THE GOLD STANDARD, MONETARY POLICY, AND THE BANKING SCHOOL - CURRENCY SCHOOL DEBATE

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INTRODUCTION

Recent papers by Barro [1979] and McCallum [1989] have refined and extended Fisher's [1911] model of the price level under a gold standard. Unfortunately, these papers emphasized models with several implications that are at variance with the stylized facts of the historical gold standard. This paper will show how the Barro-McCallum approach can be modified to permit a better understanding of the effect of monetary policy on the price level in a gold standard context. In Section V, it will be shown that the model can provide new insights into the nineteenth century debate between the Banking and Currency Schools.

I. GOLD STANDARD MODELS AND THE HISTORICAL RECORD

Under the gold standard, the nominal price of gold is fixed and the relative price of gold varies inversely with the price level. In the Barro and McCallum models, the relative price of gold, and thus the price level, is determined at each point in time by the interaction of the (stock) supply and demand for gold. The dynamics of price level movements, in response to shifts in the supply or demand for gold, are much more complex. The flow supply of gold is assumed to be a function of the relative price of gold. An increase in the stock demand for gold reduces the price level, and thus increases the flow supply of newly mined gold. Then, as the stock of gold increases over time, the steady-state flow demand for gold (depreciation) will also increase.

The Barro and McCallum models partitioned the stock demand for gold into the demand for monetary and non-monetary gold stocks. One of the peculiarities of the Barro-McCallum approach is that the impact of a shift in the monetary demand for gold on the price level is very different from the impact of a shift in the non-monetary demand for gold. Barro showed that if depreciation occurs only in the non-monetary gold stock, then, in a steady-state economy, only shifts in the non-monetary demand for gold will have a long-run impact on the price level. Alternatively, monetary policy (which impacts the gold reserve ratio, and thus the demand for monetary gold) should have no long-run impact on the price level.

One of the implications of this asymmetry is that, over time, the ratio of the monetary gold stock to the cumulative total of newly mined gold should approach zero. Although estimates of the cumulative total of newly mined gold are necessarily imprecise, the massive increases in monetary gold stocks during recent centuries appear to have prevented anything approaching the long-run equilibrium generated by the Barro and McCallum models. Warren and Pearson [1935] estimate the total world monetary gold stock in 1933 to have been about 57 percent of cumulative gold production from 1493 to 1933. And there seems to have been no tendency for this ratio to decline over time. Between 1850 and 1900, 54 percent of all newly mined gold went into monetary gold stocks; between 1900 and 1933, this ratio increased to 64 percent. Barro noted that

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in a growing world economy changes in monetary policy (the gold reserve ratio) could have a permanent effect on the price level (although not the inflation rate). Neither Barro nor McCallum, however, explored this case in any detail.

Although additional realism can be attained by replacing the assumption of a steady-state economy with a growing world economy, the replacement of this assumption in the Barro-McCallum model implies that the value of gold will increase steadily over time. (Actually, although this implication is often thought of in terms of secular deflation under a gold standard, it is not even contingent on the existence of a gold standard. In the Barro-McCallum model, the demand for non-monetary gold is also a positive function of real income.) The prediction of a steady increase in the real value of gold, however, is inconsistent with the historical record. Although the real value of gold often moves erratically, Jastram [1977] showed that, despite short-run fluctuations, the value of gold has been remarkably stable over a period of centuries. This is particularly impressive in light of the many-fold increase in world output during the same period.

Rockoff [1984, 639] suggests that deflation induced by real growth may have led to gold discoveries and that "From a very long-run perspective, the supply curve [of gold] appears to have been stable and elastic in the classical period." He also notes, however, that the data are not clear enough to rule out a series of fortuitous discoveries and technological innovations as explanations for this remarkable stability.

Section II will include a review of the Barro and McCallum approach to monetary policy under a gold standard. The most important findings of the paper are developed in Section III where it is demonstrated that the long-run stability of the value of gold can be accounted for by assuming that technological change occurs in the gold mining industry at about the same rate as in the economy as a whole. Although this alteration will restore some of the implications of the steady-state model, such as approximate long-run price stability, it will have very different implications regarding the long-run impact of monetary policy on the price level.

There is a third area in which the Barro-McCallum approach has implications at variance with the stylized facts of the gold standard. Both models predict that the price level will overshoot in response to shifts in the demand for gold. This implies that there should be some trend reversion in the price level and, therefore, that there should be some predictability to the *rate* of inflation. Barsky [1987] found first differences of the price level to be approximately white noise during the classical gold standard period. In Section III I will show that this finding has important implications for some of the parameter values in the Barro-McCallum model. In particular, Barsky's finding implies that the long-run impact of monetary policy on the price level might be greater than had been previously thought. In Section IV I will examine how the existence of short-run price rigidities can affect the path of the price level in the event of a shift in the demand for monetary gold.

II. A MODEL OF MONETARY POLICY UNDER A GOLD STANDARD

In this section I will begin by reviewing a hybrid of the Barro and McCallum models. The original notation will be employed wherever feasible. For simplicity, I will set the (nominal) price of gold equal to unity. The world's monetary demand for gold will equal:

$$(1) \qquad G_m = \lambda^* P^* k(\pi)^* y \quad \text{where } k'(\,) < 0 \text{ and } \lambda > 0.$$

In addition, y is real output, P is the price level, $k(\,)$ is the inverse of velocity, π is the rate of inflation, and λ is the ratio of the monetary gold stock to the money supply (currency). One can think of the gold ratio as exogenously determined by a single (world) central bank, or as the weighted average of ratios set by a number of independent central banks. Both Barro and McCallum define monetary policy in terms of changes in λ. This makes sense since, for an individual country, the money supply is endogenous in the long run. An autonomous increase in the money supply would result in a gradual loss of gold, eventually forcing a suspension of convertibility.[1]

The world's non-monetary demand for gold is equal to:

$$(2) \qquad G_n = f(y,\ 1/P,\ \pi), \text{ with } f_1 > 0,\ f_2 < 0, \text{ and } f_3 < 0.$$

Note that π is assumed to be equal to the opportunity cost of holding both monetary and non-monetary gold stocks. Later we will examine the implications of using the interest rate as the opportunity cost of holding gold. The inverse of the price level is the relative price of gold. Also note that we are following McCallum in allowing discrete adjustments in G_n.

At each point in time the total stock demand for gold must equal the total gold stock, G^o:

$$(3) \qquad G^o = \lambda^* P^* k(\pi)^* y + f(y,\ 1/P,\ \pi)$$

Additions to (or subtractions from) the existing gold stock will depend on the flow supply of gold, $g(1/P)$, and the rate of depreciation (which includes industrial consumption). The amount of gold lost through depreciation is assumed to be proportional to the non-monetary gold stock. The change in the total gold stock is equal to:

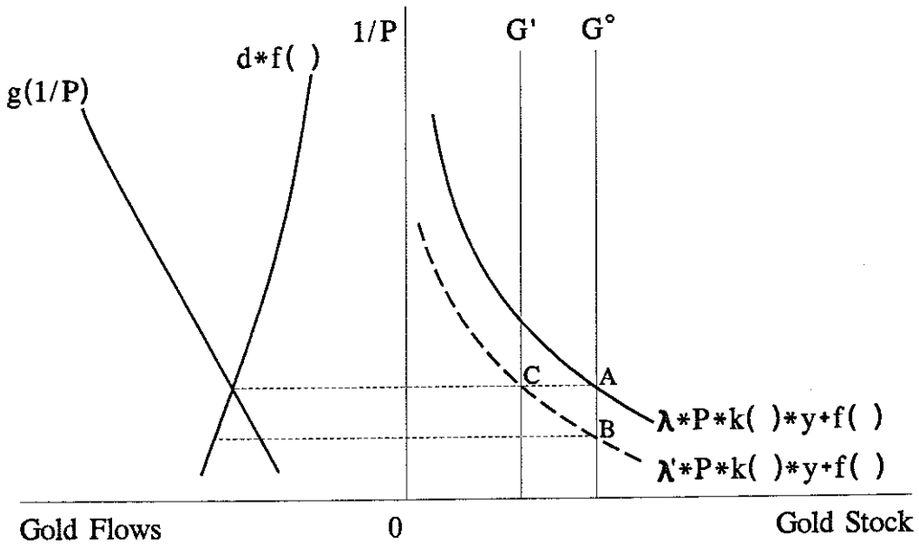
$$(4) \qquad \Delta G = g(1/P) - d^* f(y,\ 1/P,\ \pi), \text{ where } g'(\,) < 0, \text{ and,}$$

d is the rate of depreciation.

The right side of Figure 1 shows how the equilibrium price level is determined by the stock supply and demand for gold. Point A represents the long-run equilibrium in a steady-state economy. Note that the stock of gold remains stable as the flow demand (depreciation) absorbs the entire flow supply of (newly mined) gold. Figure 1 also shows the impact on the price level of a decrease in the demand for gold resulting from a decrease in the gold ratio (λ). In the short run, the price level will increase by an amount inversely proportional to the change in the relative price of gold ($1/P$). At this point, the rate of depreciation exceeds the flow supply of gold, resulting in a gradual decrease in the stock of gold (point B). At point C the price level has fallen enough so that the flow supply is again equal to the flow demand associated with depreciation.[2]

Both Barro and McCallum analyzed the preceding case under the assumption that the expected rate of inflation is zero. The solid line in Figure 2 shows the path of the price level in response to an increase in the gold reserve ratio assuming zero expected inflation. The actual inflation rate, however, is negative. Because the solution to the model assumes that individuals expect a different inflation rate from the rate generated by the model, this price-level path is not consistent with the rational expectations hypothesis (REH). Neither Barro nor McCallum explicitly modeled the path of the price

FIGURE 1



level using rational expectations. Because the REH solution is very complex, McCallum assumed the gold stock to be fixed in his derivation of the rational expectations model.

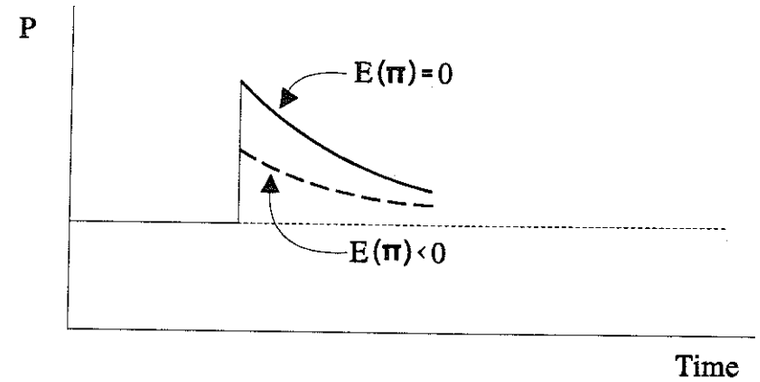
Barro speculated that if the deflation subsequent to the initial price-level increase had been anticipated, the original increase in the price level would have been smaller than in the zero expected inflation case. The anticipation of deflation would reduce the opportunity cost of holding gold, increase the demand for both monetary and non-monetary gold, and thus partially offset the inflationary impact of the initial decrease in the gold ratio.

In either case, the size of the initial increase would be positively related to the ratio of monetary gold stocks to total gold stocks (θ), and negatively related to the (absolute value of the) price elasticity of demand for non-monetary gold (n_d). In the zero expected inflation case, the initial response of the price level to a change in the gold ratio would be:[3]

$$\Delta ln\ P = [-1 + n_d*(1-\theta)/\theta]^{-1}*(\Delta ln\ \lambda), \text{ where } n_d < 0 \quad (5)$$

In contrast to McCallum, Barro assumed that non-monetary gold stocks adjust gradually to their target position. If the instantaneous (stock) price elasticity of demand for non-monetary gold is zero, then at the point in time that the gold ratio is adjusted there will be no instantaneous change in the monetary gold stock. In that case, the currency stock will instantly adjust in (inverse) proportion to the change in the gold ratio, and the price level will initially move also by an amount (inversely) proportional to

FIGURE 2



the change in the gold ratio. As in the McCallum model, however, there will be no long-run impact on the price level.

III. MONETARY POLICY IN A GROWING WORLD ECONOMY

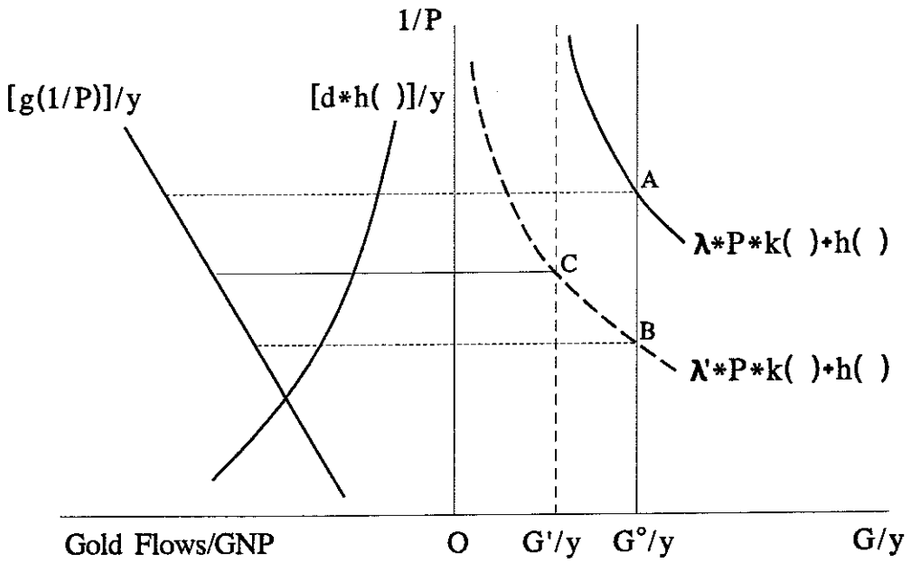
As noted in Section II, the preceding model is inconsistent with the historical record, particularly in regard to long-run movements in the relative price of gold in a growing world economy. This Section will demonstrate how altering the Barro-McCallum approach to account for these stylized facts has important implications for the long-run impact of monetary policy.

The fact that the value of gold has been stable in the face of huge increases in the demand for gold can be modeled by assuming that technological change in the gold mining industry proceeded at a rate equal to the secular increase in the demand for gold. With no loss of generality, we can assume that the income elasticity of demand for both monetary and non-monetary gold is unity:

$$G^{\circ}/y = \lambda*P*k(\pi) + h(1/P, \pi) \quad (6)$$

The right side of Figure 3 shows the stock equilibrium in the gold market. At point A the gold stock is increasing at the same rate as real output. The left side of Figure 3 shows the ratios of production and depreciation flows to real output as a function of the relative price of gold. The horizontal distance between the two functions is equal to the

FIGURE 3



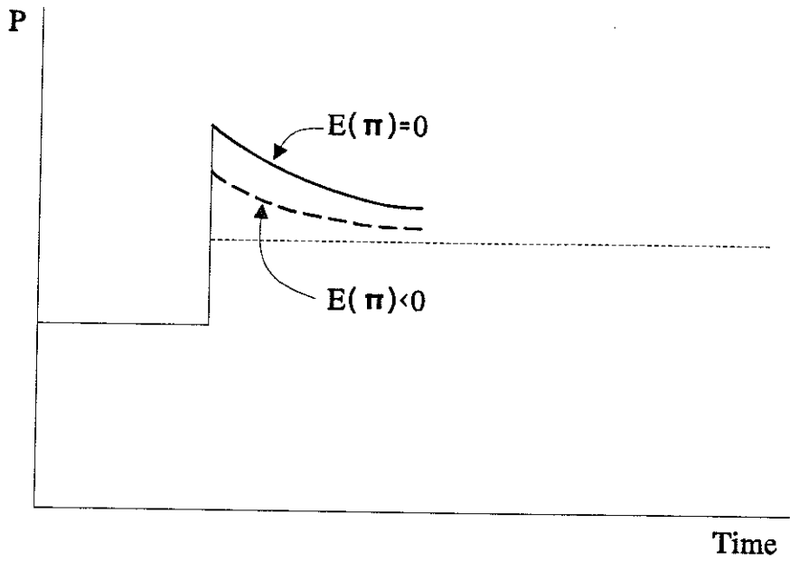
ratio of the change in the total gold stock to real output. This ratio is also equal to the product of the growth rate of real output (z) and the ratio of the gold stock to real output:

(7) $$(\Delta G)/y = z*(G/y)$$

For instance, suppose the gold stock is 1/2 of world output and the growth rate of world output is 4 percent per year. Then the (steady-state) ratio of the increase in the gold stock to the level of output would be 2 percent per year. Thus the gap between the two functions on the left side of the chart (2 percent in this case) would be equal to 4 percent of the ratio of the gold stock to world output (50 percent.)

Now suppose that expansionary monetary policies result in a decrease in the gold ratio.[4] Also assume that in the very short run both the price elasticity of demand for non-monetary gold and the price elasticity of supply (n_s) are zero. Because the non-monetary sector can only gradually absorb the gold discharged from the monetary sector, the instantaneous impact of the lower gold ratio will be entirely concentrated in the monetary sector. In that case, the price level (and the currency stock) must immediately increase in (inverse) proportion to the change in the gold ratio (as in Section II). Unlike in Section II, however, the price level will not asymptotically approach its original equilibrium. From equation 7 we can see that the original price level would not represent a stable equilibrium because at that price level the flow supply of gold (net of depreciation) is unchanged, whereas the right side of equation 7 has decreased in proportion to the decrease in G/y. The permanent change in the price level in response to a change in the gold ratio is:[5]

FIGURE 4



(8) $$\Delta ln\ P = (-1+\{n_d*[(1-\theta)/\theta]*[(z+d)/z]\}-[n_s/(\theta*z)])^{-1}*(\Delta ln\ \lambda)$$

The size of the permanent change in the price level will be negatively related to n_s, d, and (the absolute value of) n_d, and positively related to z and θ. Only in the limiting case where the two elasticities are zero would the long-run impact be equivalent to the short-run impact. In that case, monetary policy would have no impact on gold production and non-monetary demand. The higher the value of these elasticities (and the rate of depreciation) the greater the degree to which responses in the non-monetary sector, and in gold production, cause the effects of monetary policy to "erode" over time. Conversely, the higher is the value of z and, the greater is the share of the flow demand for gold that is absorbed by the monetary sector, and the greater is the long-run impact of monetary policy on the price level. The crucial difference between the Barro-McCallum models and the model developed in this section is that in Section II the steady-state flow demand for gold was assumed to be zero in the monetary sector, whereas in this model a change in λ permanently affects the flow demand for monetary gold.

The solid line in Figure 4 shows the path of the price level following a one-time reduction in the gold ratio. Note that after the initial increase, the price level will asymptotically approach its new long-run equilibrium. Unlike the case considered by Barro and McCallum, however, in the secular growth case the price level will not return to its original value.

In the price-level path shown in Figure 4, the rate of deflation, after the initial price level increase, is less than that in Figure 2. Nevertheless, as long as *some* deflation is

anticipated, the demand for gold should increase and thus further mitigate the initial price level increase. The dotted line in Figure 4 shows the REH solution, that is, the price-level path that would occur if forecasters correctly anticipated the gradual return of the price level to its long-run equilibrium. The higher is the inflation (or interest) elasticity of demand for gold, the smaller will be the amount by which the price level overshoots its long-run equilibrium.

Barsky's finding that first differences in the price level were approximately a white noise process during the gold standard era suggests that the amount of overshooting must have been small relative to other movements in the price level. The amount of overshooting is negatively related to the size of the permanent component of the change in the price level and positively related to the size of the initial price-level shock. As noted above, a high permanent component to the price-level change could be explained by a rate of depreciation that is small relative to the rate of output growth and by a relatively low value for n_s and (the absolute value of) n_d. A high inflation elasticity of demand for gold would reduce the amount of overshooting and, thus, also help to account for Barsky's finding.

Thus far we have examined monetary policy solely from the perspective of a closed-economy model. Fortunately, the model can be easily adapted to analyze monetary policies of individual countries in an open-economy setting. The monetary policy actions of a single country will only affect the world price level to the extent to which they affect the world gold ratio:

$$\Delta ln\ \lambda = \Delta ln\ \lambda^{i*}(G_m^{\,i}/G_m) = \Delta ln\ \lambda^{i*}[(\lambda^{i*}k^{i*}y^{i})/(\lambda^{*}k^{*}y)] \tag{9}$$

where the 'i' superscript denotes the values of relevant economic variables for an individual country. Note that it is the size of a country's gold stock, rather than its money supply or GNP, that is the relevant measure of a country's "size". In all other respects, however, the open-economy model has the same *qualitative* implications as the closed-economy model.

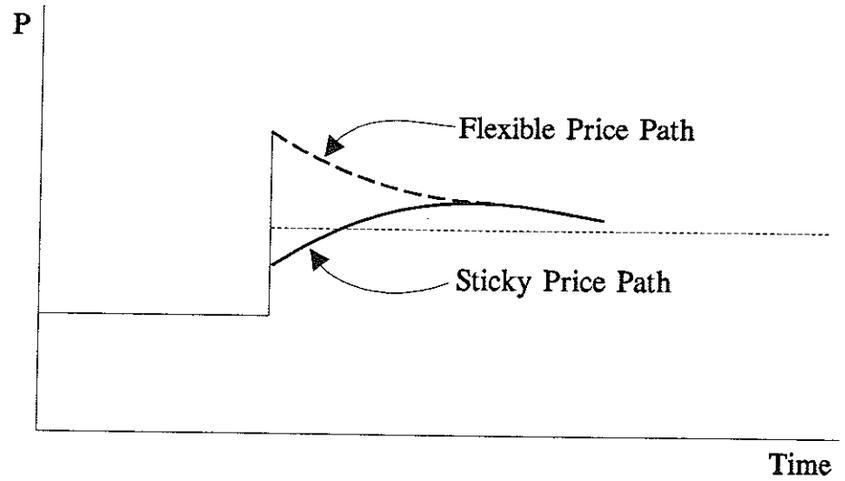
IV. MONETARY POLICY IN A DISEQUILIBRIUM CONTEXT

In each model considered thus far, money has been assumed to be neutral even in the short run. In this section, I will examine the implications of sticky prices for the price path derived in the previous section.

If some prices are sticky, the overall price level would adjust slowly to changes in the money supply. In many disequilibrium models, an increase in the money supply has relatively little *immediate* effect on the price level. Instead, the interest rate falls sufficiently to induce individuals to hold greater real balances [Dornbusch, 1976]. This response is usually referred to as the "liquidity effect".

Figure 5 shows the path of the price level following a decrease in the gold ratio in the case where the liquidity effect is dominant in the short run. In constructing Figure 5, I have made several assumptions regarding the dynamics of the price level. First, I have assumed that only a fraction of all prices are completely flexible and that the discrete change in the price level at the time the gold ratio is changed is smaller than the long-run change. (Since overshooting occurs in the flexible price model, it is *possible* that overshooting could even occur in an economy where some prices are sticky.) Second, since individual price adjustments are assumed to occur continuously, the liquidity

FIGURE 5



effect will gradually erode over time. Over a period of time sufficient for all prices to become fully flexible, the path of the price level will return to the path derived earlier in the equilibrium model.

The observation that money supply changes are associated with interest rates moving in the opposite direction is not, by itself, proof of the validity of the assumptions underlying the disequilibrium model. Barro [1989] showed that "liquidity effect" type movements in the interest rate could be produced if the monetary authority followed a particular feedback policy. Although Barro restricted his analysis to a fiat monetary system, his analysis could also be applied to the gold standard model developed in Sections II and III. In these equilibrium models, increases in the money supply (resulting from a lower gold ratio) reduce the expected rate of money growth as well as the expected rate of inflation. Interest rates would decline along with the expected rate of inflation (the Fisher effect) even if there were no change in the real interest rate. (Of course the traditional view holds that the liquidity effect occurs via changes in the real interest rate.)

V. THE BANKING SCHOOL - CURRENCY SCHOOL CONTROVERSY

Although the policy debate between members of the Banking and Currency Schools during the nineteenth century is an important part of the history of economic thought, from a modern perspective their views are remarkably similar. Both schools supported the principle of convertibility (i.e., the gold standard) and both sides agreed that, in the long run, the price level was determined by convertibility (i.e., by the supply and

demand for gold). Furthermore, both schools believed that a central bank could improve the efficiency of the monetary system.[6]

Currency School proponents such as Robert Torrens and Lord Overstone argued that the money (currency) supply should fluctuate exactly in proportion to the monetary gold stock. The currency principle could be implemented by requiring all note issuers to maintain a fixed gold ratio. This proposal would have the effect of codifying the "rules of the game". (The rules of the game required countries to change their currency stocks in response to international gold flows.)

Banking School proponents such as John Fullarton and Thomas Tooke argued that, in the absence of legal restrictions, the quantity of bank notes would be demand determined. They argued that banks should be able to accommodate changes in the demand for currency associated with changes in real output. They denied that such a policy would increase the short-run volatility of the price level. In fact, according to Laidler [1984, 150] price-level stability was accepted as a "vital principle of social organization" by both sides of the monetary policy debate.

One of the weaknesses of the Banking School argument is that they assumed the quantity of banknotes to be completely demand determined. Under a gold standard banks must hold gold reserves to insure convertibility. Because gold is a non-interest earning asset, it is costly for banks to hold gold reserves. It seems reasonable to assume that, in a unregulated environment, the gold ratio would be a negative function of the nominal interest rate. Thus, if there were an increase in the demand for currency, banks could only be induced to increase the quantity of bank notes supplied (or decrease the gold ratio) if the nominal interest rate rose along with the demand for currency. Because changes in the demand for currency can induce changes in the demand for monetary gold, it is not accurate to assume that the price level is impervious to these sorts of shocks.

The primary difference, then, between the Banking and Currency Schools lies in the behavior of the gold ratio. Adoption of the Banking School's proposal would result in a negative relationship between the gold ratio and the interest rate (and a positive relationship between the money supply and the interest rate), whereas under the currency principle the gold ratio would be fixed.

In order to compare the impact of each proposal on the volatility of the price level it may be helpful to consider the impact of an autonomous increase in real output. We will assume that the supply of gold is fixed. We can make this assumption since the model developed in Section III implies that the supply of gold is a function of the price level.[7] Thus, the policy that produces a more volatile price level in a fixed gold stock environment would also produce a more volatile price level if changes in the flow supply of gold helped to dampen price-level volatility.

An increase in real output, *ceteris paribus*, would increase the demand for both monetary and non-monetary gold, and thus reduce the price level. The apparent implication that the price level should move countercyclically might not hold, however, if output fluctuations induced procyclical movements in the interest rate.

Numerous studies have shown that nominal interest rates tend to move procyclically. A higher interest rate would directly reduce the demand for non-monetary gold. Even under the currency principle, the impact of higher interest rates on the demand for currency would induce a reduction in the demand for monetary gold. If the Banking School's proposals were in effect, both the demand for currency *and* the gold ratio would decrease when interest rates increased. In that case, the reduction in the demand for monetary gold would be even greater than under the currency principle. To summarize, under both policies fluctuations in real output will induce countercyclical price-level movements. Under the banking principle, and to a lesser extent under the currency principle, fluctuations in nominal interest rates will tend to produce a procyclical price level.

The preceding discussion suggests that the cyclicality of the price level in an economy operating under either principle is ambiguous. We do know that the price level will be relatively more procyclical under the banking principle than it would be under the currency principle. What we are actually interested in knowing, however, is which principle would result in the greatest *stability* in the price level.

If under the currency principle the price level were already procyclical, switching to the banking principle would make the price level even more procyclical, and hence, more volatile. If price-level movements were countercyclical under the currency principle, then switching to the banking principle *could* make the price level less volatile by allowing the currency stock to better accommodate fluctuations in the demand for money. Even in this case, however, it is possible that the adoption of the banking principle could increase price-level volatility by causing the price level to move from being countercyclical to being highly procyclical.

There is some empirical support for the currency principle in the numerous studies that have shown the existence of a positive correlation between price levels and nominal interest rates during the gold standard era. This relationship, named the "Gibson Paradox" by Keynes (after A.H. Gibson), occurred in both the U.S. and the U.K. during the nineteenth century. The Gibson Paradox relationship would presumably be exacerbated by the adoption of the Banking School's proposals.[8]

The preceding evidence does not, however, represent a definitive rejection of the Banking School's ideas. It may be the case that the Gibson Paradox occurred under policy regimes nothing like what *either* the Banking School or the Currency School would have preferred. If central banks conducted highly procyclical monetary policies (i.e. a highly countercyclical gold ratio) under the gold standard, then even a switch to the banking principle could have reduced price-level volatility. For instance, Sumner [1991] showed that during the first year of the Great Depression the major central banks exacerbated the impact of falling interest rates on the demand for currency (and non-monetary gold) by sharply increasing the gold ratio and thus further increasing the demand for monetary gold. Future research on this topic should evaluate the relationship between the gold ratio and prices throughout the gold standard period.

The previous analysis has focused on theoretical aspects of the Currency - Banking School debate. Further insights may be gained by considering the rhetoric used by both sides of the debate. White [1984] showed that the Currency School was concerned that adoption of the banking principle would result in "overissue" of currency while the Banking school argued that the currency stock should fluctuate with the "needs of trade" and that the "law of the reflux" would prevent overissue.

One can examine the concern about "overissue" by considering the case of a boom that led to a temporary increase in interest rates. Under the banking principle, the higher interest rate would result in a lower gold ratio and an increase in the currency stock (a desirable result from the "needs of trade" perspective). When the boom ended, the process would reverse itself and the Currency School would argue that the adjustment process could be painful — perhaps even necessitating a restriction on convertibility.

The Banking School was correct that the "law of the reflux" could prevent overissue in the sense that the currency stock is demand determined *for a given gold ratio* under a gold standard and that excessive currency production will be returned to the issuing bank. The real issue is the desirability (from the macroeconomic perspective) of the sort of movements in the gold ratio that are likely to occur if the banking principle is utilized. Mints argued that the "needs of trade" was an almost meaningless concept since:

> If prices should decline and business conditions deteriorate, the "needs" of an enterprise for borrowed funds would decrease. Hence, borrowing from the banks would decline precisely at the time when an increase in the quantity of money would be desirable from the standpoint of the whole economy. [1945, 94]

An implication of Mints's statement is that the banking principle might increase the volatility of both prices and output. This creates a very serious problem for proponents of the Banking School. The terms "deflation" and "depression" were used almost interchangeably during the nineteenth century, and output instability was viewed as one of the major evils associated with price-level volatility. As noted earlier, the currency principle would only increase price-level instability by making prices move more *countercyclically*. Thus the Banking School would be in the position of criticizing the Currency School for advocating a policy that was relatively more countercyclical than their own policy!

The implication of Mints's critique can be seen more easily if one assumes that the inflation (and interest) rate is procyclical. In that case, the model developed in Section III implies that currency velocity will be procyclical under either principle (since '*k*' is negatively related to inflation). The currency stock will almost certainly also move procyclically under the banking principle since the gold ratio will move countercylically.[9] Thus the banking principle would probably increase the volatility of nominal GNP. Although we cannot definitively assert that the banking principle would increase *price-level* volatility, those economists who prefer using nominal income stability as the central objective of monetary policy would be unlikely to support the banking principle.

VI. CONCLUSION

The gold standard model most consistent with the historical record would incorporate secular growth in output and comparable technological change in the gold mining industry. In this sort of model, monetary policy can have a permanent effect on the price level. When there is a change in the gold reserve ratio, the price level will overshoot its long-run equilibrium by a smaller amount than predicted by the Barro and McCallum models. The existence of a liquidity effect would further mitigate the initial impact of monetary policy on the price level. If there is a liquidity effect, the peak impact could occur several months, or even several years, after a change in the gold ratio.

The Banking - Currency School debate can be re-evaluated in terms of the model developed in Sections III and IV. The empirical evidence is not definitive, although some support for the currency principle can be found in studies that show interest rates and prices to be procyclical during the gold standard era.

APPENDIX

This appendix will provide a complete derivation of the instantaneous impact of a change in the gold ratio on the price level in a steady-state economy (equation 5), and the long-run impact of a change in the gold ratio on the price level in a growing world economy (equation (8)).

In the case where we are examining the instantaneous impact of a change in the gold ratio, we can assume that the total gold stock is fixed. In that case the instantaneous change in the monetary gold stock is inversely related to the change in the nonmonetary gold stock:

$$- \Delta G_n = \Delta G_m \tag{10}$$

And the rates of change for each type of gold will be proportional to their respective shares of the total gold stock:

$$- [(1 - \theta)/\theta]*(\Delta ln\ G_n) = \Delta ln\ G_m \tag{11}$$

The rate of change in the non-monetary demand for gold is related to its elasticity of demand, and the rate of change in the monetary demand for gold is related to the changes in the gold ratio and the price level (since real currency demand is assumed to be unaffected by monetary policy.):

$$[(1 - \theta)/\theta]*n_d*(\Delta ln\ P) = (\Delta ln\ P + \Delta ln\ \lambda) \tag{12}$$

The terms in equation 12 can be rearranged to produce equation 5:

$$\Delta ln\ P = [-1 + n_d*(1 - \theta)/\theta]^{-1}*(\Delta ln\ \lambda) \tag{13}$$

Equation 8 will be derived by assuming that, in the long-run, the flow supply of gold is equal to the sum of the two sources of the flow demand for gold:

$$[g(1/P)/y] = (d + z)*(G_n/y) + z*(G_m/y) \tag{14}$$

(Note that the monetary gold stock is assumed not to depreciate.) Equation 14 can also be expressed as rates of change if the sources of the demand for gold are weighted by their respective shares of the gold stock:

$$n_s*(-\Delta ln\ P) = (1 - \theta)*(d + z)*n_d*(-\Delta ln\ P) + \theta*z*(\Delta ln\ \lambda + \Delta ln\ P) \tag{15}$$

(Recall that the price level is inversely related to the relative price of gold.) Rearranging the terms in equation 15 will result in equation 8:

$$\Delta ln\ P = (-1+\{n_d*[(1-\theta)/\theta]*[(z+d)/z]\}-[n_s/(\theta*z)])^{-1}*(\Delta ln\ \lambda) \tag{16}$$

As in equation (5), this represents a first order approximation since θ is affected by changes in the gold ratio.

NOTES

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1. McCallum argues that a non-trivial monetary gold stock is required for the successful operation of a gold standard. There are two possible exceptions to this provision, however. Individual central banks could simply hold reserves of currency issued by another gold standard nation. A policy of fixed exchange rates would then imply indirect convertibility. Even in a closed-economy framework it may be possible to fix the nominal price of gold (the sine qua non of a gold standard) by merely engaging in open market operations. If this policy had *credibility*, then the actions of private speculators would help to stabilize the price of gold.
2. A similar graph appears in McCallum [1989].
3. This is actually a first order approximation since the ratio of the monetary gold stock to the total gold stock is itself a function of monetary policy. See the appendix for a complete derivation of this equation.
4. If, for instance, the world's central bank were to adopt an expansionary monetary policy that doubled the currency stock, then, assuming no instantaneous change in central bank gold stocks, the gold ratio would fall by 50 percent.
5. See the appendix for a proof of this equality.
6. Glasner [1989] and White [1984] provide excellent summaries of the views of each school.
7. The assumption that technological change in the gold mining industry occurs at the same pace as in the general economy would seem to suggest that the flow supply of gold is also a function of y. It would probably make more sense to assume that the technological change is equal to the *average* growth rate in output. And, even if output fluctuations had a positive impact on the flow supply of gold, the fact that output also affects the stock demand for gold means that output fluctuations would have the same qualitative cyclical impact under either assumption.
8. Papers by Barsky and Summers [1988] and by Lee and Petruzzi [1986] discuss how the Gibson Paradox could have resulted from the impact of changes in the interest rate on the demand for gold.
9. In principle, the countercyclical movement in the gold ratio could have been offset by a procyclical movement in the monetary gold stock, but it is unlikely that movements in the monetary gold stock were rapid enough to offset these other factors over the time frame of the business cycle [Sumner 1991].

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