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Zimbabwe's Hyperinflation Money Demand Model

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Title : **Zimbabwe's Hyperinflation Money Demand Model**

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Abstract

The research attempts to empirically study the demand for money, especially the magnitudes of the price expectation and real cash balance adjustment for Zimbabwe. Price expectation and real cash balance adjustment models are estimated. The results show that both the interest rate and the rate of change in prices are relevant variables for explaining the variations in the demand for real cash balances in Zimbabwe. Overall, the findings suggest that the Zimbabwean hyperinflation does not appear to have been a self-generating process independent of money supply.

Keywords Hyperinflation, Real Cash Balances, Price Expectation, Equilibrium, Error Correction Model

JEL Classification: E41, P24, E51

1 INTRODUCTION

Following Cagan's pioneering study of the demand for money during hyperinflation (Cagan 1956), a number of researchers have reexamined Cagan's model and estimations under a variety of alternative assumptions concerning expectations formation, notably Barro (1970), Sargent and Wallace (1973), Frenkel (1975), Sargent (1977), Abel et al.(1979), Salemi (1979), Salemi and Sargent (1979), Christiano (1987) and recently, Taylor (1991) and Michael et all (1994). The main message of Cagan's analysis is that under the conditions of hyperinflation, movements in prices are of a magnitude so much greater than that of movements in real macroeconomic aggregates that "relations between monetary factors can be studied, therefore, in what almost amounts to complete isolation from the real sector of the economy" (Cagan 1956, p. 25).

The objective of this paper is to study the demand for money, especially the magnitudes of the price expectation and real cash balance adjustment in the demand for money, during the Zimbabwean hyperinflation. Section 2 provides a brief literature review, while theoretical considerations relative to the specification of the model as well as empirical results; their economic and statistical implications are presented in Section 3. Section 4 concludes the research.

The situation in Zimbabwe from February 1999 to March 2007 (at the time of writing, though expectation in the near future are that inflation will continue to rise) eminently qualifies as hyperinflation according to Cagan (1956) definition. Cagan defined

“hyperinflation as beginning in the month the rise in price exceeds 50 percent and as ending in the month before the monthly rise in prices drops below that amount and stays below for at least a year” (p.25).

Nevertheless, this definition does not rule out a rise in price at a rate below 50 percent per month for the intervening months. The history of hyperinflation in Zimbabwe can be said to date back to early 1999. Although data shows that the country’s monthly inflation rate reached the 50 per cent mark in February 1999, this monthly rate was above 100 per cent by November 2001 before jumping to rates higher than 200 per cent by January 2003. By the December 2003, the rate was squarely at 600 per cent, though it temporarily declined through 2004 and 2005, reaching the trough of 124 per cent in March 2005. Since April 2006, the monthly rate has been above 1000 per cent; with the upward trend reaching the highest ever rate of 2200.2 per cent in March 2007.

Borrowing from Keynes (1920) suggestions, namely that ‘even the weakest government can enforce inflation when it can enforce nothing else’; evidence indicates that Zimbabwean government has been good at using the money machine print. Coorey et al (2007:8) point out that ‘Accelerating inflation in Zimbabwe has been fueled by high rates of money growth reflecting rising fiscal and quasi-fiscal deficits’. As a result of that, the very high inflationary trend that the country has been experiencing in the recent years is a direct result of, among other factors, massive money printing to finance government expenditures and government deficits. For instance, the unbudgeted government expenditure of 1997 (to pay the war veterans gratuities); the publicly condemned and unjustifiable Zimbabwe’s intervention in the Democratic Republic of Congo (DRC)’s

war in 1998; the expenses of the controversial land reform (beginning 2000), the parliamentary (2000/2005) and presidential (2002) elections, introduction of senators in 2005 (at least 66 posts) as part of ‘widening the think tank base’ and the international payments obligations, especially since 2004, all resulted in massive money printing by the government. Above these highlighted and topical expenditure issues, the printing machines has also been the government’s ‘Messiah’ for such expenses as civil servants’ salaries².

One characteristic of hyperinflation is the tendency for real cash balances to decline. This real money behaviour is shown in Figure 1. Another way to illustrate this characteristic is by the reciprocal of the real cash balances. An increase in this ratio means that the rise in price is proportionately much greater than the rise in the money supply.

Place Figure 1 here

2 LITERATURE REVIEW

The main objective of Hu (1970, 1971)’s research papers were to study the demand for money, especially the magnitudes of the price expectation and case balance adjustment in the demand for money, during the Chinese inflation, for the period covering September 1945 to May 1949. After modifying the Cagan (1956) model by estimating an extra real cash balance adjustment model, over and above the price expectation model, the following results were found in Hu’s two studies. The demand elasticity of real cash balances with respect to the rate of change in price level was -0.119, while the elasticity

of demand with respect to the interest rate was -0.316. Thus these two estimates implied that during the hyperinflation period both the rate of change in prices and the interest rate have negative effects on demand for real cash balances. On the other hand, the estimated elasticity of price expectation, α , was 0.412. This elasticity of price expectation meant that an individual only expected 41.2 percent of the price level increase to be permanent.

The results from the real cash adjustment model showed that the demand elasticity with respect to the cost of holding money was -0.174, while the elasticity of cash balance adjustment was 0.278. With these results he interpreted the positive elasticity of adjustment as supporting the hypothesis concerning the influence of past behavior on current cash holdings.

Michael et al (1994) reexamined the demand for money during German's hyperinflation period. The study showed that a remarkably well-defined demand for real cash balances existed for the German hyperinflation episode, including the final months which have previously been considered as outliers. The study's econometric analysis exploited the theory of cointegration, given the obvious nonstationarity of the time-series data that it used. The study also pointed out income variability and the necessity to distinguish between the high inflation and hyperinflation episodes, as two potential sources of model misspecification.

Through demonstration of the fact that, under only very weak assumptions concerning expectations formation (the stationarity of forecasting errors), Taylor (1991) study

showed that the hyperinflation model of money demand put forward by Cagan (1956) requires cointegration between real money balances and current inflation when both inflation and real money balances are nonstationary series.

Taylor's cointegration analysis results provided some support for the Cagan model of money demand, particularly as applied to Poland in the interwar period, as well as to Austria and Hungary. Nevertheless, the analysis suggested rejection of the null hypothesis that the authorities in these countries expanded the money supply in order to maximize the inflation tax revenue. Further, the study used the above results to test the hyperinflation model under the hypothesis of rational expectations (HMRE). Overall, the findings indicated a rejection of the HMRE.

3 MODELING MONEY DEMAND

3.1 The Demand for Money: The Theory and Specification of the Model

Among the various functions of money, the two basic functions are (i) medium of exchange and (ii) storage of value. These two functions entail that an individual will want to hold a certain amount of money because of the value of the money. As such, it is the real cash balances that concern the individual. Friedman (1956) pointed out that the individual's demand for real cash balances depends on, among other factors, his real wealth, his current real income, the interest rate, and the rate of change of prices.

Given that there is no monthly data available on real wealth for the period under investigation, and that the monthly data series for income is not up to date, the study will consider the interest rate and the rate of change of prices. Thus, the fluctuations in the demand for real cash balances can be accounted for by these two factors. With regards to the expected cost of holding money, Hu (1970, 1971) pointed out that this cost is composed of two parts: (i) the expected real return on wealth, and (ii) the expected rate of change in prices. At the same time Cagan (1956) has suggested that the real value of goods during high inflation episodes may be fairly constant because of the relative constancy of their physical depreciation. Furthermore, changes in the cost of holding money when the alternative is to hold consumer goods – as is the case during hyperinflation – are mainly accounted for by changes in the real value of nominal cash balances (Hu, 1970, 1971). Therefore, in hyperinflation, the only expected cost of holding cash balances that can account for the magnitude of the variation in real cash balances is the expected rate of change in price.

In modeling the specification of the demand for money, there is a high possibility of an identification problem. That is, the problem will be, how is it known that the specified function is not, rather, a supply curve? To avoid this dilemma it is assumed that the supply of money during hyperinflation is mainly influenced by the level of government expenditures. Such was the case in Zimbabwe for the period under study.

A number of authors including Cagan (1956), Hu (1970, 1971), Mundell (1965) and Feige (1967)) have pointed out that there are two possible lags existing in the demand function for money: (i) the lag of price expectations and (ii) the lag of cash balances adjustment. Cagan went on further by suggested that the cash balances adjustment could be very short during hyperinflation. Therefore, he estimated the lag of price expectations alone. On the other hand, Hu (1970, 1971) estimated the real cash balances adjustments as well as price expectations, after modifying Cagan's formulation. This study will follow adopted the Hu's procedure, that is the real cash balances adjustment and price expectations will be included in the model. A comparison of the two approaches (the real cash balances adjustment and price expectations models) will furnish an empirical test of Cagan's assumption that the lag in the cash balances adjustment can be ignored during hyperinflation.

3.2 Data Sources

The sample period used is from February 1999 to December 2006. All the time-series data used in this study are from the Reserve Bank of Zimbabwe (RBZ). The real money balances are defined as the ratio of money supply (M2) to consumer price index (CPI), that is, $M2/CPI$, and the interest rate is the three month deposit rate.

3.3 Stationarity and Non-Stationarity

The importance of the stationarity phenomenon arises from the fact that almost all the entire body of statistical estimation theory is based on asymptotic convergence theorems i.e., the weak law of large numbers, which assume that all data series are stationary. Nevertheless, in reality, non-stationarity is extremely common in macroeconomic time-series data such as money, inflation, consumption and exchange rates. Thus treating nonstationary series as if they were stationary will bias the Ordinary Least Squares (OLS) and thus result in misleading economic analysis. That is the model will systematically fail to predict outcomes and can also lead to the problem of spurious (nonsensical/misleading) regressions where R-squared is approximating unity, t and F -statistics look significant and valid. In essence, the problem lies with the presence of nonsensical regression that arises where the regression of non-stationary series, which are known to be unrelated, indicates that the series are correlated. Hence, there is often a problem of incorrectly concluding that a relationship exists between two unrelated non-stationary series. This problem generally increases with the sample size, and is not normally solved by including a deterministic time trend as one of the explanatory variables in order to induce stationarity.

Thus to avoid inappropriate model specification and to increase the confidence of the results, time series properties of the data are investigated. Although there are a number of methods used to test for stationarity and the presence of unit roots, the methods used here are the Augmented Dickey-Fuller (ADF) and the Philips Peron (PP) tests. By definition a

series is stationary if it has a constant mean and a constant finite variance. On the contrary, a non-stationary series contains a clear time trend and has a variance that is not constant overtime. If a series is non-stationary, it will display a high degree of persistence i.e. shocks do not die out. A series X_t is said to be integrated of order d , denoted as $I(d)$, if it must be differenced d times for it to become stationary⁷. For example, a variable is said to be integrated of order one, or $I(1)$, if it is stationary after differencing once, or of order two, $I(2)$ if differenced twice. If the variable is stationary without differencing, then it is integrated of order zero, $I(0)$. The ADF regression test can be written as:

$$\Delta x_t = \beta_0 + \lambda x_{t-1} + \beta_1 t + \sum_{i=2}^p \gamma_i \Delta x_{t-i} + \varepsilon_t \dots\dots\dots (1)$$

Where t is the time trend, p is the number of lags; ε_t is a stationary disturbance error term. The null hypothesis that x_t is non-stationary is rejected if λ_1 is significantly negative. The number of lags (n) of Δx_t is normally chosen to ensure that regression residual is approximately white noise. To this end, Table A1 of the Appendix provides unit root test results (ADF and PP tests) and the tests indicate that all the variables are stationary at first difference, that is, they are $I(1)$ variables.

3.4 Price Expectation Model

3.4.1 Long Run Cointegration Model

Following the model by Hu (1970) as well as the previous argument concerning the demand for real cash balances it can hypothesized that the demand for real cash balances

is a function of the interest rate and the expected rate of change in prices. To this end, the slightly modified Hu (1970: 454 - 456) function can be stated as follows:

$$M_t = f(R_t, P_t^*, U_t) \dots \dots \dots (2)$$

where

M_t = amount of real cash balances (M2/CPI) demanded in period t .

R_t = money interest in period t .

P_t^* = expected rate of change in prices in period t .

U_t = random disturbance in period t .

The relationship between the demand for real cash balances and the expected rate of change in prices is assumed to take the following representation:

$$\log M_t = \beta_1 \log P_t^* \dots \dots \dots (3)$$

By applying Hick (1946)'s concept of elasticity of price expectation, the algebraic relations between actual and expected rate of price changes can be formulated following Marc (1958) as:

$$(\log P_t^* - \log P_{t-1}^*) / (\log P_t - \log P_{t-1}) = \alpha \dots \dots \dots (4)$$

where $0 < \alpha < 1$ is the elasticity of expectation with respect to the rate of change in prices.

Or, it can be said that the expected change in P_t in one period is

$$\log P_t^* - \log P_{t-1}^* = \alpha [\log P_t - \log P_{t-1}] \dots \dots \dots (5)$$

Substituting (5) into (3) and rewriting gives

$$\log M_t = \beta_1 \alpha \log P_t + (1 - \alpha) \log M_{t-1} \dots \dots \dots (6)$$

Therefore, the explicit function of equation (2) is

$$\log M_t = \beta_0 + \beta_1 \alpha \log P_t + (1 - \alpha) \log M_{t-1} + \beta_2 R_t + \log U_t \dots \dots \dots (7)$$

The estimated results of equation (7) are as reported in Table 1.

Place Table 1 here

All coefficients in Table 1 are statistically significant at the ten percent level. The demand elasticity of real cash balances with respect to the rate of change in price level is -0.0004, while the elasticity of demand with respect to the interest rate is -0.016. These two estimates imply that during the hyperinflation period both the rate of change in prices and the interest rate have negative effects on demand for real cash balances. The estimated elasticity of price expectation, α is 0.174 (1-0.826). According to Hick's

definition, the estimated elasticity of price expectation implies that an individual only expects 17.4 percent of the price level increase will be permanent, but not all of it is temporary. This explanation may well represent the behavior of individuals during hyperinflation.

The long-run estimation indicates that the model fits the data well as evidenced by high values of both R^2 (adjusted R^2) and F -statistic tests, which are above 90 percent. The R -squared, which measures the “goodness of fit” of the equation is satisfactory at 91 per cent, indicating that 91 per cent of the variations in Zimbabwe’s real demand for money balances are explained by variations in the rate of change in prices, price expectation and the interest rate. The F -test statistic of 288, with a p -value of 0.000, indicates that all the three variables jointly determine the demand for real money balances in hyperinflationary Zimbabwe.

3.5 Cash Balances Adjustment Model

3.5.1 Long Run Cointegration Model

At a high level of generalization, the costs of holding money are composed of two parts: (1) the real return on wealth; and (2) the rate of changes in prices. As Cagan suggested the variations in the real value of goods because of their physical depreciation is fairly constant. Therefore, the only cost of holding cash balances that can account for the wide changes in real cash balance during hyperinflation is the rate of change in prices. The

demand for real cash balances can now be considered as a negative function of the cost of holding cash balances.

$$\log M_t^* = \delta \log P_t \dots \dots \dots (8)$$

where M_t^* denotes the desired amount of M_t .

The demand for real cash balances may also be affected by habits generated from past experiences. It can therefore be hypothesized that, the more likely it is that one held a given cash balance in the past, the more likely it is that one will hold that given level of cash balance currently. Thus, it can be said that consumers tend to build up a habitual “psychological stock” of holding cash balances. The adjustment to the desired amount of cash balances in one period is defined as

$$\log M_t - \log M_{t-1} = \gamma [\log M_t^* - \log M_{t-1}] \dots \dots \dots (9)$$

where $0 < \gamma < 1$ is the elasticity of adjustment. Substituting (8) into (9) and rewriting gives

$$\log M_t = \delta \gamma \log P_t + (1 - \gamma) \log M_{t-1} \dots \dots \dots (10)$$

With the same data used in equation (7), the log run cointegration results from equation (10) are presented in Table 2 are obtained

Place Table 2 here

The tabulated results show that all the coefficients of regression are statistically significant at the five per cent level. The demand elasticity with respect to the cost of holding money is -0.004, while the elasticity of cash balance adjustment is 0.158 (1-0.842). The positive elasticity of adjustment supports our hypothesis concerning the influence of past behavior on current cash holdings. Nonetheless, the adjustment is slow. Thus the individual may underestimate the length and intensity of the hyperinflation. Therefore, the attitude toward the cash balances adjustment is rather rigid. The estimates of equation (10) are consistent with the findings of equation (7).

3.6 Short Run Dynamics Relationships: The Error Correction Model (ECM)

The existence of at least one cointegrating vector among the variables implies that an ECM can be estimated. The ECM approach used here is useful for the formulation of a short term price expectation and real cash balance adjustment mechanisms, which models changes in the demand for real money balances in Zimbabwe in terms of changes in the other variables in the models, and the adjustment towards the long run equilibrium in each time period. This draws upon the error correction formulation, which is the counterpart of every long run cointegrating relationship.

Thus given the strong evidence of cointegration among the variables as reported in the two long run estimation above, the study also describe the corresponding short run

dynamic model for each of the two the static long run equations. The general over-parameterised short run dynamic real money balance demand equation is of the form:

$$\Delta M_t = \alpha_0 + \alpha_1 ECM_{t-1} + \sum_{i=1}^1 \alpha_{2i} \Delta M_{t-1} + \sum_{i=0}^1 \alpha_{3i} \Delta P_i + \sum_{i=0}^1 \alpha_{4i} \Delta R_t + \mu_t \dots \dots \dots (11)$$

where variables are as defined earlier. ECM_{t-1} is the error correction term (lagged one period); μ_t is the zero mean white noise error term. The results of the parsimonious short run real money demand equations (i.e., equations (7) and (10) are shown in Table 3.

As shown in Table 3, all the variables in the two ECM models are entered in first difference form. In both equations, ECM_{t-1} is the lagged error correction factor, given by the residuals from the static cointegration equations (7) and (10). In other words, ECM_{t-1} is the long run information set, represented by what economic theory posits as the equilibrium real money demand behaviour. It is a stationary linear combination of the variables postulated in theory. It is a cointegrating vector. The coefficient of ECM_{t-1} shows the speed of adjustment to long run solution that enters to influence short run movements in real money balances. The results show that the coefficient of the error term ECM_{t-1} has a negative sign, which is significant at one percent level. This is in line with theory, which expects it to be negative and less than unity in absolute terms, since we do not expect a 100 per cent or instantaneous adjustment. Thus this significant negative sign on the ECM ensures that the all the explanatory variables in ECM work together for hyperinflation to get to equilibrium in the short run.

The following specific results can be observed:

1. The statistical fit for the short run dynamic reduced form equations for Zimbabwe's demand for real money balances appears to be relatively good as indicated by adjusted R^2 values of 88 per cent in both equations and the relatively high F-statistic values above of 219.
2. All the other variables in the price expectation model, equation (7) carry expected signs and are significant at ten per cent level.
3. In the real cash balance adjustment model, equation (10), the estimated elasticity of price expectation $\alpha (= 0.98 = (1 - 0.02))$, is however not significant, even at ten per cent level, otherwise the other variable in this model, the cost of holding cash balances, is significant.

Place Table 3 here

3.7 Some Observations on the Empirical Results

Friedman [5, 10-141] pointed out that the expected rate of change in prices is one of the important variables in the demand function for money. At the same time, Cagan (1956)'s study of hyperinflation found that the expected rate of change in prices is the most important variable in the function. In this research, the results of equation (7) support Cagan's finding that the rate of change in prices explains the variations of the demand for real cash balances. Nevertheless, Cagan did not include nominal interest rate in the

demand function to test whether or not the interest rate is also an important variable affecting the demand for real cash balances. In this study empirical evidence from equation (7) suggests that the interest rate is also relevant. However, the interest rate effect is inelastic, -0.016. To this end, the results of equation (7) support the hypothesis that variations of the demand for money can be explained by both the interest rate and the expected rate of change in prices.

The present research has estimated the elasticity of price expectation as 0.174 and the elasticity of cash balances adjustment as 0.158. These estimates imply that during hyperinflation, individuals' expected rate of change in prices is less than the actual rate of change in prices while individuals' desired rate of cash balances adjustment is less than the actual rate of adjustment. These two factors help to account for the degree of stability in the demand for money even in the period of hyperinflation. Friedman (1956) and Cagan (1956) pointed out that the rising velocity of money circulation during hyperinflation is consistent with the notion of a stable demand function for money if the demand function includes the variable referring to the expected rate of change in prices. The findings of this paper suggest that the Zimbabwean hyperinflation does not appear to have been a self-generating process independent of money supply.

4 CONCLUSION

The objective of this paper was to study the demand for money, especially the magnitudes of the price expectation and real cash balance adjustment in the demand for

money, during the Zimbabwean hyperinflationary environment. The empirical findings in this study shows that both the interest rate and the rate of change in prices are relevant variables for explaining the variations in the demand for real cash balances in Zimbabwe. Nevertheless, the effects of these two variables are inelastic. The price level and elasticity of cash balance adjustment are also less than unity; thus the expected rate of change in prices is less than the actual, and the desired rate of cash balances adjustment is less than the actual. Therefore, the findings suggest that the Zimbabwean hyperinflation does not appear to have been a self-generating process independent of money supply.

FOTENOTES

- 1 Albert Makochekanwa, Department of Economics, University of Pretoria, 0001, Pretoria, South Africa; Tel: +27 (0) 12 420 4505, Email: almac772002@yahoo.co.uk.
- 2 On 16 February 2006, the governor of the Reserve Bank of Zimbabwe announced that the government had printed ZWD 21 trillion in order to buy foreign currency to pay off IMF arrears. In early May 2006, Zimbabwe's government began rolling the printing presses (once again) to produce about 60 trillion Zimbabwean dollars. The additional currency was required to finance the recent 300% increase in salaries for soldiers and policemen and 200% for other civil servants. The money was not budgeted for the current fiscal year, and the government did not say where it would come from (Wikipedia).

TABLES

Table 1: Long-run Equilibrium Model of Hyperinflation Money Demand

Dependent Variable: LN_M [Sample 1999(2) – 2006(12)]

Variable	Coefficient	Standard Error	t-statistic	Probability
LN M_{t-1}	0.826	0.05	18.12	0.0000
LN R_t	-0.016	0.005	-3.07	0.01
LN P_t	-0.0004	0.00016	-2.56	0.09
C	1.32	0.35	3.765514	0.0003
R ²	0.91	F-statistic		288
Adjusted R ²	0.90	Prob(F-statistic)		0.000
D – Watson stat	2.07			

Table 2: Long-run Equilibrium Model of Hyperinflation Money Demand

Dependent Variable: LN_M [Sample 1999(2) – 2006(12)]

Variable	Coefficient	Standard Error	t-statistic	Probability
LN P_t	-0.004	0.0022	-1.84	0.0222
LN M_{t-1}	0.84	0.04	18.95	0.0000
C	1.16	0.34	3.47	0.0008
R ²	0.903			
Adjusted R ²	0.90	F-statistic		426.16
D – W statistic	2.062375	Prob(F-statistic)		0.0000

Table 3: Parsimonious single equation ECM of Money Demand in Zimbabwe

Panel A: Equation (7) Dependent variable ΔLN_M

Variable	Coefficient	Standard Error	t-statistic	Probability
ECM _{t-1}	-0.95	0.045	-20.93	0.0000
ΔLN_R	-0.01	0.006	-1.74	0.0855
ΔLN_P	-0.15	0.038	-3.96	0.0001
C	0.007	0.004	1.61	0.1111
R ²	0.88	F-statistic		219.6
Adjusted R ²	0.88	Prob(F-statistic)		0.000

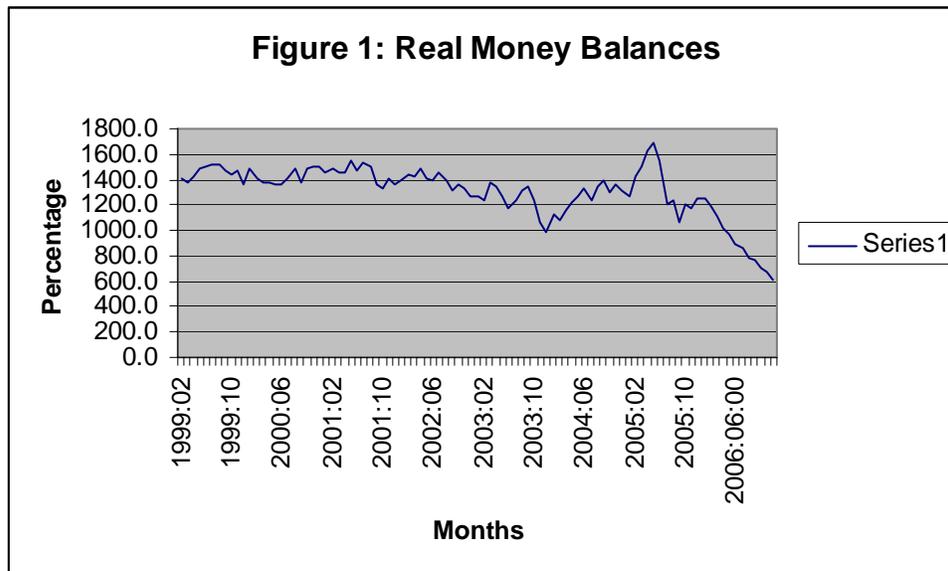
Note: ΔLN_R means differenced interest rate

Panel B: Equation (10) Dependent variable ΔLN_M

Variable	Coefficient	Standard Error	t-statistic	Probability
ECM _{t-1}	-0.96	0.045	-21.38	0.0000
ΔLN_M_{t-1}	-0.02	0.036	-0.59	0.5590

$\Delta \text{LN } P_t$	-0.13	0.039	-3.29	0.0014
C	0.004	0.004	0.96	0.3410
R^2	0.88	F-statistic	229	
Adjusted R^2	0.88	Prob(F-statistic)	0.000	

FIGURES



BIBLIOGRAPHY

Abel, A., R. Dornbusch., J Huizinga, and A. Marcus. 1979. 'Money Demand during Hyperinflation', *Journal of Monetary Economics* 5, 97-104.

Barro, R, J., 1970. 'Inflation, the Payments Period and the Demand for Money', *Journal of Political Economy* 78, 1228-63.

Cagan, Phillip, 1956. "The Monetary Dynamics of Hyperinflation", in Friedman, Milton (1956), ed., *Studies in the Quantity Theory of Money*. Chicago: University of Chicago Press.

Chang, Kia-NGau. 1958. *The Inflationary Spiral, The Experience in China, 1959-1960*. Cambridge, Mass: The Technology Press of Massachusetts Institute of Technology.

Chou, Shun-hsien. 1959. Interest, Velocity, and Price Changes Under Hyperinflation *Southern Economic Journal*, XXV: 425-33.

_____. 1963. *The Chinese Inflation, 1959-49*. New York: Columbia University Press

Christiano, L., 1987. 'Cagan's Model of Hyperinflation under Rational Expectations', *International Economic Series*, 29, 33-49.

Coorey, S., J. R. Clausen., N. Funke., S. Muñoz, and B Ould-Abdallah . 2007. 'Lessons from High Inflation Episodes for Stabilizing the Economy in Zimbabwe', IMF Working Paper, WP/07/99.

Engle, F.R, and C.W. Granger., 1991. 'Cointegration and Error Correction: Representation, Estimation and Testing', *Econometrica*, Col. 55(2), 252-56.

Feige, E., 1867. 'Expectation and Adjustment in the Monetary Sector', *American Economic Review (A.E.R)*, 57, 462-74.

Friedman, Milton. 1956. *Studies in the Quantity Theory of Money*. Chicago: University of Chicago Press, 1956.

Graham, Frank. 1930. *Exchange, Prices, and Production in Hyperinflation: Germany, 1920-23*. Princeton: Princeton University Press, 1930.

Hu Teh-Wei. 1971. Hyperinflation and the Dynamics of the Demand for Money in China, 1945-1949. *The Journal of Political Economy*, 79(1): 186-195.

_____. 1970. Dynamics of Hyperinflation in China, 1945-1949. *Southern Economic Journal*, 36(4): 453-457.

Keynes J M (1920) *The Economic Consequences of Peace*, Macmillan Press, London.

Michael, P., Nobay, A. R., and Peel, D. A. 1994. The German Hyperinflation and the Demand for Money Revisited. *International Economic Review*, 35(1): 1 – 22.

Mundell, R., 1965. ‘Growth, Stability, and Inflationary Finance’, *ournal of Political Economy (J.P.E)*, 73, 97-109.

Nerlove, Marc. 1958. *Distributed Lags and Demand Analysis for Agricultural and Other Commodities*. Washington, D.C.: U. S. Department of Agriculture.

Salemi, M. K., 1979. Adaptive Expectations, Rational Expectations and Money Demand in Hyperinflation Germany’, *Journal of Monetary Economics* 5, 593-604.

Salemi, M.K., and T.J. Sargent. 1979. ‘The Demand for Money during Hyperinflation under Rational Expectations: II’, *International Economic Review* 20, 741-58.

Sargent, T. J., 1977. ‘The Demand for Money during Hyperinflation under Rational Expectations: I’, *International Economic Review* 18, 59-82.

Sargent, T. J., and N. Wallace., 1973. ‘Rational Expectations and the Dynamics of Hyperinflation’, *International Economic Review* 14, 328-350.

Taylor, Mark P.1991. The Hyperinflation Model of Money Demand Revisited. *Journal of Money, Credit and Banking*, 23(3): 327-351.

www.wikipedia.org.

APPENDIX

Table A1: Univariate characteristics of all the variables

Series	Model	ADF			PP		Conclusion
		Lags	τ τ_μ τ_τ	ϕ_3 ϕ_1	Lags		
LN_M _t	τ_τ	1	0.30	1.39	3	-0.62	Non-Stationary
	τ_μ	1	1.47	1.35	3	0.82	
	τ	0	-1.31	-----	3	-1.27	
LN_P _t	τ_τ	2	-1.81	22.6**	3	-1.43	Non-stationary
	τ_μ	2	1.74	27	3	3.90	
	τ	2	3.05	-----	3	11.25	
LN_M _{t-1}	τ_τ	4	0.095	1.34	3	-0.88	Non-Stationary
	τ_μ	4	1.269089	1.24	3	0.63	
	τ	4	-1.50	-----	3	-1.23	
LN_R _t	τ_τ	3	-2.16	4.26	3	-2.72	Non-Stationary
	τ_μ	2	-0.65	4.55	3	-1.26	
	τ	2	0.80	-----	3	0.58	
Δ LN_M	τ_τ	3	-5.74***	20.77***	3	-9.98***	Stationary
	τ_μ	3	-5.33***	24.29***	3	-9.65***	
	τ	0	-9.51***	-----	3	-9.54***	
Δ LN_P _t	τ_τ	1	-3.62*	17.35***	3	-6.39***	Stationary
	τ_μ	1	-2.76*	22.67***	3	-4.72***	
	τ	1	-1.20	-----	3	-1.97**	
Δ LN_M _{t-1}	τ_τ	3	-5.89***	21.28***	3	-10.07***	Stationary
	τ_μ	0	-9.79***	95.80***	3	-9.79***	
	τ	0	-9.65***	-----	3	-9.66***	
Δ LN_R _t	τ_τ	4	-5.66***	30.22***	3	-13.13***	Stationary
	τ_μ	2	-9.53***	86.35***	3	-13.13***	
	τ	1	-9.48***	-----	3	-13.09***	

*(**)[***] Statistically significant at a 10(5)[1] % level

Key: τ_τ : Means Trend and Intercept

τ_μ Means intercept

τ Means None

(LN_M = log of real money demand, LN_P = log of the rate of changes in prices, LN_R =log of money interest and LN_M_{t-1} =log of price expectation)

The Augmented Dickey-Fuller and Phillips Peron results tests for non-stationarity shows that all the variables are integrated of order one, that is, they are stationary after first differencing.