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ARTICLES

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Inflation and Currency Depreciation in Germany, 1920–1923: A Dynamic Model of Prices and the Exchange Rate

EARLIER EMPIRICAL LITERATURE on the German hyperinflation has looked at various aspects of the inflationary process rather in isolation, the focus being mostly on the determinants of either the money demand, the exchange rate, or prices. The thesis brought forward by this article is that, by proceeding in this way, a number of important issues have remained unresolved. Among the unresolved issues are the strong autocorrelation of the residuals in the estimates of the demand for money, the explanation of the determinants of the real exchange rate and of the dynamic adjustment of prices and the exchange rate to monetary disturbances.

This paper presents a dynamic model of the German hyperinflation, together with its estimates, explaining simultaneously prices, the exchange rate, and the money supply. The model has the following characteristics:

- The nominal exchange rate is allowed to diverge from purchasing power parity (PPP) in the short run;
- the monetary approach to exchange rate determination and the quantity theory of money are assumed to be valid in the long run (steady-state property of the model);
- the dynamic adjustment of prices and the exchange rate to monetary disturbances is made explicit;
- currency substitution between domestic and foreign currencies is considered explicitly.

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The paper is divided in five parts. Section 1 presents a brief survey of the earlier empirical literature on the German hyperinflation, clarifying why the model presented in this paper overcomes many of the criticisms raised against the earlier literature. Section 2 presents a three-equation dynamic model of the money supply, the exchange rate and prices, while the estimates of this model are presented in section 3. A summary of the main findings is contained in section 4.

1. A BRIEF SURVEY OF THE LITERATURE

Earlier empirical research on the German hyperinflation can be classified into three main strands of theory. The first one follows the quantity theory of money and is associated mainly with the works of Bresciani-Turroni (1937), Cagan (1956), Graham (1930), Jacobs (1975, 1976) and Kahn (1975, 1977a, 1977b, 1980). The main result of this strand of theory lies in the unique determination of real cash balances by the expected inflation rate and the stability of the inflationary process.[1] The second strand of theory focuses on the exchange rate and is mainly associated with the work of Frenkel (1976), while the third one is related to the theory of rational expectations and its main contributors are Sargent and Wallace (1973) and Sargent (1977).

All three strands of theory present problems that are briefly discussed in this section. The main problems associated with the first strand are the strong autocorrelation of the residuals in the estimates of the demand for real cash balances, the stability of the model, and the unsatisfactory specification of the dynamic adjustment of prices to money creation. As for the strong autocorrelation of the residuals in the demand for real cash balances, Cagan speculated that the introduction of a variable adjustment parameter of inflationary expectations would eliminate most of the residuals autocorrelation. However, this is not the case, as Kahn (1977a) and Jacobs (1977) have shown,[2] although Kahn's estimates of the demand for real cash balances show some reduction in autocorrelation.

The strong autocorrelation of the residuals seems rather caused by a missing variable. In fact, Cagan assumed that the relevant substitution in the demand for real cash balances is only between real cash balances and domestic goods, or equivalently that the exchange rate always moves to equate the difference between foreign and domestic inflation rates. The hypothesis that PPP held during the hyperinflation

1. Various authors have analyzed the dynamic stability of Cagan's model, including Kahn (1975), Bisignano (1975), and B. Friedman (1978). In Cagan's model, the stability of the system is determined by the product of parameter β (the elasticity of the demand for real cash balances with respect to expected inflation) and parameter λ (adjustment parameter of expected inflation to actual inflation). The process is dynamically stable if the product of parameters λ and β is smaller than one. Although the product of the parameters in Cagan's estimates is larger than one, the lower bound of the 90 percent confidence interval is 0.92. B. Friedman shows that the stability conditions for the discrete version of Cagan's model is more stringent than the above-mentioned one and he concludes that Cagan's model might not be stable (see also Sommariva and Tullio 1987, appendix to ch. 3).

2. Kahn reestimated Cagan's model, assuming that the adjustment parameter λ is a function of inflation and the variability of inflation, while Jacobs introduces a nonlinearity into the formation of expectations by making the adjustment parameter λ a function of the square root of expected inflation.

is also assumed by the authors of the second strand of theory, who derived from this condition an equation for the exchange rate depending positively on the supply of nominal cash balances and negatively on the real demand for them.

The most important criticism is that PPP did not hold during the hyperinflation, at least in the short run. Abel et al. (1979) showed that very large deviations from PPP occurred during the hyperinflation in Germany. This result is reinforced by recent findings by Taylor and McMahon (1988). They showed, using the cointegration method, that the PPP hypothesis held as a long-run equilibrium condition on which the actual exchange rate tends to converge. As a logical consequence, Abel et al. (1979) introduced separately the expected changes in the exchange rate and in prices in the demand for real cash balances.[3] They found that both variables were statistically significant and that the substitution between currency and foreing assets was stronger than the one between currency and goods, a result confirmed by Taylor (1990).

The fact that PPP did not hold in the short run implies that the adjustment mechanism of prices to money creation is much more complicated than the one adopted in the Cagan and Frenkel's differential equation systems. The unsatisfactory specification of this mechamism in Cagan and Frenkel's contributions was first pointed out by Jacobs (1975). He showed that the nonstochastic form of Cagan's differential equation can be solved in two equivalent ways. In the first one, real money balances are a function of current and past inflation rates, while, in the second one, the inflation rate is a function of current and past rates of growth of nominal money balances.

Although both solutions are mathematically equivalent, they yield different estimates since the error processes differ. Jacobs showed that the second solution of the differential equation system gives a very poor fit compared to the first one. He advanced the argument that a sudden increase in the price level, not directly associated with a change in nominal money balances, results in a good fit for the first solution and a poor fit for the second one, implying that the observed money supply did not produce the observed price movements according to Cagan's differential equation system and that the specification of the dymanic structure of the model is incomplete.[4]

The problem of the relationship between money and prices has been extensively analyzed in the literature, particularly by the rational expectations theorists.[5] Most of the authors who have performed a Granger causality test between money and prices during the German hyperinflation have found that the causality was mostly

3. They used the forward premium/discount as a proxy for the expected rate of change of the exchange rate and actual inflation as a proxy for the expected one.

4. Without specifying a formal mathematical model, the dynamics of inflation and exchange rate changes had already been considered by Bresciani-Turroni in his analysis of the causes of the German hyperinflation. Bresciani-Turroni attributed great importance to the behavior of the exchange rate and considered that, after the end of the war and the removal of price and exchange controls, "the new money by flowing directly to foreign exchange markets was depressing the external value of the mark first and causing an increase in prices afterwards" (Bresciani-Turroni 1937, p. 72).

5. See Sargent and Wallace (1973), Frenkel (1977), Evans (1978), and Salemi and Sargent (1979).

from prices to money, although some evidence is found of bidirectional causality.[6] These findings are explained by Sargent and Wallace by assuming that the government was trying to maintain its expenditures constant in real terms and that the only government revenues were from inflation.

There is another explanation of the causality from prices to money. The theory of the German inflation most popular in Germany was the so-called "balance of payments theory" according to which the main causes of inflation were wage rigidities, the inelastic supply of German exports, the low elasticity of demand for them by foreigners, and, above all, the negative influence on the mark of reparation payments and of uncertainties about the progress of German-Allied negotiations. According to Holtfrerich, the Reichsbank which until the London ultimatum of May 1921 had leaned in private (but not in public) toward a quantity-theoretic explanation of the inflation, converted then at least partially to the balance of payments theory (Holtfrerich 1989, p. 169).[7] (Havenstein, the president of the Reichsbank, considered the reparation payments imposed on Germany by the London ultimatum as impossible to satisfy.) A logical corollary of the balance of payments theory is that when there are severe rigidities in the economy of the type mentioned above, the central bank cannot hold the money supply constant when the price level goes up, for instance, as a result of a sharp fall in the exchange rate. Rather, it should passively finance the increased nominal demand for money and credit (the "real-bills" doctrine). The absence of such a behavior would normally cause a recession.

Holtfrerich deals in detail with the objectives of German economic policy at the time. He includes among the most important full employment, real growth, and a high standard of living. The young German democracy was very weak, and avoiding a recession was a matter of survival for the government. Germany's political life was characterized by assassinations of finance ministers, the workers' fight for the eight-hour day, deep hatred between social classes, and great instability (Kindleberger 1986).

There is some evidence that the tendency of the Reichsbank to passively finance increases in prices has been stronger at times of weak economic activity. The most important episode of anticyclical (expansionary) monetary policy occurred in the second half of 1922. In the second quarter of 1922 real wages fell sharply, fiscal policy was very restrictive, and stock prices recorded sharp drops in real terms (Webb 1989). Although quarterly data on aggregate demand are not available, it

6. Some different results were found by Protopapadakis (1983a). He shows that the linear ARIMA model used by Sargent and Wallace to prewhiten the series of money and prices is unstable over time. By estimating the ARIMA model for different subperiods, a simple way to introduce nonlinearities, he shows that the hypothesis that prices cause money is rejected if the test is performed for the period up to mid-1922 and that the hypothesis is accepted if the test is performed for the whole period up to July 1923.

7. For an early "official" as opposed to "confidential" view of the Reichsbank on the appropriate policy in the face of increases in the price level, we report the following statement by Helfferich, quoted also by Bresciani-Turroni, on the opinions of Havenstein, the President of the Reichsbank: "The President of the Reichsbank, Havenstein, has always upheld the opinion that one could not speak of inflation, when account was taken of the great quantity of money placed to the military administration and to private firms, of the money circulating in occupied territories and of the increased need, *which was due to an increase in prices and salaries independent of monetary conditions*" (Helfferich 1923, p. 412, and Bresciani-Turroni 1937, p. 50).

seems plausible to assume that real aggregate demand fell. Historians agree that there was a credit squeeze in mid-1922 (Kindleberger 1986, Holtfrerich 1989). In July the Reichsbank reacted to the credit shortage by discounting for the first time commmercial bills on a large scale, thus opening its credit potential to the private sector at the same very favorable interest rate it was charging the Reich (Holtfrerich 1989, Webb 1989).[8] Ironically this happened when the problem of the government budget deficit had been to a large extent solved since the budget net of reparation payments, was actually in surplus.

Sharp increases in prices and in the nominal demand for money occurred during the German hyperinflation also at times of weak economic activity, as in the episode mentioned above. Wholesale prices increased by 306 percent in March and by 415 percent in June 1922 (with respect to the corresponding month of 1921). By September 1922 the rate of inflation had already climbed to 1288 percent as a result of the July change in the discounting policy of the Reichsbank.

Another episode of sharply rising prices and falling economic activity coupled with passive behavior of the Reichsbank occurred after the Allied occupation of the Ruhr in early 1923, when output and tax revenues fell owing to the strikes in the Ruhr, the budget deficit exploded, and the growth rate of the money supply was sharply increased, thus setting the stage for the final collapse of the currency.

The above discussion raises the issue of the possible bias in the estimates introduced by the assumption that the money supply is exogeneous, and of the need to at least partially endogenize the money supply in a correct specification of a model for the German hyperinflation. In the model of the next section the acceleration of the money supply will therefore be expressed as a function of nominal income and of the deviation of actual from potential output.

To summarize, this brief survey of the earlier literature on the German hyperinflation suggests that a correct model of the German hyperinflation should include (i) domestic and foreign currency substitution in the demand for real money balances, (ii) a dynamic mechanism allowing short-run deviations of the exchange rate from PPP, and (iii) a feedback from prices to money (that is, a partially endogeneous money supply). The steady-state properties of the model should, however, imply that PPP and the quantity theory of money hold in the long run.

2. A DYNAMIC MODEL OF THE GERMAN HYPERINFLATION

Table 1 describes a three-equation model for prices, the exchange rate, and the supply of nominal cash balances. This model is essentially a dynamic one, in which

8. On the real-bills doctrine followed by the Reichsbank in mid-1922 after the credit squeeze, see also Kindleberger (1986). Webb reports that Havenstein put a higher priority than his successor, Schacht, on sustaining business activity than on maintaining price stability and that the latter had fewer ties to big business (Webb 1989, p. 120). The fact that the Reichsbank adopted anticyclical policies is also reflected in the following sentence of Bresciani-Turroni: "The Reichsbank was persuaded to give exceedingly liberal credit concessions by the laments of the industrialists, who stated that they could not otherwise pay the salaries and the wages of their employees" (Bresciani-Turroni 1937, p. 77). He also accused the Riechsbank of "excessive indulgence to the interest of influential groups" (Bresciani-Turroni 1937, p. 79).

TABLE 1

A DYNAMIC MODEL OF EXCHANGE RATE CHANGES AND INFLATION[a]

1. The Exchange Rate
   $D \ln S = \alpha_1 \ln(\hat{S}/S)$ (1)
   where the partial equilibrium level of the exchange rate ($\hat{S}$) is $\hat{S} = BU/(b\hat{u}\ p_{us})$ (1a)
   and $b\hat{u}$ is the demand for real cash balances:
   $b\hat{u} = \gamma e^{-\beta_1 \pi^e} e^{-\beta_2 D\ln p^e} e^{-\beta_3 D\ln S} y^{\beta_4}$. (1b)
2. Prices
   $D \ln p = \alpha_2 \ln(BU/(p\ b\hat{u}\ )) + \delta_1 \ln(y/\bar{y})$ (2)
   and
   $D\pi^e = \lambda\ (D \ln p - \pi^e)$. (2a)
3. Supply of nominal cash balances
   $D^2 \ln BU = \alpha_3 \ln((y\ p)/BU) + \alpha_4\ D\ln((y\ p)/BU) + \delta_2 \ln(\bar{y}/y) + \delta_3\ D \ln(\bar{y}/y) + c_0$ (3)
   where y is potential output:
   $\bar{y} = y_0\ e^{\delta_4 t}$ (4)

[a] Adjustment parameters are denoted by α_i, elasticities by β_i, and other parameters by λ, δ_i, and γ.

equilibrium implies that prices change according to the quantity of theory of money, purchasing parity holds, and expected inflation is equal to actual inflation.

The model, however, does not assume that the economy is in equilibrium at each point in time, but rather that price adjustment is guided toward equilibrium through the adjustment of portfolios of holders of nominal cash balances. The adjustment postulated implies that equilibrium is reached only when existing stocks of cash balances are willingly held. Similarly, the exchange rate adjustment to purchasing power parity is guided by the partial adjustment of the actual level of the exchange rate to its partial equilibrium level, as defined by the monetary approach to the exchange rate determination.

This is essentially a representation of a "non-tatonnement" process, acknowledging the fact that trading takes place continuously, even though prices may not be in equilibrium. The existence of transaction costs, uncertainties, and other "real world" frictions are the rationale behind the postulated partial equilibrium adjustment process. The adjustment formulation allows both for damped harmonic motion and exponential approach to equilibrium, depending on the values of the adjustment parameters. The formulation as a differential equations model does not preclude rapid adjustment to equilibrium. The mean-time lag $1/\alpha_i$ may be close to zero, thus implying that the desired or partial equilibium level of a variable is approximately equal to its actual level.[9]

Equation (1) assumes that changes in the nominal exchange rate are determined by discrepancies between the partial equilibrium level of the exchange rate and its actual level. The partial equilibrium level of the exchange rate [equation (1a)] is defined according to the monetary approach to the exchange rate.

9. The mean-time lag $1/\alpha$ is the time taken for 63 per cent of the discrepancy between the actual and the partial equilibrium levels of a variable to be eliminated by changes in its actual level. This adjustment process can be represented, in general, as:

$$y(t) = (\alpha/(D + \alpha)\ \hat{y}(t)$$

Equation (1b) is a demand function for real cash balances, which is assumed to depend on (i) the expected and the actual inflation rates, reflecting respectively substitution with domestic financial assets and goods,[10] (ii) the rate of change in the exchange rate, reflecting foreign currency substitution, and (iii) on real income.

In order to keep the model as simple as possible, currency substitution has been represented by the actual rate of change of the exchange rate instead of the expected change in the exchange rate. The forward premium/discount, which could have been used as a proxy for the expected change in the exchange rate, is available only from mid-1921, thus substantially limiting the sample period. Moreover, it is doubtful whether the forward premium/discount represented then (as well as now) a good predictor of exchange rate changes.

Equation (2) states that the inflation rate adjusts to the discrepancy between the supply of nominal cash balances and the real demand for them. The formation of inflationary expectations is defined by equation (2a) and it is postulated to be of the adaptive expectations type, whereby expected inflation is determined by a first-order exponential distributed lag of actual inflation.[11] The estimate of the speed of adjustment of expected inflation to actual inflation will suggest whether these expectations are static or not.

Equation (3) represents a simple money supply process. It implies that the acceleration of nominal cash balances depends on the ratio of nominal income to nominal cash balances and on the deviation of actual from potential output, seen as a proxy for the position of the economy in the cycle. The derivatives of these two terms have also been included. The inclusion of the output gap can also be interpreted as resulting from a linearization of a nonlinear model, in which parameters α_3 and α_4 change in time according to the gap between actual and potential output. All nonconstant terms in the equation reflect the passive behavior of the Reichsbank in the face of increases in the price level and the nominal demand of money and credit (to avoid credit squeezes), as well as the closely related objective of keeping employment and real output growth at politically acceptable levels. A historical justification of such a reaction function of the Reichsbank has been given at the end of section 1. The constant term c_0 reflects exogeneous factors causing monetary growth.

The differential equation system of Table 1 has a steady-state solution. It was felt important to investigate the steady-state solution of the model because even a short-run model should conform to plausible long-run properties. The steady-state solution of this model implies that prices are formed according to the quantity theory of money, that expectations of inflation are equal to actual inflation, and that exchange rates changes are equal to the differential between domestic and foreign inflation.[12]

where $y(t)$ and $\hat{y}(t)$ are the actual and the partial equilibrium levels of the variable and D is the differential operator. This is equivalent to the first order exponential lag function:

$$y(t) = \int_0^\infty \alpha e^{-\alpha s} \hat{y}(t - s)ds$$

which lends itself readily to the concept of excess demand and supply.

10. An appropriate specification of the demand for real cash balances would include a nominal interest rate and expectations of inflation, reflecting substitution with financial assets and goods. However, since no reliable data on interest rates are available, the nominal interest rate was proxied by the expected inflation rate, under the assumption that interest rates were perfectly flexible during the German hyperinflation. In this model, actual inflation reflects substitution of cash balances with goods.

11. As shown by Sargent and Wallace (1973), there is one case in which rational and adaptive expectations can be considered equivalent. This occurs when the rate of growth of money is itself a function of current and past inflation rates.

3. ESTIMATES OF THE MODEL

The parameters of the exact discrete model equivalent to the continuous time system of Table 1 have been estimated simultaneously by full information maximum likelihood.[13] The exact discrete model was used in estimation because it gives more efficient parameter estimates, which is particularly important when using the present set of data, which is characterized by extreme variations. Another advantage in using the exact discrete model in estimation is that it allows the mean-time lags to go to zero, which is not the case when the approximate discrete model is used.

A full-information maximum likelihood estimator is perhaps the most satisfactory because it enables nonlinear within- and across-equation restrictions to be imposed on the system and it is consistent and asymptotically efficient. The efficiency enables a more stringent test of the hypothesis embodied in the model, which is of particular interest in the present case. The sample period is April 1920 to July 1923.

By substituting equation (2a) into equation (1) and (2), the model becomes a second-order differential equation system. The estimation method used (Wymer 1976) involves a transformation of the data to remove the moving average process inherent in the observations. Therefore, assuming that the specification of the model is correct, the series used for estimation should be stationary.

In order to test for stationarity of the nominal variables of the model, unit root tests were performed using a procedure developed by Dickey and Fuller (1981).[14] The tests show that the hypothesis that the dependent variables are not stationary must be rejected at the 5 percent confidence level, except for prices, for which it is rejected at the 10 percent confidence level. The hypothesis is rejected also when the test is performed on the nontransformed data.

Estimates of the parameters of the model are presented in Table 2. All estimated parameters are significantly different from zero, with the exception of the income elasticity of the demand for real cash balances. The α_1 parameter turned out to be very large, indicating that the adjustment of the exchange rate to its partial equilibrium level was extremely rapid during the hyperinflation and that the exchange rate was maintained almost all the time in partial equilibrium.[15]

12. The steady-state solution of the model is available from the author upon request.

13. It was felt that Wymer's econometric technique was the most adequate to estimate this type of model because it guarantees that the estimates of the adjustment parameters are independent of the length of the observation interval (Wymer 1972, 1976).

14. They are available from the author upon request.

15. In preliminary estimates, using an approximate discrete version of the continuous model, the parameter α_1 turns out to be equal to 5.2, significantly different from zero and larger than parameter α_2.

TABLE 2

ESTIMATES OF THE MODEL[a]

Estimated parameters		Asymptotic standard errors	Mean adjustment lag[b]
α_1	200.0[c]	—	18.7
α_2	1.604	0.423	
α_3	0.091	0.029	
α_4	0.790	0.094	
δ_1	0.166	0.124	
δ_2	3.941	1.124	
δ_3	0.403	0.078	
β_1	5.654	0.324	
β_2	0.672	0.188	
β_3	0.078	0.031	
β_4	0.067	0.102	
λ	0.268	0.026	111.9
δ_4	−0.001	0.006	
Chi-square value of the log-likelihood ratio		75.707[d]	
Carter-Nagar chi-square of the over-identified model		603.934[e]	
Carter-Nagar R^2 of the overidentified model		0.834	

[a] The sample period is April 1920 to July 1923.
[b] In days.
[c] In preliminary estimates and using an approximate discrete version of the model, parameter α_1 turned out to be equal to 5.2 and significantly different from zero. Using an exact discrete estimator, for any value of α_1 greater than 50, all other parameters remain unchanged and the log-likelihood function is flat. The high value of this coefficient, which corresponds to an extremely low mean time lag, indicates that equation (1) should really be of zero order. For this reason, this parameter was set to 200 in the final estimates of the model.
[d] The critical value at the 5 percent level of the chi-square with 63 degrees of freedom is 82.5, so that the hypothesis that the overidentifying restrictions are not consistent with the sample must be rejected.
[e] The critical value at the 5 percent level of the chi-square with 15 degrees of freedom is 25.0, so that the hypothesis that this model is not consistent with the data must be rejected.

The α_2 parameter implies a mean adjustment lag of about nineteen days, indicating that changes in nominal cash balances affected prices with a relatively long lag. The λ parameter turned out to be 0.27, implying a mean adjustment lag of about 3.7 months, more plausible than Cagan's estimate of about six months.[16] These results explain the long deviations of the exchange rate from purchasing power parity and its fluctuations during the German hyperinflation.

The estimates show that the degree of foreign currency substitution was significant, although it was much lower than the degree of substitution of cash balances with goods and financial assets. The income elasticity of the demand for real cash balances is around 0.1 and not significantly different from zero. However, this may be the result of the very low variability of output with respect to the variability of all nominal variables.[17] All the parameters of the reaction function (α_3, α_4, δ_2, and δ_3)

Using the exact discrete estimator, for any value of α_1 greater than 50, all other parameters remain unchanged and the loglikelihood function is flat. The high value of this coefficient, which is equivalent to an extremely small mean-time lag, indicates that equation (1) should really be of zero order, or $S = \dot{S}$. For this reason, this parameter was set to 200 in the final estimates of the model.

16. Other authors' estimates of the λ parameter indicate that it is far below infinity. However, in the contributions of Kahn and Jacobs, being itself a function of actual or expected inflation, it reaches values that are close to infinity during the last stages of the hyperinflation.

17. A monthly series of real output does not exist for this period. Annual real output was interpolated with monthly real imports. Although this procedure is questionable, it can be justified on the ground that Germany was already at that time a major transformer of raw materials and semimanufactured products.

turn out to be highly significantly different from zero, giving support to the hypothesis that the Reichsbank followed the real-bills doctrine and that it was very concerned with the maintenance of full employment. It should be mentioned, however, that estimating the model under the assumption that the money supply is exogeneous does not change significantly the parameter estimates, with the exception of the adjustment parameter of inflationary expectations, λ, which assumes a value closer to the one estimated by Cagan.

The chi-square statistic of the likelihood ratio indicates that the hypothesis that the overidentifying restrictions are consistent with the data cannot be rejected. It has to be remarked that the chi-square statistic of the likelihood ratio is an asymptotic test and that it is biased toward rejection in small samples. The Carter-Nagar system R^2 and the Carter-Nagar chi-square statistic of the overidentified model indicate that the model is consistent with the data.

No autocorrelation is present in the model residuals. The residuals of each behavioral equation have been regressed on both their lagged values and the lagged residuals of the other equations. Neither the autocorrelation parameters nor the cross-correlation ones were significantly different from zero, indicating absence of autocorrelation. Kahn (1980) also shows that the autocorrelation of the residuals in the demand for real cash balances is reduced when the model is estimated in continuous time. This supports the present specification of the model and the use of the exact discrete model in estimation.

The root mean square error (RMSE) of the static and dynamic forecasts that give the average error as a proportion of the actual level of the variables is about 23 percent for the change in the exchange rate and 17 percent for the inflation rate in the static forecast. For changes in the nominal balances it is about 4 percent. The RMSE in the dynamic forecast are similar to those in the static forecast. The table with the RMSE is available from the author upon request.

The estimated model is dynamically stable, as all the real parts of the eigenvalues are negative (table not shown here). Two eigenvalues have imaginary parts. This implies that the model converges to equilibrium in cycles, which have a period of about three months.

A crucial assumption in the theory of monetary analysis of inflation is that structural parameters of the demand for real cash balances should be stable. Stability analysis of these parameters indicates that this is the case for the German hyperinflation.[18] The stability of the estimated model confirms the findings by other authors that the German inflationary process was not feeding upon itself, but was caused by fiscal deficits and the excessive monetary growth.[19]

18. The model presented in Table 1 has been reestimated for the period April 1920 to March 1923. Estimates of the parameters of real cash balances lie within the confidence interval of the parameters estimated for the period April 1920 to July 1923. However, the results are not so clear cut for parameters α_2 and λ.

19. It is worth mentioning that the hyperinflation ended in November 1923 after limitations of monetary financing of the government deficit were made possible by drastic fiscal policy measures taken between August and October 1923: government loans and grants for the "Passive Resistance" in the occupied Ruhr were suspended; the government budget was freed temporarily from the burden of reparations by putting it on private industries; the expenses of the civil administration were greatly reduced by

4. SUMMARY AND CONCLUSIONS

This paper has presented a three-equation model of the German hyperinflation, explaining monetary growth, the exchange rate changes, and inflation. The monetary approach to exchange rate determination and the quantity theory of money have been assumed to be valid in the long run. In the short run, the exchange rate was assumed to diverge from PPP and the price level from the one predicted by the quantity theory. Currency substitution is introduced in the demand for real money balances and expectations of inflation are assumed to be formed adaptively.

Estimates of the model show plausible structural parameters and a realistic dynamic behavior. There is no autocorrelation of the residuals of the estimated model. Estimates of the model show that the exchange rate was responding more rapidly than prices to monetary disequilibrium, thereby explaining the large depreciation of the real exchange rate and its fluctuations during the German hyperinflation.

Estimates of the model also show that substitution between domestic and foreign assets played a significant role in the demand for real cash balances. Furthermore, the lack of autocorrelation of the residuals supports the hypothesis that the strong autocorrelation in Cagan's estimates of the demand for real cash balances was caused by a missing variable. Finally, the estimates also show that the adjustment parameter of expectations of inflation to actual inflation is far below infinity.

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Rescheduling of Sovereign Debt: Forgiveness, Precommitment, and New Money

MANY LESS DEVELOPED COUNTRIES in the past de
to meet contractual obligations on their external debt. Lenders generally
by rescheduling these debts rather than declaring them to be in default,
commercial lending to these sovereigns has virtually ceased. These borr
face an enormous debt overhang, while their lenders face substantial loss
international loan portfolios.

Among the many proposals for addressing this crisis, the relative des
debt forgiveness and new lending has been the focus of considerable d
Baker plan of 1985 emphasized additional funding coupled with grow
domestic policies rather than debt reduction. Lenders were encouraged
additional funds ("new money") to help the impaired and indebted econ
their way back to creditworthiness. However, lenders were reluctant t
funds that would increase the sovereign's debt burden without some ass
future repayment would be likely. With debt generally recognized as pro
rowers with a disincentive for investment,[1] the emphasis has now shifted
for debt forgiveness on the part of the lenders and a commitment to inte
ment by the borrowers. Both parties are viewed as benefitting by a redu
inherited debt, and possibly the provision of additional funds, if the sov
rower can commit itself to adopting policies that reduce internal consu

The authors express their appreciation for valuable comments to two anonymous refere

1. Myers (1977) was the first to note the distortion of investment choice due to existing
while Jensen and Meckling (1976) emphasized the adverse incentive effects when insiders
in our case) issue claims to outside investors.

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