9] Here, I use high-powered money as the measure of the money stock (M). One alternative to computing ratios is to convert each country's seigniorage to a dollar-equivalent value. The chief advantage to using ratios is that no assumptions are required regarding the exchange rate and purchasing power parity.

Before reporting any statistics, it is important to note that the reserve requirement ratio presents a measurement issue. In principal, the average marginal reserve requirement ratio—the ratio that applies to the next dollar deposited—would be measured.[10] In practice, however, measuring this is not so simple. There is a dizzying array of reserve requirements; U.S. banks are currently required to hold reserves equal to 3 percent of the first \$49.3 million of checkable deposits and 10 percent of all deposits above the low-reserve tranche. Therefore, it matters whether the deposits are going into small banks or large banks. In other countries, the reserve requirement structures are even more convoluted.[11]

Equations 1 through 4 are built on the notion that there is one reserve requirement ratio that is the marginal reserve requirement. To compute the marginal reserve requirement ratio, one could use the distribution of deposits across the different categories corresponding to the reserve requirement structure. For example, 20 percent of the deposits are in small U.S. banks (with less than \$49.3 million in checkable deposits) and 80 percent are in large banks. The average marginal reserve requirement ratio would be $(0.2 \cdot 0.03) + (0.8 \cdot 0.1) = 0.086$. Unfortunately, neither the United States nor any other countries report the distribution across deposit categories, which is necessary to construct such a measure. Consequently, I use the reserve-to-deposit ratio, denoted R/D, (hereafter reserve ratio) as a proxy for the reserve requirement ratio. Historically, reserve requirements have been applied against deposits included in what is the U.S. counterpart to M2. Accordingly, I use M2 less currency outside the bank as my measure of bank deposits. As it is measured, the reserve ratio ignores any extra information contained in the distribution of deposits across the alternative categories. Instead, different deposit categories are treated as if there is only one type.

Table 1 reports summary statistics for the seigniorage ratio, S/Y; as well as a monetary policy measure, g; a tax rate measure, *TAX*; and the growth rate of output, y'. On average, seigniorage revenue accounts for a fairly small fraction of total output—about 2 percent.[12] Tax receipts are, on average, about 22 percent of aggregate output. As one would probably expect, seigniorage revenue is not the primary source of government revenue.

Generally, the government budget constraint links the variables in Table 1 together. As such, the statistics describe the central tenden-

Table 1

Summary Statistics

Variables	Sample mean	Standard deviation	Minimum	Maximum
S/Y	.0211	.0201	.0025	.0998
R/D	.1712	.1303	.0068	.6402
g	.2085	.1667	.0332	.8981
TAX	.2254	.1008	.0537	.5586
y′	.0407	.0181	–.0018	.0904

S/Y Real seigniorage/real GDP
R/D Bank reserves/deposits (M2 less currency)
g Percentage change in high-powered money
TAX Tax revenue/GDP
y′ Percentage change in real GDP

cies and average dispersion of monetary policy, fiscal policy, and some aggregate measure of economic activity. The money growth rate, g, is $(M_t/M_{t-1}) - 1$. *TAX* is the ratio of tax revenue to GNP. Lastly, $y' = (Y_t/Y_{t-1}) - 1$ is the growth rate of output.

One rather interesting finding is how the reliance on seigniorage revenue is distributed. Approximately three-fourths of the countries collect, on average, less than 2 percent of GNP through money creation. Most of the variation, therefore, occurs among those countries in the top quartile of the distribution. In this sample, Ghana relies most heavily on seigniorage, collecting revenues equal to 10 percent of output, on average, through money creation. Overall, the distribution of *S/Y* ratios is quite skewed toward the low-seigniorage-reliance tail of the distribution.

Table 1 also reports the range of reserve ratios and average money growth rates. The difference between the minimum and maximum values is substantial. Reserve ratios range from a low of 0.6 percent to 64 percent. Money growth rates range from 3.3 percent to nearly 90 percent. This evidence shows that banks hold a substantial fraction of money against deposits in some countries. It also shows that some countries create money at a rapid pace.

Do countries that rely heavily on seigniorage revenue also exhibit large year-to-year volatility in their earnings from money creation? The answer indicates whether countries tend to rely on seigniorage revenue consistently or if there are periods of heavy reliance on seigniorage interspersed with periods in which countries rely less on it. A positive correlation between the seigniorage ratio and volatility would show that countries with large values of *S/Y*, for example, also tend to experience greater year-over-year variability in the *S/Y* ratio. Conversely, if the correlation coefficient is negative, then countries that have relatively high *S/Y* ratios tend to experience less variability in the year-to-year reliance on seigniorage.

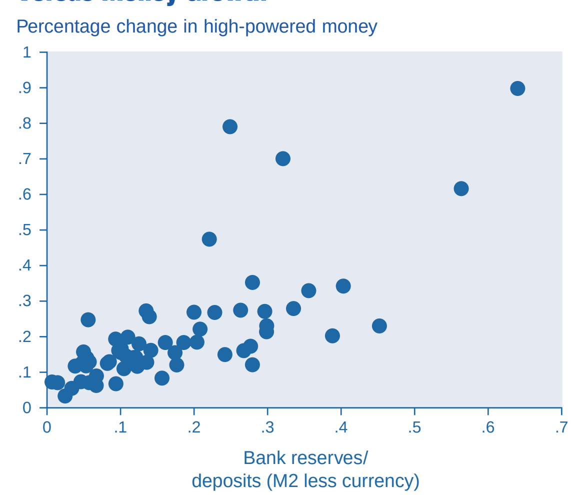
The correlation coefficient between a country's average reliance on seigniorage revenue and its sample standard deviation is 0.8462. Thus, the high correlation coefficient suggests that countries with high seigniorage rates have the greatest volatility in year-over-year realizations. In other words, countries that rely, on average, more heavily on money creation as a source of revenue also tend to exhibit the largest variability in reliance from year to year. In contrast, countries that rely relatively little on seigniorage revenue tend to receive about the same fraction of GNP from year to year.[13]

Figure 1 focuses on the two monetary policy variables. Specifically, it plots combinations of the average reserve ratio and the average money growth rate for each country in this sample. The plot suggests that a country with a high average reserve ratio has a high average money growth rate. Formal statistics support the notion that the reserve ratio and money growth are positively related; the correlation coefficient between the reserve ratio and the money growth rate is 0.72.

Thus, three facts emerge from this preliminary review of the data. These facts serve to answer the primary question of how much countries rely on seigniorage revenue. First, for most countries, seigniorage revenue accounts for less than 2 percent of output. Second, countries with the highest average reliance on seigniorage revenue also tend to have the greater year-to-year volatility in the *S/Y* ratio. Third, the evidence suggests that monetary policy settings are not independent of one

Figure 1

Cross-Country Plots of Reserve Requirements Versus Money Growth



another; countries with high money growth rates also tend to have high reserve ratios.

MONETARY POLICY AND SEIGNIORAGE

To determine whether a relationship exists between a country's monetary policy settings and its reliance on seigniorage revenue, I present results from a simple regression. Because of this potentially nonlinear relationship, I use a sufficient statistic, z, to measure monetary policy settings. Specifically, let $z = [R/D/(1 + R/D)][g/(1 + g)]$. The economics motivating this decision is sketched out in the box entitled "A Case for Combining the Money Growth Rate with the Reserve Ratio." Statistical issues also arise, in part, because of the evidence presented in Figure 1. Recall from Figure 1 (and the correlation coefficient) that countries with high average reserve ratios tend to have high average money growth rates. By studying the contribution of each of the monetary policy measures, multicollinearity is a potential problem; that is, if two independent variables are highly correlated, the standard errors of the coefficients are inflated, creating inference problems. In measuring monetary policy settings with a single variable, I am assuming that z is a sufficient statistic for monetary policy. As a sufficient statistic, z is useful because changes in it capture changes in each of the monetary policy variables being studied. As such, z is serving as a measure of the overall thrust of monetary policy as it relates to seigniorage revenue.

One additional property of z is noteworthy. It is straightforward to show that the definition of z implies a concave relationship between it and each of the two monetary policy variables. To illustrate this, consider the effect of a change in the reserve ratio, holding the money growth rate constant. As the reserve ratio increases, z increases also, but the change in z will be smaller as the reserve ratio increases. In other words, for a given increase in the reserve ratio, z will increase at a diminishing rate. The same holds if, for example, the money growth rate increases, holding the reserve ratio constant. With a positive coefficient on z, the relationship between the seigniorage rate and each of the monetary policy variables is concave.[14]

In the benchmark regression, I include the squared value of z and a constant term as additional explanatory variables. In doing so, it is possible to assess whether there are any additional nonlinearities that characterize the relationship between a country's monetary policy settings and its reliance on seigniorage revenue. If the additional quadratic term in the regression is significant, this relationship will vary as z varies. For instance, if the coefficient on z^2 is significantly less than zero, the evidence suggests that the relationship is concave. Conversely, if the coefficient on the squared term is significantly greater than zero, the evidence indicates that the relationship is convex.[15]

The results from the benchmark regression are reported in column 1 of Table 2.[16] The coefficient on z is significantly greater than zero, while the coefficient on z^2 is not significantly different from zero. Thus, the evidence is consistent with the notion that countries with high monetary policy settings (high z values) tend to rely more heavily on seigniorage revenue than do countries with lower monetary policy settings (low z values). As discussed above, the evidence suggests a positive, concave relationship between a country's reserve ratio and money growth rate and its reliance on seigniorage revenue. Further, the adjusted R^2—a measure of the variation in seigniorage that is accounted for by the regression variables—indicates the monetary policy measure accounts for more than 40 percent of the variation in the S/Y ratio, which is a reasonably good fit for a cross-country sample.

Table 2
Regression Results for Seigniorage Ratios and Monetary Policy Variable

Dependent variable: S/Y

Variable	Benchmark model	Financial sophistication I	Financial sophistication II
constant	.011* (.0032)	.0094* (.0034)	.0113* (.0032)
z	.3982† (.1788)	.4273† (.1722)	.3835† (.1808)
z^2	–.0915 (1.157)	–.1554 (1.1854)	–.0072 (1.1545)
y 65‡	—	–.338E-06 (.416E-06)	—
OECD	—	—	–.006§ (.0033)
OECD•z	—	—	–1.144* (.3909)
OECD•z^2	—	—	165.817* (37.035)
adjusted R^2	.448	.504	.437
Standard error of the estimate	.0148	.0135	.0149

NOTE: Standard errors in parentheses.

* Significant at the 1 percent level.
† Significant at the 5 percent level.
‡ Per capita real GDP in 1965.
§ Significant at the 10 percent level.

A Case for Combining the Money Growth Rate with the Reserve Ratio

In this box, I show that the *S/Y* ratio, in equilibrium, is a nonlinear function of the reserve requirement and money growth rate. This application is a modified version of the economy developed in Champ and Freeman (1994). The chief feature of the model is that a person engages in market activity for two consecutive periods. In other words, N people enter market activity at each date t, stay for two periods, and then exit. It is equivalent to interpret this setup as one in which people are alive for two periods. In this context for a particular date t, those entering the market for the first time are "the young," and those entering the second period of market activity are "the old." Each person receives labor income when young, but nothing when old. Time is discrete and is indexed by $t = 1, 2, 3$, and so on. I assume there are N people at date $t = 1$ who have only one period in the economy; members of this generation are the "initial old." Preferences are identical for all people born at date t and after.

For simplicity, I focus exclusively on a stationary version of the following economy. All people born at date $t = 1$ and later have identical preferences. Thus, without loss of generality, one can focus on the problem of the representative person, which is characterized by the following equations:

$$\max_{c1,c2}\ \ln(c_{1t}) + \beta \ln(c_{2t+1}) \tag{B.1}$$

$$y \geq c_{1t} + a_t \tag{B.2}$$

$$c_{2t+1} \leq q_{t+1} a_t \tag{B.3}$$

$$a_t = v_t m_t + d_t \tag{B.4}$$

$$v_t m_t \geq \gamma d_t, \tag{B.5}$$

where c_{1t} is the young person's consumption at date t; c_{2t+1} is old-age consumption by the person born at date t; β is the person's discount factor; y is the person's labor income; a is the total quantity of goods saved by the young person; q is the gross return on savings carried from date t to date $t + 1$; and d is the quantity of goods stored as bank deposits by the young person. A person can also choose fiat money, which is m. Here, v stands for the value of fiat money—that is, the quantity of the consumption good that can be purchased with one unit of money. The consumption good is perishable.

Equation B.1 is a function that describes the welfare a representative person receives during a market-active period. The person seeks to maximize welfare by consuming as much of the consumption good as possible. Equation B.2 represents the two options—to save or to consume—that the typical young person faces when young, while Equation B.3 indicates that the typical old person can consume up to the value of principal and interest earned on savings. Equation B.4 shows that savings are in the form of either real money balances or bank deposits. Lastly, Equation B.5 is the reserve requirement, dictating that real money balances cannot be less than γ percent of bank deposits.

I assume that deposits offer a greater return than fiat money. Consequently, the typical person will hold the minimum quantity of fiat money balances. Equations B.4 and B.5, therefore, imply that $a_t = (1 + \gamma)d_t$. Substitute for a in Equations B.2 and B.3, and solve Equation B.3 for $(1 + \gamma)d_t$, substituting the result into Equation B.2. After the algebra, the expression is

$$y \geq c_{1t} + c_{2t+1}/q_{t+1}, \tag{B.6}$$

which is the person's lifetime budget.

To maximize lifetime utility, the typical person will choose first- and second-period consumption so that

$$\frac{1}{c_{1t}} = \frac{\beta q}{c_{2t+1}}. \tag{B.7}$$

Equation B.7 is an efficiency condition. It says that labor income will be allocated between first- and second-period consumption so that the benefits received from the last good consumed when young (measured by $1/c_{1t}$) are equal to the benefits received from the last good consumed when old (measured by $\beta q/c_{2t+1}$). In this economy, the optimizing conditions imply that the typical person will spend all of the labor income. Hence, Equation B.6 holds with equality.

In a stationary equilibrium, $c_{1t} = c_{1t+1}$ and $c_{2t+1} = c_{2t+2}$ at any date t, so that one can drop the time subscripts. For a stationary equilibrium, Equations B.6 and B.7 imply that $c_1 = y/(1 + \beta)$. With $0 < \beta < 1$, the typical person will spend a fixed fraction of labor income on consumption when young.

One might ask why the equilibrium expression for c_1 does not contain q. The answer is that a change in the gross return on assets has two opposing effects on consumption when young: substitution and wealth. With the substitution effect, an increase in q, for example, makes consumption when young more expensive relative to consumption when old. (Note that in the lifetime budget constraint [Equation B.6], $1/q$ can be interpreted as the price of consumption when old.) Thus, an increase in the gross return to assets would induce people to consume less when young and more when old. With the wealth effect, when c_2 becomes less expensive, consuming more of both c_1 and c_2 is possible. As such, an increase in q, for instance, will induce people to consume more when young. Clearly, the substitution and wealth effects have opposing impacts on consumption when young. With log utility, these effects exactly offset each other. Consequently, in a stationary equilibrium the value of c_1 is independent of movements in the gross return on assets.

A Case for Combining the Money Growth Rate with the Reserve Ratio (*continued*)

With $c_1 = y/(1 + \beta)$, the level of bank deposits can be represented as

$$d = \frac{\gamma}{1+\gamma}\left(\frac{\beta}{1+\beta}\right). \tag{B.8}$$

Next, substituting Equation B.8 into Equation B.5 yields the expression for the equilibrium value of real money balances; formally,

$$v_t m_t = \frac{\beta}{1+\beta} \bullet \frac{\gamma}{1+\gamma} y. \tag{B.9}$$

Here one can see the importance of the equilibrium expression for consumption when young. Because of the substitution and wealth effects, neither the quantity of deposits nor the quantity of real money balances is affected by changes in the gross return on assets. The implication is that the tax base for real seigniorage revenue is not affected by changes in real return on assets.

Expressing the equilibrium value of real seigniorage revenue is now possible. Substituting Equation B.9 into the expression for real seigniorage revenue yields $v_t m_t (1 - 1/\theta)$. With $g = \theta - 1$, I divide the expression by y so that the equilibrium reliance on seigniorage revenue per young person is

$$\frac{s}{y} = \frac{\beta}{1+\beta} \bullet \frac{\gamma}{1+\gamma} \bullet \frac{g}{1+g}. \tag{B.10}$$

Equation B.10 indicates that the equilibrium s/y ratio is a nonlinear function of the reserve ratio and the money growth rate.[1] Indeed, it is straightforward to show that the equilibrium value of s/y is a concave function of both the reserve requirement ratio and the money growth rate (see note 12).

To see how a change in monetary policy affects the equilibrium seigniorage ratio, consider a permanent, unanticipated increase in the reserve requirement ratio. In this model economy, Equation B.5 indicates that the holdings of real money balances will increase. Remember that the equilibrium level of deposits is not affected even though q will decline. Thus, the model economy predicts that the equilibrium seigniorage ratio will rise in response to an increase in the reserve requirement.

Next, consider a permanent, unanticipated increase in the money growth rate. With faster money growth, Equation B.10 indicates that an economy's reliance on real seigniorage revenue will increase. With an increase in g, the tax rate on real seigniorage revenue will rise and the gross return on assets will decline. Because of the utility function, the equilibrium quantity of real money balances is not affected by the decline in the gross real return on assets. Thus, faster money growth translates into an increase in the seigniorage ratio.

For this model economy, the s/y ratio increases with respect to an increase in either the reserve requirement ratio or money growth rate, but at a declining rate. For different utility specifications, substitution and wealth effects would not necessarily cancel each other out. Hence, the typical person could respond to an increase in q by increasing consumption when young, thereby saving less. Accordingly, a young person could reduce holdings of real money balances by enough to see a decline in the s/y ratio for a given increase in either the reserve requirement or the money growth rate. The purpose of this box is to illustrate the basic economic trade-offs. Hence, arguing the appropriate utility specification is outside the scope of this article.

Overall, Equation B.10 suggests a particular sufficient statistic for assessing the relationship between monetary policy and a country's reliance on seigniorage revenue. Throughout the statistical analysis, I use the product $z = [\gamma/(1 + \gamma)][g/(1 + g)]$ as the measure of monetary policy.

Note

[1] Here, the s/y ratio pertains to the ratio of per capita levels, which accounts for the use of lowercase letters.

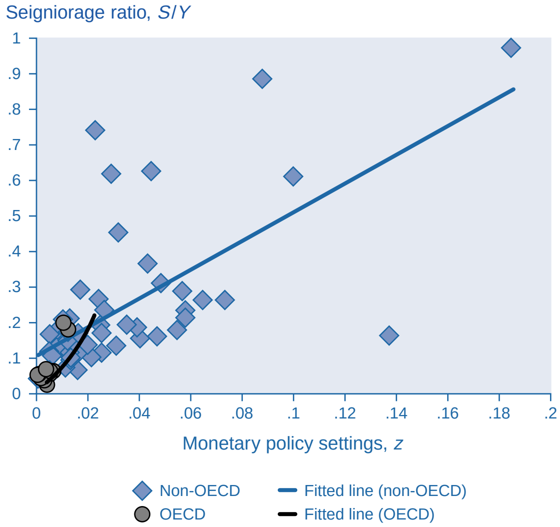
Important differences across countries could alter the relationship between monetary policy and the reliance on seigniorage revenue. For example, with only z as an explanatory variable, the regression's constant term captures any differences between countries. Insofar as differences across countries can be measured, additional insight may be gained into the relationship between monetary policy and reliance on seigniorage. Such measurements indicate whether the results obtained in this analysis are robust.

A particular concern is the ability of people to avoid the inflation tax. Such avoidance depends, in part, on a country's financial sophistication. Citizens in countries with more sophisticated financial structure, for instance, can avoid taxation by shifting to nonreservable deposits. They can also dodge the tax by shifting from currency to, say, credit cards as the means of payment. It would seem prudent, therefore, to measure a country's financial sophistication to assess whether this omitted variable affects the relationship between a country's monetary policy settings and its reliance on seigniorage.

The measure of financial sophistication should not depend on the monetary policy set-

Figure 2

Seigniorage–Income Ratio and Monetary Policy Settings



tings to get an accurate estimate of the coefficient between monetary policy and seigniorage reliance. In other words, movements in the measure should not reflect behaviors related to monetary policy settings, and yet the variable should be reasonably well correlated with a country's level of financial sophistication. In reality, finding such a measure is quite difficult. Two variables are offered as proxies for financial sophistication: the level of real per capita GDP in 1965 and a dummy variable indicating whether the country is a member of the Organization for Economic Cooperation and Development (OECD).[17] Certainly OECD membership and monetary policy settings are conceivably linked as part of a country's policy package. The more modest claim is that OECD membership and per capita real GDP are less likely to respond to movements in the monetary policy settings than are financial-sophistication measures such as bank deposits.

Figure 2 plots the combination of z and S/Y as well as separate fitted lines for non-OECD and OECD countries. Each line is fitted to a regression of the form $(S/Y)_I = c_0 + \alpha z_i + \beta z_i^2$. These two fitted lines appear quite different. Based on this preliminary look at the data, the evidence suggests that the relationship between a country's monetary policy statistic and its reliance on seigniorage revenue is different for developed countries than it is for less developed countries. Indeed, the fitted line for the non-OECD countries is upward sloping, whereas the one for the OECD countries appears to have some curvature.

I report regression results in columns 2 and 3 of Table 2. Here, I use two proxies to measure financial sophistication; one is the OECD membership, and the other is per capita real income in 1965. Two different sets of results emerge. Specifically, with per capita real income as the measure of financial sophistication, the evidence suggests a linear relationship between seigniorage reliance and z. As such, the evidence suggests, as it did when no financial sophistication measures were included, that countries that rely the most heavily on seigniorage revenue have higher monetary policy settings.

Consider, however, the results for a case in which OECD membership is used as a proxy for financial sophistication. These regression results correspond to the evidence presented in Figure 2. The formal statistical analysis supports the eyeball difference presented in the figure; that is, the z–S/Y relationship is significantly different for OECD countries than for non-OECD countries. The coefficient on $OECD \bullet z$ is negative and significant, and the coefficient on $OECD \bullet z^2$ is positive and significant. Thus, the evidence suggests that the relationship between seigniorage rates and monetary policy settings is convex. Indeed, the evidence indicates that an OECD country reaches a minimum reliance on seigniorage revenue at a value of $z = 0.0023$.

To illustrate this result, suppose one is looking at two OECD countries—country A and country B. Each has a different monetary policy setting, with country A always associated with the lower value of z. According to the regression statistics, if $z < 0.0023$ for both countries, then country B would rely less on seigniorage revenue than would country A. In contrast, for $z > 0.0023$, the regression predicts that country B would rely more on seigniorage revenue than would country A.[18]

The convex relationship exhibited by OECD countries is puzzling. In the model economy described in the box, financial sophistication would seem to permit a country's citizens to avoid the inflation tax. Given an increase in z, the equilibrium outcome for the S/Y ratio would either decline or increase, but at a decreasing rate as people avoid the inflation tax. In other words, it is reasonable to expect that increased tax-avoidance capabilities would result in a more concave relationship between a country's monetary policy settings and its reliance on seigniorage revenue, not a more convex one.

Overall, the evidence suggests that there is a systematic, positive relationship between a country's monetary policy settings and its reliance on seigniorage revenue. Thus, countries with higher monetary policy settings tend to rely more heavily on seigniorage. But compared with less financially sophisticated countries, the more financially sophisticated countries tend to rely on seigniorage revenue at an increasing rate. The findings with respect to financial sophistication are difficult to explain and deserve more attention.

CONCLUDING REMARKS

I present evidence in this article on the importance of seigniorage revenue and its relationship to monetary policy. I use cross-country observations to examine whether the average money growth rate and average reserve ratio are systematically related to a country's reliance on seigniorage revenue. Both economic and statistical considerations suggest that some combination of the money growth rate and the reserve ratio should be used in the empirical analysis. Consequently, a country's monetary policy setting is measured using a combination variable as opposed to investigating two separate relationships—one between seigniorage reliance and the reserve ratio and the other between seigniorage reliance and the money growth rate.

The main finding in this article is that there is a systematic, positive relationship between a country's monetary policy settings and its reliance on seigniorage revenue. Thus, countries that rely most heavily on seigniorage revenue tend to have the highest values of the monetary policy measure. There is some additional evidence that the relationship between the monetary policy variable and the seigniorage rate is nonlinear for OECD countries. Here, OECD membership is used as a proxy for financial sophistication. The evidence suggests that OECD countries rely on seigniorage revenue at an increasing rate for given changes in the monetary policy variable.

The findings in this article constitute a very preliminary investigation of the relationship between seigniorage revenue and monetary policy. There is always a risk of excluding a key variable in a regression, and that risk certainly holds here. One approach would be to control for a host of other environmental factors—for example, a more complete analysis of the depth and structure of financial markets.

The most surprising and, in some ways, the most interesting results are those differentiating between financially developed and less financially developed countries. If these results were to stand up to further scrutiny, economic theory would need to address the puzzle. One possible line of research would be to consider a simple open economy in which two countries differ in terms of financial sophistication and monetary policy rules.

Another avenue for future research would be to recognize that monetary policy variables and seigniorage revenue are jointly determined. While I have tried to describe the correlations without referring to any monetary policy as "causing" movements in seigniorage revenue, the estimated regressions could be interpreted as treating monetary policy as exogenous to the determination of such revenue. Edwards and Tabellini (1991) examine seigniorage revenue as the outcome of various political forces that influence, among other things, monetary policy settings. Thus, future research could attempt to disentangle the relative importance of political factors, controlling for monetary policy explicitly.

NOTES

1 See Cox (1992) for an excellent discussion of the practical relationship between the Federal Reserve and the U.S. Treasury. For an interesting description of seigniorage in medieval times, see Rolnick, Velde, and Weber (1994).

2 For reference, the United States raises, on average, about 2 percent of federal government expenditures through money creation.

3 After all the accounting is consolidated for the government and the central bank, the net change in the government's income state is that money creation amounts to a revenue source to cover various expenses.

4 Bryant and Wallace (1984) offer an explanation for the coexistence of government bonds and money. They argue that the two types of government paper effectively price discriminate between "rich" and "poor" households.

As far as my assumption about one-period bonds is concerned, I could examine a more complicated maturity structure for government debt. Such generality would not alter the conclusions that I reach about seigniorage revenue, but it would mean that I would have to keep tabs on the entire distribution of government bonds and when each one matures.

5 The reduction in reported income can come either from effective avoidance or from people working less or acquiring less capital. Of course, the discussion describes what happens to the steady-state level of income.

6 There is no explicit interest on money. Consequently, its one-period rate of return is calculated as the ratio of the date *t* price (the potential selling price) to the

date $t - 1$ price (the purchase price). Formally, this is the ratio of v_t/v_{t-1}. With $v_t = 1/p_t$, then simple substitution yields the expression for the gross real return on money.

[7] Here, the reserve requirement pins down the fraction of a person's portfolio held in the form of money balances. This approach is qualitatively the same as one in which the reserve requirement pins down the bank's portfolio.

[8] The data set is available from the author upon request.

[9] Fischer is primarily interested in describing why countries maintain national currencies. Computing the seigniorage-to-GNP ratio demonstrates how important seigniorage is. The ratio represents the command over resources that a government obtains by creating money.

[10] The income tax analog is the average marginal tax rate. See, for example, Seater (1985).

[11] Historically, the U.S. reserve requirement structure was more convoluted. In the past, for example, it mattered whether the commercial bank was located in a Reserve Bank city or outside.

[12] Interestingly, Fischer (1982) presents evidence that several governments have made substantial use of seigniorage. In Fischer's sample, which generally covers the period between 1960 and 1978, Argentina collected, on average, 6.2 percent of GNP through money creation.

[13] This result does not bear directly on the relative importance of seigniorage revenue. Rather, it bears on the issue of variability within a country across time. In short, the reader gains a sense of how the countries in the sample rely on seigniorage over time.

[14] The effect of a change in the reserve ratio, holding money growth constant, is given by the following derivative: $\partial z/\partial(R/D) = W/(1 + R/D)^2$, where $W = g/(1 + g)$. With $W > 0$, the expression says z is increasing the reserve ratio. In addition, $\partial^2 z/\partial(R/D)^2 = (-2 \cdot W)/(1 + R/D)^3$, which is negative for $W > 0$.

[15] To see this relationship, suppose the estimated regression is given by

$$S/Y = c_0 + \alpha z + \beta z^2.$$

For a country with a 1-percentage-point higher average z, an estimate of the change in S/Y is $\alpha + 2\beta z$. Thus, a 1-percentage-point change in z depends on the value of z.

[16] In all regressions, the Newey–West procedure is applied to correct any potential bias in standard errors. In this particular application, heteroskedasticity is the chief worry.

[17] Per capita real GDP comes from the Summers–Heston Penn World Tables. In addition, regressions are run using per capita real GDP for 1980 and 1994 as alternative measures of financial sophistication in case the 1965 GDP value suffers from some time-specific factors. The regressions are qualitatively the same as those reported in Table 2.

[18] Three OECD countries in this sample—France, the Netherlands, and Norway—have z values less than 0.0023. Using the method outlined in Fomby, Hill, and Johnson (1984, 58), one can compute the standard errors for the value of z at which seigniorage reliance is minimized. With 90 percent confidence, the seigniorage-reliance minimizing value of z is between 0.0022 and 0.0024.

REFERENCES

Bryant, John, and Neil Wallace (1984), "A Price Discrimination Analysis of Monetary Policy," *Review of Economic Studies* 51 (April): 279–88.

Champ, Bruce, and Scott Freeman (1994), *Modelling Monetary Economies* (New York: John Wiley and Sons Inc.).

Cox, W. Michael (1992), "Two Types of Paper: The Case for Federal Reserve Independence," Federal Reserve Bank of Dallas *Southwest Economy,* Issue 6, November/December, 3–8.

Edwards, Sebastian, and Guido Tabellini (1991), "Explaining Fiscal Policies and Inflation in Developing Countries," *Journal of International Money and Finance* 10 (March): S16–S48.

Fischer, Stanley (1982), "Seigniorage and the Case for a National Money," *Journal of Political Economy* 90 (April): 295–313.

Fomby, Thomas B., R. Carter Hill, and Stanley R. Johnson (1984), *Advanced Econometric Methods* (New York: Springer–Verlag Inc).

Rolnick, Arthur J., François R. Velde, and Warren E. Weber (1994), "The Debasement Puzzle: An Essay on Medieval Monetary Policy," Federal Reserve Bank of Minneapolis Working Paper no. 536 (October).

Sargent, Thomas J. (1986), *Rational Expectations and Inflation* (New York: Harper & Row).

Seater, John J. (1985), "On the Construction of Marginal Federal Personal and Social Security Tax Rates in the U.S.," *Journal of Monetary Economics* 15 (January): 121–35.