Nominal Contracts in a Bimetallic Standard

by

Peter M. Garber*
Brown University

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1. Introduction

Delivered nominal units will have different values under different monetary standards. Of particular historical interest are multiple commodity standards, which dominated many of the industrializing countries in the 19th century. The object of this paper is to determine the value of contracts to deliver dollars under a bimetallic standard. Since contracting in bimetallic dollars grants the short interest the option to deliver either gold or silver, a dollar contract can be evaluated by applying results from the options literature. Furthermore, treating the dollar as an option can illuminate the dynamics of the nineteenth century silver agitation.

Under a bimetallic monetary standard, the unit of account is defined as given weights of one or another precious metal.[1] Since the market relative price between the two metals rarely equals the legally implied exchange ratio, the cheaper metallic unit or its value equivalent is delivered to satisfy contracts in the nominal unit.[2]

Most discussions of the bimetallic standard focus on the necessary appearance of a sequence of monometallic epochs which alternate between deliveries of gold and silver money.[3] The observed failure of most bimetallic systems to achieve the simultaneous circulation and delivery of both metals is deemed obvious evidence of the weakness of bimetallism. Economists have proposed more sophisticated metallic or general commodity standards, such as symmetallism or tabular standards, aimed both at circumventing this monometallic circulation and at stabilizing the price level.[4] While many economists expect welfare gains from price level stabilization, it is not clear why recurrent switching from one circulating metal to another should be detrimental of itself.

The following sections contain a method to price nominal contracts under bimetallism. In the development of the pricing model and of the estimates of the bimetallic option values, this paper follows the same strategy as a recent paper by Gay and Manaster (1983) in which the option values of delivering different qualities of wheat in a futures contract are constructed. Section 2 presents a brief history of the nineteenth century U.S. coinage laws relating to bimetallism. Section 3 contains a demonstration of how to evaluate a bimetallic contract using results from the options pricing literature. First, the current value of a contract to deliver dollars one period ahead is developed, based on results in Margrabe (1978), Cox, Ross and Rubinstein (1979), and Stulz (1982). Next, the one period results are extended to determine dollar contract values for continuous time environments. In Section 4, I compute the theoretical values of actual U.S. Treasury securities promising to deliver bimetallic dollars in varying future payment streams. I compare bimetallic theoretical bond prices to actual realized prices and compute the implied option value of the bimetallic bonds relative to gold bonds. Finally, I use the option values to illuminate the progress of the silver agitation in the last quarter of the 19th century. Section 5 contains conclusions and some suggested extensions.

the respective values herein before declared".[5]

Chart I indicates the ratio of the market price of gold to that of silver from 1787-1884. In 1792, as the coinage act was passed, the market ratio was approximately 15/1. However, the ratio permanently rose above 15/1, making silver overvalued at the mint. Since contracting parties would then deliver only silver or its value equivalent to satisfy dollar contracts, the real value of the dollar was the value in terms of goods of 371.25 grains of silver.

In an act of 1834, the dollar was devalued in terms of gold. The ten dollar gold coin would now contain 232. grains (.483 Troy ounces) of gold, a devaluation of 6.3 percent, which changed to 16/1 the weight ratio of silver to gold in the dollar. Since the market relative price fluctuated between 15.5 and 16., this devaluation meant that gold or its value equivalent would now be delivered to satisfy dollar contracts. The act of 1837 slightly revalued the ten dollar coin to 232.2 grains of gold.

In 1853, the full silver weight and unlimited legal tender properties of the fractional coinage were terminated. The amount of silver in the fractional coins was reduced by 7 percent, and they were made legal tender in quantities not exceeding five dollars. Furthermore, the free coinage of fractional coins was terminated. This change meant that the ratio of silver contained in a dollar's worth of fractional coins to gold in the gold dollar was less that 15/1. The law left unchanged the definition of the silver dollar.

In 1859, the enormous Nevada Comstock Lode was discovered, a silver strike which reversed the decline in the relative value of

2. The Legal Evolution of U.S. Bimetallism

In this section I will present a brief chronology of the legal development of U.S. bimetallism. Also, I will describe some of the legislation implemented in the post-1873 agitation to restore the free coinage of silver. I have relied on Laughlin (1888), Dunbar (1893), the U.S. Senate Finance Committee (1894), and Friedman and Schwartz (1963) as sources for this discussion.

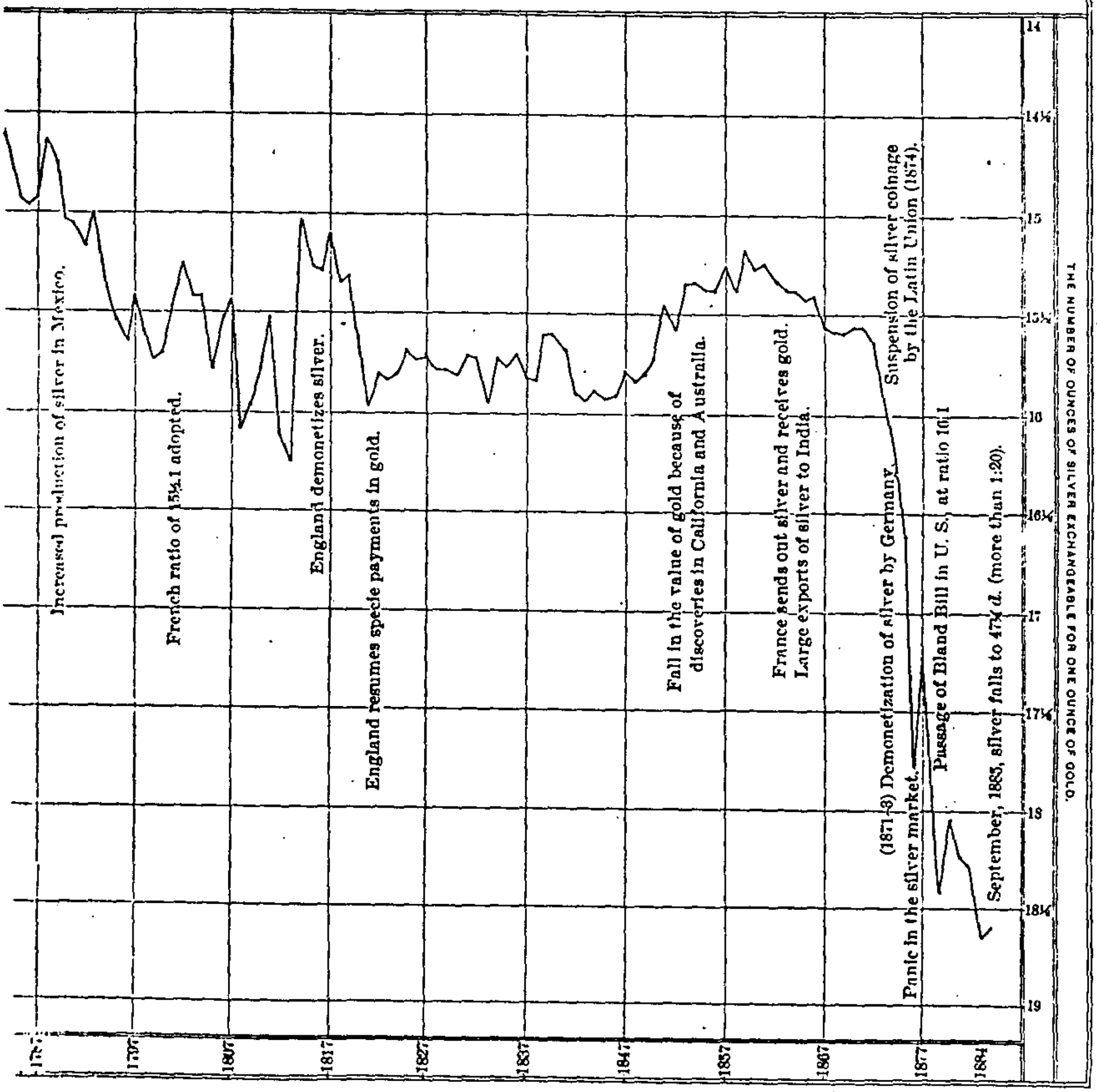
Prior to the adoption of the Constitution, foreign coins, primarily silver Spanish dollars, comprised the specie of the United States. The first national coinage was provided under the act of 1792 which established the mint and defined the dollar as 371.25 grains (.773 Troy ounces) of silver. The law authorized the coinage of a silver dollar and half-dollars, quarter-dollars, dimes, and half-dimes containing corresponding weights of silver. In addition, the mint was authorized to issue ten dollar gold coins (eagles) containing 247.5 grains (.515 Troy ounces) of gold, as well as half eagles and quarter eagles. The law defined the monetary value of a given weight of gold as fifteen times that of the same weight of silver. It provided for free coinage of both metals in that anyone delivering a given weight of a metal to the mint could receive in exchange authorized coins containing an equal weight of the same metal. This service would be provided free of charge if the delivering party were willing to allow the coinage to occur "as speedily as may be after the receipt thereof [of the bullion]". Finally, the law declared that the coins struck at the mint were lawful tender "in all payments whatsoever, those [coins] of full weight according to gold begun in the Californian and Australian strikes in the 1840's. Silver prices slowly declined until 1873 when the accelerating development of the Nevada deposits initiated a rapid fall in the silver price.

In the act of 1873, silver was effectively demonetized. The old silver dollar was not included among the silver coins authorized for minting in the U.S., although a "trade dollar" and fractional coins were allowed. Only these authorized silver coins were given legal tender status for payments not exceeding five dollars. Free coinage of legal tender silver was eliminated. By this act the metallic dollar was effectively defined as a given weight of gold alone.[6] Any contracts for future delivery of dollars were redefined by this act in that only gold or greenbacks could be delivered, where before silver could have been delivered. From the point of view of the government, which delivered only specie on its debt, its contractual option to deliver silver was now removed.[7] In addition to the U.S., other important countries abandoned silver simultaneously, i.e. Germany which had a silver standard and the Latin Union (France, Italy, and Belgium) which had a bimetallic standard.

The change would have been unimportant if the market ratio of gold price to silver price had remained below 16/1, for silver or its value equivalent would not have been delivered in any case. However, concurrent with the law's passage, the market ratio exceeded 16/1, reaching levels over the next twenty years which were unprecedented in the prior two centuries of data. Thus, anyone engaged on the short side of a dollar contract prior

Chart 1

Ounces of Silver Per Ounce of Gold



Source: Laughlin, P. 161

to 1873 would immediately feel the impact of the change in standard as a transfer from himself to his creditors. Similarly, taxpayers would recognize a transfer from themselves to the government's creditors.

The sudden rise in the market ratio triggered a quarter-century agitation to remonetize silver. First fruit of this movement was the Bland-Allison Act of 1878 which reauthorized the issue of the standard silver dollar with legal tender status. Since government obligations required only the delivery of coin, this restored the bimetallic option to the government. However, free coinage of silver was not restored. Rather, the Treasury was authorized to purchase on the open market two to four million dollars worth of silver per month to be minted into silver coins. Since the silver purchased with two million dollars produced more than two million silver dollars, the government earned seignorage from this operation. In addition, the government consistently chose to deliver gold coin on its obligations. In practice, the stock of silver dollars did not grow fast enough under the Bland-Allison Act to threaten the gold standard, defined as the delivery of the 1837 gold dollar or its value equivalent by the short side of nominal contracts.

The Sherman Silver Purchase Act of 1890 repealed the silver purchase provisions of the Bland-Allison Act, replacing them with a requirement to purchase 4.5 million ounces of silver monthly contingent on the silver price's remaining below one dollar for 371.25 grains of pure silver. Payment for the silver was made in Treasury Notes of 1890, a legal tender currency redeemable on demand into gold or silver coin at the option of the government.

Had this law remained in effect indefinitely, it would have increased the domestic credit (silver) component of the money base until only silver coin or notes convertible to silver would have been delivered to satisfy nominal contracts. Effectively, this would have been equivalent to a resumption of free coinage of silver, thereby threatening the continued circulation of gold. Within three years, the gold dollar was sufficiently threatened that the Sherman Act was repealed in the midst of the Panic of 1893.

3. Evaluating a Future Dollar Delivery

The development of the dollar contract pricing solution will proceed in two stages. First, a model of a one period ahead dollar delivery will provide a simple framework with which to illustrate the solution concepts and the usefulness of option pricing methods. Second, the contract price solutions will be developed in a continuous time environment.

a. A Two Period Example

In this example I will find the current value of a contract to deliver one dollar next period. In this section, all prices will be denominated in terms of gold. An individual portfolio will hold a short position in the dollar delivery contract and may hold either long or short positions in silver, gold, and options to supply a unit of gold in exchange for a unit of silver next period. Alternatively, it may contain an option to exchange a unit of silver for a unit of gold. In a continuous time model, Margrabe (1978) has priced an option to exchange one asset for another. I consider this kind of option because Stulz (1982) shows that the current value of a contract to deliver the lesser valued of assets A and B in the future equals the current price of A less the current price of an option to exchange B for A in the future.

In the present context, this result implies that the value of the dollar contract equals the current price of a unit of silver less the current price of the option to exchange gold for silver. Symmetrically, the value of the dollar contract also equals the price of a unit of gold less the price of an option to exchange a unit of silver for a unit of a gold next period. Stulz's result follows from an assumption that neither asset pays dividends prior to the contract's expiration. However, as monetary commodities, gold and silver should yield the usual "flow of intangible monetary services" to an individual's portfolio. Therefore, I will price a dollar contract with a more general assumption that this service flow is positive. My intention in constructing the present example is to provide some intuition for these results. The pricing formulas actually used in the empirical section will be based on generalizations of the two period model.

The procedure involved in finding V, the current value of the dollar contract, borrows directly from concepts in the option pricing literature. In particular, this example is based on the discrete-time model of Cox, Ross and Rubinstein (1979). First, I find appropriate values of gold, silver or exchange option holdings in the current portfolio which perfectly hedge the dollar contract in all future contingencies. The value of the dollar contract can be determined as the value of the opposite positions to the hedging portfolio through a simple arbitrage argument.

The current prices of gold, 1, and of silver, P_S, will move exogenously to the market for dollar contracts. I assume that only two future price pairs (P_S^*, 1) are possible: (βP_S, 1) in contingency 1 or (αP_S, 1) in contingency 2. I will also assume that $\beta P_S > 1$ and $\alpha P_S < 1$. Initially, I will assign the option to exchange a unit of gold for a unit of silver a current gold price of D_S. Later, I will derive D_S. Gold and silver units for delivery in the option are defined as the legal pure gold and silver content of the dollar, respectively.

Table 1 presents payoffs to the various assets under different future price realizations. Specifically, under contingency 1, the short side of the dollar contract would deliver a unit of gold valued at 1 since gold is the less valued metal, given the assumed future price relationship. Under contingency 2, a unit of silver worth αP_S would be delivered.

The variables x and y represent the silver and exchange option positions required to hedge the dollar contract. A positive value for x represents a long position in silver. To acquire a long silver position requires a current expenditure of $P_S x$. Next period, the silver position x will have a value of $\beta P_S x$ and $\alpha P_S x$ in contingencies 1 and 2, respectively. In addition, the monetary service flow from a long position will yield an own rate of return π_S.[8] Treating this service return as a payoff in future gold and defining $r_S = 1 + \pi_S$ yields the contingency 1 and 2 entries in Table 1. Note that a short position in silver requires the direct payment of the silver own rate of interest, since the lender forgoes the silver service flow. This is the analog of a short sale of a stock which pays a dividend; both the future delivery of the stock and the payment of interim dividends are required of the short interest.

A positive y represents a short position or sale of the exchange option. The seller of the option currently receives D_s in exchange for the option. The seller is committed to deliver a unit of silver in exchange for a unit of gold if the buyer exercises the option. In contingency 1, the option will be exercised since $\max(\beta P_s - 1, 0)$ is positive, and the seller of an option incurs an expenditure of $\beta P_s - 1$. In contingency 2, the option will not be exercised and the seller incurs no future expenditure from his option position.

The next task is to find the silver and option positions which perfectly hedge the dollar delivery contract. It is easy to verify that the dollar contract is hedged by a portfolio which is long $1/r_s$ units of silver and short one exchange option. With this portfolio, the net expenditure is zero for both contingencies. Since the opposite position from the hedging portfolio produces exactly the same future expenditure realizations as the dollar contract, precluding the existence of current arbitrage profits requires that $V = P_s/r_s - D_s$. Symmetrically, I could hedge the dollar contract with a portfolio of gold and options to receive gold in exchange for silver so that $V = 1/r_g - D_g$.

Table 1
Receipts and Expenditures in Establishing Asset Positions:
Silver and Exchange Option Portfolio

	Now	Next Period Contingencies 1	2
Dollar Contract	V	-1	$-\alpha P_s$
Silver	$-P_s x$	$\beta P_s r_s x$	$\alpha P_s r_s x$
Exchange Option	$D_s y$	$-(\beta P_s - 1)y$	0

Next, I must derive the value D_s of the exchange option. The option can be hedged with positions in gold and silver alone. The flows associated with asset positions are presented in Table 2. The gold values of the unit of silver in the exchange option are βP_s and αP_s under contingencies 1 and 2, respectively. The exchange option can be interpreted as a standard call option on a unit of silver with a striking price of unity. Since the value of silver in contingency 1 exceeds unity, the option will be exercised, requiring an expenditure of $[\beta P_s - 1]$ from the short position. In contingency 2, the option will not be exercised. The entries for silver in Table 2 are identical to those in Table 1. Analogous to silver, the monetary metal gold yields a monetary service flow denoted by the own rate of return π_g. A long position y in gold will be entered as a receipt of yr_g in both contingencies, where $r_g = (1 + \pi_g)$. Conversely, a short position in gold must not only deliver the borrowed gold next period but also pay the own rate of return π_g.

Table 2
Receipts and Expenditures in Establishing Asset Positions: Silver and Gold Hedging Portfolio

	Now	Next Period Contingencies 1	2
Call Option	D_s	$-(\beta P_s - 1)$	0
Silver	$-P_s x$	$\beta P_s r_s x$	$\alpha P_s r_s x$
Gold	$-y$	$y r_g$	$y r_g$

From Table 2, it can easily be shown that the hedging portfolio is $x = [\beta P_s - 1]/[\beta - \alpha] r_s P_s$, and $y = -[\alpha P_s] r_s x / r_g$. Then, the gold value of the exchange contract is $D_s = [P_s x + y]$. In an analogous manner, the value, D_g, of an option to exchange a unit of silver for a unit of gold can be computed.

b. Pricing a Dollar Delivery Contract in a Continuous Time Model

Stulz (1982) has developed a pricing formula for a European call option on the less valuable of two risky assets in a continuous time framework. A European call option can be exercised only on the expiration date. For the special case in which the striking price is zero, such an option is a contract to deliver one of two assets, where the short position has the option of which asset to deliver. The option will always be exercised at the expiration date, and the short side will always deliver the less valuable of the two assets. This is exactly the contractual arrangement of an agreement to deliver future dollars in a bimetallic standard. If the future delivery is simply the repayment of a previous loan, then the special case of a zero striking price materializes.

Specifically, I will assume that the relative price of silver in terms of gold is driven by the following stochastic process:

$$dP_s/P_s = \mu dt + \lambda dZ \qquad (1)$$

where μ is the instantaneous expected percentage relative price change of silver. λ is the associated instantaneous standard error, assumed constant. Z is a Wiener process. The time t gold price of silver is denoted $P_s(t)$. In addition, gold and silver holdings yield a constant percentage own service flow π_g and π_s, respectively. Again, gold is the numeraire.

Using an argument analogous to that in the previous section, the current market value of an agreement to deliver one dollar at time $t+\theta$ can be expressed as

$$V(P_s(t), \theta) = \exp[-\pi_s\theta]P_s(t) - D_s(P_s(t), \theta)$$

$$= \exp[-\pi_g\theta] - D_g(P_s(t), \theta) \qquad (2)$$

where $D_s(P_s, \theta)$ is the value of an option to deliver a unit of gold in exchange for silver after θ periods. $D_g(P_s(t), \theta)$ is the value of an option to deliver a unit of silver in exchange for a unit of gold.

To see that formula (2) is the appropriate pricing solution for the dollar contract, consider a portfolio long $\exp[-\pi_s\theta]$ units of silver and short an option to deliver one unit of gold in exchange for a unit of silver at time $t+\theta$. At time $t+\theta$, the value of the portfolio's assets is

$$[P_s(t+\theta)\exp(\pi_s\theta)]/\exp(\pi_s\theta) - [P_s(t+\theta) - 1] = 1$$

if $P_s(t+\theta)>1$. The first term represents the future capital value plus the service return evaluated in gold of the long position in silver. The value of the dollar contract is also 1 if $P_s(t+\theta)>1$ for then gold will be delivered. If $P_s(t+\theta)<1$, the dollar contract and the portfolio both are valued at $P_s(t+\theta)$. Since the portfolio and the dollar contract have identical payoffs, precluding profitable arbitrage opportunities guarantees that (2) is the current value of the dollar contract.

To derive the price D_s, assume that gold and silver positions form a hedging portfolio. Margrabe's (1978, p. 179) results imply that pricing an option to exchange gold for silver is then equivalent to pricing a call option on an asset where the exercise price is unity. Since gold is numeraire, the analog to the percentage rate of return on riskless loans in the usual call pricing exercise is π_g. The difference between the current case and Margrabe's example is that both assets pay continuous dividend yields. Therefore, to find the price in gold of the call option requires that I use Merton's (1973) modification of Black and Scholes option pricing formula.[9] The price in gold of the call option is

$$D_s = \exp[-\pi_s\theta]P_s(t)N(d_1) - \exp[-\pi_g\theta]N(d_2) \quad (3)$$

where

$$d_1 = [\ln(P_s(t)) + (\pi_g - \pi_s + \lambda^2/2)\theta]/\lambda\sqrt{\theta}$$

and

$$d_2 = d_1 - \lambda\sqrt{\theta}.$$

$N(z)$ is the value of the cumulative standard univariate normal distribution function evaluated at z. λ^2 is the variance of the percentage change in the relative price between the gold and silver content of the dollar.

Substituting from (3) into (2) completes the calculation of V. More generally, bimetallic coupon bonds which make discrete payments $H(\theta)$ at $\theta = 1, 2, 3, \ldots, N$, have a current value of

$$VB(P_s(t)) = \sum_{\theta=1}^{N} V(P_s(t), \theta)H(\theta) \quad (4)$$

4. The Nominal Values of U.S. Bimetallic Securities

In this section I will apply the nominal contract pricing formula to compute the theoretical value of default free bonds promising to pay bimetallic dollars. I will employ formula (4) except that I will compute security values in nominal rather than in gold terms. I simply multiply (4) by $\hat{P}_g$, the nominal value of the gold dollar. For P_s, the price of the silver dollar in terms of gold dollars, I substitute $\hat{P}_s/\hat{P}_g$, where $\hat{P}_s$ is the nominal value of the silver dollar. $\hat{P}_s$, $\hat{P}_g$, π_s, and π_g are obtained from actual observations. I report the steps required to compute $\hat{P}_g$ and $\hat{P}_s$ in the Appendix. For π_g, I use the beginning of January yield on British 3% Consols from 1818-1882 and 2.5% annuities from 1883-1895. Since Great Britain adhered to a monometallic gold standard for most of the period and paid these loans in gold throughout the period, the Consol and annuity yields represent the yield on pure gold loans. For π_s, I used the beginning of January yield on various long term Prussian loans. Along with the rest of the German states, Prussia maintained a pure silver standard through 1873, so these yields represent the yield on pure silver loans. However, in 1873 Prussia switched to a gold standard. Since there was no major country other than India on a silver standard after this time, I have simply continued to use the 1873 silver yield for the remaining years of the sample.[10] This might understate the actual yield since silver depreciated rapidly in this period.

I estimated λ^2 for each year by computing the sample variance of actual percentage changes in the relative value of the gold dollar to the silver dollar. In the results which I will report here, the sample consists of the ten previous years' percentage changes. I have also constructed estimates for λ^2 by sampling backward fifteen years and by sampling forward ten and fifteen years. The computed theoretical values of bond prices hardly vary with these changes in the method for computing estimates of λ^2. Based on estimates of λ^2, these computed values of the bimetallic bond prices are themselves estimates of the true bimetallic bond prices. All the series substituted in formula (4) are reported in Table 7 in the Appendix.

a. Potential Problems in Applying the Bimetallic Pricing Formula

Options Excluded from the Pricing Formula

The pricing formula for the dollar contract was derived from the assumption that only the bimetallic option was available for the debtor. In practice, several other options were available to the government in paying off its securities; and these may cause the observed market prices to deviate from the theoretical prices.

First, the government had the option of directly defaulting on its obligations. However, this was an unlikely step for a government as well-established as that in the U.S. in the 19th century. More likely, the government would default indirectly either by devaluing the legal content of the dollar in terms of one or both metals or by adding a new overvalued legal tender. The U.S. government exercised both of these options in the 19th century in the 1834 devaluation and the 1862-78 addition of greenbacks as an overvalued legal tender. Neither of these changes affected the payment streams of existing government debt. By 1834, the federal government had paid off the national debt, so the devaluation affected only private obligations. However, to the extent that the public anticipated future possible devaluations prior to 1834, the anticipated relative price movement of the metal content of the dollar would consist of the anticipated market movement of the relative price of pure ounces of metal <u>and</u>

anticipated movements in the ratio of silver to gold in the dollar.

The greenbacks were made legal tender for all payments except interest payments on the public debt, and the government continued to pay gold coin on its debt throughout the greenback era. However, since the repayment of principal with U.S. Notes was not explicitly prohibited, there was extensive fear that the government would pay the principal in paper currency. This possiblity ended in the March, 1869 Public Credit Act, which assured future payment in coin. From 1862-69, however, the possibility of repayment in greenbacks forced high nominal yields on government debt and produced a wide divergence between bimetallic security values and the actual prices of government debt.

In most of its bonds, the U.S. government maintained a redemption option; typically, a contract stated that the bond was redeemable at the option of the government after a given date. Rarely was there an explicit maturity. The existence of this feature made the duration of the payments stream uncertain to the lender and may therefore have affected the price of the bond. However, since most bonds were issued at high wartime coupon rates, the government almost always redeemed them immediately after reaching the contracted earliest redemption date.

In a few issues, the government gave the lender a par convertibility option into other securities. The option could be exercised on demand or, in some cases, after a certain period of time. In addition, the government gave holders of certain securities an ex-post convertibility option, although the option was not a feature of the written contract. Because of difficulties with pricing convertible securities, I have eliminated the contractually convertible bonds from the sample.

An additional option of the government was the possibility of switching to a monometallic payment policy. Thus, it might have decided to continue delivering gold to pay off its debt even if silver became the overvalued metal. While this option would add to the cost of paying off the debt, it was the option actually exercised in the 1873 removal of the free coinage and legal tender status of silver; and it continued in force even after the restoration of legal tender silver dollars in 1878.

Other Assumptions in the Pricing Formula

In deriving the pricing formula, I assumed that the yield on pure gold and silver loans is independent of the length of the loan. However, the actual rates vary across observations. Agents, accounting for this variation, would act so that realized prices would differ from the bimetallic formula's prediction. For the series on pure silver loans, I have used yields on the long term bonds of Prussia, which switched from a silver to a gold standard in the 1870's. These data may not represent the interest payments on pure silver loans if anticipations of a possible switch were built into the bond prices of the silver standard era.

Finally, the pricing formula is based on an assumption that the relative price between silver and gold is exogenous to which metal circulates in the bimetallic country. However, since some metal circulates as a medium of exchange, it is reasonable to presume that a switch in the circulating metal would feed back on the relative price. To avoid this problem requires a small country assumption for the bimetallic countries.

b. Empirical Results: Realized Prices, Theoretical Prices, and the Value of the Bimetallic Option

The periods from 1818-1834 and from 1843-1859 can be considered the heyday of the bimetallic dollar. Prior to 1818, the circulation of Treasury Notes in the War of 1812 led to a suspension of specie payments and a divergence of the dollar from its metallic definition. By 1818, this divergence had terminated and the possibility that the government might default disappeared. Also, Great Britain and Prussia were firmly attached to the gold and silver standard, respectively. From 1834-1843, the government either had no debt at all or the debt consisted only of short term notes for which no meaningful price quotations are available. By 1860, the credit of the country was in question, and from 1862-69 the public feared that the government would pay principal in greenbacks. The bimetallic standard free from fears of default was restored only from 1870 to 1873, but the bill to remove free coinage and legal tender status for silver was already moving through the Congress.

In Table 3, I report actual prices and predicted bimetallic prices for 18 different bond issues in the market from 1818 to 1896.[11] I also report the theoretical value which each bond would have if its promised dollar payments were explicitly gold dollars.

Finally, I report the bond's bimetallic option value relative to a pure gold standard, i.e. the value of an option to deliver silver in exchange for gold. I compute the option value

Table 3

Bond Prices: Actual, Predicted Bimetal, Option Value, and Gold Bond

Year	7% Stock of 1815 Actual	Bimetal	Option	Gold	5% Loan of 1820 Actual	Bimetal	Option	Gold
1818	109.5	105.5	17.6	123.0				
1819	104.5	106.6	9.7	123.0				
1820	104.0	104.4	8.4	112.8				
1821	108.9	104.4	11.7	116.0	102.5	93.9	18.0	111.9
1822	107.0	104.3	10.6	114.8	109.0	96.7	18.4	115.1
1823	103.5	102.9	9.3	112.2	106.0	96.8	18.5	115.3
1824	102.3	102.5	6.8	109.3	106.5	103.5	13.3	116.7
1825					110.3	103.0	12.1	115.1
1826					100.0	101.5	9.6	111.1
1827					109.3	101.8	9.5	111.3
1828					108.8	102.1	7.0	109.1
1829					101.6	102.8	7.4	110.2
1830					100.0	101.2	8.1	109.3
1831					101.0	100.7	6.3	107.0

Year	5% Loan of 1821 Actual	Bimetal	Option	Gold	4.5% Loan of 1824 (5/24/24) Actual	Bimetal	Option	Gold
1822	109.0	95.9	21.3	117.2				
1823	105.8	96.0	21.8	117.8				
1824	107.0	104.5	15.6	120.2				
1825	111.0	104.0	15.3	119.4	105.5	100.2	11.9	112.0
1826	100.0	102.1	12.0	114.2	98.8	99.0	9.4	108.4
1827	108.5	102.8	11.4	114.2	102.0	99.7	9.3	109.0
1828	107.5	103.5	9.1	112.5	100.5	100.4	6.9	107.3
1829	106.0	105.3	9.0	114.3	98.5	101.5	7.3	108.8
1830	105.0	102.8	11.6	114.4	101.3	100.3	8.1	108.3
1831	105.8	102.6	8.0	110.6	102.3	100.2	6.3	106.5
1832	103.8	102.0	7.7	109.7				
1833	101.3	101.6	8.96	110.6				
1834	100.0	101.0	6.37	107.3				

Year	Exchange 4.5% Stock of 1824 Actual	Bimetal	Option	Gold
1825	105.0	100.2	14.0	114.1
1826	97.8	98.8	11.0	109.7
1827	102.3	99.6	10.6	110.2
1828	103.0	100.5	8.3	108.8
1829	101.0	102.3	8.4	110.7
1830	102.5	100.5	10.3	110.8
1831	103.5	100.7	7.4	108.0
1832	100.3	100.4	7.0	107.4
1833	100.1	100.4	8.2	108.6

Table 3 (Continued)

Bond Prices: Actual, Predicted Bimetal, Option Value, and Gold Bond

Year	Loan of 1842 Actual	Bimetal	Option	Gold	Loan of 1843 Actual	Bimetal	Option	Gold
1843	101.0	128.8	12.2	141.0				
1844	115.8	133.5	7.7	141.1	103.6	111.1	4.2	115.4
1845	114.5	132.6	8.5	141.1	103.0	111.0	3.7	114.7
1846	107.5	128.5	8.1	136.6	98.5	108.5	3.5	112.0
1847	101.0	127.9	6.5	134.4	91.5	108.3	2.0	110.3
1848	98.5	116.8	11.6	128.4	91.5	102.6	4.6	107.2
1849	107.0	122.7	6.0	128.7	99.3	105.1	1.6	106.6
1850	108.8	119.3	11.3	130.6	100.1	103.6	2.5	106.2
1851	112.5	123.5	5.0	128.5	102.0	104.3	0.2	104.5
1852	111.5	122.8	4.0	126.8	100.9	102.6	0.1	102.8
1853	114.3	121.1	4.5	125.6	100.0	101.0	0.0	101.0
1854	116.5	117.0	4.4	121.3				

Year	Loan of 1846 Actual	Bimetal	Option	Gold	Loan of 1847 Actual	Bimetal	Option	Gold
1848	96.8	111.4	7.4	118.8	99.3	120.4	14.7	135.0
1849	104.5	114.8	3.2	118.0	108.3	128.0	8.1	136.0
1850	106.5	112.0	5.9	118.0	111.0	124.1	15.4	139.4
1851	107.0	114.0	1.5	115.6	115.3	129.6	8.0	137.6
1852	105.0	112.0	1.3	113.3	116.3	129.9	6.3	136.2
1853	108.5	110.3	0.9	111.2	119.8	128.0	7.3	135.8
1854	106.5	107.4	0.4	107.8	121.1	122.7	8.1	130.8
1855								
1856								
1857								
1858					112.5	118.9	4.8	123.7
1859					114.0	115.2	7.3	122.0

Year	Loan of 1848 Actual	Bimetal	Option	Gold
1849	109.0	128.4	8.4	136.8
1850	112.3	124.5	15.8	140.2
1851	115.4	130.2	8.3	138.5
1852	117.0	130.6	6.6	137.1
1853	119.5	128.6	8.1	136.7
1854	121.3	123.2	8.5	131.6
1855				
1856				
1857				
1858	112.0	119.6	5.2	124.7
1859	111.0	115.8	7.7	123.5

Table 3 (Continued)
Bond Prices: Actual, Predicted Bimetal, Option Value, and Gold Bond

	Loan of 1858				Loan of 1860			
Year	Actual	Bimetal	Option	Gold	Actual	Bimetal	Option	Gold
1866	92.5	155.6	2.8	158.4	96.5	152.1	1.2	153.2
1867	102.5	143.7	4.4	148.1	105.0	140.8	1.8	142.6
1868								
1869	114.0	138.5	7.4	145.8	120.0	138.1	1.5	139.6
1870	110.0	125.0	4.7	129.7				
1871	105.0	115.7	0.5	116.3				

	Loan of July and August, 1861				5% Loan of 1881			
Year	Actual	Bimetal	Option	Gold	Actual	Bimetal	Option	Gold
1868	108.4	158.6	14.1	172.7				
1869	113.8	151.	21.8	172.7				
1870	117.1	135.9	17.5	153.4				
1871	110.3	130.5	6.9	137.4				
1872	115.0	126.2	7.9	134.1	110.0	117.7	7.4	125.1
1873	114.6	129.2	5.3	134.6	111.3	121.2	5.0	126.1
1874	117.3	122.1	8.1	130.2	111.0	115.1	7.6	122.7
1875	118.3	121.5	8.5	130.0	113.8	115.3	8.0	123.2
1876	119.6	116.9	11.6	128.4	116.9	111.6	10.9	122.5
1877	114.1	111.9	7.5	119.3	112.0	107.5	7.0	114.6
1878	106.6	96.8	12.4	109.2	105.3	93.7	11.8	105.6
1879	106.4	88.0	18.8	106.7	107.0	85.8	18.1	104.0
1880	104.3	91.4	12.9	104.2	103.4	89.9	12.4	102.3
1881	101.5	87.3	14.1	101.5	101.5	86.7	13.8	100.5

	4.5% Loan of 1891				4% Loan of 1907			
Year	Actual	Bimetal	Option	Gold	Actual	Bimetal	Option	Gold
1878	103.3	95.5	18.9	114.5	101.75	90.3	25.0	115.3
1879	104.9	88.0	26.0	113.9	99.5	83.4	32.2	115.6
1880	106.4	92.6	21.2	113.8	103.0	88.0	28.9	116.8
1881	102.0	89.9	23.3	113.1	112.5	85.7	31.5	117.2
1882	114.4	91.3	21.1	112.4	117.6	87.3	30.2	117.5
1883	113.1	88.0	24.6	112.6	119.5	84.5	35.8	120.2
1884	114.9	88.8	23.5	112.3	123.8	85.5	37.0	122.6
1885	112.6	86.8	23.8	110.6	121.8	83.9	37.4	121.3
1886	112.8	80.6	28.1	108.7	123.0	78.2	41.1	119.3
1887	110.3	79.7	28.0	107.7	127.5	77.6	43.0	120.6
1888	107.5	76.5	30.0	106.5	126.0	74.8	47.1	121.9
1889	108.5	72.9	31.3	104.2	126.0	71.6	46.0	117.6
1890	105.0	75.7	27.0	102.8	126.3	74.8	44.4	119.2
1891	102.0	82.4	18.5	100.9	121.0	81.7	36.2	117.9
1892					117.0	73.7	44.6	118.3
1893					113.5	64.4	53.5	117.8
1894					113.0	53.5	64.5	118.1
1895					113.3	52.3	65.8	118.1
1896					110.0	51.7	66.5	118.2

Table 3 (Continued)
Bond Prices: Actual, Predicted Bimetal, Option Value, and Gold Bond

	Loan of 1904				Loan of 1925			
Year	Actual	Bimetal	Option	Gold	Actual	Bimetal	Option	Gold
1895	117.0	56.3	65.4	121.7				
1896	113.3	55.3	65.2	120.4	116.3	51.5	86.9	138.4

Table 4
Characteristics of Bonds in the Sample

Bond Number	Name of Bond	Coupon Rate	Payment Period	Date Redeemable
1	7% Stock of 1815	7%	Quarterly	January, 1825
2	War Loan of 1815	6%	Quarterly	January, 1827
3	War Loan of 1812 a. 6% Loan of 1812 b. Exchanged 6% Stock of 1812	6%	Quarterly	January, 1825
4	War Loan of 1813 a. 16 Million Loan of 1813 b. 6 Million Loan of 1813 c. Undesignated Loan of 1813	6%	Quarterly	January, 1823
5	War Loan of 1814 a. Ten Million Loan of 1814 b. Six Million Loan of 1814 c. Undesignated Loan of 1814	6%	Quarterly	January, 1827
6	5% Loan of 1820	5%	Quarterly	January, 1832
7	5% Loan of 1821	5%	Quarterly	January, 1835
8	4.5% Loan of 1824 (5/24/24)	4.5%	Quarterly	January, 1832
9	Exchange 4.5% Stock of 1824	4.5%	Quarterly	January, 1834
10	4.5% Loan of 1824 (5/26/24)	4.5%	Quarterly	January, 1832
11	Exchange 5% Stock of 1822	5%	Quarterly	January, 1833
12	5.5% Loan of 1841	5.5%	Quarterly	January, 1845
13	6% Loan of 1841	6%	Quarterly	January, 1845
14	Loan of 1842	6%	Semiannual	January, 1863
15	Loan of 1843	6%	Semiannual	January, 1853

Table 4 (Continued)
Characteristics of Bonds in the Sample

Bond Number	Name of Bond	Coupon Rate	Payment Period	Date Redeemable
16	Loan of 1846	6%	Semiannual	December, 1856
17	Mexican Indemnity Stock	5%	Semiannual	January, 1852
18	Loan of 1847	6%	Semiannual	January, 1868
19	Loan of 1848	6%	Semiannual	July, 1868
20	Loan of 1858	5%	Semiannual	January, 1874
21	Loan of 1860	5%	Semiannual	January, 1871
22	Loan of July and August, 1861 (Includes Loan of 1863)	6%	Semiannual	July, 1881
23	5% Loan of 1881	5%	Quarterly	April, 1881
24	4.5% Loan of 1891	4.5%	Quarterly	July, 1891
25	4% Loan of 1907	4%	Quarterly	July, 1907
26	Loan of 1904	5%	Quarterly	January, 1904
27	Loan of 1925	4%	Quarterly	January, 1925

by subtracting the bimetallic bond value from that of the gold bond. The option value represents the wealth transfer from a debtor to a creditor of a sudden switch from a bimetallic standard to a gold standard. For the period 1818-1834, the option value produced discounts in dollar bonds of from 6% to 17% from the value of the gold bond. The 6% minimum discount represents the amount by which the gold dollar was undervalued at the mint at the time of the 1834 devaluation. For example, the 5% Loan of 1821 had an option value of 6.37 dollars at the time of its expiration in 1834; this amount is the value of an "in the money" option just before its expiration date. Discounts much above 6% occur early in the life of a bond and represent the possibility that the value of silver may decline greatly during the remaining life of the loan.

By the 1840's there had been a 6% devaluation of the gold dollar and large gold discoveries which guaranteed that gold would circulate as money. In this period, the option feature of the bimetallic contract was an "out of the money" option, so the option component produced a much lower percentage discount from the value of a gold bond relative to the earlier period.[12]

By 1873, even after a rapid depreciation of silver, the option feature of the bimetallic bond was still "out of the money". The Loans of 1858 and 1860, which were extinguished before the 1873 demonetization of silver, attach little value to the silver delivery option. Even the longer term loans attach values to the bimetallic option in the early 1870's which are comparable to those prevailing in the 1840's when there was little chance of exercise. Thus, there appears to have been a transfer from debtor to creditor in eight year loans, i.e. in the Loan of July and August, 1861 and the 5% Loan of 1881, of no greater than 5% of the value of the debt when silver was demonetized in 1873.

Only by the late 1870's with the continued decline in silver did the option value rise to unprecedented levels. By this time, the dollar was de facto a gold dollar, as evidenced by the near equality between the realized bond values and the gold bond values. This equality emerges for the first time in the entire sample in the late 1870's. The bimetallic option values are indicative of the magnitude of the transfer from creditor to debtor which would have occurred with the reintroduction of free silver. By the 1890's, the potential transfer reached levels exceeding 50% of the realized value of the bonds. The rapidly increasing potential transfer parallels the increasing intensity of the silver agitation, which reached its peak in the mid-1890's.

For the period 1818-1834, 1842-1859, and 1818-1859, I have formed a regression equation

$$B_{jt} = \phi_1 PG_{jt} - \phi_2 EG_{jt} + u_{jt}, \quad (5)$$

where B_{jt}, PG_{jt} and EG_{jt} are the realized price, the gold bond value, and the value of the option to acquire a unit of silver in exchange for a unit of gold, respectively, of bond j at time t. If the option features other than the bimetallic option are of minor importance in determining the bond's market value, then $\phi_1 = \phi_2 = 1$. Carrying out an ordinary least squares regression for a data set consisting of the 71 observations from 1818-1834, the results are:

Table 5
Relation Between Bond Price, Gold Bold and Gold Exchange Option

Period	ϕ_1	ϕ_2	R^2	Observations
1818-1834	.96 (.0093)	.31 (.095)	.999	71
1842-1859	.96 (.013)	1.82 (.223)	.997	52
1818-1859	.91 (.012)	.10 (.15)	.995	123

I have also formed the analog to (5) using PS_t, the price of the bond if payments were in silver dollars, and ES_t, the price of the exchange option of gold for silver:

$$B_{jt} = \phi_1 PS_{jt} - \phi_2 ES_{jt} + u_{jt}, \quad (6)$$

The parameter estimates are contained in Table 6.

Table 6
Relation Between Bond Price, Silver Bond, Silver Exchange Option

Period	ϕ_1	ϕ_2	R^2	Observations
1818-1834	1.003 (.0051)	-.54 (.22)	.999	71
1842-1859	.95 (.012)	3.00 (.58)	.997	52
1818-1859	.97 (.011)	.91 (.50)	.994	123

In the case of the silver bond and silver exchange option for the entire period, the estimators are appoximately as predicted. For the sub-periods and for all the gold bond estimates the coefficients of the exchange options differ significantly from predicted values. This divergence of the parameter estimates from the theoretical predictions is not atypical of results in the empirical options pricing literature. For example, Gay and Manaster (1983), in regressions of futures prices on current wheat prices plus storage costs and on the delivery quality option value find that their estimates diverge significantly from the theoretical prediction. In the bimetallic case, other option features may have been important in these bonds in the pre-Civil War period. Alternatively, a bias built into the option value estimate may affect the results.[13]

5. Conclusion

Modern finance theory has provided methods for pricing a wide variety of previously inaccessible assets. A natural realm of application of recent option pricing developments lies in evaluating nominal contracts under bimetallism. Once the option feature of such contracts can be priced, the magnitude of the transfer involved in switching from a bimetallic to a gold standard can be determined. A trace of the dynamics of the option value serves as a backdrop for the dynamics of the 19th century silver agitation. More generally, the realization that pricing formula for the simple bimetallic option is available generates an anticipation that contracts with more complicated additional option features may also be evaluated.

Notes

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1 More accurately, legal tender coins defined as equal to a certain number of units of account contain precisely defined weights of one or the other precious metal.

2 Rolnick and Weber (1983) have recently discussed circumstances under which Gresham's Law will not apply, using the U.S. bimetallic and greenback periods as examples. Even in such circumstances the value equivalent of the overvalued metal will be delivered to satisfy dollar contracts.

3 This is particularly true of Laughlin (1888) who was strongly opposed to bimetallism. However, less partisan writers such as Marshall (1887), Fisher (1923), and Barro (1978) also raise this issue. For a concentration on the delivery option dimension of bimetallism, see Jevons (1899). Also, see U.S. Congress (1877), p. 11, pp. 91-101, for a statement of the nature of the option feature from the pro-bimetallic camp.

4 Symmetallism prescribes the definition of the dollar in terms of a basket of metals, where a given weight of each metal is contained in the basket. There is no option associated with the

short interest. In a tabular standard, the dollar is valued according to a particular price index. See e.g. Friedman (1984) for a recent description of a tabular standard and Marshall (1887) on symmetallism.

[5] Why a bimetallic standard was the preferred standard of the political process is not clear. Although carefully considered, the reasons for selecting the 1792 system outlined by Hamilton (1791) seem to have had their basis in the existing system of circulating coinage bequeathed to the U.S.

[6] The greenbacks, introduced in 1862, were also legal tender; but by 1879 they were redeemable in coin under the Resumption Act of 1875.

[7] There is some evidence that silver was demonetized in anticipation of the decline in its relative price. See e.g. O'Leary (1960).

[8] One can interpret the silver and gold positions as positions in pure silver and gold loans instead of as holdings of the metal coins. π_s and π_g then represent the own rate of return on silver and gold loans, respectively.

[9] For a simplified discussion of this formula, see Smith (1976, p.26).

[10] In the appendix I discuss the nature of Indian rupee bonds and their rate of return.

[11] I have calculated similar series for nine other bonds issued in this period. Since the pattern is similar to those reported in Table 3, I have not included them in this report.

[12] The Loans of 1842, 1847 and 1848 expired in 1863, 1868, and 1868, respectively. The relatively high value of the option for these bonds reflects their long remaining lives. The shorter term Loans of 1843 and 1846 had very low option values in this period.

[13] Since they are non-linear functions of the unbiased λ^2 estimates, the bimetallic bond estimates are generally biased, as shown by Butler and Schachter (1983a, 1983b, undated). Typically in the options pricing literature, no correctives are applied to remove the bias. Though Butler and Schachter have provided such a corrective, I have not applied it at this stage, so the results reported in this section, though consistent with standard practice in the options pricing literature, are biased.

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Data Appendix

I have used several price and yield series in computing the dollar contract prices in the text. In particular, I employ series on both the market nominal prices of and the relative price between the quantities of gold and silver legally contained in the dollar. In addition, I have used yield series on bonds requiring the delivery of only gold or only silver. In this appendix, I will describe the construction of these series.

The Ratio of Fine Ounces of Gold to Fine Ounces of Silver

From 1800-1817, I used annual average ratios of nominal gold to nominal silver prices, as reported in Laughlin, p. 290. These were market ratios gathered by Soetebeer from trading in Hamburg.

From 1818-1896, I used the nominal prices of standard gold and standard silver in London in early January, as reported in The London Times through 1844 and in The Economist from 1845-1896. The silver prices for 1824 and 1825 were taken from Tooke (1838, p. 385). I have used London rather than New York prices because of the greater standardization of the metals which were traded in London. Throughout the century, London was the central market for silver. Weekly New York prices for American gold coin, Spanish gold doubloons, and Spanish silver dollars are available from 1817 in the New York Commercial. However, as discussed in government papers written by Treasury Secretary Ingham in 1830 [see Senate Executive Document No. 58 (1879), pp. 558-584] recommending the use of London prices to gauge the market ratio between gold and silver, the weights of the coins traded in New York varied sufficiently that one can place no faith in their consistency. By the time of the Civil War, the New York gold market had become an active and accurate indicator of the market price of standard gold. Also, by the 1870's accurate silver prices are available from New York trading. However, to maintain consistency, I use the London prices throughout. Since most government bond prices were taken from mid-January or later, I chose early January gold and silver prices to allow for the transmission of information about metal price movements to New York.

To begin the construction of the series, let p'_g and p'_s represent the nominal price in pence of an ounce of fine gold and silver, respectively. From 1822 onward, Great Britain maintained a gold standard in which one ounce of gold, 11/12 fine, had a nominal value of 934.5 pence. Since a standard ounce of silver was 37/40 fine, Laughlin, p.295, provides a formula for producing the market ratio of the number of ounces of fine silver to an ounceof fine gold: $p'_g / p'_s = 943/x$ where x is the current price of standard silver in pence.

For 1818-21, the nominal price of gold varied, and there was no direct market quote for standard gold. However, the London Times provided prices for "Foreign Bar Gold". I presumed that foreign bar gold was standard gold. The price of standard gold multiplied by 12/11 is the price of fine gold, i.e. p'_g = [(Foreign Bar Price in Pence)]*12/11. Then the ratio of fine silver to fine gold for 1818-21 is: $p'_g/p'_s = p'_g / [x \; 40/37]$.

I will refer to an element of this series as q_t. For 1800-1895, I report the values of q_t in Table 7.

The Nominal Values of the Gold and Silver Content of the Dollar

From the q_t series, I computed the nominal prices $\hat{P}_g$ and $\hat{P}_s$ of the legal amount of gold and silver in the dollar, respectively. For the entire sample, the legal silver content of the dollar was .7733 fine ounces. Through 1834, the legal gold content of the dollar was 24.75 grains or .0515625 fine ounces. From 1835 to 1837, the legal gold content was 23.2 grains or .048333 fine ounces; and from 1838 onward, the legal gold content of the dollar was 23.22 grains or .048375 fine ounces.

Until 1834, silver was overvalued at the mint, so silver coins circulated in payment of dollar obligations. The nominal price of the silver dollar, $\hat{P}_s$, was therefore one dollar; and the nominal value of an ounce of fine silver was 1.293 dollars. The nominal value of the gold dollar can be determined from the market relative price between gold and silver, the nominal price of silver, and the gold content of the dollar. Through 1834, $\hat{P}_g = 1.293 \times q_t \times .0515625 = .06667 q_t$.

From 1835 to 1861, the gold dollar circulated as money, so the nominal price of the gold dollar was one dollar. From 1835-37, the nominal price of a fine ounce of gold was therefore 20.689669 dollars; while from 1838-61, the nominal value of a fine ounce was 20.671835 dollars. The nominal value of the silver content of the dollar was $\hat{P}_s = 20.6897(.7733)/q_t = 16./q_t$ from 1835-37; and from 1838-61, $\hat{P}_s = 20.67184(.7733)/q_t = 15.9855/q_t$.

From 1862-78, greenbacks were delivered in payment of dollar contracts (except government debt payments and explicit gold loans). However, an active gold exchange began in January, 1862, so the nominal market price of the gold dollar $\hat{P}_g$ is directly available on a daily basis for this period. I have taken price data from Mersereau (1877) to coincide with the dates for which bond prices are reported. The nominal price of the silver dollar is $\hat{P}_s = .7733P_g/(.048375q_t) = 15.9855P_g/q_t$.

From 1879-96, gold again circulated so the nominal price of the gold dollar was one dollar and that of the silver dollar was $\hat{P}_s = 15.9855/q_t$. For the period 1800-96, I report the nominal prices of the gold and silver content of the dollar in Table 7.

Bond Prices and Characteristics

For the prices of U.S. government bonds, I have used January issues of the weekly quotes in New York Prices Current from 1800-1817. From 1817-1876, I have used the January price quotes from New York Commercial. From 1877-96, I have used January price quotes from Commercial and Financial Chronicle. When quotes were listed as a bid-asked spread, I let the average represent the price. Since some outstanding securities were not listed every day, I could not always employ price quotations from the same day. Most often, I used prices in the middle of January, but for some issues in some years, I had to employ price information from the end of January or the beginning of February. In Table 3, I list the prices of some bonds used in the sample years. In Table 4, I list the coupon and redemption characteristics of these bonds; this information was taken from Bayley (1881) and DeKnight

(1900).

I did not include every bond issued as part of the sample. For some issues the repayment period was completely at the discretion of the government, so they were hard to price. Therefore, I did not include such loans as the 5.5% Stock of 1795, the 4.5% Stock of 1795, the Navy 6% Stock, the Converted 6% Stock of 1807, the Temporary Loan of 1812, the Mississippi Stock, the 5% Loan of 1816, and the Bounty-Land Scrip. For Treasury Notes, the issue and redemption dates were uncertain, so I could not interpret the nature of the payment stream represented by a given price. Thus, I had to eliminate short term debt issued in the War of 1812, the 1837-40 depression, the Mexican War and the Civil War from the sample. Also eliminated are the 5-20's of the Civil War, the Consols of 1865, and the Consols of 1868 because of the uncertain redemption time associated with these issues. Finally, the 7-30's of 1864 and 1865 were eliminated because they contained a contractual convertibility feature and because they were payable in greenbacks. Included in the sample are 27 of the approximately 125 government securities issued between 1790 and 1895.

To derive the yield on a pure gold loan, I used the early January London ex-coupon prices of 3% Consols from 1818-82. I found these prices in issues of The London Times from 1818-1845 and in The Economist from 1846-82. After 1882, I used the London prices of 2.5% annuities as reported in The Economist to compute the gold loan yield because the consol price was affected by an increasing probability of par redemption as the market yield declined. See Homer (1963), pp. 192-200 or Fenn (1883), pp. 24-30 on this issue.

To derive the yield on pure silver loans, I used the prices of Prussian bonds from 1818 to 1873, a period when Prussia was on a pure silver standard. These yields are available in Kahn (1884, p. 209-212). From 1818 to 1843, I used the end of December prices for 4% government bonds to derive silver yields applicable to January of the next year. From 1844 through 1868, I used end of December prices for 3.5% government bonds. For the 1870 yield, I used the March 30, 1870 price of 4% bonds because of the termination of the 3.5% price series. For the January, 1871 and 1872 yields, I used the end of December, 1870 and 1871 prices of 4% bonds. For the 1873 yield, I used the December, 1872 price of 4.5% bonds because of a break in the 4% series. For 1874-1896, I simply continued to use this 1873 silver bond yield of 4.03%.

Since India was also on a silver standard until it shifted to a gold standard in 1894, an alternative would have been to use the yield on rupee bonds to represent the silver loan yield for 1874-1893. India shifted from a bimetallic to a silver standard in 1835. However, since India was governed by the East India Company, rupee bonds were not traded in London. The only official external borrowing was represented by the sterling denominated debt of the East India Company. With the rebellion of 1857, the East India Company was replaced by the Imperial Government as the Government of India, and immediately this government began to finance itself by selling securities in London. Since the Government of India was a creature of the British government, its debt was considered almost as secure from default as British government debt.

Indian debt was mainly denominated in sterling, but a large amount of rupee paper traded in London. A category of rupee debt called "Enfaced Paper" was the most regularly quoted in the London markets. The rupee coupon and principal of Enfaced Paper was payable in London as a rupee draft on Calcutta. The most often quoted of the Enfaced Paper was the 4% Enfaced Paper. Since this instrument was payable on three months notice, it was comparable in its option features to the British 3% Consols. The yields on this security for 1871-1893 as reported in Table 8 do not differ greatly from the 4.03% yield that I employed for the last twenty years of the sample.

Table 8
Percentage Yields in January on 4% Enfaced Paper

Year	Yield
1871	4.14
1872	3.94
1873	3.87
1874	3.92
1875	
1876	3.82
1877	3.99
1878	4.13
1879	
1880	
1881	3.93
1882	
1883	3.88
1884	
1885	3.92
1886	3.99
1887	4.11
1888	3.94
1889	4.01
1890	3.98
1891	3.98
1892	3.84
1893	3.77

Source: The Economist, various issues.

Table 7

Data

YEAR	DOLLAR PRICE OF GOLD	DOLLAR PRICE OF SILVER	GOLD RATE OF RETURN	SILVER RATE OF RETURN	LAMBDA SQUARE
1818	1.0235300	1.0000000	0.0369231	0.0598489	0.0007918
1819	0.9984404	1.0000000	0.0388350	0.0558464	0.0008255
1820	1.0141087	1.0000000	0.0446097	0.0586081	0.0008679
1821	1.0567188	1.0000000	0.0430108	0.0570410	0.0010330
1822	1.0567188	1.0000000	0.0390244	0.0539629	0.0008934
1823	1.0567188	1.0000000	0.0378549	0.0541148	0.0008807
1824	1.0567188	1.0000000	0.0347826	0.0445261	0.0002748
1825	1.0349751	1.0000000	0.0318725	0.0446927	0.0003151
1826	1.0392523	1.0000000	0.0369231	0.0467836	0.0003161
1827	1.0567188	1.0000000	0.0380952	0.0455840	0.0003176
1828	1.0392523	1.0000000	0.0363636	0.0438755	0.0003534
1829	1.0567188	1.0000000	0.0346821	0.0398010	0.0002897
1830	1.0567188	1.0000000	0.0320000	0.0435967	0.0002807
1831	1.0567188	1.0000000	0.0371517	0.0425908	0.0001283
1832	1.0567188	1.0000000	0.0364742	0.0428188	0.0001283
1833	1.0747814	1.0000000	0.0347826	0.0412371	0.0001541
1834	1.0567188	1.0000000	0.0339943	0.0400661	0.0001857
1835	1.0000000	1.0095482	0.0330579	0.0393767	0.0005415
1836	1.0000000	1.0116692	0.0327869	0.0393120	0.0005344
1837	1.0000000	1.0180321	0.0339463	0.0388980	0.0004823
1838	1.0000000	1.0086784	0.0332410	0.0389294	0.0004941
1839	1.0000000	1.0256310	0.0323450	0.0386007	0.0004516
1840	1.0000000	1.0256310	0.0332871	0.0386164	0.0004516
1841	1.0000000	1.0235119	0.0334262	0.0383079	0.0004553
1842	1.0000000	1.0129166	0.0335196	0.0384923	0.0004814
1843	1.0000000	1.0057964	0.0317881	0.0387409	0.0004432
1844	1.0000000	1.0044403	0.0309278	0.0346535	0.0004398
1845	1.0000000	1.0086784	0.0300000	0.0357143	0.0000589
1846	1.0000000	1.0044403	0.0316623	0.0372340	0.0000597
1847	1.0000000	1.0192747	0.0320427	0.0379404	0.0000777
1848	1.0000000	1.0002022	0.0350877	0.0440252	0.0001042
1849	1.0000000	1.0129166	0.0337553	0.0395480	0.0000915
1850	1.0000000	1.0107975	0.0309677	0.0414201	0.0000914
1851	1.0000000	1.0447025	0.0310479	0.0392157	0.0001978
1852	1.0000000	1.0298700	0.0308483	0.0369881	0.0002088
1853	1.0000000	1.0404654	0.0299625	0.0384615	0.0002056
1854	1.0000000	1.0447025	0.0322148	0.0421687	0.0002031
1855	1.0000000	1.0447025	0.0330579	0.0408163	0.0002045

YEAR	DOLLAR PRICE OF GOLD	DOLLAR PRICE OF SILVER	GOLD RATE OF RETURN	SILVER RATE OF RETURN	LAMBDA SQUARE
1856	1.0000000	1.0425844	0.0345324	0.0425532	0.0002015
1857	1.0000000	1.0510607	0.0317460	0.0428135	0.0001910
1858	1.0000000	1.0425844	0.0318302	0.0412979	0.0001541
1859	1.0000000	1.0171547	0.0309677	0.0414815	0.0002162
1860	1.0000000	1.0510607	0.0313316	0.0406977	0.0003082
1861	1.0000000	1.0383453	0.0324324	0.0393989	0.0002290
1862	1.0299997	1.0651302	0.0329218	0.0389603	0.0002105
1863	1.3362494	1.3931513	0.0324324	0.0398474	0.0002068
1864	1.5162497	1.5809172	0.0328767	0.0384615	0.0002051
1865	2.2599993	2.3562393	0.0333333	0.0391061	0.0002051
1866	1.4324999	1.4965363	0.0344333	0.0413589	0.0002051
1867	1.3437500	1.3867350	0.0332410	0.0422961	0.0002103
1868	1.3349991	1.3663874	0.0326087	0.0433437	0.0002105
1869	1.3512497	1.3837472	0.0324324	0.0497512	0.0001535
1870	1.2187500	1.2499886	0.0325203	0.0492308	0.0000415
1871	1.1087494	1.1371679	0.0326087	0.0417755	0.0000312
1872	1.0974998	1.1279554	0.0323450	0.0437956	0.0000311
1873	1.1212492	1.1369200	0.0325645	0.0403023	0.0000352
1874	1.1049995	1.0864906	0.0326975	0.0403023	0.0001033
1875	1.1237497	1.0954008	0.0326975	0.0403023	0.0000999
1876	1.1274996	1.0679970	0.0319574	0.0403023	0.0001310
1877	1.0687494	1.0372591	0.0317460	0.0403023	0.0002333
1878	1.0000000	0.9112019	0.0318302	0.0403023	0.0005271
1879	1.0000000	0.8412723	0.0315375	0.0403023	0.0008972
1880	1.0000000	0.8889520	0.0307692	0.0403023	0.0013970
1881	1.0000000	0.8645825	0.0304183	0.0403023	0.0013870
1882	1.0000000	0.8815350	0.0300375	0.0403023	0.0014806
1883	1.0000000	0.8518692	0.0284000	0.0403023	0.0015116
1884	1.0000000	0.8624637	0.0269000	0.0403023	0.0015639
1885	1.0000000	0.8455109	0.0272000	0.0403023	0.0015652
1886	1.0000000	0.7882957	0.0279000	0.0403023	0.0018390
1887	1.0000000	0.7819386	0.0268000	0.0403023	0.0016569
1888	1.0000000	0.7533311	0.0256000	0.0403023	0.0015028
1889	1.0000000	0.7204852	0.0277000	0.0403023	0.0011857
1890	1.0000000	0.7522714	0.0262000	0.0403023	0.0010297
1891	1.0000000	0.8222012	0.0265000	0.0403023	0.0019960
1892	1.0000000	0.7416763	0.0256000	0.0403023	0.0027475
1893	1.0000000	0.6473773	0.0252000	0.0403023	0.0040244
1894	1.0000000	0.5382448	0.0242000	0.0403023	0.0059480
1895	1.0000000	0.5255303	0.0232000	0.0403023	0.0059273
1896	1.0000000	0.5191731	0.0220000	0.0403023	0.0059683