The Yugoslav Hyperinflation of 1992–1994: Causes, Dynamics, and Money Supply Process[1]

Pavle Petrović

University of Belgrade and CES MECON, Kameniĉka 6, 11000 Belgrade, Federal Republic of Yugoslavia

Željko Bogetić

International Monetary Fund, Fiscal Affairs IS-3574, 700 19th Street NW, Washington, DC 20431

and

Zorica Vujošević

University of Belgrade and CES MECON, Kameniĉka 6, 11000 Belgrade, Federal Republic of Yugoslavia

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The paper demonstrates that the Yugoslav hyperinflation, the second highest and the second longest episode in economic history, was driven by excessive money supply that monetized various deficits that emerged upon the disintegration of the country. The identified cointegrating relations showed that money growth was weakly exogenous and affected inflation via currency depreciation. This indicates the presence of exchange-rate-based pricing, whereas the exogeneity of money implies that money was the common stochastic trend fueling currency depreciation and inflation. Money growth itself followed a random walk with a drift, which, together with its exogeneity, was a result of the Central Bank's loss of control over the money supply process. *J. Comp. Econom.,* June 1999, **27**(2), pp. 335–353. The University of Belgrade and CES MECON, Kameniĉka 6, 11000 Belgrade, Federal Republic of Yugoslavia; International Monetary Fund, Fiscal Affairs IS-3574, 700 19th Street NW, Washington, DC 20431; and the University of Belgrade and CES MECON, Kameniĉka 6, 11000 Belgrade, Federal Republic of Yugo-slavia.   © 1999 Academic Press

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1. INTRODUCTION

The Yugoslav hyperinflation of 1992–1994 was historically unique and significant due to its extreme peak and duration. At its peak, in January 1994, the monthly inflation rate reached 313 million percent, thus becoming the second highest recorded rate of inflation after the Hungarian hyperinflation of 1945–1946. In addition, the Yugoslav hyperinflation lasted 24 months so that, after the Russian hyperinflation in the 1920s which lasted 26 months (Cagan, 1956), it is the second longest ever recorded. During these 24 months, between February 1992 and January 1994, the price level rose by a factor of 3.6×10^{22}, which is second only to the most severe Hungarian hyperinflation (3.8×10^{27}), but well ahead any other: 10^{11} in China after World War II, 10^{10} in Germany in the 1920s, etc. (Cagan, 1987). Since the Yugoslav hyperinflation was in all respects much more virulent than the well-known hyperinflation in Germany in the 1920s, we consider worth exploring its causes and dynamics.

The hyperinflation in the Federal Republic of Yugoslavia, i.e., Serbia and Montenegro,[2] was associated closely with the disintegration of the former Yugoslavia, the ensuing loss of monetary and fiscal control, wars in the region, and the comprehensive international economic embargo imposed on the country. As inflation gained pace, output in the Federal Republic of Yugoslavia halved and the fiscal deficit reached 28% of GDP.

These facts seem consistent with a monetary view of the Yugoslav hyperinflation, which emphasizes the main role of fiscal shock in triggering an excessive increase in the money supply to monetize the deficit. Nonetheless, currency depreciation also played an important role in the dynamics of the Yugoslav hyperinflation. Therefore, one could also test for a competing balance of payments explanation that stresses the role of the external sector, e.g., exchange rate or terms of trade shocks, in propagating high inflation (Dornbusch et al., 1990).

A monetary approach to hyperinflation states that the price level is set in the money market by the interaction of money supply and demand. As a result, two main lines of research have emerged in the study of hyperinflation. The first focuses on the search for stable money demand and was pioneered by Cagan (1956). The second is an exploration of the money supply process advanced by Sargent and Wallace (1973). In this paper, we concentrate on the latter as the former has already been treated elsewhere (Petrović and Vujošević, 1996).

Sargent and Wallace (1973) suggest that, during hyperinflation, the government resorts to money creation to finance a given fiscal deficit in real terms. This in turn implies that the government will increase the growth rate of the money supply as the purchasing power of money declines, i.e., as inflation increases. Under fiscal dominance, the money supply will depend on past inflation, i.e., it will be statistically endogenous to the inflationary process. Assuming rational expectations, the public will be able to predict the money supply by looking at

[2] In April 1992, these two republics established the Federal Republic of Yugoslavia.

the path of inflation. Therefore, the empirical implication of fiscal dominance and rational expectations for hyperinflation is that the money supply process is endogenous.

The problem with the monetarist view that money growth is endogenous in a state of fiscal dominance is that it cannot explain the runaway inflation associated with the large and growing deficit that has been observed in most hyperinflations, including the Yugoslav one. The monetarist model predicts stable inflation that will settle at the point where a maximum inflation tax is appropriated. If, however, the fiscal deficit is unsustainable, i.e., it is larger than the maximum inflation tax, the public will perceive this and a currency collapse, instead of lasting hyperinflation, should take place almost immediately (Roberts, 1993). Alternatively, a government can finance an unsustainable and increasing deficit by printing money only when seigniorage is larger than the inflation tax. However, this can occur only if real money holdings are increasing and consequently inflation is decreasing, i.e., in a state of deflation instead of hyperinflation (Buiter, 1987). Thus, when an unsustainable fiscal deficit is monetized, the monetarist model predicts either almost immediate currency collapse or deflation, while we actually observe lasting hyperinflation.

Empirical evidence on money supply endogeneity in hyperinflation is mixed, i.e., endogeneity has been found in some hyperinflations but not in others. Furthermore, the endogeneity obtained for the most famous German hyperinflation (Sargent and Wallace, 1973) has been questioned (Protopapadikis, 1983). Cagan (1987) suggests that, during hyperinflation, the money supply process might change in an unpredictable way. One reason for this proposition is that the money supply is governed by short-term discretion, which is dominated by current economic conditions and immediate political pressures. Heymann and Leijonhufvud (1995) called this regime a random walk monetary standard and stressed that the uncertainty of forecasts grows exponentially with the distance from the present.

The first object of this paper is to explore whether a monetary or balance of payments view better explains the Yugoslav hyperinflation. In particular, was excessive money supply growth or currency depreciation the driving force of the hyperinflation? Second, we investigate the money supply process to determine whether it was an endogenous process or one that grew mainly in an unpredictable, exogenous fashion. Third, bearing in mind the monetarist proposition that prices are set in the money market, we explore the role, if any, that exchange-rate-based pricing played in the Yugoslav hyperinflation.

Our investigation starts with estimating and testing without imposing specific restrictions. Precisely, we perform variance decomposition (Montiel, 1989) and Granger causality testing within a vector autoregression (VAR) model consisting of inflation, currency depreciation, and money stock growth (Section 3). Then, based on the obtained results, we proceed in Section 4 to set and test restrictions. Thus, we identify the long-run structure in the cointegrating system (Johansen, 1995; Johansen and Juselius, 1994) among the variables considered and extract

the common stochastic trend (Hoffman and Rasche, 1996). We also test whether money supply growth follows a random walk. The background for the above econometric analysis is provided in Section 2, where some evidence on the origins of the Yugoslav hyperinflation are reviewed and its fiscal and monetary dynamics are presented. The conclusions are given in Section 5.

2. BACKGROUND OF THE YUGOSLAV HYPERINFLATION: ORIGINS AND FISCAL AND MONETARY DYNAMICS

In February 1992, following the collapse of the former Yugoslavia and its common market and the outbreak of fighting in Croatia and Bosnia–Herzegovina, monthly inflation in Serbia and Montenegro reached the 50% mark conventionally used to classify hyperinflation (Cagan, 1956). Inflation peaked in January 1994, reaching an estimated 313 million percent per month, whereas the black market exchange rate depreciated 58 million percent.[3] On January 24, 1994, a stabilization program was launched that included currency reform; the result was an abrupt halt of inflation.[4]

The origins of the Yugoslav hyperinflation go back to at least the end of 1990 when the elections held in all six republics of the former Yugoslavia indicated that the country was breaking up *de facto.* As the country disintegrated in 1991 and 1992, interregional trade collapsed, causing a severe downturn in the output of many industries. The Federal Republic of Yugoslavia was left with much of the huge bureaucracy, including the sizable military and police, which previously served a much larger country. The escalation of fighting in Croatia and Bosnia–Herzegovina and the rapidly deteriorating regional security situation, with the associated transfers to the Krajinas,[5] led the authorities to postpone any orderly fiscal adjustment, particularly of expenditures.

In May 1992, the United Nations imposed an international embargo on almost all commercial transactions with the Federal Republic of Yugoslavia, including foreign trade, financial transactions, and transportation, and in April 1993 the embargo was broadened to all transactions and transportation except humanitarian aid. Consequently, a sharp decline in output, which was driven largely by the

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[3] The inflation rate of 313 million percent is an official estimate. However, when compared with the black market depreciation rate of 58 million percent, which is based on more reliable data, the official inflation rate seems to be overestimated.

[4] Stabilization, within the broader context of the Yugoslav hyperinflation, has been analyzed in Bogetić et al. (1994).

[5] We refer to the entities that evolved on contested territories within Croatia and Bosnia–Herzegovina. In Croatia, it was the self-proclaimed Serbian Republic of Krajina (SRK), which was subsequently subdued militarily and incorporated into Croatia. In Bosnia–Herzegovina, it was the self-proclaimed Bosnian Serb Republic. In the absence of internationally acceptable and recognized terms, we use the terms "Krajinas," one in Croatia and one in Bosnia–Herzegovina, to denote the entities outside the Federal Republic of Yugoslavia that were the main recipients of transfers over the previous years.

TABLE 1

Federal Republic of Yugoslavia: Annual Economic Indicators 1991–1993

	1991	1992	1993
Inflation (retail prices) (%)[a]			
Annual average	117.8	8954.3	1.16×10^{14}
Monthly average	10	55	1011
Monthly average annualized	234	1913	1.15×10^{36}
GDP ($ billion)[b]	23.2	15.8	10.9
Growth rate (%)	−10.9	−31.9	−30.8
GDP per capita ($)	2000	1500	1000
Money M1: end of period (% GDP)	6.9	2.8	0.2
Inflation tax on M1 (% GDP)	16	15	22
Seigniorage on base money (% GDP)	10.4	9.6	10
Real exchange rate (1989 = 100)	67	112	733[c]
Tax revenues (% GDP)[d]	34	20	13 11
Government expenditures (% GDP)[d]	47	41	47 39
Fiscal deficit (% GDP)[d]	13	21	34 28
Exports of goods and services (% GDP)	25	20	
of which goods	20	16	
Imports of goods and services (% GDP)	26	27	
of which goods	24	25	
Net imports of goods and services (% GDP)	0.8	7	
of which goods	4	8	
Net transfers	−2	−6	

[a] Inflation rates are calculated as the differences of natural logarithms as in Cagan (1956).

[b] As in most Eastern European countries, the Yugoslav Statistical Office used and regularly reported the material balances definition of "social product," i.e., it excluded health, educational, financial, housing, and other services. However, the Statistical Office made an estimate of GDP in 1994; starting from this estimate we find that a good approximation of GDP for the period 1991 to 1993 would be to increase the corresponding "social product" by a factor of 1.15. In this paper GDP is primarily used to obtain various shares, and these shares are not sensitive to increasing "social product" by a factor of 1.1 or 1.2 as compared to 1.15.

[c] An increase in the real exchange rate index signifies real exchange rate depreciation. When December is excluded from the estimate of the real exchange rate, the number is much lower at 156. We are inclined to take this lower figure as a measure of the real depreciation in hyperinflationary 1993, as the official estimate of the inflation rate in December 1993 is somewhat unreliable.

[d] For 1993, the first column shows the estimate of the Federal Government, while the second column gives the estimate of the authors. The official estimate is distorted, in our opinion, by improper accounting of extreme hyperinflation in 1993. Therefore we offer our correction of official estimate, but nonetheless we report both estimates.

disintegration of the country and the international embargo, and the ensuing extreme monetary and fiscal expansion, led to hyperinflation.

As shown in Table 1, per capita income dropped from US$2,000 in 1991 to only US$1,000 in 1993. In this respect, the Yugoslav hyperinflation is similar to the Hungarian hyperinflation of 1945–1946 during which there was a sharp drop in output to between 40 and 50% of the prewar level (Bomberger and Makinen,

1983). The increasing fiscal deficit reported in Table 1 reflects the inability or unwillingness of the authorities to undertake the necessary fiscal adjustments in response to the severe shocks that caused a significant decline in output and external trade flows. The fiscal deficit increased from 3% of GDP in 1990 to 28% in hyperinflationary 1993 and reached 71% of total expenditures. The level and dynamics of the deficit are similar to those recorded in other classical hyperinflations, such as in Austria and Germany in the 1920s, and Hungary in the 1940s (Dornbusch and Fischer, 1986, for Austria and Germany, and Siklos, 1989 for Hungary).

The public revenues recorded a dramatic decline. In 1993, the real level of tax revenues fell to just one-sixth of the 1991 level. Relative to output, this decline was large as well, from about 34% in 1991 to only 11% in 1993. During 1993, the monthly collection of tax revenues in real terms fluctuated considerably from US$144 million in January 1993 to only US$27 million in January 1994. When annualized, the latter figure is equivalent to only 3% of GDP, indicating a complete collapse of the tax system.

Significant monetization of the fiscal deficit had already started in 1991. The seigniorage on base money was high throughout the 1991 to 1993 period (see Table 1), at approximately 10% of GDP. This figure is comparable to that reported for Bolivia in the 1980s (Kiguel and Liviatan, 1992, p. 9) and appears to be characteristic of hyperinflation. An increase in seigniorage preceded hyperinflation and was used to finance the widening budget deficit. In 1991, seigniorage at 10.4% of GDP and the budget deficit at 13% of GDP were of similar magnitude.

As in other hyperinflationary episodes, excessive growth of the money supply was followed by a sharp decrease in real money holdings; the share of M1 in GDP decreased from 15% to 7%, 3%, and 0.2% during hyperinflation (Table 1). However, seigniorage did not decrease, although its monthly values displayed considerable variability (Petrović and Vujošević, 1996). The replacement of domestic with foreign currency was accompanied by almost complete dollarization of the Yugoslav economy. There is ample anecdotal evidence that the German mark became the unit of account and partly the means of exchange. Daily black market exchange rates were universally known and followed by street dealers, housewives, peasants at the green market, and managers of banks and enterprises. Economic decisions were based on current and expected exchange rate movements. On the other hand, money supply figures were known only to experts and with more than a month's lag.

The money supply process in the Yugoslav hyperinflation was somewhat peculiar due to the Central Bank's loss of control over money creation. Money was also issued, although illegally, by the four regional central banks[6] and the

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[6] These refer to the Central Bank of Serbia, the Central Bank of Montenegro, and the Provincial Central Banks of Vojvodina and Kosovo.

Social Auditing Service.[7] Furthermore, money was leaking from commercial banks and, in the end, was created by households that issued extensively temporarily unbacked checks.[8]

In fact, only a fraction of the total increase in the money supply was used to cover the federal fiscal deficit. Central Bank credits to the government covered the federal government's budget deficit, which, however, accounted for only one-fifth to one-sixth of the total deficit. The estimate for seigniorage collected by the federal government in 1993 at 2.9% to 3.4% of GDP is very close to the estimate of its budget deficit at 3.5% of GDP. The remaining deficit was due largely to the deficit of the budget of the Republic of Serbia and to a much lesser degree, because of its small relative size, to the budget deficit of the Republic of Montenegro. Both republican budgets included large outlays for pensions, medical insurance and education.

The bulk of the money supply, therefore, went to cover regional deficits, but it was also distributed as soft loans to support production in large socially owned firms that were severely hit by the UN economic embargo. Accordingly, the money supply did not target the amount of revenue needed to cover the given fiscal deficit, as suggested by Sargent and Wallace (1973), but instead reacted in a disorderly manner while monetizing the large number of local deficits. Consequently, in the Yugoslav hyperinflation one should not expect a money supply process that was well tracked by the path of inflation but rather an unpredictable one.

In summary, the evidence supplied in this section suggests that the money supply fueled Yugoslavia's hyperinflation by monetizing various deficits and that, in due course, control over money creation was lost. Thus, the monetary regime was dominated completely by a number of uncoordinated short-term decisions and could be well described as a random walk monetary standard. On the other hand, widespread dollarization indicates the role of exchange-rate-based pricing. We proceed to explore these conjectures in a formal way.

3. THE MONETARY VIEW VS THE BALANCE OF PAYMENTS VIEW: VARIANCE DECOMPOSITION AND GRANGER CAUSALITY IN AN UNRESTRICTED VAR

A general procedure for ascertaining formally the relative importance of the money supply and currency depreciation in fueling the Yugoslav hyperinflation is to decompose the forecasting error variances of inflation (dp), currency

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[7] The Social Auditing Service, an agency inherited from the former Yugoslavia, acted as the financial policeman and auditor of all state and social enterprises and their bank accounts.

[8] The acting Central Bank Governor at the time, Mr. Bozidar Gazivoda, stated that the Central Bank did not control all the flows of the base money expansion because it was also expanding at the republican level. Furthermore, he insisted that the Central Bank did not have any knowledge of, or control over, the creation of a significant part of the money supply growth. (*Ekonomska politika,* November 15, 1993.)

depreciation (*dex*), and money growth (*dm*), using estimated VAR. Montiel (1989) used this procedure to assess whether the monetary or balance of payments explanation holds in several hyperinflationary episodes. The first view implies that the money supply, through the monetization of the fiscal deficit, fuels inflation, whereas the second one states that exchange rate shocks are the dominant factor in propagating inflation. These two views will be tested for the Yugoslav hyperinflation.

The data used are logarithms of the retail price index (*p*), the black market exchange rate (*ex*), and M1 for money (*m*), and consequently their first differences, i.e., *dp*, *dex*, and *dm*, are the corresponding growth rates.[9] As explained above, gray money was created mainly when the deposit accounts of banks and enterprises were increased illegally and M1 was directly affected. Consequently, M1 includes informal money creation and, hence, is the proper measure of the money supply in the Yugoslav hyperinflation.

The sample begins in December 1990, when it became clear that the country began to disintegrate and 30% nominal devaluation indicated the start of new inflation. The sample ends with October 1993, since the inflation data for December 1993 and January 1994 are unreliable;[10] November 1993 was omitted from the sample because the inflation rate increased 10 times and this could not be explained by the model.

As we show later, *dp*, *dex*, and *dm* are nonstationary variables integrated of order one (I(1)) and they cointegrate. However, one may estimate the unrestricted VAR of the above I(1) variables, since the estimates obtained have the same asymptotic properties as the maximum likelihood estimates of VAR, which use stationary variables and observe cointegration restrictions (Sims, Stock and Watson, 1990 and Lutkepohl, 1991). An unrestricted VAR is well suited to explain data interdependencies because it captures the dynamics in an unconstrained fashion (Canova and Gianni, 1998). The results obtained with the unrestricted VAR will be used to advance certain conjectures and test them in the next section by imposing corresponding restrictions.

Variance decomposition is performed using the Choleski decomposition of the covariance matrix of VAR residuals that gives a lower triangular orthogonal matrix, which is unique up to the ordering of the variables (Canova, 1995). The ordering of the variables determines the contemporaneous relations between

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[9] The sources for the data are as follows. The retail price index is taken from various issues of the Yugoslav Federal Statistical Office publication; M1 is taken from the National Bank of Yugoslavia Bulletin, various issues. The black market exchange rates were collected by the authors from the black market and from daily newspapers.

[10] This is obvious when inflation data for these months are compared with either money growth or currency depreciation, i.e., they differ in the order of magnitude. Even if this is neglected, the inflation series through December and January becomes I(2), and therefore cannot be combined with the I(1) series of currency depreciation and money growth. Other studies (Cagan, 1956) also have problems with explaining periods of extreme hyperinflation towards the end of the period.

TABLE 2

Decomposition of Forecast Error Variance (%)

Shocks	10-month forecasts			20-month forecasts		
	dp	dex	dm	dp	dex	dm
	Ordering A: dm–dex–dp					
dp	35	19	25	30	20	23
dex	24	33	18	25	27	18
dm	41	48	57	45	53	59
	Ordering B: dex–dm–dp					
dp	28	15	16	23	14	15
dex	31	33	31	33	34	32
dm	41	52	53	44	52	53
	Ordering C: dp–dex–dm					
dp	33	32	35	35	35	36
dex	31	30	24	27	27	24
dm	36	38	41	38	38	40

Note. The numbers are percentages that sum to 100 in each column. Decomposition is based on the VAR model of order 3. The lag length is determined by the Schwarz and the Hannan–Quinn information criteria. Additionally, the residuals for the VAR model of order 3 are uncorrelated.

them; e.g., if dm precedes dp then innovations[11] in dp do not contemporaneously affect the dm variable. As there is no apriori economic reason for ordering the variables, the identification achieved contains an element of arbitrariness. Therefore, one should explore whether the results are robust to the choice of ordering by investigating different alternatives.

The results of the variance decomposition, obtained from the estimated unrestricted VAR model, are reported in Table 2. We explored the three relevant orderings such that the innovations in each variable appear as an exogenous shock to the system.

As can be seen, in panels A and B unexpected shocks in money supply, relative to other innovations, clearly have the strongest impact on each of the three variables, i.e., inflation, exchange rate depreciation, and money growth. Even in panel C, where both inflation and currency depreciation precede money growth, innovations in money still have a slightly higher impact than shocks to inflation, which appear second strongest.

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[11] Innovations, or unexpected shocks, are processes uncorrelated with all of the past and, hence, they represent "news" that is unpredictable using past information (Canova, 1995). They are obtained from estimated VAR residuals.

TABLE 3

Granger Causality Tests: *F*-Statistics

	Variables: *dp*, *dex*, and *dm*		
	Equation for:		
	dp	*dex*	*dm*
dp	6.95 (0.00)	2.00 (0.14)	0.71 (0.56)
dex	23.03 (0.00)	0.20 (0.89)	0.29 (0.83)
dm	1.74 (0.19)	5.78 (0.00)	1.19 (0.34)

	Variables: *dp* and *dm*	
	Equation for:	
	dp	*dm*
dp	1.21 (0.33)	1.62 (0.21)
dm	5.28 (0.01)	1.97 (0.15)

Note. p-values are given in parentheses.

These results support the monetary view that money, as opposed to currency depreciation, was propelling Yugoslav hyperinflation. However, the impact of unexpected shocks in the exchange rate on the other two variables is also considerable, indicating that currency depreciation may have played an important role in the Yugoslav hyperinflation. Lastly, there is a nonnegligible impact of inflation innovations on the other variables.

However, the obtained results do not support Sargent and Wallace's (1973) view that money is endogenous and prices are exogenous, although the fiscal deficit was monetized in the Yugoslav hyperinflation. Nonetheless, since there is some feedback from inflation to money, we explore this view by testing Granger causality. This test will allow us to discriminate between the monetary and balance of payments views.

The same trivariate system (*dp*, *dex*, and *dm*) is employed (also Dornbusch et al., 1990, p. 38) and causality testing is appropriate even though the variables are I(1) because they cointegrate (Sims et al., 1990; Lutkepohl, 1991). The bivariate system (*dp* and *dm*) used by Sargent and Wallace (1973) is also considered. The results obtained are reported in Table 3. Estimates for the trivariate system show that inflation is Granger-caused by currency depreciation (first equation) and that currency depreciation is Granger-caused by money growth (second equation), while the third equation implies that money growth is exogenous. Similarly, in the bivariate system money is exogenous and prices are endogenous.

Thus, Sargent and Wallace's (1973) view that money is endogenous does not

hold for the Yugoslav hyperinflation.[12] Moreover, the obtained pattern of Granger causality refutes the balance of payments view since this view implies that the exchange rate is exogenous (Dornbusch et al., 1990). However, the result obtained above, i.e., that currency depreciation significantly affects inflation while money growth does not, does point to the importance of exchange-rate-based pricing. Finally, the fact that money growth is exogenous and affects significantly currency depreciation supports the monetary explanation of the Yugoslav hyperinflation. Therefore, in the next section, we test explicitly these conjectures concerning exchange-rate-based pricing and money driven inflation by imposing the corresponding restrictions, thus identifying the long-run structure and extracting the common stochastic trend.

4. EXCHANGE-RATE-BASED PRICING AND THE ROLE OF THE MONEY SUPPLY: IDENTIFICATION OF THE LONG-RUN STRUCTURE AND THE COMMON TREND

The result that money growth was exogenous and directly affected exchange rate depreciation, which in turn determined inflation, suggests testing for the following transmission mechanism:

$$dp_t = \gamma dex_t + \psi_t \tag{1}$$

$$dex_t = \delta dm_t + \nu_t. \tag{2}$$

This system means that inflation (dp_t) is indexed to exchange rate depreciation (dex_t), and the latter (dex_t) depends on money growth (dm_t), while ψ_t and ν_t are stationary disturbances. Thus, money growth ultimately drives inflation, but the link between money and inflation runs through exchange rate depreciation.

The transmission mechanism advanced in Eqs. (1) and (2) can be tested using cointegration analysis, i.e., identification (Johansen and Juselius, 1994; Johansen, 1995) and exogeneity testing (Johansen, 1988). Provided that the variables considered have one unit root each, we can test for cointegration between them. If our model is correct, two cointegrating vectors should be obtained, and upon identification, they should reduce to Eqs. (1) and (2). The next step would be to test for exogeneity within the obtained system of cointegrating variables. We expect to find that money is weakly exogenous in Eq. (2), as is the exchange rate in Eq. (1). Therefore we proceed with unit root testing, followed by testing and estimating cointegration vectors, identifying the long-run structure and, finally, exogeneity testing.

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[12] In a different set-up, i.e., the VAR model based on the Cagan money demand, feedback from prices to money is obtained for the Yugoslav hyperinflation (Petrović and Vujošević, 1996) as well as for the classic European hyperinflations (Engsted, 1994). However, in that model, the presence of feedback indicates the forward-looking behavior of the public (Engsted, 1994), rather than supporting the money supply process advanced by Sargent and Wallace (1973). The endogeneity of the money supply process should be tested directly using inflation and money growth as has been done above.

TABLE 4

Tests for Unit Roots

	Augmented Dickey–Fuller (ADF)			Phillips–Perron (PP)		
	dp_t	dex_t	dm_t	dp_t	dex_t	dm_t
H_0: I(2) H_1: I(1)	−10.11	−8.41	−7.35	−10.44	−9.15	−7.72
H_0: I(1) H_1: I(0)	−0.07	−0.17	−0.85	−0.85	−0.71	−0.39

Note. The number of corrections in the augmented Dickey–Fuller (ADF) test statistics is equal to 1 for dp and dex and to 0 for dm. The latter implies uncorrelated errors, thereby suggesting that dm is a random walk. The Newey–West (1987) lag window of order 1 is used, while the Phillips–Perron (PP) test statistic is computed. The critical value for the ADF and PP tests, that are calculated in the regression with a constant and a trend, equals −3.54 (−3.20) at the 5% (10%) significance level and 35 observations (MacKinnon, 1991).

The values of the augmented Dickey–Fuller and the Phillips–Perron test statistics are reported in Table 4.[13] It can be seen that inflation rate (dp), exchange rate depreciation (dex), and money growth (dm) are integrated of order one. Having discerned that the variables of interest have one unit root each, we tested the cointegration between them. The results obtained using Johansen's procedure (1988, 1991) are given in Table 5.

The values of the test statistics indicate the presence of two cointegrating vectors. Two of the trace statistics, 70.40 and 21.09, are higher than the respective 5% critical values, 29.38 and 15.34, but the third, 2.89, is lower than the 5% critical value 3.84; hence, only two cointegrating vectors exist. The same result is obtained with maximum eigenvalue test statistics. Estimates of the two cointegrating vectors, along with the adjustment coefficients, are given in Table 6. The two cointegrating vectors are not determined uniquely in terms of stationarity since any linear combination of them is also stationary. For that reason, other criteria are needed to choose from the set of cointegrating relations to identify the model.

The proposed model implies that money growth should be excluded from the first vector and inflation from the second. Furthermore, if money growth is to be weakly exogenous, adjustment coefficients α_{13} and α_{23} should be zero. Hence, testing the advanced long-run structure of Eq. (1) and Eq. (2) is equivalent to

[13] As explained earlier, the sample runs from 1990.12 to 1993.10, and thus contains 35 observations, which might be considered small. However, Taylor (1991) and Engsted (1994), while performing extensive unit roots and cointegration testing, used Cagan's 1956 data from the six classic European hyperinflations with sample sizes varying from 20 to 26 observations with only the German sample containing 34 observations. In general, econometric studies of hyperinflations are restricted to small samples.

TABLE 5

Testing Cointegration between the Inflation Rate, Money Growth,
and Exchange Rate Depreciation

Rank	Eigenvalue	Trace test
$r = 0$	0.786	70.40
$r \leq 1$	0.434	21.09
$r \leq 2$	0.087	2.89

Note. A constant term enters VAR unrestrictedly. The number of lags in VAR models equals 3 (see the note to Table 2). The 5% critical values for the trace tests are as follows: 29.38 for $r = 0$, 15.34 for $r \leq 1$, and 3.84 for $r \leq 2$ (Hansen and Juselius, 1995).

imposing and testing the restrictions described above. These restrictions allow us to test the model because they yield an over identified system (Johansen and Juselius, 1994). Because the unrestricted estimates reported in Table 6 suggest that the above restrictions might hold, we proceed to estimate the model under the imposed restrictions and test the restrictions (Johansen and Juselius, 1994). The estimated cointegration vectors and adjustment coefficients are reported in Table 7.

The value of the corresponding χ^2 statistic with two degrees of freedom equals 0.14 with p-value 0.93 and indicates that the null hypothesis, stating that the restrictions imposed are valid, cannot be refuted. Thus, the advanced long-run structure, which posits long-run relations between inflation and currency depreciation and between currency depreciation and money growth, is accepted, along with the weak exogeneity of money.

Once again, only two adjustment coefficients, α_{11} and α_{22}, are significant, and these are the same ones that were significant when the vectors were estimated without restrictions. These results imply that the first cointegrating relation enters only the inflation equation (d^2p), while the second cointegrating relation enters only the depreciation equation (d^2ex). The former suggests that the long-run relationship between inflation and exchange rate depreciation affects short-run changes in inflation (d^2p), but not those in currency depreciation (d^2ex). Thus, prices adjust to exchange rate movements and depreciation is weakly exogenous with respect to inflation. The significance of α_{22} indicates that the long-run relationship between currency depreciation and money growth influences short-run changes of the former (d^2ex), but not those of the latter (d^2m). It follows that the exchange rate adapts to variations in money and, consequently, that money growth is weakly exogenous with respect to currency depreciation. Thus the cointegrating relations are depicted as follows:

$$dp = 1.17dex \tag{3}$$

$$dex = 0.96dm \tag{4}$$

TABLE 6

Cointegration vectors

Variable	β_1	β_2
dp	1	0.49
dex	−1.20	1
dm	0.04	−1.51

Long-run adjustment coefficients

Equation	α_1	α_2
d^2p	**−1.99**	−0.14
	(−8.21)	(−0.73)
d^2ex	−0.28	**−1.08**
	(−0.73)	(−3.45)
d^2m	0.11	0.12
	(0.24)	(0.31)

Note. t-values are given in parenthesis, while the significant coefficients are given in bold; d^2 stands for the second difference.

The preceding cointegration analysis is consistent with the transmission mechanism advanced in Eqs. (1) and (2). Starting from the three-variable system containing inflation, exchange rate depreciation, and money growth, we have identified a model with two cointegrating relations (3) and (4) corresponding to

TABLE 7

Model Estimated under the Imposed Restrictions

Cointegration vectors

Variable	β_1	β_2
dp	1	0.00
dex	−1.17	1
dm	0.00	−0.96

Long-run adjustment coefficients

Equation	α_1	α_2
d^2p	**−2.12**	−0.13
	(−8.15)	(−0.41)
d^2ex	−0.89	**−1.70**
	(−1.94)	(−3.31)
d^2m	0.00	0.00

TABLE 8

Significance of Lagged d^2p and d^2ex in ECM for Prices: p-values of F-test

Sample start	90, 12	91, 5	91, 6	91, 7	91, 8	91, 9	91, 10	91, 11	91, 12
d^2p	0.03	0.05	0.07	0.07	0.07	0.08	0.09	0.11	0.12
d^2ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(1) and (2). Exogeneity testing justifies the normalization of cointegrating vectors (3) and (4), i.e. that inflation depends on exchange rate depreciation (3), and that exchange rate depreciation depends on money growth (4). Hence, we have demonstrated that inflation is fueled ultimately by the money supply although through exchange rate depreciation, which confirms the presence of exchange-rate-based pricing.

Another important aspect of pricing in hyperinflation is the basis on which short-run adjustments are made. At moderate rates of inflation, prices adjust to past inflation and currency depreciation does not play a prominent role. As inflation accelerates, currency depreciation becomes increasingly important for price adjustments. Some evidence from hyperinflations in Bolivia (Sachs, 1986) and Germany (Dornbusch et al., 1990) supports the view. In regressions of current prices on the current exchange rate and lagged prices, lagged prices were an important predictor at low rates of inflation while the exchange rate became an important predictor when inflation surged.

Since we have already determined that, in the long run, inflation depends on currency depreciation (Eq. (3)), we may use the corresponding error-correction model (ECM) for prices (d^2p) to explore price adjustments in hyperinflation. The estimated ECM contains the long-run relation between inflation and currency depreciation (Eq. (3)) and lagged values of second differences in prices (d^2p) and exchange rates (d^2ex).

As seen from Table 8, when ECM is estimated for the whole sample, the lagged prices (d^2p) are jointly significant at the 3% level of significance. If the first few months of relatively low inflation are excluded, lagged prices become insignificant, indicating that they are no longer good predictors of current prices. However, the exchange rate remains significant even for shorter periods. Thus, as early as November 1991 and even before the beginning of hyperinflation, inflationary dynamics was exclusively determined by currency depreciation and inflationary inertia had withered away. These results support the hypothesis that, as inflation surged, exchange rates ultimately became the basis for prices.

Another way to explore the driving force of the Yugoslav hyperinflation is to investigate the source of the nonstationarity of inflation, currency depreciation, and money growth. This can be accomplished by extracting the common sto-chastic trend, an approach that is closely related to the above cointegration analysis (Johansen, 1995). The two cointegration vectors among the three vari-

ables imply that there is only one common stochastic trend. Since money is the only weakly exogenous variable in the above cointegration system, it follows that the stochastic trend in the money supply is the common stochastic trend. Therefore, the money supply renders the exchange rate and inflation nonstationary and explains their long-run behavior. Unexpected shocks in money growth have a permanent effect on all three variables, while innovations in inflation and currency depreciation have only transitory effects. We also determined that the permanent component of the series, i.e., money growth, tracked the original series well. This suggests that transitory components were unimportant and that money propelled both inflation and currency depreciation.[14]

Having determined that money fueled the Yugoslav hyperinflation, we focus on the money supply process itself and explore whether the monetary regime subscribed to a random walk monetary standard, i.e. whether money growth followed a random walk. The unit roots tests reported in Table 4 above show that money growth does follow a random walk with a drift; namely, it has a unit root with a drift and uncorrelated errors. Since the variance-ratio test is more reliable than the Dickey–Fuller test used in Table 4, we used it and the results confirm the random walk property of money growth (Lo and MacKinlay, 1989).[15] The estimated drift (0.09) indicates that the money supply was growing at an accelerating rate, which kept on increasing each month by 9 percentage points. On the other hand, noncorrelated errors imply that changes in money growth (d^2m) were unpredictable. Thus, the results confirm the presence of a random walk monetary standard (Heyman and Leijonhufvud, 1995).[16]

5. CONCLUSIONS

This paper demonstrates that the monetary view explains Yugoslav hyperinflation better than the balance of payments view. Specifically, it was excessive money growth that fueled the hyperinflation. However, there are two important caveats to the monetary view. First, there is persuasive evidence of exchange-rate-based pricing, i.e., that money fueled hyperinflation via exchange rate depreciation. Accordingly, this result suggests that prices might not be set in the money market, as stated by the monetary view, but rather that they were indexed to the exchange rate. Second, despite monetization of the fiscal deficit, the money supply was not endogenous. Being exogenous, i.e., nonpredictable by either inflation or currency depreciation, and following a random walk with a drift, the money supply grew mainly in an unpredictable way.

These results are supported by the following econometric evidence. Variance decomposition indicates that, irrespective of the ordering, unexpected shocks in the money supply had the strongest impact on inflation, thus pointing to the

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[14] Details on the common trend analysis are available from the authors upon request.

[15] Results on the variance-ratio test are available from the authors upon request.

[16] This standard includes the case of random walk with drift, see Heyman and Leijonhufvud, 1995, p. 51.

monetary explanation as opposed to the balance of payments view and suggesting exogeneity of money. These two results are confirmed by Granger causality testing, which showed that causality ran from money growth to currency depreciation and from currency depreciation to inflation. This evidence, in addition, supports exchange-rate-based pricing. The identified long-run structure within the system of cointegrating variables demonstrates that money growth was weakly exogenous and fueled currency depreciation, which in turn propelled inflation. Money growth, being the only weakly exogenous variable in the cointegrating system, was the common stochastic trend that governed the long-run dynamics of both inflation and currency depreciation. Additional evidence in favor of exchange-rate-based pricing is supplied by recursive testing within the error-correction model for inflation dynamics; this indicates that inflationary inertia disappeared in the hyperinflation and exchange rates ultimately became the basis of pricing.

Unpredictability of money growth is supported additionally by the fact that money followed a random walk with a drift because money growth had one unit root with a drift and uncorrelated errors. The positive drift value implied accelerating money growth, while the uncorrelated errors showed that changes in money growth were unpredictable. Thus the positive drift, i.e., the deterministic trend, captures the feedback from the deteriorating fiscal situation caused by hyperinflation to money supply and, consequently, introduces some predictability into the money supply process. On the other hand, an unpredictable random walk component of the process, i.e., the stochastic trend, is compatible with the Central Bank's loss of control over money creation and the consequent highly disordered money supply process.

To summarize, in spite of fiscal dominance, the money supply process in the Yugoslav hyperinflation grew mainly unpredictably, as suggested by Cagan (1987), rather than in a predictable, and hence endogenous, way as advanced by Sargent and Wallace (1973). That is to say, money growth could not be predicted by either inflation or currency depreciation and, although it exhibited an increasing trend, its changes were unpredictable. The monetary regime could be described as a random walk monetary standard (Heyman and Leijonhufvud, 1995), that was dominated by short-term decisions and was highly unpredictable apart from an increasing trend. The low predictability of money supply growth, on the other hand, could explain tentatively the nondecreasing seigniorage noted in the Yugoslav hyperinflation, thus reconciling the monetization of fiscal deficits and lengthy hyperinflation.

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