

Federal Reserve Bank of Minneapolis
Research Department Working Paper

GRESHAM'S LAW OR GRESHAM'S FALLACY?

Arthur J. Rolnick and Warren E. Weber

Working Paper 236
PACS File 3425

June 1983

NOT FOR DISTRIBUTION
WITHOUT AUTHORS' APPROVAL

*This paper was written for the National Bureau of Economic Research Macro Conference to be held July 7 and 8, 1983, Cambridge, Massachusetts.

The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System. The material contained is of a preliminary nature, is circulated to stimulate discussion, and is not to be quoted without permission of the authors.

If the fixed legal ratio of the coins differs from the market value of the metals, the coin which is underrated entirely disappears from circulation, and the coin which is overrated alone remains current.

Nicole Oresme, 1364
(quoted in Laughlin 1916, p. 420)

Oresme's claim--that bad money drives out good money (or that money overvalued at the mint drives out undervalued money)--is one of the oldest and most cited in economics. References to it date back at least as far as Aristophanes and have been made around the world, in such diverse countries as Chile, England, France, Japan, and the United States. (See Laughlin 1916, pp. 423-27.) Credit for this hypothesis, though, is usually given to England's 16th century master of the mint, Thomas Gresham, who in a letter to Queen Elizabeth noted that heavier metal coins were being exported while lighter ones circulated.

Most economists refer to this claim as a law. John Kenneth Galbraith says that Gresham's law may be the only law universally accepted among economists because it has no serious exceptions in the data (Galbraith 1975, p. 10). Moreover, Galbraith seems to be in good company; favorable references to Gresham's law appear, for example, in works by J. Laurence Laughlin (1886, 1916), Irving Fisher (1915), W. Stanley Jevons (1918), and Milton Friedman and Anna Schwartz (1971) and in virtually every modern money and banking textbook. (See, for instance, Fusfeld 1976, Lockett 1980, and Prager 1982.)

Despite its seemingly universal acceptance, the claim that, when market and legal prices of money differ, the bad money drives out the good does not warrant its status as a law. The claim has no convincing explanations and many overlooked exceptions. Existing explanations are unconvincing because they typically imply potentially unbounded profits for traders. Either these profits are generated by a hypothetical coinage policy implying such large losses for a mint that it would very quickly go out of business, or else they are generated by legal tender laws implying large losses for the public which could easily--and even legally--be avoided. Besides that, contrary to Galbraith's assertion, a close examination of only a small part of monetary history reveals many experiences that do not correspond to the claim. They include several periods in 19th century U.S. history and a striking period in 17th century England when both bad and good money circulated.

We propose an alternative hypothesis of what happens when legal prices of money deviate from market prices. The implications of legal tender laws and the costs of using a medium of exchange at a nonpar price support two claims about what happens in such a situation:

- The money overvalued at the mint becomes the unit of account; that is, it circulates at its par value.
- Small-denomination money (money less than one dollar) undervalued at the mint tends to disappear from circulation while large-denomination undervalued money usually circulates at a premium.

Examining a variety of historical episodes when market and legal prices were different, we find our "law" can explain history much better than Gresham's.

Gresham's Law--Flawed in Theory and Practice

The claim that money overvalued at the mint drives out money undervalued at the mint has often been used to explain problems that have arisen with systems of multiple currencies. Most often it has been used to explain why bimetallism gave way to monometallism. Gresham's law also has been applied when light-weight coins replaced heavier ones and when paper money replaced commodity money.

Problems arise with multiple currency systems because eventually the legal or stamped price of one money relative to another varies from the market rate of exchange. Since only one price can prevail in equilibrium, something has to give, and according to Gresham's law, what gives is the undervalued (good) money; it disappears from circulation. The good money disappears, the claim is, because selling it for its intrinsic value is more profitable than using it as a medium of exchange. It is therefore hoarded for that purpose, and the bad money becomes the medium of exchange and the unit of account.

The questionable force that is said to drive Gresham's law is the lure of potentially unbounded profits for currency traders. These profit opportunities are supposed to arise either from a very generous mint policy or from a very naive and law-abiding public. We argue that it is unlikely that either a mint policy or the public can properly be characterized in this way. Moreover, examining only a sampling of history, we find that numerous currency systems have emerged that contradict the claim that bad money drives out good.

Theoretical Flaws

If a mint is to operate so that traders are induced to cull the good money, it must be willing to exchange on demand one money for the other at the legal price. We label this a liberal coinage policy. Daniel Fusfeld (1976, p. 259) asserts that such a policy caused gold to be driven out of circulation after the passage of the U.S. coinage act of 1792:

The reason for the disappearance of gold was that silver could be brought to the mint and exchanged for gold at the ratio of one ounce of gold for 15 ounces of silver. The gold could then be exchanged on world markets for 15 1/2 ounces of silver. A profit of one-half ounce of silver could be made on each set of transactions. As long as this differential was greater than the costs of the transactions plus shipping costs, silver would be imported into the United States, exchanged for gold at the Treasury and the gold exported for sale abroad. The result was that the country's gold reserve disappeared and was replaced by silver. It was an illustration of Gresham's law that the cheaper metal circulates and the more expensive one disappears, or "bad money drives out good."

That mints really operated as Fusfeld claims the U.S. mint did is doubtful for two reasons. One is that we can easily construct models in which a liberal mint policy is not feasible. Our Appendix demonstrates this; it contains a simple version of an overlapping generations model, one with two commodity monies, in which no equilibrium exists if the mint is willing to exchange the good and bad money at a nonmarket ratio on demand. Although this result hinges on our fixed-return production function, it suggests that, if there is a large enough outstanding stock of both com-

modity monies available when the mint offers a bargain price for one of the monies, then the mint will quickly run out of resources. In such a situation, assuming a bounded budget, the mint then will either revoke its policy or go out of business.

The other reason to doubt that mints operated under a liberal mint policy is that we know of no mints that did. Consider, for example, Section 14 of the U.S. coinage act of 1792 (Laughlin 1886, pp. 227-28):

As soon as the said bullion shall have been coined, the person or persons by whom the same shall have been delivered, shall, upon demand, receive in lieu thereof coins of the same (emphasis added) species of bullion which shall have been so delivered, weight for weight, of the pure gold or pure silver therein contained....

Thus, contrary to Fusfeld's assertion, at least while this act was binding, the U.S. mint did not exchange gold for silver on demand at the price of 1 ounce of gold for 15 ounces of silver. Private individuals bringing silver bullion to the mint could only expect silver coins in return; likewise, those bringing gold bullion could only get gold coins. Furthermore, we have been unable to find records of any mint that even tried to operate under a liberal coinage policy. Of course, a few such mints may have existed, but even if they did, that would not be enough to justify the innumerable references to Gresham's law.

Some advocates of Gresham's law recognize that mints did not provide an opportunity for potentially unbounded profits in currency trading. They claim, however, that legal tender laws did. In this claim, too, currency traders are supposedly offered

the possibility of large profits, but now it is by trading with a general public who are accepting all currency at legal prices. Laughlin (1916, p. 431) describes the view that profits can be obtained in this way:

Supposing the kinds of money in question to have a ratio to each other in the market different than they have in the legal ratio, then it will be seen at once that the cheaper will not drive out the dearer unless they are equally a legal tender for common uses. The opportunity to earn the profit obtained by changing one for the other depends on their being equally acceptable at some places of receipts....

The legal tender explanation for Gresham's law, however, is just as suspicious as the one based on a liberal coinage policy. The public can easily--even legally--avoid legal tender laws so that no profitable opportunities arise for currency traders. Legal tender laws say the public must accept in payment for all transactions (debts, taxes, and purchases of goods and services) particular monies at their legal (par) price. No provision in such laws, though, prevents the public from implicitly quoting prices in the legally overvalued (bad) money. If prices were quoted in the bad money, merchants and creditors would be more than willing to accept the good money at par. They would be willing, in fact, to pay a premium to those consumers and debtors who used the good money. These informal arrangements would not be in violation of the legal tender laws. And they would leave little, if any, profitable opportunities for currency traders and thus no reason for good money to disappear from circulation.

Practical Flaws

That there are no convincing explanations for Gresham's law does not necessarily mean the claim that bad money drives out good is wrong. We may simply be unable to explain the obvious. Nevertheless, on closer examination, what some have asserted to be obvious turns out to be obscure. Examining only the 19th century U.S. experience and one 17th century English experience with bimetallism, we discover many periods that do not fit the claim--enough exceptions to challenge what has been called an unchallenged law of economics.

1792-1853--Two U.S. Exceptions. The period between 1792 and 1853 contains two serious exceptions to Gresham's law. One is the U.S. experience with the Spanish milled dollar. This was a heavier coin than the U.S. silver dollar (which made it undervalued, or good, in relation to the U.S. dollar) and was legal tender, yet it was not driven out of circulation.^{1/} The Spanish dollar was popular in the U.S. colonial period and remained current at least until the dramatic increase in world gold production in the late 1840s. Laughlin (1886, p. 54) estimates that there were over 5 million Spanish dollars and parts of dollars in 1830, 22 percent of the value of all coins circulating in the United States. From 1792 to 1811, Taxay (1966, p. 231) reports, the Spanish dollar circulated at a premium over the U.S. dollar, a premium ranging from one-fourth of 1 percent to 1 percent. And it continued to circulate at a premium in later years, according to William H. Crawford, secretary of the treasury in 1819 (Laughlin 1886, p. 53, fn. 1). In this instance, the bad money (U.S. silver

coins) failed to drive out the good (Spanish dollars). Instead of being exported or hoarded, this good money circulated at a premium.

The other exception to Gresham's law during this period involves just monies coined by the U.S. mint. These were gold and silver coins, and their changing relative status (as good and bad money) in these years provides a test of Gresham's law.

For its first 42 years, the U.S. mint overvalued silver. On April 2, 1792, Congress passed a coinage act establishing a national mint and authorizing the issuance of gold and silver coins. The gold was to be issued in the larger denominations, the largest being the ten-dollar coin, the eagle, and the smallest being a quarter eagle. The silver was to be issued in the smaller denominations: the half disme (which is comparable to our nickel), the disme (comparable to our dime), the quarter, the half-dollar and the dollar. The act allowed individuals to bring unlimited amounts of gold and silver bullion to the mint and have it coined without a charge; if they demanded immediate exchange, a charge of one-half of 1 percent would be levied. The act also established a 15-to-1 legal ratio between silver and gold coins, the market price in 1792. Soon after the passage of the act, the market price for gold rose, and it remained higher than the legal price until June 24, 1834, when the second major coinage act raised the legal price to 16-to-1. Between mid-1792 and mid-1834, therefore, gold was the undervalued (good) money and silver was the overvalued (bad) money.

After mid-1834 and until the early 1850s, when Congress reduced the silver content of all small-denomination coins, the status of gold and silver currency was reversed. The legal ratio of 16-to-1 was higher than the market price for gold and remained that way the rest of the century. Thus, gold became the money overvalued at the mint and silver became the undervalued.

Gresham's law would predict from these facts that the only current coinage would be silver before 1834 and gold thereafter. But the Gresham's law prediction would be wrong.

Between 1793 and 1846,^{2/} the U.S. mint coined a substantial amount of undervalued bullion. Moreover, there is a close positive correlation between the minting of gold and the minting of silver coins over the 53-year period. Table 1 presents the dollar values of gold and silver coins minted during our two sub-periods. When gold was undervalued at the mint (1793-1833), a hefty 25 percent of the coinage was gold; when silver was undervalued at the mint (1834-46), nearly half--a full 45 percent--of the coinage was silver. Now consider the graph of the values of the annual U.S. coinage of gold and silver from 1795 to 1846. (Data for the individual years 1793 and 1794 are not available. See Table 3.) Notice how closely these two series move. Except for the years from 1822 to 1833, when very few gold coins were produced, the series are almost coincident; the simple correlation coefficient between the values of gold and silver coinage over the entire period is .76. If there was profit to be made coining silver and melting gold coins before 1834 and coining gold and melting silver coins thereafter, the opportunities do not appear to be reflected in U.S. coinage statistics.

Proponents of Gresham's law might object that the coinage numbers are only part of the argument. They might argue that coins go to the market which values them most highly. Therefore, undervalued coins are sent to other countries, where they are valued by weight, and overvalued coins remain at home, where they are valued by tale. Yet, this part of the argument for Gresham's law is not supported by the data either. In the United States' undervalued gold period, the percentage of the gold that was exported was larger than the percentage of the silver. However, the dollar values of the exports of the two types of coins were the same. (See Table 2.) Furthermore, that a larger percentage of the minted gold was exported during this period is not surprising; only gold was minted in large denomination, making gold coins much more convenient for large-scale transactions, like exports, than silver coins, which were no bigger than half-dollars.^{3/}

Two Later 19th Century U.S. Exceptions. Continuing on in U.S. history, we find two more exceptions to Gresham's law, most notably, experiences during the early part of the greenback era (1862-79) and the time just after the Bland-Allison Act of 1878.

Greenbacks were legal tender notes issued by Congress to help finance the Civil War. To be consistent with Gresham's law, they should have driven both gold and silver out of circulation, for greenbacks were the bad money of their day. By the act of February 25, 1862, Congress was authorized to issue \$150 million worth of greenbacks. The two subsequent acts of July 11, 1862, and March 3, 1863, authorized an additional \$300 million. Due to

speculation on the outcome of the war and resumption, the gold price of these notes fell from their par value when first issued to 91 cents on the dollar by June 27, 1862, and to 84 cents by July 22, 1862. Six months later it had fallen to 68 cents, and by July 22, 1864, it had fallen below 40 cents.^{4/} Over most of the early Civil War years, therefore, greenbacks were the overvalued money (in this instance, overvalued by the U.S. Treasury, which was accepting all legal tender money at par) and specie the undervalued.

It is generally well known that, within a few months of the introduction of greenbacks, severe shortages of small-denomination silver developed. According to Laughlin (1886, p. 87), newspapers were reporting the problem of small coins disappearing as early as July 2, 1862. And the seriousness of the problem is revealed by the congressional act of July 17, 1862, which authorized postage and other U.S. stamps to serve as small-denomination legal tender currency.

What is less well known is whether or not greenbacks drove out larger-denomination gold coins. Some textbooks claim they did (Leavens 1939, p. 23, and Prager 1982, p. 32, for example), but Bernard Moses, writing in 1892, makes clear that in the West, despite the presence of greenbacks, gold remained the unit of account and a medium of exchange. He says that a contributor to the San Francisco Daily Herald wrote that greenbacks were also current there, but at a discount (Moses 1892, p. 18).

A writer in this journal, February 16, 1863, found very little difficulty arising from the use of legal tender notes; for they had a market value, and most people were ready to receive them at that value.

Out East it appears that the money system was reversed. There, according to Moses (1892, p. 15), greenbacks were accepted as the unit of account and gold circulated at a premium.

Gold was the fancy stock in the Eastern States. It was not true that legal tender notes were below par, as compared with labor and commodities. The fact was that gold and silver were above par.

The greenback era is therefore another exception to the rule that bad money drives out good.

The last 19th century U.S. example we present that contradicts Gresham's law is the coexistence of the trade and Bland dollars in the early 1880s. Both of these were U.S. silver dollars, but the lighter-weight Bland dollar failed to drive out the heavier-weight trade dollar.

The trade dollar was authorized by the U.S. coinage act of 1873 for a very specific purpose: to increase trade with China, a nation that particularly favored silver. The act authorized the minting of dollars containing 420 grams of silver, more than any other silver coin in existence, and by 1878 close to 36 million had been minted. Because Congress had only intended the trade dollar for export, it revoked the trade dollar's legal tender status in 1876. Nevertheless, in 1877 many of these dollars were circulating in the United States.

In 1878, under the Bland-Allison Act, Congress authorized the minting of another silver dollar, the so-called Bland dollar. (Congress had suspended the minting of all silver dollars except the trade dollar in 1873.) The new dollar was to contain less silver than the trade dollar (only 412 1/2 grams), but it was given legal tender status. The mint was allowed to issue from 2 million to 4 million such dollars per month; within two years, almost 50 million had been coined.

By 1880, therefore, the United States had two silver dollars of different weight. If Gresham's law had been operative, the trade dollar should have disappeared. In fact, both coins circulated (Laughlin 1886, p. 208). The Bland dollar was current at par; the trade dollar apparently circulated at its gold price, which varied around 93 cents. Contrary to Gresham's law, the lighter-weight Bland dollar not only failed to drive out the heavier-weight trade dollar; it also managed to circulate at a higher price than the heavier-weight dollar.

One Irresistable English Exception. Finding exceptions to Gresham's law in 19th century U.S. history has not been very hard. Although we suspect many more exceptions could be found in other periods as well as in other countries, we did not investigate all the possibilities. The examples we have described are enough to make our point: Bad money does not necessarily drive out good money. We did, however, come across one other exception that deserves mentioning because it is such an obvious contradiction to the previously unchallenged law. This exception occurred in 17th century England when the English mint began producing,

along with the silver shilling, a new gold coin. (See Jenkinson 1805, Kenyon 1884, and Breckinridge 1903.) Known as the guinea, the new coin quickly became the undervalued currency at the mint but circulated at a premium.

The guinea was first issued in 1663 at the legal price of 20 shillings, yet it never circulated at that price. The significance of a legal price in 17th century England was similar to what it was to become in 19th century America. The guinea, although not inscribed with any shilling denomination, was legal tender for all payments, including taxes, at 20 shillings. In 1663, this legal price was well below the guinea's market price; that is, the guinea was undervalued at the English mint, and the shilling was overvalued. Gresham's law, however, apparently did not operate. Consider the account of Charles Jenkinson (1805, p. 78), the first Earl of Liverpool, on the price at which the guinea circulated:

A Guinea...was ordered in the Mint Indenture to pass for 20s.; but it immediately became current at a higher rate, by general consent, without any authority from Government. Mr. Locke, and other writers, who lived during these times, asserts, that during the reigns of Charles II. and James II. the Guinea passed at from 21s. to 22s.; and Mr. Locke further adds...that the Gold Coins varied in their value "according to the current rate;" that is, according to the relative value of Gold to Silver at the market. The subjects of this country paid no attention on this occasion to the rate set upon these Coins in the Mint Indenture.

For many years, the premium was no more than two shillings, but by 1690 the guinea was trading for 30 shillings, that is, with a 10

shilling premium. Part of the reason for the premium was that the public commonly clipped the hammered silver coins. This led to the recoinage act of 1692, which called in all shillings to be reminted and milled (grooved on their edges) so that they could not be profitably clipped. The premium on the guinea fell from 10 to 1.5 after this recoinage of the shilling. The price of 21.5 shillings was then made the new legal price, which remained above market rates thereafter.^{5/}

Beyond Gresham's Law

We have argued that there are no convincing explanations for the claim that bad money drives out good. We have also cited historical examples to show that there are numerous exceptions to the claim. Nevertheless, we do not mean to imply that bad money never drives out good money. We do mean to point out, though, that when it does and how it does still require explanation.^{6/} What can confidently be expected to happen when two monies exist and their market and legal prices differ? We now offer a hypothesis that does not rely on potentially unbounded profits and that confronts historical experience much better than Gresham's law.

Finding the Philosopher's Stone

In arguing against the coinage act of 1853 to reduce the weight of U.S. small-denomination silver coins, Andrew Johnson (quoted in Laughlin 1886, p. 85 and its fn. 2) anticipated a Modigliani-Miller kind of irrelevance theorem.

Congress can not regulate the value of the coin....If we can, then...I ask the House and the country if the philosopher's stone has not been discovered?...The commercial world will take the coins for what they are intrinsically worth, and not for what the legal stamp represents them to be worth.

...So far as coin is concerned, the changing of our standard of gold and silver has no more effect upon the gold and silver coinage of the United States than a change in the standard of weights and measures would have upon the price of our cotton or wheat.

Johnson's version of the Modigliani-Miller theorem is that mint prices are irrelevant to what becomes the unit of account and the rate at which two currencies exchange; the market can easily price coins by their weight instead of by their face value. (An irrelevance theorem of this kind is proved in the Appendix.)

Johnson's argument evidently did not convince many in Congress because the act was passed and the silver content of small-denomination coins was reduced. Presumably to Johnson's surprise, the intent of the law was realized. The new lighter-weight coins had no trouble circulating at their par value. While the older, heavier-weight coins disappeared from circulation, the newer coins were quite visible.

Hence, just as Gresham's law ascribes too much power to government decrees, Johnson's irrelevance claim ascribes too little. This conclusion leads us to ask some basic questions. Why does money undervalued at the mint circulate side-by-side with overvalued money in some economies but not in others? And what determines which money becomes the unit of account? Our answers to these questions depend on two properties of an economy:

- The existence of a legal tender law.
- The costs of using a currency at a nonpar price.

We think the existence of a legal tender law plays a critical role in determining which money serves as the unit of account. Our reasoning is the same as that we used earlier to explain how these laws could be legally avoided. According to a frictionless general equilibrium theory, what serves as the unit of account, or numeraire, is indeterminate; one good serves this function as well as another. As we argued previously, though, if both the undervalued and the overvalued currency must be accepted for all payments at their par values, agents will set their price in the overvalued currency and be more than willing to accept the undervalued at par. A legal tender law can thus be viewed as placing transactions costs on undervalued money when it is used as the unit of account, thereby breaking the indeterminacy implied by general equilibrium theory in favor of the overvalued money.

Even though the existence of a legal tender law might explain which money becomes the unit of account, it does not predict when undervalued money circulates at a premium and when it

does not. We argue that whether or not a currency circulates at a premium depends on the costs incurred in paying such premiums. Clearly, if the costs are zero, Andrew Johnson would have been right. However, the transactions costs of paying a premium may not be zero or even close to zero, especially for small-denomination currency. And when costs are nonnegligible, the public will usually be better off bundling small-denomination currency, that is, accumulating and using large quantities of it. As a result, small-denomination coins will more or less disappear from circulation.

This tendency for small-denomination currency to disappear stems from the fact that paying premiums on small-denomination currency tends to be more costly than paying them on large-denomination currency. There are two reasons for this extra cost. One is simply that small-denomination currency tends to be greater in number and to have a higher velocity than larger-denomination currency.

The other reason is the fact that currency systems generally do not include a continuum of denominations: there have rarely been fractional coins smaller than a penny. This means that paying the fractional part of any premium usually involves some rounding. And that becomes especially costly on small denominations. Consider a silver dollar, for example, that is worth 104.2 cents in gold. The silver dime is then worth 10.42 cents and the silver nickel 5.21 cents. Rounded up, the premium on the silver dollar would be 5 cents. The premium on a dollar's worth of dimes or nickels (used in individual transactions), though,

would be even more: as much as 10 cents (1 cent on each dime) or 20 cents (1 cent on each nickel). Generally, the smaller the denomination, the more costly it is to pay the fractional part of a premium.

Because of this additional cost, traders are not likely to pay premiums on individual small-denomination coins. Thus, the public is not likely to use these coins as a medium of exchange and is, rather, likely to collect them into large quantities which will exchange at a full premium. That is, individual units of small-denomination currency will tend to be bundled and taken out of circulation.

To summarize, our hypothesis is that, when two types of money are coined and made legal tender and their legal and market prices differ, the following is likely to happen:

- The money that is overvalued at the mint emerges as the unit of account.
- The money that is undervalued at the mint
 - circulates at a premium if it is large-denomination.
 - is bundled into large quantities and used as a store of value if it is small-denomination.

Confronting History

To test our hypothesis, we return to three of the 19th century U.S. periods we examined earlier, and once again history appears to support us. In these periods, currency overvalued at the mint (or the Treasury) tended to be the unit of account. And when undervalued currency did not circulate, it tended to be small-denomination coins.

Bad Money Becomes the Unit of Account. Between 1792 and 1833, when silver was overvalued and gold was undervalued at the U.S. mint, silver seems to have been the unit of account. Evidence that contracts and prices were written in silver appears in congressional testimony and reports that preceded the U.S. coinage act of 1834. In 1830, for example, Secretary of the Treasury Samuel D. Ingham argued against debasing gold and for a silver standard by pointing out that all contracts at that time were being made in terms of silver (Laughlin 1886, p. 70). Similarly, in 1833, a congressional committee arguing for a single silver standard (quoted in Laughlin 1886, p. 60, fn. 1) claimed that

Silver is the ancient currency of the United States, the metal in which the money unit is exhibited, the money generally used in foreign commerce, and that description of the precious metals in the distribution of which we exercise an extensive agency. The committee, upon due consideration of all attendant circumstances, are of opinion that the standard of value ought to be legally and exclusively, as it is practically, regulated in silver.

Soon after the coinage act of 1834, when gold was debased and became the money overvalued at the mint, gold began to replace silver as the unit of account. As is clear in the graph we looked at earlier, coinage of gold increased dramatically the first three years of the new act, suggesting debtors were taking advantage of the cheaper money. Laughlin (1886, p. 65) estimates that after 1834 a debtor could pay off a \$16,000 debt (implicitly priced in silver) with newly minted gold coins which had a face value of \$16,000 but which would only cost \$15,700 in silver.

Presumably, lenders and traders soon realized the potential loss in continuing to price their contracts (or their goods and services) in silver, for by the late 1840s, gold appears to have become the unit of account. In 1850, Representative C. L. Dunham said, "We have had but a single standard for the last three or four years. That has been, and now is, gold" (Laughlin 1886, pp. 79-80). And in discussion of the 1853 coinage act, Representative Charles Skelton said, "Gold is the only standard of value by which all property is now measured" (Laughlin 1886, p. 82, fn. 2).

Finally, we come again to the greenback era (1862-79), which also supports our claim that the overvalued currency becomes the standard. Recall that Moses (1892, p. 15) reports that in the East the greenback (the overvalued currency relative to specie) circulated at par.

It was not true that legal tender notes were below par, as compared with labor and commodities. The fact was that gold and silver were above par.

But recall that Moses (1892, p. 18) also reports that in California gold was the standard and greenbacks were current at a discount. This does not contradict our hypothesis that overvalued currency becomes the unit of account, because California passed legislation in April 1863 which effectively nullified the U.S. legal tender law. That legislation permitted contracts to be stated in a specific kind of currency. (What was known as the Specific Contract Act was upheld by the U.S. Supreme Court in July 1864.) In effect, greenbacks were not legal tender in California because they did not have to be accepted for payment at par.

Denomination Determines Good Money's Fate. These three periods in 19th century U.S. history thus support part of our hypothesis, that legal tender laws imply that the overvalued currency becomes the unit of account.^{7/} These periods also provide evidence to support the other part, that undervalued large-denomination currency is likely to circulate at a premium while undervalued small-denomination currency tends to be bundled and disappear from circulation.

During the silver standard period (1792-1833), of the undervalued currency, only the large denominations seem to have circulated. At that time, undervalued large-denomination currency consisted of gold coins and Spanish dollars that contained more silver than the U.S. dollar. As is apparent in Table 2, most of the gold was exported, but as mentioned earlier, the Spanish dollar circulated for many years at a premium (Taxay 1966, p. 231, and Laughlin 1886, p. 53, fn. 1). The small change available during this period consisted of U.S. silver coins and a substantial amount of Spanish coins. The small-denomination Spanish coins contained less silver than the U.S. coins (just the opposite relationship as between the Spanish and U.S. dollars), and as our hypothesis predicts, the undervalued small U.S. coins had trouble circulating. Robert Patterson, director of the U.S. mint, provides evidence of this in his April 2, 1807, letter to President Jefferson (quoted in Taxay 1966, p. 126):

Small Spanish Silver coins are extremely plenty, I believe in most of the commercial towns, and as their nominal and circulating value is considerably above their real intrinsic value, they will

neither be sent to the Mint, used in Manufactures, nor carried out of the country, but indeed are daily increasing by importation. Small Coins of the U. States will therefore be less necessary for the sake of change, while foreign small silver continues to be a circulating medium. We lately struck at the Mint nearly a quarter of a million of Silver dismes: it is however with the utmost difficulty (emphasis added), that we can prevail upon any of the Banks to accept of them, and in fact nearly half the number still remain in our vaults.

Patterson's letter suggests that at least small transactions were implicitly stated in Spanish prices; that is, small Spanish silver coins circulated at their nominal value. For U.S. silver coins to circulate, therefore, they would have had to exchange at a premium, and that probably wasn't worth the effort for most people. That the mint had difficulty getting banks to use this money, therefore, is consistent with our hypothesis.^{8/}

Our other two periods also generally support our prediction for large- and small-denomination undervalued currency. In both periods, the undervalued small-denomination currency tended to disappear from circulation. After silver became the undervalued currency in 1834, remember, the United States developed a small-change shortage which led to the 1853 act authorizing the mint to produce lighter-weight silver coins. The problem recurred when greenbacks were introduced in 1862. These notes depreciated so much that small-denomination silver coins again became undervalued, and again they disappeared. Yet, in at least one of these periods, some undervalued large-denomination currency managed to circulate, and not at face value. The undervalued silver dollars

did not circulate much in either period. According to Laughlin (1886, p. 82), they completely disappeared well before the 1853 act. However, as noted earlier, in the East during the greenback era, while the overvalued greenbacks exchanged at par, an undervalued money, gold, "was the fancy stock" (Moses 1892, p. 15): it circulated at a premium.^{9/}

Summary

Standard economic theory predicts that in equilibrium only one price for a good can prevail. Thus, when the legal price of two monies is not the same as the market rate of exchange, either one of the monies does not circulate at its legal price or one does not circulate at all. The popular claim is that, when the legal price is out of line with the market, the money overvalued at the mint drives out the money undervalued. This claim has become generally accepted today and is known as Gresham's law.

We have argued that this claim does not deserve its status as a law. The explanations why it is supposed to be true simply do not hold up under scrutiny. It is unlikely that mints could ever operate in a way required for bad money to drive out good, and there is no evidence that any mints ever did. Nor could legal tender laws cause such a result, since they are legally and easily avoided. Furthermore, history does not support Gresham's law. An examination of only a small part of U.S. and English coinage history reveals episodes that do not conform to the law's prediction. In many instances, both bad and good money appear to have been current.

We have gone on to argue that, when legal and market prices vary (which they eventually must), the overvalued money becomes the unit of account and, sometimes, some of the undervalued money circulates at a premium. All of the undervalued circulates when the costs of using currency at a nonpar price are insignificant. When these costs are significant, though, under-

valued small-denomination currency tends to disappear. Nearly all of the evidence we examined is consistent with our hypothesis.

We do not claim, therefore, that bad money never drives out good money. We do assert, though, that Gresham's law is wrong. "Bad money tends to only drive out small-denomination good money" may not be quite as catchy a phrase, but it is a much better law.

Table 1

U.S. Coinage of Gold and Silver, 1793-1846

| Period | DOLLAR VALUES | | | PERCENTAGES OF TOTAL MINTED | |
|---------------------------------|---------------|--------------|--------------|--------------------------------|--------|
| | Total | Gold | Silver | Gold | Silver |
| 1793-1833 (Gold Undervalued) | \$48,100,959 | \$11,825,800 | \$36,275,069 | 25% | 75% |
| 1834-46 (Silver Undervalued) | 73,308,259 | 40,515,843 | 32,792,416 | 55 | 45 |

Source of basic data: Laughlin 1886, pp. 249-50

Table 2

U.S. Minting and Distributing of Coins, as of January 1, 1834

| Type | Total Minted | DOLLAR VALUES | | PERCENTAGES OF TOTAL MINTED | |
|----------------|-----------------|---------------------|-------------|--------------------------------|------------|
| | | -----Estimated----- | | Exported | Circulated |
| | | Exported | Circulated | | |
| U.S. Silver | \$36.3 mil. | \$10.1 mil. | \$26.2 mil. | 28% | 72% |
| U.S. Gold | 11.8 mil. | 10.3 mil. | 1.5 mil. | 87 | 13 |
| U.S. Specie | \$48.1 mil. | \$20.4 mil. | \$27.7 mil. | | |
| Foreign Specie | | | 11.3 mil. | | |
| TOTAL | | | \$39.0 mil. | | |

Sources of basic data: Minted---Laughlin 1886, pp. 249-50
 Circulated---Total: Krooss 1969, p. 1051
 Gold: Laughlin 1886, p. 71, fn. 1
 Foreign Specie: Laughlin 1886, pp. 54-55

All other data are derived from the data available in the above sources.

Table 3
The Price of Gold and the U.S. Coinage of
Silver and Gold, 1793-1884

| Years | PRICE OF GOLD (in ounces of silver) | | TOTAL U.S. COINAGE | |
|-----------|---|---------------|--------------------|--------------|
| | Market | U.S. Legal | Silver | Gold |
| 1793-1795 | 15.31 | 15.00 | \$ 370,683.80 | \$ 71,485.00 |
| 1796 | 15.65 | " | 79,077.50 | 102,727.50 |
| 1797 | 15.41 | " | 12,591.45 | 103,422.50 |
| 1798 | 15.59 | " | 330,291.00 | 205,610.00 |
| 1799 | 15.74 | " | 423,515.00 | 213,285.00 |
| 1800 | 15.68 | 15.00 | 224,296.00 | 317,760.00 |
| 1801 | 15.46 | " | 74,758.00 | 422,570.00 |
| 1802 | 15.26 | " | 58,343.00 | 423,310.00 |
| 1803 | 15.41 | " | 87,118.00 | 258,377.50 |
| 1804 | 15.41 | " | 100,340.50 | 258,642.50 |
| 1805 | 15.79 | " | 149,388.50 | 170,367.50 |
| 1806 | 15.52 | " | 471,319.00 | 324,505.00 |
| 1807 | 15.43 | " | 597,448.75 | 437,495.00 |
| 1808 | 16.08 | " | 684,300.00 | 284,665.00 |
| 1809 | 15.96 | " | 707,376.00 | 169,375.00 |
| 1810 | 15.77 | 15.00 | 638,773.50 | 501,435.00 |
| 1811 | 15.53 | " | 608,340.00 | 497,905.00 |
| 1812 | 16.11 | " | 814,029.50 | 290,435.00 |
| 1813 | 16.25 | " | 620,951.50 | 477,140.00 |
| 1814 | 15.04 | " | 561,687.50 | 77,270.00 |
| 1815 | 15.26 | " | 17,308.00 | 3,175.00 |
| 1816 | 15.28 | " | 28,575.75 | 0.00 |
| 1817 | 15.11 | " | 607,783.50 | 0.00 |
| 1818 | 15.35 | " | 1,070,454.50 | 242,940.00 |
| 1819 | 15.33 | " | 1,140,000.00 | 258,615.00 |
| 1820 | 15.62 | 15.00 | 501,680.70 | 1,319,030.00 |
| 1821 | 15.95 | " | 825,762.45 | 189,325.00 |
| 1822 | 15.80 | " | 805,806.50 | 88,980.00 |
| 1823 | 15.84 | " | 895,550.00 | 72,425.00 |
| 1824 | 15.82 | " | 1,752,477.00 | 93,200.00 |
| 1825 | 15.70 | " | 1,564,583.00 | 156,385.00 |
| 1826 | 15.76 | " | 2,002,090.00 | 92,245.00 |
| 1827 | 15.74 | " | 2,869,200.00 | 131,565.00 |
| 1828 | 15.78 | " | 1,575,600.00 | 140,145.00 |
| 1829 | 15.78 | " | 1,994,578.00 | 295,717.50 |

Table 3 (continued)

| Years | PRICE OF GOLD (in ounces of silver) | | TOTAL U.S. COINAGE | |
|-------|---|---------------|--------------------|---------------|
| | Market | U.S. Legal | Silver | Gold |
| 1830 | 15.82 | 15.00 | \$2,495,400.00 | \$ 643,105.00 |
| 1831 | 15.72 | " | 3,175,600.00 | 714,270.00 |
| 1832 | 15.73 | " | 2,579,000.00 | 798,435.00 |
| 1833 | 15.93 | " | 2,759,000.00 | 978,550.00 |
| 1834 | 15.73 | 16.00 | 3,415,002.00 | 3,954,270.00 |
| 1835 | 15.80 | " | 3,443,003.00 | 2,186,175.00 |
| 1836 | 15.72 | " | 3,606,100.00 | 4,135,700.00 |
| 1837 | 15.83 | " | 2,096,010.00 | 1,148,305.00 |
| 1838 | 15.85 | " | 2,333,243.00 | 1,809,595.00 |
| 1839 | 15.62 | " | 2,176,296.00 | 1,355,885.00 |
| 1840 | 15.62 | 16.00 | 1,726,703.00 | 1,675,302.50 |
| 1841 | 15.70 | " | 1,132,750.00 | 1,091,597.50 |
| 1842 | 15.87 | " | 2,332,750.00 | 1,834,170.00 |
| 1843 | 15.93 | " | 3,834,750.00 | 8,108,797.50 |
| 1844 | 15.85 | " | 2,235,550.00 | 5,428,230.00 |
| 1845 | 15.92 | " | 1,873,200.00 | 3,756,447.50 |
| 1846 | 15.90 | " | 2,558,580.00 | 4,034,177.50 |
| 1847 | 15.80 | " | 2,379,450.00 | 20,221,385.00 |
| 1848 | 15.85 | " | 2,040,050.00 | 3,775,512.50 |
| 1849 | 15.78 | " | 2,114,950.00 | 9,007,761.50 |
| 1850 | 15.70 | 16.00 | 1,866,100.00 | 31,981,738.50 |
| 1851 | 15.46 | " | 774,397.00 | 62,614,492.50 |
| 1852 | 15.59 | " | 999,410.00 | 56,846,187.50 |
| 1853 | 15.53 | " | 9,077,571.00 | 39,377,909.00 |
| 1854 | 15.33 | " | 8,619,270.00 | 25,915,918.50 |
| 1855 | 15.38 | " | 3,501,245.00 | 28,977,968.00 |
| 1856 | 15.38 | " | 5,135,240.00 | 36,697,768.50 |
| 1857 | 15.27 | " | 1,477,000.00 | 15,811,563.00 |
| 1858 | 15.38 | " | 8,040,730.00 | 30,253,725.50 |
| 1859 | 15.19 | " | 6,187,400.00 | 17,296,077.00 |
| 1860 | 15.29 | 16.00 | 2,769,920.00 | 16,445,476.00 |
| 1861 | 15.26 | " | 2,605,700.00 | 60,693,237.00 |
| 1862 | 15.35 | " | 2,812,401.50 | 45,532,386.50 |
| 1863 | 15.37 | " | 1,174,092.80 | 20,695,852.00 |
| 1864 | 15.37 | " | 548,214.10 | 21,649,345.00 |
| 1865 | 15.44 | " | 636,308.00 | 25,107,217.50 |
| 1866 | 15.43 | " | 680,264.50 | 28,313,945.00 |
| 1867 | 15.57 | " | 986,871.00 | 28,217,187.50 |
| 1868 | 15.59 | " | 1,136,750.00 | 18,114,425.00 |
| 1869 | 15.60 | " | 840,746.50 | 21,828,637.50 |

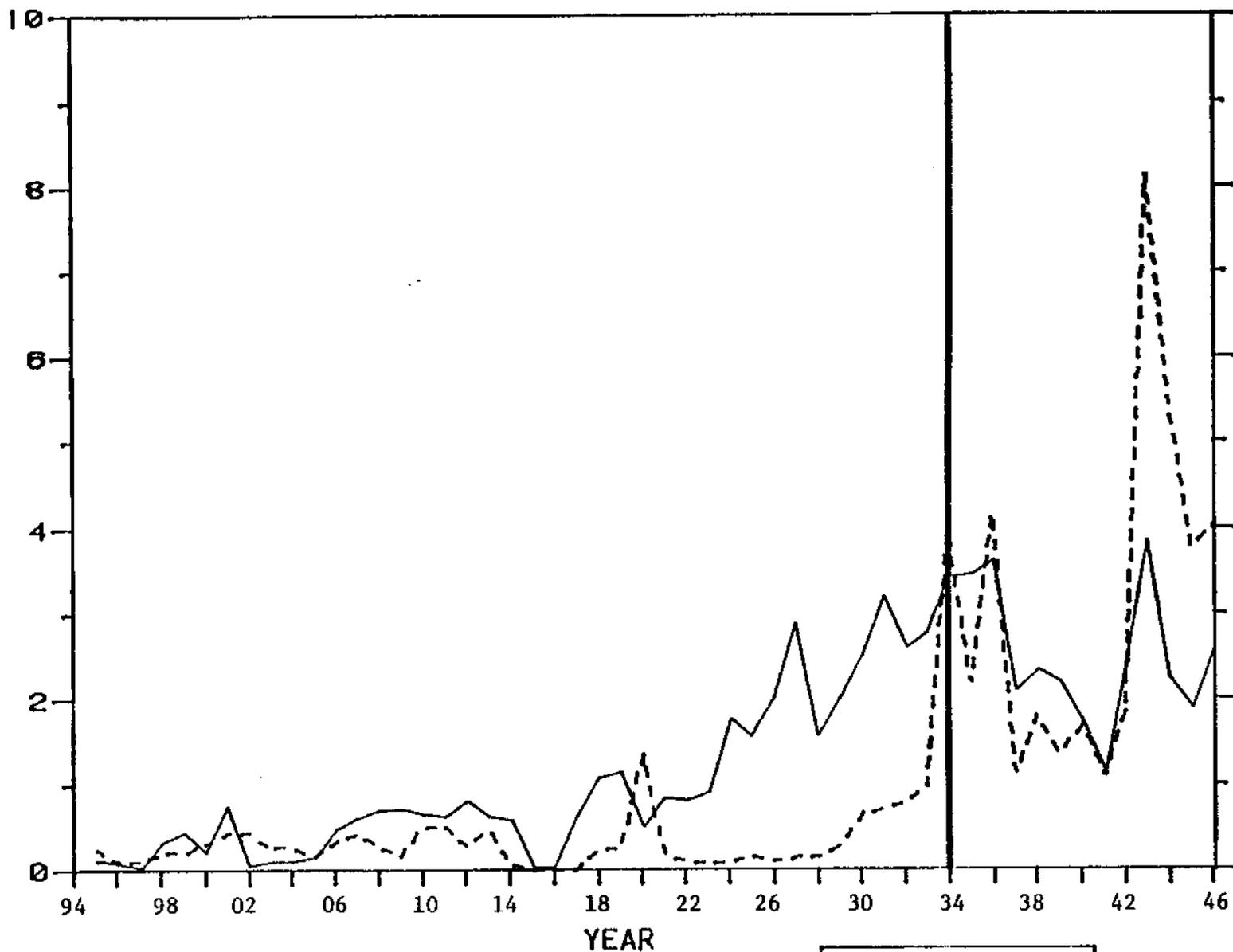
Table 3 (continued)

| Years | PRICE OF GOLD (in ounces of silver) | | TOTAL U.S. COINAGE | |
|-------|---|---------------|--------------------|-----------------|
| | Market | U.S. Legal | Silver | Gold |
| 1870 | 15.57 | 16.00 | \$ 1,767,253.50 | \$22,257,312.50 |
| 1871 | 15.57 | " | 1,955,905.25 | 21,302,475.00 |
| 1872 | 15.65 | " | 3,029,834.05 | 20,376,495.00 |
| 1873 | 15.92 | " | 2,945,795.50 | 35,249,337.50 |
| 1874 | 16.17 | " | 5,983,601.30 | 50,442,690.00 |
| 1875 | 16.62 | " | 10,070,368.00 | 33,553,965.00 |
| 1876 | 17.77 | " | 19,126,502.50 | 38,178,962.50 |
| 1877 | 17.22 | " | 28,549,935.00 | 44,078,199.00 |
| 1878 | 17.92 | " | 28,290,825.50 | 52,798,980.00 |
| 1879 | 18.39 | " | 27,227,882.50 | 40,986,912.00 |
| 1880 | 18.06 | 16.00 | 27,942,437.50 | 56,157,735.00 |
| 1881 | 18.24 | " | 27,649,966.75 | 78,733,864.00 |
| 1882 | 18.27 | " | 27,783,388.75 | 89,413,447.50 |
| 1883 | 18.64 | " | 28,835,470.15 | 35,936,927.50 |
| 1884 | 18.58 | " | 28,773,387.80 | 27,932,824.00 |

Source: Laughlin 1886, pp. 221-23, 249-50

ANNUAL U.S. GOLD AND SILVER COINAGE, 1795-1846

\$ MILLIONS



— SILVER
- - - GOLD

SOURCE: LAUGHLIN 1888, PP.249-50

Footnotes

1/On February 9, 1793, Congress repealed legal tender standing for all but a few foreign specie, and of these few, only Spanish coins were current by 1796 (Taxay 1966, p. 67). Spanish coins kept their legal tender standing in the United States until 1874.

2/The dramatic increase in world gold production in the late 1840s led to large amounts of gold being coined at the U.S. mint. Since Gresham's law cannot be given credit for the discoveries that led to the increased gold production, we only consider the coinage data through 1846.

3/In 1804, President Jefferson suspended the coinage of dollars, and none were coined again until 1846.

4/For a complete list of daily price quotes for greenbacks, see Mitchell 1903, Appendix A, Table 2.

5/Sir Issac Newton, who was master of the mint in the early part of the 18th century, is frequently blamed for England's conversion to a gold standard because he had convinced the English authorities to lower the legal price of the guinea to 21 shillings. The blame seems misplaced. The legal price of the guinea had been above the market price well before Newton took office, and silver had been leaving the country at least as early as the turn of the century. Newton estimated that in 1717 the guinea was worth only about 20.8 shillings in the market and recommended that the legal price be dropped from 21.5 to 21.0 (Breckinridge 1903, p. 45). He effectively saved the English Treasury 0.5 shillings on each guinea it received for taxes. It thus appears that Newton

may properly be blamed for raising taxes, but not for the silver exportation that had been going on long before he came to office.

6/In an attempt to salvage Gresham's law, Sargent and Wallace (1983, pp. 26-31) impose quite restrictive legal restrictions. In their model, by only allowing the public to use paper receipts (for gold and silver), instead of coins, as a medium of exchange, the government is able to influence which commodity is used in exchange and which is used in production. However, such legal restrictions have seldom been imposed; they probably never have been before the 20th century.

7/The period of 17th century England we studied earlier also supports this part of our hypothesis: during that time, overvalued silver currency was the unit of account. According to Jenkinson (1805, p. 79),

the public was...disposed to measure the value of every thing bought and sold, by the Silver Coins, as best adapted to the state of our commerce at that time...Gold Coins therefore took their natural or intrinsic value, compared with those of Silver, and rose in their price in like manner with every other commodity.

8/In Table 2, we report that as of January 1, 1834, \$26 million worth of U.S. silver coins and \$11 million of foreign specie circulated, which seems to imply that eventually many U.S. silver coins were used in transactions. On closer examination of the data, though, we find that most were not. These circulation numbers overstate what was actively used because they include specie held by banks. According to Krooss (1969, p. 1051), of the \$39 million of specie in circulation (\$28 million U.S. and \$11

million foreign), only \$12 million (the composition of which is unknown) was outside the banking system. So of the \$26 million worth of U.S. silver supposedly circulating, at most 46 percent was actively used. And we suspect that the actual percentage was much less than this because only 25 years earlier, according to Patterson, much of what actively circulated was foreign specie.

9/Some of the Bland dollar experience does not seem consistent with our entire hypothesis. The Eland dollar was the overvalued money in the 1880s, and it circulated at par as we predict. The undervalued gold currency also circulated in this period. However, it did so at par, not at a premium. See Laughlin (1886, pp. 208-10) for one explanation of why this occurred.

Appendix

A Model of Commodity Money Under Three Alternative Coinage Policies

Is it feasible for a mint to act as Gresham's law requires, that is, to set a legal price for two metals, a price at which it is willing to exchange them on demand? The model we present in this appendix suggests it is not; if the legal price differs from the market price, an equilibrium will not exist.

To demonstrate this infeasibility result, we describe below what happens in an economy when a mint operates under three alternative policies. First, we examine a free coinage policy. Under this policy, the mint merely weighs, assays, and stamps metals into coins on demand. It does not exchange one kind of metal for the other at the legal price. We find not only that the free coinage policy is feasible, but also that, under it, only one metal might be coined. This result, however, cannot be interpreted as Gresham's law since the mint's behavior and the legal price have nothing to do with it.

Second, we examine a liberal coinage policy, one in which there is free coinage and the mint does trade the metals at par as Gresham's law requires. We show that equilibrium generally does not exist under this policy.

Finally, we consider a more realistic policy than the liberal one. We look at a mint which follows a liberal policy until it runs out of resources and then reverts to free coinage. Not surprisingly, we find that the equilibrium under this mixed coinage policy is the same as that under the free coinage policy.

A Model of Commodity Money

To examine coinage policies that could give rise to Gresham's law, we draw on Sargent and Wallace's (1983) model of commodity money. This is an overlapping generations model which begins at time $t = 1$ and continues forever. Each generation in the model consists of \bar{n} members who each live two periods. In each period t , there are \bar{n} members of generation $t - 1$ (the old) and \bar{n} members of generation t (the young). The economy has one nonstorable consumption good (bread) and two perfectly storable metals (gold and silver)--metals, that is, which do not physically appreciate or depreciate.

We assume that each agent h born at time t in this economy receives an endowment $w_t^h(z)$ of the consumption good at time z . We let $c_t^h(z)$ be this agent's consumption of bread at time z . This agent is assumed to have preferences given by the function $u_t^h[c_t^h(t), c_t^h(t+1)]$, which is assumed to be continuous, twice differentiable, and concave and to satisfy these conditions: (a) there is no satiation; (b) $u_1/u_2 \rightarrow \infty$ as $c_t^h(t)/c_t^h(t+1) \rightarrow 0$, and $u_1/u_2 \rightarrow 0$ as $c_t^h(t)/c_t^h(t+1) \rightarrow \infty$; and (c) both $c_t^h(t)$ and $c_t^h(t+1)$ are normal goods.

Further, this economy has two reversible technologies. One converts a unit of bread into $\phi_g(t)$ units of gold or one unit of gold into $\phi_g^{-1}(t)$ units of bread. The other converts one unit of bread into $\phi_s(t)$ units of silver or one unit of silver into $\phi_s^{-1}(t)$ units of bread. We make these technologies functions of time in order to allow for changes in productivity. Finally, to complete the environment of this economy, we assume that a mint exists.

We now confront this economy with several different ways that a mint could perform.

Free Coinage Policy

First, the mint follows a free coinage policy. Under this policy, the sole function of the mint is to weigh, assay, and stamp into coins of a certain weight and fineness all the gold and silver bullion the public wants coined. We assume that minting is costless to society. Further, to provide a rationale for the existence of the mint, we assume that there is a legal prohibition against storing uncoined gold or silver.^{1/}

Under the free coinage policy, the individual maximizes utility subject to the single-period budget constraints given by

$$(1) \quad c_t^h(t) + \ell_t^h(t) + p_g(t)g_t^h(t) + p_s(t)s_t^h(t) \leq w_t^h(t)$$

$$(2) \quad c_t^h(t+1) \leq w_t^h(t+1) + r(t)\ell_t^h(t) + p_g(t+1)g_t^h(t) \\ + p_s(t+1)s_t^h(t)$$

where $\ell_t^h(t)$ represents one-period consumption loans made by the agent at time t ; $r(t)$ is the gross one-period interest rate on these loans; $g_t^h(t)$ and $s_t^h(t)$ are, respectively, the gold and silver holdings of this agent at time t ; and $p_g(t)$ and $p_s(t)$ are the market prices of, respectively, gold and silver, in terms of the time t consumption good.

^{1/}The same effect would be obtained by assuming that, due to costs of weighing and assaying bullion, uncoined gold or silver does not circulate.

In any equilibrium under a free coinage policy, it is true that the metals' market prices equal their technology prices; that is,

$$(3) \quad p_g(t) = \phi_g^{-1}(t)$$

$$(4) \quad p_s(t) = \phi_s^{-1}(t).$$

This proposition can easily be demonstrated. Suppose, on the one hand, that $p_g(t) > \phi_g^{-1}(t)$. Then individuals would demand an infinite quantity of bread to use as an input to gold production since more bread could be obtained by selling gold in the market than by using gold to produce bread. Thus, there would be an excess demand for bread at all such market prices. If, on the other hand, $p_g(t) < \phi_g^{-1}(t)$, then the demand for gold as an input to bread production would be infinite at all such prices. [The same type of argument, of course, demonstrates (4).]

Now, let $C_t[r(t)] = \sum_{h=1}^{\bar{n}} c_t^h(t)$ be the aggregate demand for the consumption of bread which results from the utility maximization of the agents of generation t at time t . Similarly, define the aggregate demands for gold and silver by agents of generation t at time t as $G_t[r(t)] = \sum_{h=1}^{\bar{n}} g_t^h(t)$ and $S_t[r(t)] = \sum_{h=1}^{\bar{n}} s_t^h(t)$. Let $W_t(t) = \sum_{h=1}^{\bar{n}} w_t^h(t)$ represent all of generation t 's endowments of bread at time t . Finally, assume that the old hold all of the initial stock of $G(0)$ units of gold and $S(0)$ units of silver.

With this notation, we can now define equilibrium under this policy.

Definition. Given $\{\phi_g(t)\}$ and $\{\phi_s(t)\}$, $t > 1$, the nonnegative sequences $\{C(t)\}$, $\{G(t)\}$, $\{S(t)\}$, and $\{r(t)\}$ are an equilibrium for a free coinage policy if (3) and (4) hold and if, for $t > 1$,

$$(5) \quad G_t[r(t)] \{ [p_g(t+1)/p_g(t)] - r(t) \} = 0$$

$$(6) \quad S_t[r(t)] \{ [p_s(t+1)/p_s(t)] - r(t) \} = 0$$

$$(7) \quad W_t(t) = C_t[r(t)] + p_g(t)G_t[r(t)] + p_s(t)S_t[r(t)].$$

From (5) and (6) we find that gold will not be coined if $p_g(t+1)/p_g(t) < p_s(t+1)/p_s(t)$ and in that case $r(t) = p_s(t+1) \div p_s(t)$. If the above inequality is reversed, then silver will not be coined and $r(t) = p_g(t+1)/p_g(t)$. Thus, in general only one of the two metals will be coined and held.

Define $F[r(t)] = W_t(t) - C[r(t)]$ to be the aggregate saving of the young at t , and let $\theta(t) = \max \{ p_g(t+1)/p_g(t), p_s(t+1)/p_s(t) \}$. Then, given our assumptions on agent utility functions, a necessary and sufficient condition for an equilibrium in which both bread and one of the two metals are coined and held in all periods is that, for $t > 1$,

$$(8) \quad F_t[\theta(t)] > 0.$$

This condition states that, at a gross interest rate of $\theta(t)$, in the aggregate the young desire to be net savers. In this equilibrium, $r^*(t)$, the equilibrium value of the gross rate of return, will be equal to $\theta(t)$ and the aggregate holdings of gold or silver will be equal to $F[\theta(t)]$. If (8) is not satisfied, however, then $r^*(t)$ will satisfy $F[r^*(t)] = 0$ and neither of the two metals will be held.

At first glance, the free coinage policy appears to imply Gresham's law, since in equilibrium, at most, one of the two metals will be held. However, unlike the usual discussions of Gresham's law, in which the determination of which metal is held is affected by the coinage ratio set by the mint, here the determination is based on which metal yields the higher rate of return. Further, the rate of return depends only on the changes in technology over time and not on the mint's behavior. In fact, if storing uncoined metals were not prohibited, the existence of the mint would be irrelevant to the economy's equilibrium.^{2/}

Liberal Coinage Policy

Now we make the mint take on an additional function. Not only is it required to coin gold and silver on demand, but it is also required to exchange gold for silver on demand. We will refer to this combination of functions as a liberal coinage policy.

The mint in our economy must exchange the two metals at the ratio of $d(t)$ units of gold per unit of silver; that is,

$$(9) \quad g(t) = d(t)s(t).$$

We will refer to $d(t)$ as the mint ratio. We make it a function of time because it will change over time. We assume that changes in

^{2/}It can be shown that, under a free coinage policy, if a legal or technological minimum size restriction exists on the coinage of the higher-yield metal, then both metals will be held. From the viewpoint of U.S. history, such a technology restriction seems reasonable since gold coins of less than \$2.50 denomination were inconvenient due to their extremely small physical size.

the mint ratio occur deterministically. The mint is also assumed to have an endowment of $m(t)$ units of bread in period t (which can be thought of as having been taxed away from the private sector). The mint uses this endowment to buy either gold or silver, according to the prevailing technologies. Then it coins the gold or silver and exchanges the coins for bullion offered by private agents. We assume that $m(t)$ is large enough to meet agents' demands for either gold or silver.

Under the liberal coinage policy, each metal has two prices in terms of bread. Gold, for example, has a technology price, $\phi_g^{-1}(t)$, and a mint price, $\phi_s^{-1}(t)d^{-1}(t)$. In any equilibrium under this policy, the price of each metal in the market equals either the technology or the mint price, whichever is smaller; that is,

$$(10) \quad p_g(t) = \min \{ \phi_g^{-1}(t), \phi_s^{-1}(t)d^{-1}(t) \}$$

$$(11) \quad p_s(t) = \min \{ \phi_s^{-1}(t), \phi_g^{-1}(t)d(t) \}.$$

This proposition can be demonstrated with the same reasoning used to demonstrate (3) and (4). First suppose that $p_g(t) > \min \{ \phi_g^{-1}(t), \phi_s^{-1}(t)d^{-1}(t) \}$. Then individuals would demand an infinite quantity of bread, either to use as an input to gold production directly or to buy silver to exchange for gold at the mint. Thus, there would be an excess demand for bread at all such prices. Now suppose the opposite, that $p_g(t) < \min \{ \phi_g^{-1}(t), \phi_s^{-1}(t)d^{-1}(t) \}$. Then the demand for gold would be infinite at all such prices. [This type of argument also demonstrates (11).]

Note, however, that if $p_g(t) = \phi_g^{-1}(t)$, because the technology price of gold is less than the mint price, then, from (11), $p_s(t) = \phi_s^{-1}(t)d(t)$ --the mint price of silver is less than the technology price. The reverse is true too. Consequently, unless the mint ratio equals the ratio of the technology prices--unless $d(t) = \phi_s(t)/\phi_g(t)$ --individuals will always have an infinite demand for one of the two metals. Suppose, for example, that $\phi_s^{-1}(t) > \phi_g^{-1}(t)d(t)$, so that the mint price of silver is less than the technology price. In this case, individuals would demand an infinite quantity of silver from the mint in order to endlessly engage in the following transactions: produce gold using bread according to the technology, demand silver from the mint in exchange for this gold, produce bread from the silver according to the technology, use this bread to produce gold, and so forth. Agents would desire the opposite transactions when $\phi_g^{-1}(t) > \phi_s^{-1}(t)d^{-1}(t)$.

We conclude, therefore, that, when $d(t) \neq \phi_s(t)/\phi_g(t)$, no equilibrium exists under a liberal coinage policy. In other words, the policy that is supposed to support Gresham's law cannot.

Mixed Coinage Policy

Finally, we consider a more realistic policy than the liberal one, what we will call a mixed coinage policy. We relax the assumption that the mint's resources are sufficient to cover the coinage demands of agents in the economy. Instead, we assume that the amount of resources is a binding constraint. Further, we

assume that $d(t) \neq \phi_s(t)/\phi_g(t)$; the mint ratio is not equal to the technology ratio. Consequently (from the above discussion of the liberal coinage policy), we know there will be an infinite demand for either gold or silver from the mint which must necessarily exhaust its resources. Once the resources of the mint have been exhausted, the economy is again under the free coinage policy. The only function the mint then serves is to provide capital gains to individuals who happen to be fortunate enough to exchange one metal for another before the mint runs out of resources.

Thus, the definition of equilibrium under the mixed coinage policy is the same as that under the free coinage policy. Further, only one of the two metals will be held under the mixed policy, and the decision on which that is depends solely on which has the higher rate of return. The decision, that is, is independent of the mint ratio.

However, the mixed coinage policy has one unique implication. Under this policy, both metals may be coined. This can happen if, for example, it pays both to take gold to the mint to exchange it for coined silver and, once the mint runs out of resources, to have gold coined to store. In this case, the coined silver will be melted down and used to produce bread. Consequently, even though the mint ratio does not affect either the relative price of the two metals or the equilibrium of the economy, that ratio might determine whether or not both metals are coined.

Nonetheless, even if both metals happen to be coined under this policy, the economy's equilibrium sequences will not be consistent with Gresham's law. For example, a change in the mint

ratio might cause one metal to start being coined. Since the new coin would merely be melted and turned into bread, though, it would not drive the other coin out of circulation.

References

- Breckinridge, S. P. 1903. Legal Tender: A Study in English and American Monetary History. Chicago: University of Chicago Press. (Reprint. 1969. New York: Greenwood Press.)
- Carlile, William W. 1901. The Evolution of Modern Money. London: Macmillan Company. (Reprint. 1969. New York: Augustus M. Kelley.)
- Fisher, Irving. 1915. Why Is the Dollar Shrinking? New York: Macmillan Company.
- Friedman, Milton, and Schwartz, Anna Jacobson. 1971. A Monetary History of the United States, 1867-1960. Princeton: Princeton University Press.
- Fusfeld, Daniel R. 1976. Economics. 2d ed. Lexington, Mass.: D. C. Heath and Company.
- Galbraith, John Kenneth. 1975. Money: Whence It Came, Where It Went. Boston: Houghton Mifflin Company.
- Jenkinson, Charles. 1805. A Treatise on the Coins of the Realm; in a Letter to the King. London: Effingham Wilson, Royal Exchange. (Reprint. 1968. New York: Augustus M. Kelley.)
- Jevons, W. Stanley. 1918. Money and the Mechanism of Exchange. New York: D. Appleton and Company.
- Kenyon, Robert Lloyd. 1884. Kenyon's Gold Coins of England. London: Bernard Quaritch. (Reprint. 1970. New York: Augustus M. Kelley.)
- Krooss, Herman E., ed. 1969. Documentary History of Banking and Currency in the United States, Vol. 2. New York: Chelsea House Publishers and McGraw-Hill Book Company.

- Laughlin, J. Laurence. 1886. The History of Bimetallism in the United States. New York: D. Appleton and Company.
- _____. 1916. The Principles of Money. New York: Charles Scribner's Sons.
- Leavens, Dickson H. 1939. Silver Money. Bloomington, Indiana: Principia Press, Inc.
- Luckett, Dudley G. 1980. Money and Banking. 2d ed. New York: McGraw-Hill Book Company.
- Mitchell, Wesley Clair. 1903. A History of the Greenbacks. Chicago: University of Chicago Press.
- Moses, Bernard. 1892. "Legal Tender Notes in California," Quarterly Journal of Economics (October): 1-25.
- Prager, Jonas. 1982. Fundamentals of Money, Banking, and Financial Institutions. New York: Harper and Row.
- Sargent, Thomas J., and Wallace, Neil. 1983. A Model of Commodity Money. Research Department Staff Report 85. Federal Reserve Bank of Minneapolis.
- Taxay, Don. 1966. The U.S. Mint and Coinage: An Illustrated History From 1776 to the Present. New York: Arco Publishing Company, Inc.