

Business Review

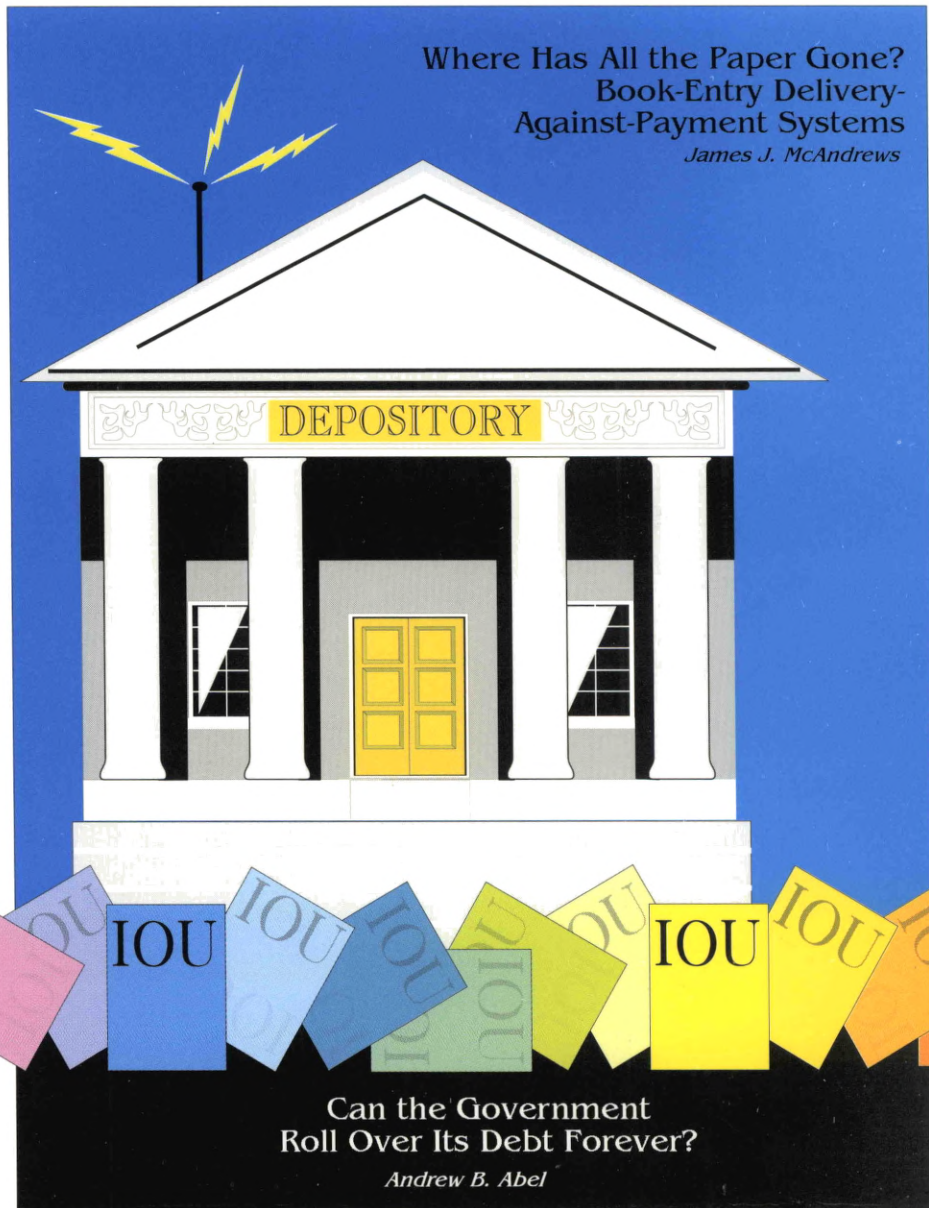
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Book-Entry Delivery-
Against-Payment Systems

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CAN THE GOVERNMENT ROLL OVER ITS DEBT FOREVER?

Andrew B. Abel

The enormous federal deficit has led the government to resort to rolling over its debt: issuing new debt to cover interest on existing debt. Can the government go on doing this forever? Can it go on doing this without resorting to the politically impolitic act of raising taxes or cutting expenditures? Can the government, or any entity, run a Ponzi game? Read Andy Abel's article for some answers to these provocative questions.

WHERE HAS ALL THE PAPER GONE? BOOK-ENTRY DELIVERY-AGAINST- PAYMENT SYSTEMS

James J. McAndrews

Throughout history, whenever money or valuables of any kind have changed hands, security and various types of risk have presented problems. The formation of depositories provided a solution to at least some of these problems. Depositories are still around, and modern securities markets use them to effect "paperless" trades: a depository records a security trade by debiting the account of the seller and crediting the account of the buyer. No paper changes hands. This system has reduced the costs and changed the risks of settling trades. James McAndrews' article examines how these systems work and discusses what advantages are involved and what risks remain.

Can the Government Roll Over Its Debt Forever?

*Andrew B. Abel**

In the past dozen years, the federal government has regularly run large deficits, usually well in excess of \$100 billion per year. The amount of federal government debt outstand-

ing has quadrupled during this time, from a value of \$908 billion at the end of fiscal year 1980 to a value of \$3,665 billion at the end of fiscal year 1991. Even after correcting for inflation, the amount of government debt has grown by a factor of 2.5 over this period. This apparent explosion in the amount of government debt has led to spirited and protracted public debate about federal tax policy and federal expenditures. Despite the widely professed desire to reduce the federal deficit and to limit the growth of federal government debt, a consensus about how to achieve these alleged goals has not yet emerged. Faced with continuing deficits, the

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government has resorted to rolling over its debt—that is, issuing new debt to pay the interest on existing debt and to pay off holders of maturing debt.

Is rolling over the debt the solution that we have been looking for? Can the government simply roll over its debt forever without having to take the politically costly steps of raising taxes or cutting expenditures in the future? This article discusses the feasibility of rolling over government debt forever. As we will see, this question is related to another important question about the future of the economy: Is the economy as a whole saving an appropriate amount for the future? In addition, both of these questions are related to the question of whether an entity can run a Ponzi game.

THE SIMPLE ARITHMETIC OF GOVERNMENT DEBT ACCUMULATION

To address the question of whether the government can roll over its debt forever, we need to quantify the factors that contribute to the growth of government debt over time. We begin by specifying the relationship between government deficits and the growth rate of government debt. Then we examine whether the public would be willing to hold ever-increasing amounts of government debt, thereby permitting the government to roll over its debt forever.

Primary and Total Deficits. Although it is tempting to think of both “debt” and “deficits” as representing the “D word,” there is an important distinction between debt and deficits. Government debt is the liability of the government owed to holders of government bonds at any particular moment; it is measured in dollars as of a particular date, such as \$3,665 billion as of September 30, 1991. A government deficit is the excess of government expenditures over government receipts during a particular period. The government deficit equals the increase in the amount of government debt during a particular interval; it is measured in terms

of dollars per unit of time, such as \$320.9 billion per year during fiscal year 1991 (October 1, 1990 - September 30, 1991). In terms of familiar accounting concepts, government debt is a balance sheet concept, whereas the government deficit is an income statement concept.

Although the definition of the government deficit as the excess of government expenditures over government receipts during a particular period seems fairly unambiguous, actually two different deficit concepts are widely used. The difference between these two deficit concepts lies in whether interest payments on government debt are included as part of government expenditure. One deficit concept, known as the primary deficit, does not include interest payments on the government debt as part of government expenditure. Thus, the primary government deficit is calculated as all noninterest expenditure by the government minus government receipts. The primary government deficit was “only” \$34.9 billion in fiscal 1991 (Table 1).

The other deficit concept, known as the total deficit or simply the deficit, includes interest payments by the government as part of government expenditure. Thus the total deficit equals total government expenditure, including interest payments, minus government receipts. In fiscal 1991, interest payments by the government amounted to \$286.0 billion, so that the total government deficit of \$320.9 billion exceeded the primary government deficit by \$286.0 billion.

Why are there two different deficit concepts? The reason economists and policymakers look at both of these deficit concepts is that each concept provides the answer to a different question. Specifically, the primary deficit answers the question: Are current taxes sufficient to pay for spending on current government programs? More precisely, the primary deficit measures the extent to which spending on current programs exceeds the taxes currently collected. The total deficit answers a different

TABLE 1
Government Deficit
Fiscal Year 1991
(October 1, 1990 - September 30, 1991)

Government Expenditures	
Noninterest expenditures ^a	\$795.3 billion
Interest payments by government ^b	\$286.0 billion
Total expenditures ^c	\$1,081.3 billion
Government Receipts ^c	\$760.4 billion
Primary Deficit = \$795.3 billion - \$760.4 billion = \$34.9 billion	
Total Deficit = \$1,081.3 billion - \$760.4 billion = \$320.9 billion	

^aSource: calculated as total expenditures minus interest payments by government.

^bSource: Treasury Bulletin, March 1992.

^cSource: Economic Report of the President, 1992, Table B-75.

question: How much will the government have to borrow to pay for its expenditures? The total deficit during a year measures the increase in government debt during that year.

The Debt-GNP Ratio. How do we gauge whether a government's debt is too large? One way to gauge the size of a government's debt is by the government's ability to repay the debt. Governments that have access to larger tax bases would be able to support larger amounts of debt than governments with smaller tax bases. For the federal government, we can gauge the size of the tax base by some measure of national income, such as Gross National Product (GNP) or Gross Domestic Product (GDP). In this article, we will use GNP as the measure of national income, and thus we will use the ratio of government debt to GNP—known as the debt-GNP ratio—to gauge the size of government debt.

The historical behavior of the debt-GNP ratio over the last century in the United States is shown in Figure 1. Notice that the debt-GNP ratio rose sharply during World War I and World War II, and then fell gradually after these wars (and also fell gradually for about a half century after the Civil War). In addition to the increases in the debt-GNP ratio during wars, the debt-GNP ratio also rose sharply during the Great Depression of the 1930s and during the 1980s.

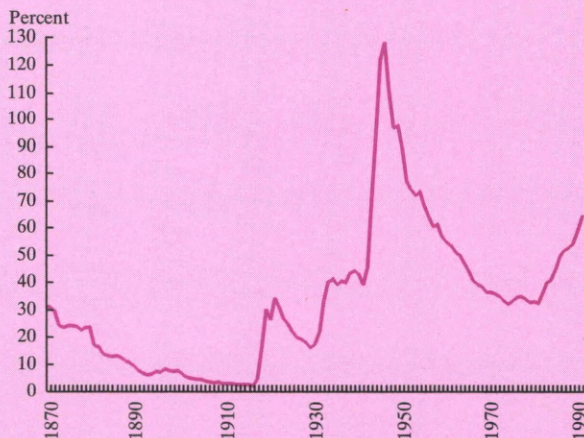
What causes the debt-GNP ratio to increase from one year to the next? Just as a matter of simple arithmetic, the debt-GNP ratio will rise whenever the growth rate of the numerator, i.e., the growth rate of government

debt, is higher than the growth rate of the denominator, i.e., the growth rate of GNP. As we have discussed earlier, the increase in government debt during a year equals the total deficit, which in turn equals the primary deficit plus interest payments by the government. Thus, the debt-GNP ratio tends to increase when (1) the primary government deficit is large; (2) interest payments by the government are large; and (3) the growth rate of GNP is small. The following equation, which is an approximation derived in Appendix A, captures the simple arithmetic of government debt accumulation:

$$(1) \text{ growth rate of debt-GNP ratio} = \begin{aligned} & \text{primary deficit/debt} \\ & + \text{interest rate} \\ & - \text{growth rate of GNP} \end{aligned}$$

Note that when the growth rate of the debt-

FIGURE 1
Debt-GNP Ratio



Sources: Ratio of government debt to GNP. Source of government debt (end of fiscal year): 1869-1939 from Historical Statistics of the United States, series y338; 1940-1969 from Banking and Monetary Statistics, 1941-1970, Table 13.1, C; 1970-1979 from Federal Reserve Board Annual Statistical Digest, 1970-1979, Table 27; 1980-1989 from Federal Reserve Board Annual Statistical Digest, 1980-1989, Table 26; 1990-1991 from Treasury Bulletin, March 1992, Table FD-1. Source of GNP: 1869-1958, Balke, Nathan S. and Robert J. Gordon, Appendix B Historical Data, in *The American Business Cycle: Continuity and Change*, Robert J. Gordon (ed.), Chicago and London: The University of Chicago Press, 1986; 1959-1991 from Data Resources Incorporated (1960 GNP is 2 percent higher in DRI than in Balke and Gordon).

GNP ratio is positive, this ratio is growing, and when the growth rate of the debt-GNP ratio is negative, the debt-GNP ratio is falling.

The three components of the growth rate of the debt-GNP ratio on the right-hand side of equation (1) explain, in an arithmetic sense at least, the historical behavior of the debt-GNP ratio shown in Figure 1. The sharp increase in the debt-GNP ratio during both world wars resulted from sharp increases in the primary deficit (Figure 2). Of course, the increase in the primary deficit reflects the large increase in military expenditure during wartime. The rise

in the debt-GNP ratio during the Great Depression resulted from large declines in GNP during the early 1930s and from large primary deficits beginning in 1932. The decline in the debt-GNP ratio during the three-and-a-half decades following World War II resulted from a combination of factors: (1) a small—indeed usually negative—primary deficit; and (2) an interest rate that was usually smaller than the growth rate of GNP. However, during the 1980s the debt-GNP ratio departed from its typical pattern of peacetime behavior and began to rise. Arithmetically, the positive growth rate of the debt-GNP ratio was accounted for by a relatively large ratio of the primary deficit to government debt in the early 1980s and by the fact that

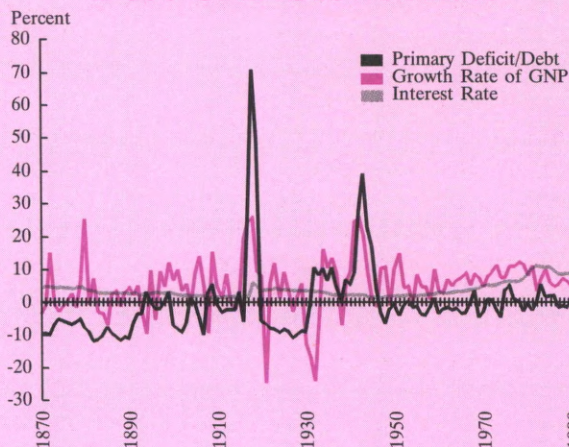
the interest rate exceeded the growth rate of GNP for most of the 1980s.

Rolling Over Government Debt. Our discussion of the debt-GNP ratio was motivated by the desire to gauge the size of government debt relative to the government's ability to repay that debt. What problems might be associated with a high value of the debt-GNP ratio? If the debt-GNP ratio were to become too large, the public might begin to suspect that one day the government would default on its debt, and this suspicion might make the public unwilling to buy additional government debt.

There are many ways the government could default on its debt. The government could simply renounce its liabilities and refuse to pay holders of government bonds. Alternatively, the government could heavily tax the principal and/or interest on government bonds, effectively defaulting on at least a fraction of its liabilities. More subtly, the government could print money and create inflation, which reduces the real purchasing power of its dollar liabilities represented by government bonds. Another problem with a very high debt-GNP ratio is that the interest payments on government debt become a very large fraction of GNP. If the debt-GNP ratio becomes extremely large, the increase in government debt needed to pay the interest on the outstanding government debt could become larger than all of GNP,¹ and the public would not be able to buy this debt.

The willingness or unwillingness of the public to buy additional government debt when the debt-GNP ratio gets large determines whether the government can roll over its debt forever. If a policy of rolling over government debt forever would cause the debt-GNP ratio to grow forever without bound, the public would be-

FIGURE 2
Components of
Debt-GNP Growth Rate



Sources: Primary deficit calculated as total deficit minus interest payments by the government. Source of total deficit: 1869-1939 from Historical Statistics of the United States, series y337; 1940-1991 from Economic Report of the President, February 1992, Table B-74, on-budget. Source of interest payments: 1869-1969: from Historical Statistics of the United States, series y461; 1970-1991 from Treasury Bulletin, various issues, Table FFO-3. Interest rate calculated as interest payments in current fiscal year divided by government debt at end of previous fiscal year (see note to Figure 1 for source of data on government debt). Growth rate of GNP calculated from GNP data described in note to Figure 1.

come unwilling to buy the government debt offered for sale and the rollover policy would have to terminate. However, if the debt-GNP ratio falls forever when the government is pursuing a rollover policy, it would be possible to roll over government debt forever.

But how could the debt-GNP ratio fall forever while the government is rolling over its debt? To answer this question, we will first precisely define a policy of rolling over the debt in terms of the primary deficit, and then we will use equation (1) to see how the debt-GNP ratio changes over time under a policy of debt rollover.

¹ If the debt-GNP ratio exceeds the reciprocal of the interest rate on government bonds, interest payments on government debt would exceed GNP.

Quite simply, a government is rolling over its debt if its primary deficit is zero, so that its total deficit equals its interest payments on government debt. In this case, the government sells additional government bonds (debt) to pay the interest on government debt and to pay off holders of maturing government debt. If the government can run a zero primary deficit forever, selling bonds to cover the total deficit, then it can roll over its debt forever. Whether the government is able to run a zero primary deficit forever depends on whether the debt-GNP ratio eventually becomes too large when the government runs a zero primary deficit year after year.

To see if a government can run a zero primary deficit forever, we simply set the primary deficit in equation (1) equal to zero and observe that in this case the growth rate of the debt-GNP ratio equals the interest rate minus the growth rate of GNP. If the interest rate is higher than the growth rate, the debt-GNP ratio grows forever without bound, and eventually the government would lose its ability to roll over its debt. However, if the interest rate is smaller than the growth rate of GNP, the growth rate of the debt-GNP ratio would be negative, and the government could roll over its debt forever. For instance, if the interest rate is 3 percent per year and the growth rate of GNP is 4 percent per year, interest payments amount to 3 percent of government debt. If the government sells new bonds to pay these interest payments, the supply of government debt will increase by 3 percent per year, which is less than the 4 percent annual growth rate of GNP. Thus, the debt-GNP ratio would decline.

For most of the last century in the United States, the interest rate on government debt has been lower than the growth rate of GNP (Figure 2). In fact, the average interest rate on government debt was 4.12 percent per year, and the average growth rate of GNP was 5.86 percent per year over the period 1869-1991. If this pattern with the average interest rate below the

average growth rate were to continue to hold forever, it would appear that the U.S. government could roll over its debt forever.

WHAT HAPPENS WHEN THE INTEREST RATE IS LESS THAN THE GROWTH RATE OF GNP?

We have seen that over the last century the average interest rate on government debt was lower than the average growth rate of GNP. One important implication of having an interest rate lower than the growth rate of GNP is that the government can roll over its debt forever. In this section, we discuss two other important—and surprising—implications of having an interest rate lower than the economy's growth rate.

The Economy Has Too Much Capital. The most important factor determining the standard of living of future generations is the long-run rate of economic growth. One of the primary ways that an economy can help promote economic growth is to save for the future by increasing the capital stock of productive equipment and structures. This process of capital accumulation combines a present sacrifice in the form of reduced present consumption with a future benefit in the form of increased future output and consumption. At various times in recent history, policymakers have made the judgment that the future gain is worth the present sacrifice, and national economic policy focused directly on stimulating capital formation by providing tax incentives in the form of accelerated depreciation allowances and the investment tax credit.

Is it possible for an economy to overdo it? More precisely, is it possible for an economy to accumulate and maintain a level of capital that is unambiguously too high? Surprisingly, the answer is yes. An economy can accumulate so much capital that the current sacrifice associated with current investment actually leads to a future sacrifice in the form of reduced future consumption. In this situation, the present

sacrifice associated with capital formation is clearly not worth undertaking. An interest rate smaller than the growth rate of the economy signals that such a situation exists.

To see how it would be possible to have too much capital, suppose a piece of capital requires \$5 worth of resources every year to maintain it in working order, but the capital contributes additional output worth only \$4 per year. The economy would be suffering a net loss of \$1 per year and would be better off without the capital.² At the level of the national economy, we can say that an economy has too much capital if in every year the amount of resources devoted to creating new capital and maintaining old capital is greater than the contribution to total output of the total capital stock. To put this condition in the language of national income accounting, an economy has too much capital if in every year gross investment (the amount of resources devoted to new capital formation and replacement of depreciated capital) exceeds gross capital income (which measures the contribution of capital to total output). We write this condition as:

(2) too much capital if:

gross investment > gross capital income
in every year.

Now we can relate the condition for too much capital to the relationship between the interest rate and the growth rate. This relationship is clearest for an economy growing at a

constant rate year after year, so let's suppose that the economy is growing at constant rate g every year. Thus, for example, GNP is growing at the rate g and the total capital stock, K , is also growing at the rate g . With the capital stock growing at the rate g per year, the amount of net capital formation during a year is gK . In addition, some resources are devoted to replacing capital that depreciates during the year. Letting d be the fraction of the capital stock that depreciates during a year, the total amount of depreciation during a year that must be offset by capital formation is dK . Gross investment is the sum of net capital formation and depreciation:

$$(3) \text{ gross investment} = gK + dK = (g + d)K$$

The contribution of capital to total output is measured by gross capital income. Letting R denote the gross rate of return on capital, we have:

$$(4) \text{ gross capital income} = RK$$

Comparing gross investment in equation (3) with gross capital income in equation (4), we see that the economy has too much capital if $(g + d)K > RK$ in every year, or equivalently:

(5) too much capital if:

$$g + d > R$$

in every year

To see the role of the interest rate in this condition, we observe that in an economy in which there is no uncertainty, the interest rate r would equal the net rate of return on capital, which is the gross rate of return R minus the rate of depreciation. In symbols we have:

$$(6) \quad r = R - d$$

(interest rate) (net rate of return on capital)

Finally, we obtain the condition for too much capital in terms of the interest rate and the growth rate by subtracting the depreciation rate d from both sides of equation (5) and using the fact that $r = R - d$ to obtain:

²In this numerical example, net investment is zero, but the same principle applies when there is positive net investment. For example, consider a firm that operates a factory with a work force that grows by 2 percent per year. If the firm maintains a constant ratio of capital to labor, the firm's capital stock would grow by 2 percent per year. However, if the contribution to total output of each unit of capital is only 1 percent of the value of the capital stock, then the firm would be pouring more resources into the factory than it gets out of the factory, and it would be better off closing that factory.

(7) too much capital if: $g > r$
in every year.

Thus, we can see that in the absence of uncertainty, an economy growing at a constant rate has too much capital if the interest rate is less than the growth rate. An economy in this situation could realize both a present gain and a future gain by permanently reducing the amount of investment. Present consumption would increase as the economy's current resources shifted from investment to consumption. Future consumption would increase as fewer resources were, on net, poured into the formation and maintenance of capital. As a result of the reduction in investment, the capital stock would fall, and as capital became less abundant, the rate of return on capital would increase. When the rate of investment has fallen enough, the net rate of return on capital and the interest rate will rise above the growth rate of the economy, so that the symptom of too much capital will disappear.

Recall that during the period 1869-1991 the average interest rate in the United States was smaller than the average growth rate. Thus, equation (7) would seem to suggest that the United States has too much capital. We will take another look at this provocative implication later in this article.

Ponzi Games. In the early 20th century, Charles Ponzi promised investors the opportunity to double their money in 90 days by investing in international postal coupons. Over the course of eight months, Ponzi acquired about \$15,000,000 from 40,000 investors. Not surprisingly, Ponzi's promises proved to be too good to be true, and Ponzi was arrested in August 1920.³ Economists now use the term "Ponzi game" to describe a situation in which an entity (a person, business, or government) sells securities to investors and never uses any of its own

money to pay dividends or interest or to repay the principal. Any subsequent payments (such as dividends, interest, or return of principal) to holders of these securities are financed by selling additional securities. Our discussion will focus on rational Ponzi games, which are Ponzi games in which there is no fraud or deceit on the part of the seller of securities and no lack of understanding or foresight on the part of buyers of these securities.

As a simple example of a rational Ponzi game, consider an entity that sells \$100 million of long-term bonds, promising to pay an interest rate of 4 percent per year. At the end of one year, when it is time to pay investors \$4 million in interest, the entity sells an additional \$4 million of bonds to investors, bringing total bonds outstanding to \$104 million. Then at the end of two years, when \$4.16 million of interest (4 percent of \$104 million) is due, the entity sells an additional \$4.16 million of bonds, and so on. The amount of bonds outstanding grows at the rate of interest, which is 4 percent per year in this example. For this Ponzi game to be feasible, the public must be willing to hold the ever-increasing amount of bonds issued. If investors' wealth is growing at, say, 5 percent per year, there would be sufficient demand by the public for newly issued bonds, and thus the entity would be able to sell additional bonds to pay the interest on its debt without having to use any of its own resources.

In the Ponzi game described above, suppose that the entity selling the bonds is the government. Then the Ponzi game amounts to rolling over government debt forever. The Ponzi game will be feasible, that is, the government will be able to roll over its debt forever, provided that the growth rate of aggregate wealth exceeds the interest rate. The growth rate of aggregate wealth is not readily measured, but in the absence of a trend in the ratio of wealth to GNP, the growth rate of aggregate wealth can be proxied by the growth rate of GNP. Thus, the government will be able to roll over its debt

³See O'Connell and Zeldes (1992).

forever if the growth rate of GNP exceeds the interest rate.⁴

To summarize, if the interest rate is lower than the growth rate of GNP, (1) the economy has too much capital; (2) entities can run rational Ponzi games; and (3) in particular, the government can roll over its debt forever. As we have seen, over the last century in the United States, the average interest rate has been lower than the average growth rate of GNP. Thus, it might seem that the United States has too much capital, that entities can run rational Ponzi games, and that the government can roll over its debt forever. However, these three results do not strike most observers as plausible descriptions of the U.S. economy. The implausibility of these results stimulated new research into these questions in the past several years. A point of departure for much of this research is the fact that the results presented above were derived under the assumption of a constant interest rate and a constant growth rate, but, as is evident in Figure 2, the interest rate, and especially the growth rate, have displayed substantial variability in the United States. Recent research has focused on uncertainty as the source of variation in the interest rate and the growth rate and has found that the results summarized above need to be substantially altered when uncertainty is incorporated into the analysis.

THE IMPORTANCE OF UNCERTAINTY

Recent research into the questions of whether an economy has too much capital and whether a government can roll over its debt forever has shown that simply comparing the average interest rate and the average growth rate of the economy can produce misleading answers to these questions. Much of this research is ongoing and many important questions remain unanswered, but this research has yielded some important insights.

Another Look at Whether an Economy Has Too Much Capital. In a world without uncertainty, we can compare the interest rate and the growth rate of the economy to determine whether the economy has too much capital. In deriving equation (7) we used the fact [equation (6)] that in the absence of uncertainty, the net rate of return on capital, $R - d$, equals the interest rate, r , on government debt. However, in the presence of uncertainty, the rates of return on different assets, in particular the rates of return on capital and on government bonds, can in general differ. Thus, the comparison of the interest rate and the growth rate in equation (7) is no longer appropriate for assessing whether an economy has too much capital.

In the presence of uncertainty, the appropriate criterion for determining whether an economy has too much capital is equation (2): If gross investment exceeds gross capital income in every year, the economy has too much capital. If gross investment is less than gross capital income in every year, we conclude that the economy is not plagued by too much capital. A recent study⁵ has examined gross investment and gross capital income in the United States for the period 1929-1985 and found that

⁴The discussion in this article ignores distortions arising from taxes or from externalities. In a recent paper, Ian King (1992) has argued that with endogenous growth arising from externalities in the stock of knowledge, it is possible for Ponzi games to be feasible even though the economy does not suffer from overaccumulation of capital. This result arises because the private and social returns to capital differ in the presence of externalities. Capital overaccumulation occurs if the social rate of return to capital is lower than the growth rate of the economy, and Ponzi games are feasible if the private rate of return to capital is lower than the growth rate of the economy. In King's model, the social rate of return can be higher than the growth rate, which can be higher than the private rate of return.

⁵ Andrew B. Abel, N. Gregory Mankiw, Lawrence H. Summers, and Richard J. Zeckhauser, "Assessing Dynamic Efficiency: Theory and Evidence," *Review of Economic Studies*, 56 (January 1989), pp. 1-20.

in every year, including the Great Depression of the 1930s, gross investment was less than gross capital income. Thus, despite the fact that the average interest rate was less than the average growth rate of the economy, we can conclude that the United States was not afflicted with too much capital.⁶ This study also examined six other countries, including Japan, which is often cited as a country with high rates of saving and investment. For all of these countries, including high-investing Japan, gross investment was always less than gross capital income, and hence, none of these countries had too much capital.

Debt Rollover When the Average Interest Rate Is Lower Than the Average Growth Rate.

We have just seen that the introduction of uncertainty invalidates the comparison of the average interest rate and the average growth rate for the purpose of determining whether an economy has too much capital. Now we will see that the introduction of uncertainty also invalidates the comparison of the average interest rate and the average growth rate for the purpose of determining whether a Ponzi game is feasible. We focus this discussion on a particular Ponzi game, namely rolling over government debt forever. This section presents a numerical example with the following surprising feature: despite the fact that the interest rate on government debt is lower than the average growth rate of GNP, the expected value of the debt-GNP ratio grows without bound. Eventually, the government would become unable to roll over its debt.

Before presenting this example it is useful to calculate an exact expression for the growth rate of the debt-GNP ratio when the government is following a rollover policy. (Equation

(1) is an approximate expression.) Remember that a rollover policy means that the primary deficit is zero in every year. If the current amount of government debt is B and if the government has a zero primary deficit, its total deficit is rB , where r is the interest rate. Thus, the government must sell an additional rB bonds, and the amount of bonds next year rises to $(1+r)B$. If the current level of GNP is Y and if the growth rate of GNP over the next year is g , the level of GNP next year is $(1+g)Y$. Thus, the value of the debt-GNP ratio next year is $[(1+r)/(1+g)][B/Y]$, which is $(1+r)/(1+g)$ times as large as the current debt-GNP ratio, B/Y . Thus, if r is larger than g , so that $(1+r)/(1+g)$ is larger than one, the debt-GNP ratio grows between this year and next year. Alternatively, if r is smaller than g , so that $(1+r)/(1+g)$ is smaller than one, the debt-GNP ratio falls between this year and next year. These results are consistent with the approximation in equation (1).⁷

Now we can discuss the numerical example presented in Table 2, which has the following features: the interest rate r is constant and is smaller than the average value of g , the growth rate of GNP. However, g varies in such a way that the average value of $(1+r)/(1+g)$ is greater than 1, so that the expected value of the debt-GNP ratio in the next period is always greater than the current value of the debt-GNP ratio. In this example, the uncertainty comes from the fact that GNP growth is unpredictable from one period to the next. To make the example simple, suppose that GNP growth is determined by the flip of a fair coin each period. If the coin comes up heads, GNP grows by 60 percent during the next period, and if the coin

⁶ This conclusion is based on the implicit assumption that the fact that gross investment has always been smaller than gross capital income will continue forever.

⁷ The approximation involved in equation (1) is that the growth rate of a ratio is approximately equal to the growth rate of the numerator minus the growth rate of the denominator. (See Appendix A, Derivation of the Growth Rate of the Debt-GNP Ratio.)

TABLE 2
A Growing Debt-GNP Ratio
with the Interest Rate
Below the Average Growth Rate

period	1	2	3
debt	\$100	\$104.70	\$109.62
GNP	\$1000	\$600 (50%) \$1600 (50%)	\$360 (25%) \$960 (25%) \$960 (25%) \$2560 (25%)
expected GNP	\$1000	\$1100	\$1210
debt/GNP	0.10	0.1745 (50%) 0.0654 (50%)	0.3045 (25%) 0.1142 (25%) 0.1142 (25%) 0.0428 (25%)
expected debt/GNP	0.1000	0.1200	0.1439

comes up tails, GNP falls by 40 percent.⁸ Thus, if GNP is currently \$1000, there is a 50 percent chance that next period's GNP will be \$1600 and a 50 percent chance that next period's GNP will be \$600. Thus, the average, or expected, value of next period's GNP is \$1100 ((\$1600+\$600)/2), which represents a 10 percent expected growth rate.

Now suppose that the interest rate on government debt is always 4.7 percent per period, which is less than the average growth rate of the economy, and let's see how the debt-GNP ratio behaves in this economy. Suppose that in period 1 the amount of government debt is \$100. Thus, the debt-GNP ratio is \$100/\$1000 = 0.10.

The first panel of numbers in Table 2 shows the evolution of government debt over time. With a 4.7 percent interest rate, the

⁸ These large changes in GNP in this example were chosen to make the effects very apparent. To make the example seem more realistic, think of a period as being a decade rather than a year. Notice that between 1929 and 1933 in the United States real GNP fell by 30 percent and nominal GNP fell by 46 percent, so a 40 percent drop in GNP during a decade is not inconceivable. However, the probability of such a bad decade is almost surely much less than the value of 50 percent assumed in this example.

amount of government debt grows at the rate of 4.7 percent per period. Thus, government debt equals \$104.70 in period 2 and \$109.62 in period 3.

The second panel of numbers in Table 2, which shows GNP, requires a little additional explanation. As shown in the first column, GNP is \$1000 in period 1. The second column shows that there is a 50 percent chance that GNP in period 2 will be \$600 and a 50 percent chance that GNP in period 2 will be \$1600, so that the expected value of GNP in period 2 is $(\$600 + \$1600)/2 = \$1100$. The third column of numbers shows the possible values of GNP in period 3. If GNP in period 2 is \$600, there is a 50 percent chance it will fall by 40 percent, to \$360, in period 3, and a 50 percent chance it will rise by 60 percent, to \$960, in period 3. Alternatively, if GNP in period 2 is \$1600, there is a 50 percent chance it will fall by 40 percent, to \$960, in period 3, and a 50 percent chance it will rise by 60 percent, to \$2560, in period 3. Taking account of all of these possibilities for the value of GNP in period 3, there is a 25 percent chance it will be \$360, a 50 percent chance it will be \$960, and a 25 percent chance it will be \$2560. The average, or expected, value of GNP in period 3 is \$1210.

The third panel of numbers in Table 2 shows the possible values of the debt-GNP in each of the three periods. These numbers are calculated by dividing the value of debt in the first panel by the value of GNP in the second panel. For example, in period 2, debt will equal \$104.70. There is a 50 percent chance GNP will equal \$600, in which case the debt/GNP ratio will be $\$104.70/\$600 = 0.1745$, as reported in the third panel; there is a 50 percent chance GNP will equal \$1600, in which case the debt/GNP ratio will be $\$104.70/\$1600 = 0.0654$. The average, or expected, value of the debt-GNP ratio in period 2 is $(0.1745 + 0.0654)/2 = 0.1200$, which is higher than the debt-GNP ratio in period 1. Despite the fact that the interest rate is smaller than the average growth rate of GNP, the risk of a sharp

drop in GNP makes the expected value of the debt-GNP ratio in period 2 higher than the value of the debt-GNP ratio in period 1. As shown in the third column, the expected value of the debt-GNP ratio in period 3 is 0.1439. In fact, the expected value of the debt-GNP ratio will grow at a rate of approximately 20 percent per period forever. Eventually, the expected value of the debt-GNP ratio would become so large that the government would be unable to roll over its debt despite the fact that the interest rate on government debt is lower than the average growth rate of the economy.

WHAT CAN WE CONCLUDE ABOUT UNITED STATES FISCAL POLICY?

We have shown that in the presence of uncertainty it may be impossible for the government to roll over its debt forever, even though the average interest rate is lower than the average growth rate of GNP. So, how then do we empirically assess whether the government can roll over its debt forever? This question is at the frontier of economic research and has not yet been fully resolved. Nevertheless, recent research has yielded some insights and some speculation about future findings.

One important insight is that if an economy has too much capital, Ponzi games are possible and the government can roll over its debt forever. However, a recent study cited earlier⁹ found that none of the countries studied, including the United States, is afflicted by too much capital.

Does the finding that an economy does not have too much capital imply that Ponzi games are not possible and, in particular, that the government cannot roll over its debt forever? In a world without uncertainty, the answer to this question would be "yes," as we illustrated earlier. Unfortunately, the answer is ambigu-

⁹ Abel, Mankiw, Summers, and Zeckhauser (1989).

ous in the presence of uncertainty: in some economies that do not have too much capital, it is possible for the government to roll over its debt forever, while in other economies that do not have too much capital, it is impossible for the government to roll over its debt forever.¹⁰

The current state of economic research suggests that the crucial issue for determining whether a government can roll over its debt forever is whether there is a rich enough set of existing securities in the economy. If the set of existing securities is not rich enough in the relevant sense, government debt might be such a sufficiently different and attractive security that investors would welcome the opportunity to hold it in their portfolios and would allow the government to roll over its debt forever. However, if the set of existing securities is sufficiently rich, government debt may not be sufficiently different or attractive for investors to allow the government to roll its debt over forever.¹¹ Unfortunately, the current state of economic research does not allow a convincing empirical test to distinguish between these two cases, so we cannot yet test whether an actual government can roll over its debt forever.¹²

¹⁰Technically, under certainty, capital overaccumulation is a necessary and sufficient condition for Ponzi games and for rolling over government debt forever. Under uncertainty, capital overaccumulation is a sufficient, but not necessary, condition for Ponzi games and for rolling over government debt forever.

¹¹Blanchard and Weil (1992) present examples of economies that do not have too much capital. In some of these examples, the set of securities is not sufficiently rich, and the government can roll over its debt forever. In other examples, the set of securities is sufficiently rich, and the government cannot roll over its debt forever.

¹²A related—and also unresolved—question is why the average interest rate on government debt is so much lower than the average rate of return on capital. One potential explanation is that there is a very rich set of securities available but investors are very risk averse and essentially

Although we cannot yet empirically test whether an economy can roll over its debt forever, we are not left entirely in the dark about the future course of U.S. fiscal policy. Recently, Henning Bohn (1991a) has developed and implemented a test of whether a government is following a sustainable policy. This is not a test of whether a zero primary deficit accompanied by rolling over the debt is permanently sustainable. Rather it is a test of whether the historical tax and expenditure policies of the government can be permanently maintained without a major shift in the conduct of policy. Applying this test to data on U.S. fiscal policy, Bohn finds that this policy is sustainable. An important component of this conclusion is the finding that, on average, U.S. fiscal policy produces a smaller primary deficit (or a larger primary surplus) when the debt-GNP ratio becomes larger. This tendency of the government to run smaller (or even negative) primary deficits as the debt-GNP ratio gets larger is a means of keeping the debt-GNP ratio from growing too large.

While Bohn's result that U.S. fiscal policy is sustainable may appear comforting, this finding focuses attention on potentially painful choices. If the United States is to follow its historical pattern of reducing primary deficits when the debt-GNP ratio rises, the increase in the debt-GNP ratio over the past dozen years would seem to require a reduction in the primary deficit. Such a reduction in the primary deficit would require an increase in tax revenues and/or a cut in government expenditure, neither of which will be universally popular.

pay a large premium for the opportunity to hold safe government debt. In this case, the government would not be able to roll over its debt forever. Another potential explanation is that the set of securities is not sufficiently rich and that investors find government debt sufficiently different and attractive that they willingly hold it at a low interest rate. In this case, the government might be able to roll over its debt forever. See Bohn (1991b).

Derivation of the Growth Rate of the Debt-GNP Ratio

Let B be the amount of government bonds outstanding, and let Y be the measure of national income, such as GNP. Thus the debt-GNP ratio is B/Y . The growth rate of any ratio is approximately equal to the growth rate of the numerator minus the growth rate of the denominator so that

$$(A1) \quad \frac{\Delta(B/Y)}{B/Y} = \frac{\Delta B}{B} - \frac{\Delta Y}{Y}$$

where the symbol Δ denotes the change from one period to the next. The change in government bonds, ΔB , equals the total deficit, which equals the primary deficit plus interest payments:

$$(A2) \quad \Delta B = \text{primary deficit} + rB$$

where r is the interest rate on government bonds, so that rB is the amount of interest payments by the government. Now divide both sides of (A2) by the amount of government bonds B to obtain

$$(A3) \quad \Delta B/B = \text{primary deficit}/B + r$$

Now let g denote the growth rate of income so that

$$(A4) \quad \Delta Y/Y = g$$

Substituting (A3) and (A4) into (A1) yields

$$(A5) \quad \frac{\Delta(B/Y)}{B/Y} = \text{primary deficit}/B + r - g$$

which is equation (1) in the text of the article.

An Economic Model of the Interest Rate and the Growth Rate

This appendix presents a general equilibrium model underlying the example presented in Table 2. Suppose that consumption equals output in every period as in the widely used Lucas (1978) asset pricing model. The standard condition determining the riskless interest rate r in a representative consumer economy is

$$(B1) \quad (1+r)\beta E_t\{u'(c_{t+1})/u'(c_t)\} = 1$$

where $E_t\{\cdot\}$ is the expectation conditional on information at time t , c_t is consumption per capita at time t , $u'(c_t)$ is the marginal utility of consumption at time t , and $\beta > 0$ is the time preference discount factor (so that $\beta^{-1}-1$ is the rate of time preference). Assume that the utility function is logarithmic so that $u'(c_t) = 1/c_t$. In this case, equation (B1) becomes

$$(B2) \quad 1+r = [\beta E_t\{(c_t/c_{t+1})\}]^{-1}$$

Now let $g_{t+1} = (c_{t+1}/c_t) - 1$ be the growth rate of consumption and output between time t and time $t+1$, and assume that g_{t+1} is i.i.d. over time. Under this assumption we have

$$(B3) \quad 1+r = [\beta E\{1/(1+g_{t+1})\}]^{-1}$$

The ratio of the debt-GNP ratio in period $t+1$ to the debt-GNP ratio in period t is $(1+r)/(1+g_{t+1})$ and the expected value of this ratio is

$$(B4) \quad E\{(1+r)/(1+g_{t+1})\} = E\{1/(1+g_{t+1})\} [\beta E\{1/(1+g_{t+1})\}]^{-1} = 1/\beta$$

Notice that if $\beta < 1$, then $1/\beta > 1$ and the expected value of the debt-GNP ratio grows over time. The example in Table 2 is based on the following assumptions: $\beta = 0.8333$; and $\Pr\{1+g_{t+1} = 0.6\} = \Pr\{1+g_{t+1} = 1.6\} = 0.5$. These assumptions imply that $1+r = 1.0473$, $E\{1+g_{t+1}\} = 1.1$, and $E\{(1+r)/(1+g_{t+1})\} = 1/\beta = 1.2$.

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Where Has All the Paper Gone? Book-Entry Delivery-Against- Payment Systems

*James J. McAndrews**

In the late 1960s the New York Stock Exchange reduced the number of days and hours of trading in an attempt to decrease the volume of stock trading. The reason was the “paper crisis”: the trading firms could not manage to deliver and receive promptly the huge volume of securities traded each day. The highest daily volume of trade in 1968 was just over 21 million shares. In 1990 the highest daily volume of trade was 292 million shares. Yet this extraor-

dinary increase in trading activity was accommodated without a crisis of any sort. What has allowed Wall Street to manage the huge increase in volume?

Many forms of automation contribute to the ability to settle the increased volume of trading in financial markets. Probably the most important consideration, however, is that today most securities listed on the New York Stock Exchange (and many others as well) never have to be moved at all. They are immobilized in a depository and therefore do not have to be delivered after a trade. Instead of the time-consuming and laborious task of delivering, examining, and counting the traded securities,

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a seller simply transfers ownership to the buyer by instructing the depository to debit its security account and to credit the account of the buyer. The "back office" where trades are settled has become, in an important sense, paperless.

The immobilization of securities in a depository has reduced the costs of settling trades and also has changed the risks that are always present in completing agreed-upon transactions. By combining the transfer of the security on the books of the depository with simultaneous transfer of payment for the security, the depositories have made it possible to eliminate the risk that the seller would lose its security after delivery but before payment was made. However, settling trades through a depository requires that the depository and its system for ensuring completion of trades be safe; otherwise the users of the depository would be at risk of losing expected settlement payments or securities.

Efficient and safe settlement of trades is important in lowering the costs of financing investment and in fostering ease of access to our economy's financial markets. Trading volume typically peaks at times of stress in financial markets as many people wish to trade securities. During the 1987 market break, for example, over 608 million shares changed hands on one day on the New York Stock Exchange. If the system of settlement were unable to manage such a large volume of trade, especially at such a critical time, investors might lose confidence in the safety and integrity of our financial markets. Such a belief could increase the costs of funds to our nation's firms and governments. In this article, we will examine the security depositories, their methods of completing trades, and their role in reducing the costs and risks of transacting securities.

BOOK-ENTRY DEPOSITORIES

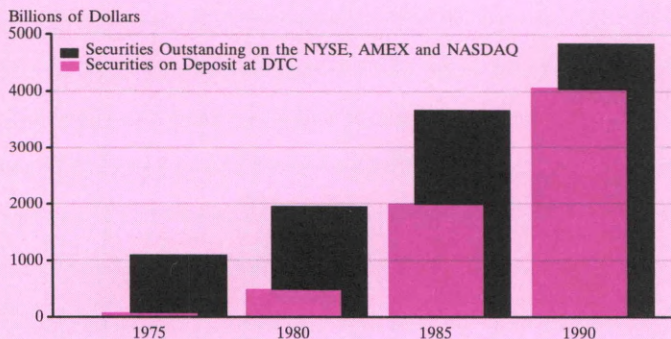
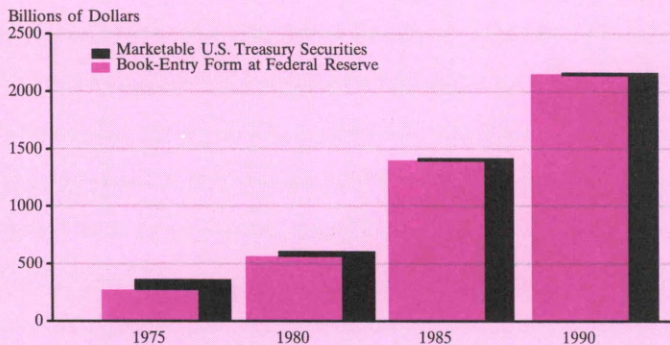
A book-entry depository is a specialized financial institution that accepts securities for

safekeeping and maintains transferable accounts of those securities. Book-entry transactions can be completed more easily and at lower cost than transactions in which the securities are in paper form for two reasons. First, immobilizing the securities in one location is the least costly method of safekeeping securities, since it saves on the duplication of vault, security, and maintenance costs. Second, book-entry transfer of securities is quicker and cheaper than the physical transfer of securities. Book-entry transfer is accomplished by electronically debiting the account of the seller of securities and crediting the account of the buyer, while physical transfer requires that both the buyer and seller count the securities and verify that the right bundle of securities is delivered. Furthermore, physical transfer of securities requires expensive security and insurance arrangements to protect against theft, loss, and fire.

The growth in book-entry deposits of securities has been rapid. As shown in the figure on page 21, over 98 percent of U.S. Treasury securities are now in book-entry form at the Federal Reserve System. Indeed, all U.S. Treasury securities are now issued only in book-entry form; that is, there are no paper securities in the first place, and the securities exist only as entries in the Fed's computer system. Other U.S. government securities, such as those issued by government-sponsored enterprises and federal agencies, as well as the securities of many international organizations also are in book-entry form at the Federal Reserve System.

Many other securities, including corporate stocks and bonds, municipal bonds, and the mortgage-backed securities of the Government National Mortgage Association (GNMA, or Ginnie Mae) are on deposit in private depositories. (See *Book-Entry Depositories* on page 22.) For example, in 1990, 66 percent of the shares of all U.S. companies listed on the New York Stock Exchange were held in book-entry form at the Depository Trust Company, the largest private book-entry depository. Corporate stocks and

Book-Entry Deposits of Outstanding Securities



Note: All dollar figures are in billions.

Source: U.S. Bureau of the Public Debt; Federal Reserve Bank of New York; *NYSE Fact Book*, various years; *AMEX Fact Book*, various years; National Association of Securities Dealers; *Depository Company Annual Report*, various years.

and risk. In the great trading center of Amsterdam, hundreds of different types of coins of many countries circulated. Traders had to be able to identify the specific coin as well as to determine the amount of the precious metal in the coin. Each merchant would have to weigh the coins in order to assess their value—but who monitored the accuracy of the scales? Furthermore, the weight of the coins imposed costs on their movement, and the risks of loss and theft were significant. The solution to this increasingly clumsy means of payment was found in the creation of the Bank of Amsterdam—a depository of coins.

Adam Smith, in *Wealth of Nations*,¹ reports that "[i]n order to remedy these inconveniences, a bank was established in 1609 under the guarantee of the city. This bank received both foreign coin, and the

bonds are often issued in paper form, then registered, immobilized, and transferred to a book-entry system.

That a depository can economize on the costs and risks of the physical movement of a commonly traded object is an old idea. In the 16th and 17th centuries, traders, who were paid in gold and silver coins, faced problems of cost

light and worn coin of the country at its real intrinsic value in the good standard money of the country, deducting only so much as was necessary for defraying the expence [sic] of

¹Adam Smith, *Wealth of Nations*, Book IV, Chapter III (The University of Chicago Press, 1976), pp. 504-05.

Book-Entry Depositories

The Federal Reserve, as fiscal agent for the U.S. Treasury, most federal agencies, and certain international organizations, issues, maintains, and transfers ownership of debt securities issued by these entities.

Started in 1971, the Fedwire book-entry safekeeping and transfer system now holds more than 98 percent of the marketable U.S. Treasury debt in book-entry form. The par value of the securities on the system exceeds \$3 trillion, and about 47,000 transfers are processed on an average day. The system maintains accounts for approximately 8500 institutions that use these accounts to safekeep and clear transfers for themselves as well as for their customers.

For securities not on deposit at a Federal Reserve Bank, private cooperative depositories have been created, typically by market participants, to provide the benefits of book-entry deposit of securities. These depositories have grown increasingly sophisticated and provide a host of services too numerous to describe. All are members of the Federal Reserve system and so are examined and supervised by the Fed. All are registered clearing agents and therefore are regulated by the Securities and Exchange Commission.

The Depository Trust Corporation (DTC), begun in the late 1960s, is the largest private book-entry depository. It holds corporate debt and equity securities on deposit, as well as municipal debt securities. The market value of securities held by DTC at year-end 1990 was \$4.1 trillion. This amount included 66 percent of all the shares of U.S. companies listed on the New York Stock Exchange, 41 percent of all the shares issued over the counter, and 43 percent of the shares listed on the American Stock Exchange. Some 87 percent of outstanding municipal bonds and 77 percent of the corporate debt listed on the New York Stock Exchange are held by DTC for its participants. DTC is owned by its participants.

The Philadelphia Depository Trust Company (PHILADEP) and the Midwest Securities Trust Company (MSTC), in Chicago, also safekeep corporate debt and equity and municipal debt. At year-end 1990, they held on deposit securities whose value was 3 percent of the value of securities on deposit at DTC. Both were created in the early 1970s. PHILADEP and MSTC are wholly owned subsidiaries of the Philadelphia Stock Exchange and the Midwest Stock Exchange, respectively.

The Participants Trust Company (PTC) was formed in 1989 to provide a book-entry depository for Government National Mortgage Association (GNMA) mortgage-backed securities. As of February 1992 it had more than \$627 billion in par value of such securities on deposit—about 90 percent of the outstanding issues. It has operated on a same-day funds settlement system from its inception.

coinage, and the other necessary expence [sic] of management. For the value which remained, after this small deduction was made, it gave a credit in its books. This credit was called bank money... Bank money...has some other advantages. It is secure from fire, robbery, and other accidents: the city of Amsterdam is bound for it; it can be paid away by a simple transfer, without the trouble of counting, or the risk of transporting it from one place to another." Smith eloquently states the advantages of the

book-entry system for coin. Modern security book-entry depositories have accomplished the task of taking a much traded item—a security—and, by immobilizing it and converting it to book-entry form, made transacting it as easy as writing a check.

Our discussion reflects that the cost of book-entry delivery of securities is less than the cost of physical delivery. One illustration of the lower cost is the decline in the *fail rate* since the introduction of book-entry depositories. A fail

is a failure by the seller to deliver the security at the time of settlement. It can occur for any number of reasons, such as an inability to find the security or slow movement of the security from the seller to the buyer. When a fail occurs, both the buyer and seller incur a cost of delay in receiving both funds and securities. In Ginnie Mae security trades, for example, the fail rate was estimated to be 25 percent as recently as 1985. Since 1989 most of these securities have been immobilized by Participants Trust Company. Today the fail rate in Ginnie Mae trades is about 6 percent.² Another illustration is the reduction in time required to complete a delivery electronically rather than physically. In a joint U.S. Treasury-Federal Reserve study on automating operations in government securities, it was found that "no more than two minutes elapsed time is required to complete an incoming telegraphic transfer as compared with nearly two hours when physical delivery is made."³

DELIVERY-AGAINST-PAYMENT

In addition to reducing the costs of transferring securities, book-entry deposit of securities can reduce the risks of default by one party in a trade because depositories can combine book-entry transfer of securities with transfer of money. With the ability to transfer both money and securities, the depository can match, simultaneously, a delivery of securities with the payment for those securities. This method, called delivery-against-payment, offers a way

to complete or settle a previously agreed-upon transaction by making payment if, and only if, delivery of the security is made. Ordinary cash transactions, such as the purchase of groceries for cash, are made by delivery-against-payment.

Delivery-Against-Payment Eliminates "Principal Risk." An ideal delivery-against-payment system eliminates an important source of risk in any transaction: if either payment or delivery takes place before the other side of the transaction is completed, the party that fulfilled its obligations might lose the entire sum (the principal amount) if the other party defaults and is unable to complete its side of the transaction.

An example is the risk to a store owner who accepts a check in exchange for some item, such as clothing. The store gives the clothing to the customer but will not receive payment until the check clears. If the check is not honored by the customer's bank because of insufficient funds, for example, it may be impossible to retrieve the clothing from the customer.

A more pertinent example is the risk of theft when paper securities had to be delivered (in advance of payment) before the advent of book-entry depositories. Brokerage firms would send the securities by messenger at the end of the day. It was common practice not to provide a guard unless the messenger was carrying over \$1 billion worth of negotiable securities. Theft insurance rates were escalating quickly in 1969-1970, leading to an insurance crisis in 1971, when the largest insurer of securities announced that it would no longer offer the coverage. The securities industry, the Federal Reserve System, and other interested parties worked quickly to implement a book-entry system for U.S. Treasury securities in 1971 to alleviate the crisis.

Book-entry depositories can implement delivery-against-payment in two ways. One way is to transfer the money and the securities simultaneously. By doing so, neither side of the

²Reported in "Progress and Prospects: Depository Immobilization of Securities and Use of Book-Entry Systems," Division of Market Regulation, U.S. Securities and Exchange Commission, June 14, 1985, and by the Participants Trust Company.

³"Joint Treasury-Federal Reserve Study of the U.S. Government Securities Market," Staff Studies-Part 3, December 1973.

transaction is exposed to principal risk. This is essentially the way the Federal Reserve operates its book-entry system.

The other way is to transfer securities provisionally until payment is made later. Provisional transfer of a security means that the seller's securities account is debited even if the buyer does not have enough money to pay for the security at that moment. Later, perhaps at the end of the day, the buyer is expected to have sufficient funds to make payment. If payment is made, the securities transfer is final; if not, the securities transfer is reversed, and the seller keeps the security. Alternatively, rather than reversing the transfer, delivery can be provisional upon the buyer's posting sufficient collateral to ensure payment to the seller in the event that the buyer cannot pay cash at the end of the day. The private book-entry depositories transfer securities in one of these two ways.

"Principal Risk" With Physical Delivery. With physical transfer of securities, the seller has to deliver the security before payment because the buyer accepts the security subject to count and examination. So simultaneous transfer is not possible. If a third party, such as a clearinghouse, would perform the examination and count, the physical security transfer to the buyer could be made provisional on payment. But third parties are not always available, so settlement is often simply sequential. As a result, the seller is at risk that the buyer might default in the time after delivery but before payment.

Indiana Jones provides us with a dramatic example of the risks of sequential settlement. In the movie "Raiders of the Lost Ark," Indiana Jones and his South American guide, Satipo, are attempting to escape the many traps in the temple from which Indiana has taken a golden idol. Satipo crosses a chasm in their path, but in doing so, he breaks the rope used to swing across it. Indiana is on the wrong side of the chasm with the golden idol; Satipo is across the chasm with Indiana's famous whip. "Give me

the whip!" demands Indiana. "Throw me the idol, I throw you the whip," replies Satipo. Indiana hesitates as a stone door descends to block their escape. "No time to argue!" insists Satipo. Indiana has no choice but to comply. He throws the idol, but Satipo defaults. He drops the whip with a sneering "Adios, Señor."

As luck would have it, Indiana Jones proved resourceful enough to manage his escape without Satipo's completing his end of the transaction, but the default in settling the sequential whip-for-idol trade illustrates the pitfalls of settling a trade without being able to count on the fact that both ends of the transaction will be completed. Indiana suffered principal risk in settlement with Satipo, and Satipo intentionally defaulted. Default, however, is a risk even when no one intends to default; rather, a firm may find itself illiquid or insolvent in the middle of the day after receiving securities but before having paid for them.

BOOK-ENTRY DEPOSITORIES AND THEIR DELIVERY-AGAINST-PAYMENT SYSTEMS

Several book-entry depositories exist: the Federal Reserve System for Treasury and agency securities and the four privately owned book-entry depositories for stocks, corporate and municipal bonds, and various other securities.⁴

The Fed's delivery-against-payment system is a real-time, gross settlement system. It is a real-time system because the transaction takes place at the time of day when the seller notifies the Fed of the transaction. For example, when a bank sells Treasury securities to another bank, it notifies the Fed on the settlement day to

⁴See Patrick Parkinson et al., "Clearance and Settlement in U.S. Securities Markets," Staff Study 163, The Board of Governors of the Federal Reserve System, for more information on the settlement systems for securities.

transfer the securities to the buyer against a payment. The Fed debits the buyer's reserve account and transfers the funds to the seller's reserve account; at the same time the Fed debits the seller's security account and credits the buyer's security account. The transfers occur within seconds. It is a gross settlement system because the gross amounts of both cash and securities for each of a bank's transactions are exchanged during the day. For example, it may be that the buyer and the seller change roles in a partially offsetting transaction later in the day. That transaction would be treated separately from the earlier transaction.

Unlike the Fed, the private depositories' delivery-against-payment systems employ payment netting systems. During the day the participant may buy and sell many securities. The depository keeps track of the transactions of its participants and at the end of the day it nets all transactions—each participant simply pays to or receives from the depository the difference between total sold and total bought. Even though the participant may have made thousands of trades during the day, it will either owe or be due only one amount of money. Since later transactions may partially offset earlier ones, netting can greatly reduce the total value of transfers that have to be made.⁵ As a result, netting reduces the liquidity costs of settlement. It does so, however, at the expense of increasing certain risks that all transactions may be unable to settle because of the failure of one participant.

Private depositories employ one of two types

of payment: next-day funds settlement or same-day funds settlement. (See *Same-Day Funds Settlement* on page 26.) In the former the payment at the end of the day is typically made by certified check (payable the next day), while in the latter, payment is made by wire transfer. These two systems ensure delivery-against-payment in different ways.

In the next-day funds settlement system, deliveries of securities are made throughout the day, but they are provisional until the final settlement payment is received at the end of the business day. If payment for a security is not made because a party is illiquid—it neither has the funds available to make payment nor can it borrow to make payment—then the security delivery is reversed. Since the security never left the depository, reversal is accomplished by a transfer from the defaulting party back to the original seller.

In the same-day funds settlement system, deliveries of securities are made throughout the day and are provisional upon the buyer's posting collateral of sufficient value to ensure the payment necessary for the securities. Rather than reverse security deliveries, the same-day systems use the collateral to effect payment in the event of a default. If the buyer defaults, the depository will seize the collateral and sell it. Since this will take time, the depository itself must have sufficient liquidity to make the payment due to the seller of the securities.

POTENTIAL RISKS AND CONTROLS IN DELIVERY-AGAINST-PAYMENT SYSTEMS

Although the development of properly designed delivery-against-payment systems has substantially reduced principal risk, we have seen that other risks arise in these systems. The depositories have established extensive control measures intended to protect the depository and its participants from these risks.

In the Federal Reserve book-entry system, the Fed extends intraday credit to those institu-

⁵See Brian Cody, "Reducing the Costs and Risks of Trading Foreign Exchange," this *Business Review*, November/December 1990; and R. Alton Gilbert, "Implications of Netting Arrangements for Bank Risk in Foreign Exchange Transactions," *Federal Reserve Bank of St. Louis Review*, January/February 1992, for discussions of netting arrangements. Netting also reduces bookkeeping costs in trades with many participants.

Same-Day Funds Settlement

Same-day funds settlement requires that the payment for a security be made by wire transfer rather than by certified check. Hence, same-day settlement means that funds are immediately available to the seller; payments made by check are not available until the next day (and are therefore subject to some small risk of overnight bank failure). U.S. securities markets are planning to move to same-day funds settlement for all securities transactions. Currently, only some securities in the U.S. are settled in same-day funds.

Same-day settlement requires greater monitoring than does next-day funds settlement to ensure adequate liquidity. If a participant in a next-day funds system experiences an unexpected shortfall in liquid balances at the end of the day, it has the opportunity to obtain liquidity the next day to fund its liability. However, a same-day funds system allows little time to obtain liquidity to fund a settlement shortfall. Therefore it is especially important for a same-day funds system to maintain sufficient liquidity to fund the settlement payments at day's end, should a participant default occur.

The greater difficulty of obtaining funds on a same-day basis makes reversing securities deliveries more problematic in the same-day funds settlement systems. When a security delivery is reversed, the seller of the security is placed under increased liquidity pressures. Since the seller anticipates payment at the end of the day, it may invest anticipated funds during the day, prior to settlement. However, if the buyer of the security defaults and the security delivery is reversed back to the seller, it must fund this addition to its portfolio. This is correspondingly more difficult when the cash to do this must be paid on the same day. As a result, systems using same-day funds rely more on full collateralization of security deliveries during the day (expecting to sell the defaulting party's securities later) rather than reversal of security deliveries. In its policy statement on the desirable features of same-day settlement systems, the Federal Reserve System actively discourages reversal of security transfers in the event of a default. Because selling the securities takes time, this requires that the same-day systems have greater liquidity on hand to fund the same-day payment of a defaulting participant.

Two private book-entry depositories have same-day funds settlement systems: the Participants Trust Company for GNMA securities and the Depository Trust Company for commercial paper and various other securities. Their procedures to ensure adequate liquidity are similar. Most important, these systems rely on full collateralization of any participant's net debit, debit caps that limit the risk exposure of the system due to any one participant, and committed lines of credit to the depository at least as large as the largest debit cap of any participant.

Full Collateralization. Full collateralization of a participant's net debit is achieved by marking to the previous day's closing price the securities the participant is due to receive. These securities themselves provide part of the participant's collateral, but they are valued at their market price minus a "haircut." This undervaluation is intended to cover expected movements in the price of the security in the next few days when the depository would liquidate the security in case of default. The rest of the collateral must consist of a participant's fund, at least part of which must be in cash, and the rest in short-term Treasury securities, a type of security that is easily sold.

Net Debit Caps. Net debit caps are imposed on each participant so that no one participant's default would imperil the ability of the system to effect settlement payments for all other participants. The cap is determined based on the liquidity resources of the participant.

Committed Line of Credit. The depositories that manage same-day funds settlement systems attempt to ensure final settlement. By paying for committed lines of credit that are at least as large as the largest net debit cap for any participant, the depository is able to complete settlement even in the event that the system's largest net debtor would default.

tions whose Fed accounts have insufficient funds to pay for incoming securities at the time of transfer. As a result, these participants incur daylight overdrafts in their Fed accounts. Should a participant fail during the time it has a large daylight overdraft with the Fed, then the Fed may lose the value of the overdraft. Because of this the Fed is exposed to *credit risk* from its participants. We will discuss the procedures the Fed has put in place to control this risk after considering the risks that arise in the private settlement systems.

Because they net money payments throughout the day and settle their transactions only at the end of the day, the private delivery-against-payment systems rely on participants that are net debtors to be able to make final settlement payment at the end of the day. The possibility that a net debtor (of money or securities) would be unable to settle at a designated time gives rise to *liquidity risk*.

Because all firms wish to earn a high return, each firm has an incentive to economize on cash holdings. Cash (transactions accounts at banks) yields low returns but is necessary to make payments. Firms constantly monitor their cash positions to maintain sufficient cash to make their payments, but not excess cash, which would lower their return. Because firms economize their cash holdings, the failure to receive an expected payment can easily cause a firm to be "illiquid" and unable to make the settlement payment on schedule. Hence all parties are subject to liquidity risk.

Replacement-cost risk, or market risk, is a type of credit risk. For example, in the same-day settlement systems, if a participant defaults, its collateral is seized and later sold to pay for its obligations to the depository. Although the collateral is set to cover losses as large as can be expected in one to two days given the historical record of price volatility, there is a risk that the market value of the collateral could decline precipitously by the time it is sold.

In a netting system, the failure of one partici-

pant to make settlement payment imposes increased liquidity pressures on the depository and on other participants, since the defaulting party was a net debtor to them. For example, in a next-day settlement system, if a seller has a security delivery reversed back to it and does not receive its expected payment, it may become unable to fulfill its own obligations, since it then must fund a larger portfolio of securities than it had anticipated. The risk arises that one party after another will become illiquid and unable to settle, and the payment system itself will fail. This *systemic risk* would result in the failure of all the transactions to be settled that day. The participants would have to revert to bilateral settlement, and the benefits of the multilateral system would be lost, at least for a time.

Risk Control Measures in Book-Entry Depositories. Depositories have instituted several risk-control measures to reduce the chance of the failure of any individual settlement and, more important, to reduce the chance of any systemic failure of the settlement system.

Membership standards that restrict participation to firms with high levels of capital can reduce the risk of failure. Well-capitalized firms can better withstand unexpected shortfalls of funds, since they should be better able than thinly capitalized firms to quickly borrow to meet settlement payments and to absorb credit losses without becoming insolvent. Private depositories have explicit standards that participants must meet in order to join the system. For example, Participants Trust Company requires that its participants meet specific capital requirements.

All book-entry depositories *monitor* their participants for signs that the participant is subject to especially severe liquidity or solvency pressures or operational problems. Depositories study the financial statements and regulatory filings of participants to keep abreast of changes in participants' financial conditions.

All book-entry depositories impose *debit caps*,

or limits on the amount of the debit position a firm can build during the day, to limit the exposure the system has from any one participant. The debit cap is determined on the basis of the participant's liquidity resources and contributions to the participant fund. In the Fed's book-entry system, debit caps serve to limit daylight overdrafts.

The Fed has proposed *pricing daylight overdrafts* to restrain the incentive that a participant has to overuse daylight credit from the Fed. By charging a fee for each dollar of credit it extends to a participant for a daylight overdraft, the Fed expects that its participants will find ways to reduce their current reliance on this source of credit.⁶

All settlement systems require each participant to maintain a participant fund, or clearing fund. This fund partly collateralizes the participant's obligations to the organization and can serve as a liquidity backstop in the case of default of another participant. Typically, cash and short-term Treasury securities are acceptable for contributions to the participant fund. The level of required contributions to participant funds is not adjusted often.

In the same-day funds net settlement systems, participants are also required to post collateral (see *Same-Day Funds Settlement*). Collateral requirements are meant to fully cover the obligations that a participant has to the organization for all but the most extreme one-day changes in the value of the participant's collateral.⁷ The collateral is adjusted (by marking the collateral to its market value) each time a trade is entered into the system. Some of the

collateral must be in cash, while the bulk of it may be in the security to be delivered in the system.

The rules governing *loss sharing* among nondefaulting participants in the event of a default by a counterparty are part of the risk control system in net settlement arrangements. These rules vary by depository. An illustration of a loss-sharing rule is that once a participant defaults, the depository can seize the collateral of that participant and later sell it. In the meantime, the depository, using its liquidity, makes the payment that the defaulting participant failed to make. Any losses incurred in this operation may be recovered by first liquidating the defaulting party's clearing fund.⁸ Next the depository can charge the loss to its own retained earnings; next it can charge losses to other participants' clearing funds.

If the depository charges losses to the settlement counterparties of the defaulting party, this action encourages bilateral monitoring by each participant of its counterparties. If the losses are charged equally to all participants, this action mutualizes risk and reduces the participants' incentives for monitoring settlement counterparties.

The depositories themselves typically maintain committed *bank lines of credit* to provide liquidity in the event of a participant's default. Closing out a participant's position takes time, and the depository, to prevent further liquidity pressures on the system, must have access to liquid funds. The two leading private depositories, Participants Trust Company and the

⁶See David B. Humphrey, "Market Responses to Pricing Daylight Overdrafts," *Economic Review*, Federal Reserve Bank of Richmond, May/June 1989.

⁷Because of the greater liquidity pressures in the same-day funds systems, the Federal Reserve discourages reversal of security deliveries in these systems.

⁸In the next-day funds systems, reversal of security transactions may not always be possible. For example, a counterparty to a defaulting firm may be at its debit limit; a reversal would not be permitted under the existing debit caps. In this case, the depository may then decide to close out the defaulting party's position (possibly incurring a loss), in which case the loss-sharing rules become applicable.

Depository Trust Company, retain committed bank lines of credit in an amount in excess of the largest net debit allowed for any one participant.

Finally, *operational safeguards* are an important part of depositories' risk control system. Security of the data transmitted through the system, adequacy of the system's size, alternative sources of power and communication networks, and backup of the automated facilities are all important components of ensuring access to the system, even in the case of loss of power or some other major disruption to the facilities. Off-site backup facilities are a minimum requirement for major delivery-against-payment systems.

PUBLIC POLICY TOWARD PRIVATE DELIVERY-AGAINST-PAYMENT SYSTEMS

Public policy has supported the development of book-entry depositories, with the Fed and the Treasury actively involved in creating the book-entry system for U.S. Treasury and agency securities. The Securities and Exchange Commission (SEC) has sponsored workshops for the securities industry to share ideas for managing the book-entry systems. While the SEC supports the immobilization of securities, it believes that the individual investor should be able to obtain a certificate if she so desires.⁹

The Working Committee of the Group of 30 Clearance and Settlement Project has adopted a set of recommendations concerning settlement of trades.¹⁰ One important goal of this

group is to harmonize the methods of settlement internationally as a greater flow of capital across countries occurs and more firms are listed on both domestic and foreign stock markets. Included among the group's recommendations are the following:

Each country should have an effective and fully developed central securities depository, organized and managed to encourage the broadest possible industry participation (directly and indirectly)...

Delivery versus payment should be employed as the method for settling all securities transactions.

Payments associated with the settlement of securities transactions and the servicing of securities portfolios should be made consistent across all instruments and markets by adopting the "same day" funds convention.¹¹

The Board of Governors of the Federal Reserve System has issued a policy statement regarding private delivery-against-payment systems that settle, directly or indirectly, over Fedwire.¹² The Board provides guidance regarding issues of intraday credit risks and payment risk management arising from such systems. It outlines liquidity, credit, and op-

economic policy issues. In 1988, the Group of 30 began a project to improve the world's clearance and settlement systems. The Working Committee of the Group of 30 Clearance and Settlement Project was formed to further develop the recommendations of the Group of 30.

¹¹Group of 30 Clearance and Settlement Project, "Year-End Status Report 1990," Group of 30, 1990 M Street, N.W., Suite 450, Washington, D.C.

¹²This policy statement was issued on June 15, 1989, and is reprinted in Parkinson et al. (See footnote 4.)

⁹See "Progress and Prospects: Depository Immobilization of Securities and Use of Book-Entry Systems," Division of Market Regulation, U.S. Securities and Exchange Commission, June 14, 1985.

¹⁰The Group of 30 is an independent, nonpartisan, non-profit international organization, composed of senior financial industry participants and researchers with interests in

erational issues that should be considered in a same-day funds settlement system.

CONCLUSION

Book-entry deposits of securities, along with the delivery-against-payment system book entry makes possible, have become an important feature of the securities market in the U.S. In these systems, the computerized technology that makes this cost- and time-saving method

of safekeeping and transferring securities possible must be complemented by carefully crafted control measures that limit the credit and liquidity risks that inevitably remain in any payment system. The primary regulators of the securities industry and the industry itself have identified further immobilization of securities and the movement to same-day funds settlement as important developments to pursue in the future.

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