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CENTER DISCUSSION PAPER NO. 545

MANAGING EXCHANGE RATE CRISIS: EVIDENCE FROM THE 1890'S

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Yale University and NBER

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Abstract

In this paper I investigate the effectiveness of the monetary authority's borrowing policies in resolving exchange rate crises. I show why obtaining loans or lines of credit in foreign currency may avoid, at least temporarily, the devaluation of a fixed exchange rate. I also consider the problem of the optimal size of the loan and/or the line of credit. The analysis focuses on a particular episode of foreign exchange rate pressure, during the troubled years between 1894 to 1896. My conclusion is that the borrowing policy followed by the U.S. Treasury in those years was effective in avoiding the collapse of the United States' gold standard. Moreover, my findings indicate that the amount of the borrowing undertaken by the Treasury might have been optimal.

1. Introduction

Exchange rate crises have recently received considerable attention. Theoretical research started by Krugman [1979] and expanded by Flood and Garber [1984], Grilli [1986], Obstfeld [1986] among others, has stressed the relationship between collapses of fixed exchange rates and speculative runs on the international reserves of the monetary authorities. Empirical application of these models has been attempted by Blanco and Garber [1986] for the case of the recurrent devaluation of the Mexican peso during the 1970's and the early 1980's. Exchange rate crises, however, are not a recent phenomenon, rather they have characterized the history of the international monetary system. The abandonment of the gold standard at the start of World War I, the progressive deterioration and definitive breakdown of the classical gold standard in the 20's and early 30's, and the numerous readjustments of the exchange rates during the the Bretton-Woods period demonstrate how exchange rate crises are not a unique characteristic of contemporary exchange rate systems.

An interesting empirical problem is to analyze how monetary authorities have behaved when faced with such exchange rate emergencies. Typically, in these circumstances, foreign exchange authorities have tried to borrow international reserves. In this paper I show why obtaining a line of credit in foreign currency may be an effective policy in order to avoid a devaluation, and I discuss how to determine the optimal size of the loan. This is done through the study of a particular episode: the exchange rate crises of 1894-96. There are several reasons that justify the choice of this specific incident. First, because of a subsequent Congressional investigation, we have a complete and detailed record of the actions undertaken by the Treasury at that time. Second, I think that it is interesting to see how certain policies, typical of today's central bank

operations, were already known and used in times when a central bank did not exist.

The structure of the paper is as follows. In section two the essential economic and institutional environment of the period is reviewed. Section three models the relationship between borrowing and the viability of a gold standard. In section four the framework developed in section three is used to study the exchange rate crisis of 1894-96. Section five analyzes the issue of the optimal amount of foreign exchange loans, and applies the result to examine the characteristics of the Treasury borrowing operation of February 1895. Section 6 concludes.

2. The Essential Institutional and Economic Environment of the Period¹

After January 1, 1879, as prescribed by the Resumption Act of June 14, 1875, legal tender paper money had to be redeemable in coins. Even if "coin" meant, at the time, either gold or silver, the Treasury always redeemed in gold, de facto supporting a gold standard system.

In order to guarantee the redemption of the notes, the Treasury had two alternatives: (i) to use the surplus revenue or (ii) to issue bonds of the kind authorized by the Refunding Act (July 14, 1870).²

The viability of the gold standard did not present any problems during the 80's. In particular, between 1885 and 1890, a constant government surplus guaranteed a large amount of gold reserves, well above the required minimum of

¹ For a more detailed analysis of the period, see Garber and Grilli (1985), and Simons (1968).

² The Refunding Act authorized the Treasury to issue three different kinds of bonds: (1) 10 year @ 5% (2) 15 year @ 4.5% (3) 30 year @ 4%.

\$100 million.³ The period of monetary instability started early in the 90's. The underlying cause of the precariousness of the period was excess money supply that was generated by two different sources:

(a) Between 1890 and 1893, the Sherman Act caused a steep increase in the paper component of the money supply, by forcing the Treasury to make huge monthly purchases of silver in exchange for a new kind of paper money (the Treasury Notes of the 1890's).⁴

(b) During the years between 1893 and 1896 the Congress did not allow any form of borrowing to finance the large and continuous deficit that originated in the period. The Treasury had the option of either monetizing the deficit by using previously accumulated legal tender, or issuing the kind of bonds authorized by the Resumption Act, once the gold reserves had fallen below the minimum.⁵

During those years the viability of the gold standard became more and more uncertain; the Congress and the Treasury had to take various actions in order to avoid its collapse: the Sherman Act was repealed November 1, 1893 and the Treasury undertook four bond issues, in February 1894 (\$50 million),

³ This lower bound for the gold reserves originated in the Act of July 12, 1882 which established that any time the gold reserves of the Treasury fell below \$100 million, the Treasury had to suspend the issuing of gold certificates. After that, \$100 million was considered to be the minimum level of the gold reserves in the Treasury, as set down by the Judiciary Committee of the House of Representatives in a report submitted on July 6, 1892. The report stated: "That it was the intention of the Congress to fix the minimum amount of this reserve fund at \$100 million gold and gold bullion, and that it should be maintained at that sum, seems clear from the language of the Act [of 1882]."

⁴ The Sherman Silver Purchase Act was passed on July 14, 1890.

⁵ Note that, by the Act of May 31, 1878, the Treasury was forbidden to cancel or retire any of the U.S. notes then outstanding.

in November 1894 (\$50 million), in February 1895 (\$62.3 million, plus approximately \$20-25 million in lines of credit), and in January 1896 (\$100 million).

3. Borrowing Operations and the Viability of the Gold Standard

This section presents a simple model which permits one to analyze the effects of foreign currency borrowing policies on the viability of a gold standard. An international gold standard, like the one prevailing in the 1890's, can be interpreted as a fixed exchange rate regime, where the fixed parities are given by the ratios of the gold content of the various currencies. Similarly, the gold reserves of the monetary authorities can be interpreted as foreign currency reserves. In the rest of the paper, we assume that the international economy is composed by two countries: a domestic economy (the U.S.), and a foreign economy (the U.K.).

Formally we can measure the viability of a fixed exchange rate system at time t with the probability that a speculative attack on the fixed parity will occur at time $t+1$. This probability function can be obtained from the following monetary model of the exchange rate for a small economy:⁶

$$m_t - p_t = \beta + \gamma y_t - \alpha i_t + w_t \quad (1)$$

$$i_t - i_t^* = E_t e_{t+1} - e_t \quad (2)$$

$$p_t - p_t^* = e_t + u_t \quad (3)$$

⁶ This model has been widely used in speculative attack literature. For a more detailed explanation of solutions to these types of models, see Flood and Garber (1984a), Blanco and Garber (1986) and Grilli (1986).

Here m , p , e , and y are the logarithms of money stock, price level, exchange rate in dollars per pound and a measure of real activity; i is the nominal interest rate and w and u are uncorrelated stochastic disturbances. The parameters α , β , γ are all positive, and E_t is the expectation operator conditional on information at time t . British variables are marked with asterisks, and all variables are assumed to be exogenous to the exchange rate.⁷

The model can be solved for the (shadow) flexible exchange rate:

$$e_t = \frac{1}{1+\alpha} \sum_{j=0}^{\infty} \left(\frac{\alpha}{1+\alpha} \right)^j E_t h_{t+j} \quad (4)$$

where

$$h_{t+j} = m_{t+j} - \beta - \gamma y_{t+j} + \alpha i_{t+j}^* - w_{t+j} - p_{t+j}^* - u_{t+j} \quad (5)$$

The money stock in a gold standard can be defined as the sum of two components: (i) the gold in circulation plus the part of the paper money backed by gold reserves in the Treasury and (ii) the silver in circulation plus the paper money not backed by gold reserve, which I defined as the domestic component of the money supply (DC_t).

The basic idea underlying the speculative attack literature is that the

⁷ The actual form of equation (3) that we used in the empirical section is:

$$p_t - p_t^* + k = e_t + u_t$$

where k is constant such that $\text{mean}(e) = \text{mean}(p - p^* + k)$. This is to make the price levels, which are index numbers, compatible with the exchange rate which is in $\$/L$.

fixed parity will be viable until it becomes profitable to attack it. This will happen as soon as the exchange rate expected to prevail right after the attack (the shadow exchange rate) exceeds the given parity.⁸ The level of the shadow exchange rate depends critically on what kind of regime is expected to prevail once the gold standard collapses. I assume that, in this circumstance, a paper money that is convertible in silver will be established.

In the post-attack regime, to which equations (1) - (5) refer, gold goes out of circulation. The money stock is given by the sum of the domestic component and the amount of reserves still in the Treasury after the collapse of the gold standard. By defining G^m to be the level of gold reserves at which the Treasury abandons the defense of the gold standard (5) can be rewritten as:

$$h_{t+j} = \log(DC_{t+j} + G^m) - \beta - \gamma y_{t+j} + \alpha i_{t+j}^* - w_{t+j} - p_{t+j}^* - u_{t+j} \quad (6)$$

In this framework, the probability that a speculative attack will occur in the next period is given by:

$$\Pr\left\{ \frac{1}{1+\alpha} \sum_{j=0}^{\infty} \left(\frac{\alpha}{1+\alpha}\right)^j E_t h_{t+j} \geq e \right\} \quad (7)$$

where e is the fixed parity. It is now easy to see why borrowing gold decreases the probability that an attack will occur during the next period.

⁸ We are referring to a buying attack, i.e. when speculators buy foreign reserves (gold) from the monetary authorities, expecting to profit from a devaluation of the domestic currency. For a model in which selling attacks, i.e. attacks aiming to profit from a revaluation of the currency, are also considered, see Grilli (1986).

Borrowing, in fact, reduces the post-attack money supply and, therefore, it reduce the level of the h_{t+j} 's. Similar results can be found in Garber and Grilli (1986) and Buitier (1986).⁹ Therefore, to issue bonds or to obtain lines of credit provides an effective instrument to enhance the viability of the system in the short run.

If our interpretation of the facts is correct, the probability of a speculative attack on the gold standard between 1889 (the year in which our analysis starts) and 1896 should have followed a specific time pattern. In particular, the probability should start to increase gradually by mid-1890, when the Sherman Act was passed. It should then reach a peak around the end of 1893 when the Sherman Act was repealed. From 1894 to 1896 it should decrease back toward zero, and the reduction should be concentrated in discrete jumps occurring at the time of the borrowing operations. In order to verify the validity of our analysis, in the next section we estimate the probability of the collapse of the gold standard between January 1889 and December 1896.

4. Estimating the Probability of a Speculative Attack

In order estimate the probability of a speculative attack we have to compute the expected shadow exchange rate, which is a function of all future expected h_{t+j} . The first step in our procedure will be to estimate the variable h_t . This requires estimates of the money demand function and an assumption about the value of G^m . In the following we assume that the Treasury will give up the defence of the parity once the gold reserves in its

⁹ Buitier also proves that in the long run the probability of an attack will increase as a result of borrowing, because of the increase in interest costs.

vault are completely exhausted (i.e. $G^m = 0$).

Since we are interested in computing the post-attack floating (shadow) exchange rate, we should be estimating the money demand function prevailing during the post-attack flexible exchange rate regime. Since the gold standard did not collapse, the only data available refers to the fixed exchange rate regime. However, the demand for cash balances need not be dependent on the particular exchange rate regime. On the contrary, it could be shown that under reasonable conditions this will not be the case.¹⁰ I assume that this independence property holds and I estimate the money demand equation (1) using monthly data in the period 1889:01-1896:12. Given the potential dependence of the domestic interest rate on the money supply process, consistent estimates were obtained by instrumental variables, using the British interest rate, the lagged domestic output and the lagged domestic interest rate as instruments¹¹. The estimate of the money demand parameters are given in Table 1. All coefficients are significant and have the expected signs. We can now compute an estimate of h_t using equation (6) under the assumption that $G^m = 0$. To estimate time t shadow exchange rate we also need to compute $E_t h_{t+j}$ for $j \geq 0$. In order to calculate these expected values, we must make some assumption about the stochastic processes governing the set of state variables included in h_t . A natural way to interpret h_t is as the difference between money supply (dc_t) and the factors determining money demand (i.e. $md_t = \beta + \gamma y_{t+j} - \alpha i_{t+j}^* + w_{t+j} + p_{t+j}^* + u_{t+j}$). A crucial characteristic of the period

¹⁰Penati and Pennacchi (1986), for example, show that this type of independence holds if the representative agent has a separable logarithmic utility function in consumption and real cash balances.

¹¹In the appendix we provide a detailed description of the data. In obtaining the estimate presented in Table 1 we also correct for the autocorrelation in the residuals.

under consideration is the change that took place in the domestic credit creation. Two major switches in monetary policy occurred in the 1890's: the approval and the subsequent repeal of the Sherman Act. Consequently, we decided to break the sample into three parts and to model dc_j in each period with different ARIMA processes. On the other hand, there is no reason to believe that an analogous shift occurred in the variables generating the post-attack money demand. Therefore, a unique ARIMA process for the whole period was estimated for md_j . The result of the time series identification and estimation procedure are summarized in Table 2. While dc_t appears to be AR(1) in all three subperiods, md_t is best approximated by a constant plus white noise.

These estimated processes can be used to compute $E_t h_{t+j} = E_t dc_{t+j} - E_t md_{t+j}$. We now have everything necessary to compute the time series of the probability of attack, which is presented in Figure 1. The time pattern displayed by this probability confirms our theoretical analysis. The viability of the gold standard was not a problem until August of 1890, as indicated by the probability of an attack being zero before that period. As our model predicted, the probability of collapse of the fixed exchange rate regimes increases steadily during the three years following the approval of the Sherman Act, reaching a maximum in October 1893, when the Act was repealed. Between 1894 and 1896 the probability decreases on average, with most of the decline occurring when the borrowing operations were undertaken.

5. On the Optimal Size of the Loan

In order to address the issue of the optimal amount of borrowing we have to identify the trade-off involved in borrowing international reserves. On the one hand, borrowing allows to reduce the probability of a collapse of the

fixed exchange rate regime, which is considered a valuable arrangement by the monetary authority¹² On the other hand, the operation is costly in terms of interest payments and, more generally, in term of possible increases in the interest rate induced by the bond issue. Formally, we can describe the problem of determining the optimal size of the loan as follows:

$$(P-1) \quad \min_{N, G^c} \Pr(B_t)$$

$$\text{s.t. } PVC(B_t) \leq C_t$$

where B_t is the amount of the loan, $PVC(B_t)$ is the present value of the cost of the borrowing operation, and C_t is the maximum cost that the monetary authorities are willing to pay in order to guarantee the viability of the gold standard. In addition, in the environment under consideration there existed other constraints of institutional nature. Specifically, the Treasury was constrained in the choice of borrowing instruments by the Refunding Act (see footnote 2). Moreover, such borrowing could take place only in order to replenish gold reserves when they had fallen below their minimum level of \$100 millions.

How can we determine whether the borrowing policy of the Treasury during the 1890's was the outcome of an optimization process of the kind described above? A minimal test is to verify that the institutional constraints were satisfied. This was indeed the case: the type of bonds used were among the ones allowed by the Refunding Act and , at the time of the borrowing

¹²Here we do not elaborate on why this might be the case. A paper that discusses the optimality of fixed exchange rates is Mundell (1973).

operations, the Treasury 's gold reserves were below \$100 millions (see Figure 2). In the following, we propose a more interesting way of investigating the rationale behind the behavior of the Treasury and the optimality of its actions. This will involve the use of information that are revealed by the particular circumstances in which the third issue (February, 1895) took place.

The bond issue of February 1895 is particularly intriguing because in that episode, the Treasury used the the services of a syndicate of private bankers. The terms of the agreement are stated in the contract that J.P. Morgan and August Belmont, as representatives of the syndicate, signed with the U.S. Treasury. The Belmont-Morgan contract stipulated the purchase of gold coins by the Treasury, in exchange for 30 year 2.4% bonds. The par value of the issue was \$62.3 million. It was purchased by the syndicate at a price equivalent to 3.75% at par. In addition, and of most importance, the syndicate agreed that "...so far as it lies within their power, will exert all financial influences and will make all legitimate efforts to protect the Treasury of the United States against withdrawals of gold, pending the complete performance of the contract."

With this provision the syndicate granted the Treasury a zero-interest line of credit in gold for the duration of the contract.¹³ Throughout the duration of the contract, in fact, the syndicate delivered between \$20 and \$25 million in gold to the Treasury, in exchange for legal tender. This operation, therefore, guaranteed the Treasury both a long term financing, i.e. the 30 year bonds, and a short term financing, i.e. the line of credit.

¹³ The duration of the contract was implicitly fixed at six months. The use of the term "line of credit" is perhaps inaccurate in this context. The real nature of the deal was an on-call exchange of gold for paper money. The contract had additional minor provisions that will not be expressly considered in the present paper. For a discussion, see Garber and Grilli (1985).

Note that the contract has the characteristic of a "firm commitment" contract, one by which the investment banker underwrites the entire issue, guaranteeing to the issuer a fixed amount of funds. However, the choice of this contract, instead of other alternative forms like "best effort," was made for other reasons in addition to the insurance advantage. It is quite possible that the Treasury expected to be able to market the issue directly, at a price higher than the one agreed upon with the syndicate. The spread not only compensated the syndicate for undertaking the risk and for the distribution efforts, but was also a way to pay for the line of credit. This form of contract enabled the Treasury to secure short term financing without obtaining an explicit approval from the Congress, which they were not willing to concede.

Following the approach taken above, we view the Belmont-Morgan contract as the result of an optimization problem that the Treasury had to solve in order to assure the practicability of the gold standard. In addition to the constraints we mentioned before, the Treasury had to guarantee a minimum level of profit to the syndicate, in order to compensate it for underwriting the bond issue and for providing the line of credit. Recalling that the probability of a speculative attack is a monotonically decreasing function in the amount of gold borrowed, we can express the optimization problem as:

$$\begin{aligned}
 \text{(P-2)} \quad & \max_{N, G^C} p'N + G^C \\
 \text{s.t. (a)} \quad & \pi = [p(N) - p']N - I(G^C) \geq K \\
 \text{(b)} \quad & G_o^T < 100 \\
 \text{(c)} \quad & r \leq r_{\max} \text{ (or } p' \geq p'_{\min} \text{)}
 \end{aligned}$$

N and G^c represent the number of one dollar bonds in the issue and the dollar amount of line credit respectively. π is the profit of the syndicate; p , a function of N , is the price at which the bond is purchased by the public and p' is the price at which it is underwritten by the syndicate; I , a function of G^c , is the cost of providing the line of credit; K is the minimum level of profit required by the syndicate in order to perform the services; G_o^T is the level of gold reserves in the Treasury before the contract was signed; r is the interest rate at which the bond issue is underwritten and r_{\max} is its maximum possible level. In writing constraint (c) we assumed that the cost of the borrowing operation can be approximated by the interest paid on the loan. Note that, given the characteristics of the bond (i.e. 30 years @ 4%) and assuming that the last constraint holds with equality, the knowledge of r_{\max} implies the knowledge of p'_{\min} , and vice versa. The maximum allowed yield of the operation has been implicitly revealed by the contract itself to be $r_{\max} = 3.75$, and we take it as a given parameter.

In order to determine whether the behavior of the Treasury was consistent with this interpretation of the facts, we solve the above optimization problem, derive the "optimal contract" as prescribed by our theory, and compare it with the actual Belmont-Morgan contract.

The solution of P-2 requires an estimate of constraint (a) which, in turn, requires information about the demand for Treasury bonds, $p(N)$, about the costs of providing the line of credit, $I(G^c)$, and about the amount of profits, K , that the syndicate intended to make.

a. The Demand for Treasury Bonds

To derive the relationship between the size of the bond issue and the price at which it could have been distributed by the syndicate, the following

strategy was used. As mentioned in section 2, in November 1894 the Treasury issued a \$50 million, 10 year bond @ 5%, to replenish the gold reserves that had fallen below the required minimum of \$100 million. All the bids made for the bond are recorded in the report of the investigation conducted by the Committee on Finance in 1896.¹⁴ With these data, the demand function faced by the Treasury on that occasion can be traced out, and it is presented in Figure 3.

In addition to this function, the report provides an additional piece of information. In particular, it reveals that a syndicate of bankers, J. P. Morgan among them,¹⁵ made two separate bids for that bond issue. They offered to purchase the whole issue at a price of 1.17077 per \$1 par value, or to purchase any part of it at 1.168898. Note, however, that if the syndicate expected to face the same demand function that the Treasury was facing, it would have incurred a loss by acquiring the whole issue at 1.17077, since the equilibrium price along the Treasury demand curve was 1.16306. If we assume that the syndicate was behaving rationally, we have to conclude that it expected a larger demand for the bond than the one faced by the Treasury.

The reason for this difference is that the individuals may have had an incentive to report a price to the Treasury that was lower than their true reservation price. This is because of the particular structure of the auction used to allocate the issue. The Treasury, in fact, was adopting a discriminating auction, in which the bonds were assigned at the price bid,

¹⁴ The Committee was appointed to investigate the Treasury bond sales that occurred during the years 1894-96.

¹⁵ Contrary to the Belmont-Morgan syndicate, the composition of this syndicate is known. Even if we cannot be certain about it, it is very likely that most of the members of the syndicate of November 1894 were also members of the February 1895 syndicate.

starting from the highest bid and working downward until the whole issue was allocated. Under a discriminating auction, the mean and the variance of the bids are lower than they would be under competitive auction, under which the agent reveals his true reservation price.¹⁶ This implies that the demand curve derived from the bids to the Treasury has to be flatter and have a lower intercept than the true demand curve, which the syndicate expected to face. Despite the fact that the actual allocation mechanism used by the syndicate is not known, a close examination and review of the journals of the time suggests that competitive auction was utilized.¹⁷

We must recover the actual demand faced by the syndicate -- a demand different from the one faced by the Treasury. Knowledge of this syndicate's demand function will be used to construct an estimate of the demand faced by the February 1895 syndicate. Since the two issues occurred within 10 weeks of each other, we can make the reasonable assumption that the market demand did not change in such a short period of time. As a result, after accounting for the fact that part of this demand (\$50 million) was satisfied by the November issue, we can consider it to be the demand for the February 1895 bond as well.

The demand function has to pass through the price at which the syndicate sold the November 1894 issue (1.19).¹⁸ This condition, with an assumption of linearity (i.e. we assume $p(N) = a - bN$), identifies a set of possible demand curves. This set can be further narrowed by recognizing the existence of a maximum price that any individual would be willing to pay for the bond. The

¹⁶ These results can be found in Vickery (1966), Smith (1966), and Harris and Raviv (1981), among others.

¹⁷ Commercial and Financial Chronicle, February 1895.

¹⁸ Commercial and Financial Chronicle, December 1, 1894.

maximum price has to be equal to or less than 1.24, which corresponds to a yield of 2.3%, the interest rate of British consols, that were expressly payable in gold. Moreover, the maximum price has to be greater than or equal to 1.21, which correspond to the slope of the linear approximation of the Treasury's demand function. This condition guarantees that the Syndicate's demand function is steeper than the one faced by the Treasury. The set of these demand curves is represented by the shaded area in Figure 4. The contracts corresponding to different demand curves in this family will be computed to see if any of them support the actual Belmont-Morgan contract as an optimal outcome.

b. The Syndicate's Expected Profit

The report on the November 1894 issue also contains information that can be used to identify the level of profit that the syndicate intended to earn, as a return on the underwriting services that it provided. If the Treasury had accepted the "all or nothing" bid, the syndicate's expected profit would have been:

$$K_1 = (p(N_1) - p_1)N_1 \quad (8)$$

where p is the expected demand function faced by the syndicate, N_1 is the size of the issue (\$50 million) and p_1 is the price offered by the syndicate for the "all or nothing" arrangement. K_1 is given by the area p^*ABp_1 , in Figure 5. If, instead, the Treasury had accepted the "all or any part" offer, the syndicate profit would have been:

$$K_2 = (p(N_2) - p_2)N_2 \quad (9)$$

where N_2 is the number of one dollar bonds that the Treasury would allocate to the syndicate, and p_2 is the price offered by the syndicate under the "all or any part" arrangement.¹⁹ K_2 is given by the area EACD in Figure 10. Note that the price at which the syndicate is able to sell the bonds it underwrites is the same under the two arrangements, that is $p(N_1)=p(N_2)=1.19$. If we assume that the syndicate profit is a linear function of the number (in millions) of underwritten securities,²⁰

$$K_i = k_0 + k_1 N_i \quad i = 1, 2 \quad (10)$$

equations (8) and (9) can be solved to obtain $k_0 = 0.19$ and $k_1 = 0.015$. k_0 and k_1 are in the same units as K_i , i.e. in millions of dollars.

c. The Cost of Providing the Line of Credit

The last piece of information needed to solve the maximization problem is an estimate of the cost of providing the line of credit. By providing the line of credit, the syndicate lost the opportunity to earn the interest that is obtainable by lending the gold on the London market. The cost of the operation in terms of the interest loss is $i_6^* G^c$, where i_6^* is the six month interest rate in London.²¹

¹⁹ The value of $N_2=50-16.5=33.5$, where 16.5 is the quantity of bonds on the Treasury demand function, corresponding to p_2 .

²⁰ This linear form is often used in actual contracts. See Mandelker and Raviv (1977).

²¹ Note again that six-months was the duration of the contract, i.e. the period during which the syndicate had to provide the line of credit.

The syndicate, in addition to the interest loss, was also bearing a second cost component, i.e. the capital loss that it expected in case the gold standard collapsed. If the Treasury were forced, by a speculative attack, to abandon the defense of the parity, the dollar would have been devaluated vis-a-vis the pound, thus increasing the price of gold. Since the syndicate, in providing the line of credit, was exchanging gold for dollars with the Treasury, it would have suffered a loss proportional to the size of the devaluation. This expected capital loss is given by the spread between the domestic and foreign interest rates, and it is represented by the interest parity condition. Therefore, the total cost of providing the line of credit can be approximated by $i_6 G^c$, where i_6 is the domestic, six month interest rate.

d. Solving the Maximization Problem: The Belmont-Morgan Contract

We finally have all of the elements to solve P-2. The first order conditions , can be solved to give:

$$N = (a - k_1 - p'(1 - i_6 - k_1)) / 2b \quad (11)$$

$$G^c = (i_6 + k_1)^{-1} \{ [((a - k_1 - p')^2 - (p'(i_6 + k_1))^2) / 4b] - k_0 \} \quad (12)$$

By substituting into (11) and (12) the values of the parameters derived in the previous sections, we obtain the optimal values of N and G^c corresponding to different demand functions in the permissible set described above. The results are reported in Table 3. Here b are the slopes of the

linear demand functions ²² N and G^C are in millions of dollars, and $p(62.3)$ is the price implied by each demand curve, given that $N=62.3$. The values of $b=0.0004$ and $b=0.001$ represent the boundaries of the feasible set. However, since the syndicate actually sold the issue at approximately 1.125,²³ we can confidently concentrate our attention to the bottom part of the Table. Recall that in the actual contract N was \$62.3 million and G^C was at least \$20 million. Therefore, our analysis produces a set of simulated contracts which are quite similar to the Belmont-Morgan contract. We interpret this result as evidence that the Treasury's borrowing policy of the 1890's was motivated by the desire of maintaining the gold standard and that, in so doing, it behaved in an efficient way.

6. Conclusions

This paper analyzes the behavior of monetary authorities when facing an imminent collapse of the exchange rate. In particular, it studied the effectiveness of borrowing international reserves to avoid devaluations. The attention was focussed on a particular episode, i.e. the exchange rate crisis of 1894-96. We concluded that borrowing policies are effective in avoiding temporary exchange rate crises, and that the specific borrowing policy followed by the U.S. Treasury in that event was not only effective but also optimal when considered in the light of the economic environment and the set of institutional and political constraints that it was facing.

Nowadays, the procedure of borrowing from private bankers has been

²² Remember that the intercept is the same for all demand functions, and it is equal to 1.19, i.e. the price at which the issue of November 1894 was sold by the Syndicate.

²³ Commercial and Financial Chronicle, February 1895.

replaced by the practice of obtaining lines of credit from foreign monetary authorities (central banks). It is interesting to note, however, how the basic mechanism of obtaining short-term lines of credit, instead of a formal long-term loan like the one introduced in the episode we considered, is still in operation. In fact this kind of device is institutionalized in exchange arrangements like the EMS where private banking syndicates are replaced by the pool of the central banks participating in the system. A natural extension of this analysis is to study the timing and the size of the borrowing of international reserves which occurred in more recent years, in particular during the working of Bretton Woods and of the European Monetary System.

Data Appendix

1. The money stock is given by the sum of : (i) gold coins and gold certificates in circulation, (ii) silver dollars, subsidiary silver coins and silver certificates in circulation and (iii) Treasury Notes, U.S. Notes (greenbacks), National Bank Notes and Currency Certificates in circulation. All Monetary aggregates are taken from the National Monetary Commission (1910).

2. The domestic component of the money supply has been computed by subtracting the gold, gold certificates in circulation, and the gold reserves in the Treasury from the total money stock in circulation.

3. The U.S. price index is the Warren & Pearson price index from "Index Number of the Wholesale Prices of all commodities, 1720 to 1932," in Warren and Pearson (1933), Table 1 pg. 10.

4. The U.K. price index is the Sauerbeck price index from "Monthly Fluctuations of the Index Number of Forty-Five Commodities," in Sauerbeck (1895) and (1897).

5. As a measure of the level of activity, I used bank clearings outside New York City, from Macaulay (1938), Table 27. Bank clearings represent dollar totals of checks and drafts drawn on individual banks and credited to the accounts of other banks through the city clearing house association to which the individual bank belonged. New York City's large volume of bank clearings is attributable to financial transactions that largely reflect stock and bond

transactions. As a result, bank clearings outside New York City are a more reliable indicator of the movement in output and trade than total clearings.

6. The U.S. nominal interest rate is the interest rate on call loans; the U.K. interest rate is the interest rate allowed for deposits at call by Discount Houses, from the National Monetary Commission (1910) and the Commercial and Financial Chronicle, various issues.

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TABLE 1

MONEY DEMAND ESTIMATE: JANUARY 1889 - DECEMBER 1896

Parameter	Estimate	Standard Error	D.W.
β	4.435	1.140	2.05
γ	0.755	0.311	
α	0.040	0.0129	

TABLE 2
ESTIMATES OF dc_t PROCESS

	a_1	a_2	σ	Q(20)
Jan89-Aug90	0.359 (0.560)	0.945 (0.085)	0.009	9.22
Sept90-Oct93	0.323 (0.178)	0.954 (0.026)	0.012	13.87
Nov93-Dec96	0.734 (0.449)	0.893 (0.065)	0.019	16.35

ESTIMATES OF md_t PROCESS

	a_1	σ	Q(20)
Jan89-Dec96	5.602 (0.018)	0.178	11.11

Note: Standard errors are in parenthesis. Q(20) is the Q-statistics for 20 lags testing for the residuals being white noise

Table 3

Optimal Contracts

b	N	G ^c	p(62.3)
0.0004	140.39	55.17	1.16508
0.0005	112.31	43.10	1.15885
0.0006	93.60	35.05	1.15262
0.0007	80.22	29.30	1.14639
0.0008	70.20	24.99	1.14016
0.0009	62.40	21.64	1.13393
0.001	56.15	18.96	1.12770