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Money Demand, Seigniorage and Aid shocks

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Abstract

Zimbabwe has recently experienced record hyperinflation of 80 billion percent a month. This paper uses new data from Zimbabwe to investigate money demand under hyperinflation using an ARDL estimation for the period 1980-2008. The results produce plausible convergence rates and long- run elasticities, indicating that real money balances are cointegrated with the inflation rate. Evidence is also presented that suggests prices are being driven by increases in the money supply rather than by changes in price setting behaviour. The paper additionally uses the estimated elasticity on the inflation variable to calculate the maximum level of seigniorage revenue that could be raised in the economy. Actual seigniorage levels increased dramatically after 2000, with inflation eventually exceeding the rate required to maximize this revenue stream. This is discussed in relation to international financing constraints and the collapse of the domestic tax base.

J.E.L classification: E31, E41, E42, E58, E62, E63, E65, O24

Keywords: Hyper Inflation, Cointegration, Money Demand, Parallel market exchange rate, Zimbabwe

1 Introduction

1.1 Motivation

In January 2009 almost ten years of high inflation came to an end in Zimbabwe. Since 2001 Zimbabwe had experienced rates of inflation above 100% annually, since 2006 this rose over 1,500% annually. Using a newly created price series we show that in September 2006 monthly inflation exceeded 50 percent per month entering an extended period of hyperinflation, as defined by Cagan (1956).[1]

The authorities in Zimbabwe view the recent high inflation period through two prisms. First they maintain that the private sector bid up prices speculatively in order to maximise profits and exert extreme pressure on the economy.

> 'Speculation has surfaced at an alarming pace in virtually all sectors of the economy, with the demand for cash in the economy rising at astronomical rates, as people are positioning themselves to take advantage of rent-seeking opportunities.' RBZ (2006)

Second they maintain that negative aid shocks and international sanctions have contributed to the economic decline since 2000, including the high inflation rate. Zimbabwe has experienced development assistance and external financing shocks as access to International Finance Institution (IFI), European Union etc, assistance has been withheld from the country.[2] This explanation suggests that printing money is one way the authorities have sought to finance the gap between expected government revenue (including grants and aid) and actual receipts.

> 'Over the past 4 years the Central Bank has maintained that the declared and undeclared sanctions are one of the main hindrances to our collective efforts to turning around the economy.' RBZ (2008)

This paper seeks to examine these explanations in more depth. A long-run money demand function is estimated for the Zimbabwean economy. This allows preliminary testing of the endogeneity between money and prices, where

[1] Cagan (1956) defines hyperinflation as beginning in the month the rise in prices exceeds 50 percent and ending in the month before the monthly rise in prices drops below that amount and stays below for at least a year. Cagan himself admits that this measure is 'purely arbitrary'. This definition is however useful as a convention and serves the purpose of this paper.

[2] Domestic tax receipts have also declined dramatically.

some evidence is found that increased money supply, rather than private sector price speculation, may have driven inflation in Zimbabwe. The paper then characterises deficit financing behaviour in Zimbabwe over recent years and finds that a precipitous decline in tax revenues did indeed spark a need for increased domestic revenue raising. It is shown that this was met by large increases in seigniorage revenue, especially as external financing was not able to keep up with the fiscal demand.

1.2 Methodology

First we construct a new price series, based on the parallel market rate of foreign currency in Zimbabwe, to deflate money balances and establish an inflation series. This new price series does not suffer from the issues surrounding the domestic price series, especially the publication delays of the CPI in recent years. Until mid-2008 (beyond the estimation period of this paper) all domestic prices were set in Zimbabwe dollars (the sole legal tender).

The initial (OLS) estimation results confirm that during periods of high inflation holdings of real money balances (demand for money) are explained in large part by the expected inflation rate, as in Cagan (1956). The importance of accounting for large shocks when estimating money demand functions for developing economies is also illustrated. An autoregressive distributed lag (ARDL) model, Pesaran & Shin (1999) is then estimated. This confirms initial results and establishes a long-run (for over 26 years) money demand function for Zimbabwe.[3]

Endogeneity is clearly an important issue. To investigate whether the private sector bids up prices speculatively we test for the "self-perpetuation" of prices following Khan (1980) as well as for Granger-causality of the money supply in determining the price level in Zimbabwe. The self-perpetuation of prices is rejected outright.[4] Non-explosive price movements provide evidence that increased money supply, rather than private sector price speculation, may be driving inflation in Zimbabwe. The absence of appropriate instruments for

[3]Previous work estimated money demand functions for periods of up to 15 years in Zimbabwe.

[4]Granger-causality of *prices* is not rejected, though Granger-causality of *money* (by prices) is also not rejected.

exogeneity testing does weaken this finding.

To investigate the characteristics of the funding deficits in Zimbabwe in recent years the revenue raising options open to the government are examined. These comprise domestic tax revenue, development assistance and seigniorage. Although the total value of development assistance declined in the early 2000s it now makes up a larger proportion (close to 20%) of total government revenue than at any time between 1981 and 2000. Seigniorage, as a proportion of total revenue, has also increased from 5% in 1981-1982 to over 40% between 2003 and 2007. The big story then is that total government revenue has declined by over 50% from its peak in the mid-1990s, due in large part to a precipitous decline in domestic (primarily tax) non-seigniorage revenue.

1.3 Outline of the Paper

In Section 2 relevant theoretical literature on hyperinflation and the estimation framework employed in the paper is outlined. Section 3 highlights key elements of Zimbabwe's recent history and motivates the choice of exogenous variables to be used in the estimation procedure. Section 4 defines the data, data issues and data innovations. Section 5 estimates a long-run money demand function for the Zimbabwean economy and tests for exogeneity of the explanatory variable. Section 6 examines maximum and actual seigniorage generated (given the estimated money demand function) as well as domestic government revenue and aid data. Section 7 concludes.

2 Estimation Strategy

The estimation strategy employed in this paper consists of several steps. First a parsimonious money demand function, similar to that used by Cagan (1956) is estimated. An innovation in this paper results in augmentation of the basic money demand function to include large and sustained structural shifts that are important in the estimation of macroeconomic relationships, particularly in developing countries. Given these controls and high persistence of the dependent variable the estimation framework then employs an error correction formulation to account for the model's dynamics (both long and short-run). Stability of the price variable is then investigated. This allows inference on causality of money in the money demand relationship, in the absence of appropriate instrumentation.

Given the estimation of a robust long-run money demand function and the rejection of price instability this section then describes the calculation of revenue maximising inflation rates. Finally prior estimates of money demand under high inflation in Zimbabwe are noted.

2.1 Hyperinflationary Money Demand Functions

Cagan (1956), the seminal work on hyperinflation and money demand, notes that hyperinflation allows the relationship between money and prices to be studied in isolation to the real sector of the economy. The primary hypothesis in the Cagan model is that changes in past and current levels of money, M, *cause* the hyperinflation of prices, P. The Cagan demand for money function, under hyperinflation is:

$$\ln M_t - \ln P_t = -\alpha E_t[\ln P_{t+1} - \ln P_t] \tag{2.1}$$

2.2 Sustained Structural Shocks

Estimation is initially carried out on the following log-linear model:

$$\ln M_t - \ln P_t = \phi + \alpha(\ln P_t - \ln P_{t-1}) + \lambda D_{i,t} + \epsilon_t \tag{2.2}$$

where the error term, ϵ_t captures an autoregressive process:

$$\epsilon_t = \beta\epsilon_{t-1} + \mu_t \tag{2.3}$$

with stationary innovations, μ_t. $D_{i,t}$ are dummy variables capturing large and sustained structural shifts to the Zimbabwean economy. Capturing these shocks is important in the estimation of money demand functions, especially in developing economies where such shocks may have large effects on macro-economic variables of interest and where high frequency data on national income etc. are not available. For further detail on the dummy variables included in the model see Section 3.

There is a large literature on the impact of shocks to for example, economic growth. However there is little work on the conflict between modelling large shocks and modelling time-series behaviour in estimating macroeconomic relationships for developing countries. This paper shows that this is nevertheless an important issue. The persistence of the dependent variable can be overestimated by the AR(1) term, which tends to absorb much of the explanatory power of the exogneous variables. Excluding the AR(1) process initially (setting $\beta = 0$) yields a very good fit, as seen in Table 5, on inclusion of the exogenous variables. The persistence of the dependent variable[5] cannot be overlooked however, and subsequent estimation of an AR(1) process (setting $\beta \neq 0$) and finally an error-correction process (as $\beta \approx 1$) are carried out also.

2.3 Accounting for Dynamics

As (several) variables of interest (money and prices) are characterised by unit root behaviour, Pesaran & Shin (1999) Autoregressive Distributed Lag (ARDL) cointegrating techniques are used to estimate the model in an error-correction mechanism (ecm) framework.

[5]The low Durbin-Watson statistics in the initial estimation is evidence of autocorrelated errors.

The ARDL model is of the form

$$\begin{aligned}\Delta \ln \frac{M_t}{P_t} = \gamma + \sum_{i=1} \phi_1 \Delta \ln \frac{M_{t-i}}{P_{t-i}} + \sum_{i=0} \phi_2 \Delta \pi_{t-i} \\ + \delta_1 D_{i,t} + \mu_t \\ + \lambda_1 \ln \frac{M_{t-1}}{P_{t-1}} + \lambda_2 \pi_{t-1}\end{aligned} \tag{2.4}$$

Where π_t is the inflation rate at time t and the other variables are as previously described.

This estimation approach is appropriate for the relatively small sample size in this paper (monthly data from 1980 to 2008). Pesaran & Shin (1999) show that the ARDL approach is better than alternate estimators of long-run relationships in the presence of large, exognenous shocks and shorter time horizons. The ARDL model also avoids the classification of variables into $I(1)$ or $I(0)$.

To establish cointegration, the null of no cointegration $H_0 : \lambda_1 = \lambda_2 = 0$ is tested against the alternative of $H_1 : \lambda_1 \neq 0 \lambda_2 \neq 0$ by means of an F-test. The asymptotic distribution of this F-statistic is non-standard regardless of the time-series behaviour of the underlying variables.[6] Pesaran et al. (2001) have established a set of bounds tables of appropriate critical values covering all possible classifications of the variables into $I(1)$ or $I(0)$. If the F-statistic lies above the upper level of the band the null is rejected, indicating cointegration.

Once the test for cointegration is passed equation (2.4) is estimated using an appropriate lag selection criterion, in this case Schwarz Bayesian Criteria (SIC). Appropriate identification of the lag structure is important for identification of the true dynamics of the model. Thus long-run estimates of the elasticities of interest can be calculated and further diagnostic tests can be carried out.

2.4 Causality and Stability

Although Cagan's main hypothesis is that of monetary expansion driving the price level, he did note that agents may influence the real value of cash holdings by bidding up or down the price level - independent of increases in the supply of money. Speculators may thus be able to drive prices to levels that are not supported by the expansion of the money supply, as maintained by authorities

[6] I.e. whether the variables are $I(1)$ or $I(0)$.

in Zimbabwe.

Ideally the money supply would be instrumented for in the estimation procedure to test for the exogeneity of the money supply. In the absence of an appropriate instrument two tests are carried out. First dynamic stability tests are carried out on the inflation rate, Khan (1980). Second Granger-causality testing is undertaken, to test whether prices assist in predicting levels of nominal money balances, Lutkepohl (2007).

Prices become self-perpetuating where rises in prices immediately produce a proportionately greater decline in RMBs, causing the stability of the price-money relationship to break down. Cagan (1956) noted that this occurs only when the absolute slope of the demand function is is high *or* the lag in expectations is very short. This provides a mechanism to test for the causal relationship between money and prices in the model.

Khan (1980) establishes a continuous time model to test for self-perpetuating prices. This can be approximated by the reduced form discrete time model:

$$\Delta \ln \frac{M_t}{P_t} = \frac{1}{1+0.5\beta}[\gamma^* - \alpha\beta\Delta \ln P_t - \beta \ln \frac{M_{t-1}}{P_{t-1}}] + u_t \tag{2.5}$$

To examine the conditions required for stable (in the sense of Khan and Cagan) prices this is maximised with respect to inflation. The necessary and sufficient condition for stability of the inflation rate turns out to be:

$$1 - \alpha\beta < 0 \tag{2.6}$$

or equivalently, $\alpha\beta < 1$.[7] Estimating (2.5), results in three parameters and three unknowns. Solving for α and β allows us to test for stability of prices directly.

We can also test for the relationships between money and prices in the Granger-causality sense. This is carried out by estimating an ARDL model for prices regressed on the nominal money supply and vice versa. Insignificant error correction terms indicate weak exogeneity (pre-requisite to accept exogeneity in the Granger-causality sense) whilst insignificant lagged level variables indicate a rejection of Granger-causality.

[7]Further details of this model can be found in Khan (1980).

2.5 Seigniorage Revenue

Cagan (1956) notes that increases in the supply of money allow governments to raise seigniorage revenue. Governments are able to purchase non-monetary (real) goods, services and assets using newly issued money. This real revenue stream is measured as the difference in the stock of money in the economy, deflated by the price level (LHS (2.7)). It is calculated as the sum of inflation tax proceeds (first term on RHS of (2.7)) and the change in the holdings of real money balances (second term on RHS of (2.7)). The left hand-side of this equation is calculable directly from the data.

$$\frac{dM}{dt}\frac{1}{P} = \frac{M}{P}\left(\frac{dP}{dt}\frac{1}{P}\right) + \frac{d\left(\frac{M}{P}\right)}{dt} \tag{2.7}$$

Equation (2.7) indicates that there are limits to the amount of real revenue governments can raise by issuing new money. High inflation results in reduced holdings of real money balances, shrinking the effective tax base for this revenue stream.[8] Looking only at situations of constant rates of money growth the seigniorage revenue maximising rate of inflation can be found directly from the Cagan demand for money relationship. Recall the Cagan model, rewritten as:

$$\ln(\frac{M}{P}) = \gamma - \alpha\pi \tag{2.8}$$

Where $\pi = \Delta p_{t+1}$, α is the parameter of interest (the semielasticity of demand for money with respect to prices) and γ is a constant.

Let $\pi = C$ when rate of money growth is constant, and maximise with respect to C,

$$\frac{M}{P} = e^{(-\alpha C+\gamma)} \tag{2.9}$$

$$C = \frac{1}{\alpha} \tag{2.10}$$

Thus the revenue maximising inflation rate (under constant money growth) is:

$$\frac{1}{\alpha} = \text{rate per period with continuous discounting}$$

[8]Similarly, during low inflation governments may not be raising as much revenue as is possible if they were to increase the money supply even marginally.

This 'tax' is easy to collect. And if the tax rate on printing money increases rapidly enough, revenue can exceed the theoretical maximum under constant tax rate situations (this as people fail to anticipate the money supply increases quickly enough).

Here the revenue maximising inflation rate is established for the Zimbabwean economy and the sources of government financing decomposed to examine the relative importance of tax, seigniorage and external (ODA) financing for authorities between 1980 and 2007.

2.6 Money Demand Estimation for Zimbabwe

Previous work on money demand estimation in Zimbabwe to mention includes Munoz (2006) and Kovanen (2004). Both estimate superconsisent OLS parameters (after testing for cointegrating relationships) in an Engle-Granger framework for money demand over the period (and sub-periods within that) of the country's independent history. Kovanen estimates a money demand function for the period 1980-1995. Munoz finds significant parameter estimates over a shorter time-period in the early 2000s.

It is shown that the estimates here fall within the range of estimates in Munoz (2006) and Kovanen (2004), which strengthens the validity of the results.

3 Exogenous Events Affecting Money Demand

In the Cagan (1956) model for money demand under hyperinflation, the inflation rate is the primary determinant of real money balances (RMB) in periods of high inflation. In Zimbabwe there are are several classes of exogenous country-wide shocks that have similarly large effects on macroeconomic variables. These exogenous shocks are employed as a result of a lack of conventional macroeconomic variables available at the desired frequency (monthly) for this economy. These six dummy variables assist in co-determining the equilibrium level of RMB in our estimation of a demand for money function.

These variables are climatic (drought), political (post-independence boom, civil war, judicial crisis) and economic (exchange rate appreciation and exchange rate auction). A brief outline of each is carried out below.

3.1 Drought

The country (traditionally drought-prone) has faced five major droughts between 1999 and 2008. These affected the agricultural harvests in 1999/2000, and the four harvests between 2001 and 2005. These droughts are likely associated with changes in the price level and thus changes in the holdings of real money balances. Dore et al. (2008) notes that droughts have had large negative effects on growth and other variables throughout Zimbabwe's history.

3.2 Political Factors

A recent report (Dore et al. 2008, p.8) notes that "exceptionally high growth rates" followed Zimbabwe's immediate post-independence period. Growth of 10.7% and 9.7% were recorded for 1980 and 1981 respectively. It is expected that this high growth phase would have positively affected macro-economic variables including the price level. This describes the *Post-Independence Boom* variable.

Similarly *Civil War* can be expected to negatively affect macroeconomic variables exogenously. (Stoneman & Cliffe 1989, p. 47) describes the "consolidation of the ZANU government"[9] as including "strong-arm methods used to

[9]The Zimbabwe African National Union - Patriotic Front (ZANU - PF) is the party of Robert Mugabe, current president of Zimbabwe.

pacify the local [Matabele] population" in reaction to acts of terrorism by "dissidents" in rural Matabeleland after three cabinet members were dismissed in 1982.

The *Judicial Crisis* is also expected to co-determine RMBs in Zimbabwe. This variable measures the time-period coinciding with the resignation of several senior judges in Zimbabwe and thus increasing domestic political instability. This as a result of the government stating its inability to "guarantee the judges' safety" (Carver 2002, p.8) in the face of opposition to the Supreme Court finding that the fast track land reform programme (FTLRP) was unconstitutional,

Zimbabwe's involvement in the *DRC war* occurred between August 1998 (governments of Angola, Namibia and Zimbabwe agree to assist the Kabila government after a meeting in Harare) and October 2003 (second round of elections held after an official cease-fire and formation of a transitional government). Zimbabwe's involvement included increased military spending placing further pressure on the domestic budget during this time, Dore et al. (2008). As is *Civil War*, *DRC war* can be expected to negatively affect macroeconomic variables exogenously.

Elections have increasingly been associated with times of domestic political tension and upheaval and can be expected to affect macroeconomic variables exogenously. Elections occur roughly every five years in Zimbabwe. This dummy registers 'one' in the month in which parliamentary, presidential or referenda elections were held between 1980 and 2008, there have been 11 instances of elections taking place in Zimbabwe over the time period of interest covering 13 parliamentary, presidential or referenda elections (some elections were run concurrently).

3.3 Economic Factors

The Zimbabwean authorities have controlled the exchange rate in Zimbabwe for much of the last 28 years (and under the Smith government since 1965) using exchange control and centrally managed allocation of foreign currency. Except from April 1995 to December 1997, aligning the domestic exchange rate with a specific currency was seldom undertaken. During the mid-1990s the Reserve Bank of Zimbabwe pegged the value of the Zimbabwean dollar to the

US dollar, Mabugu (2001), leading to real appreciation. Although there were limits on the amounts of foreign currency that could be purchased, this period saw convertibility of the ZWD internationally and market determined allocation of foreign reserves. The dummy variable capturing this is *ER Peg Period*. This commitment to an exchange rate peg and the liberalisation of the allocation of foreign exchange had large effects on several macroeconomic variables, including the price level.

The early 2000s saw the return to centrally allocated foreign currency and a fixed exchange rate with intermittent devaluations. The result was non-convertibility of ZWD abroad, local shortages of foreign exchange as well as a return to centralised allocation these reserves. So it was with much fan-fare that a system of foreign exchange auctioning was established by the Reserve Bank at the start of 2004. This was to allocate scarce foreign exchange to the highest bidder (defacto floating exchange rate) and a return to market determined allocation of foreign currency. *Exchange Rate Auction* captures this event. The introduction of the auction system coincides with a significant alteration in expectations regarding exchange rate policy. This would be captured by conventional macroeconomic variables (the real exchange rate, national income, the price level) if there were available at the required frequency.

3.4 Summary of Structural Change Variables

Exogenous dummy variables to be included in the money demand function include:

- Drought: runs for 13 months from November in each of the years 1982, 1984, 1991, 1999, 2001-2005.
- Independence: April 1980 to June 1983
- Civil war: January 1983 to June 1985
- Exchange rate appreciation: April 1995 to January 1997
- DRC War
- Election Dummies

- Judicial crisis: February 2002 to March 2003
- Exchange rate auction: January 2004
- DRC War: August 1998 to October 2003
- Elections: Usually March but occasionally February and/or June in the years 1980, 1985, 1990, 1995, 1996, 2000, 2002, 2005, 2008.

4 Data and a New Price Index

In this section we outline the variables and data sources employed in this paper. We also discuss several issues encountered in constructing the data set. These include timing issues, the quality of the Zimbabwean CPI, use of alternative price series (criteria are established for an alternate price series) and merging three alternate price series to yield our new price index.

4.1 Data

Data is monthly from January 1980 to early 2008.[10] The variables of interest are:[11]

- The consumer price index (CPI), money (M1) and three-month time deposit rate:
- Parallel market exchange rate (CER) data:
- Government budget[12] and overseas development assistance data[13] (ODA):
- Stock market returns:
- Imports, trade-partner exports to Zimbabwe:

Inflation (and stock market returns) are measured as the log difference over 12 months (using monthly data). These moving averages dampen the volatility of monthly rates of change and abstract from seasonality issues. Real money balances are constructed by deflating the money supply by the CER. Budget data is deflated by the CER. DAC and trade data is denominated in USD by the OECD and IMF respectively.

Table 1 shows that the mean of these variables has changed considerably in the last decade. This coincides with large increases in inflation rates and declining real money balances seen in Zimbabwe since 2001.

[10] All ZWD denominated data is transformed to reflect the 2006-2008 dollar, i.e. in August 2006 three zeros were removed from the currency and in August 2008 ten zeros were removed from the currency to allow reintroduction of lower denomination notes in order to cope with the very high rates of inflation.

[11] See Appendix A for details on the sources of these variables.

[12] Budget data is annual from 1980-1997, quarterly from 1998-2005Q2 and monthly from 2006-2007.

[13] Aid data is annual.

Table 1: *Summary Statistics, by Decade*

	Log (RMB)	Inflation rate (using CER)	Inflation rate (using CPI)	3mnth deposit rate	log(real imports)	stock market returns
			1980-2008			
Mean	6.21	1.00	0.80	3.01	-0.58	0.65
Maximum	7.17	23.35	14.65	5.65	0.64	6.83
Minimum	4.63	-0.58	0.03	1.25	-3.34	-4.49
Observations	337	333	331	333	333	333
			1980-1999			
Mean	6.32	0.19	0.19	2.65	-0.40	0.17
			2000-2008			
Mean	5.93	2.76	2.14	3.93	-1.04	1.70

Source: Authors calculations.

4.2 Real Money Balances

The dependent variable in our money demand estimation is a measure of real money balances (RMB). The quality of the price series has a major impact on the construction of this variable. The domestic price series will include bias due to difficulties surrounding data collection and implementation of appropriate price updating techniques. This signals differences between the actual CPI and the measured CPI.[14]

A mis-match between the money and price data collection techniques also affects the RMB variable during accelerating inflation. This occurs due to money being an end of period variable and prices a mid-period variable. However, this timing mis-alignment is far outweighed by the quality of the CPI, especially as inflation accelerates.[15]

These two issues surrounding CPI quality have become more pronounced in recent years, coinciding with accelerating inflation rates and seemingly resulting in large increases in RMB, for example in Figure 3. Munoz (2006) adds that the inclusion of controlled prices and exclusion of goods traded on the parallel market also affect the quality of the measured versus the actual CPI. That said, even the (flawed) CPI series shows the rapid acceleration of inflation since 1999 with two distinct phases of very high inflation. Figure 1[16] shows that in early 2004

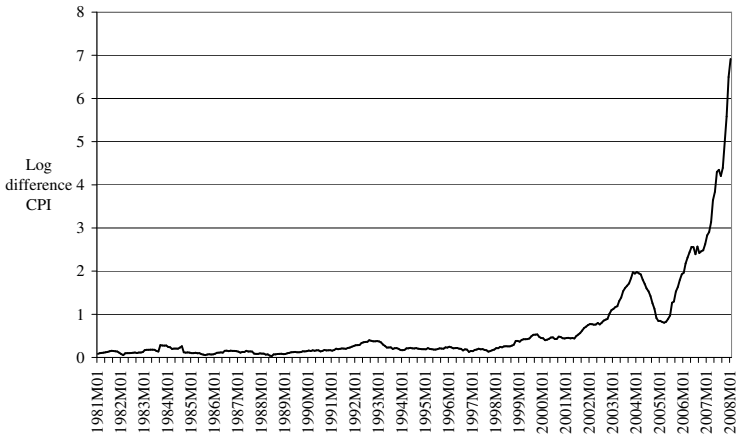
[14]Separately, as hyperinflation set in the CSO faced increasing delays in publication of its monthly series which is required in increasingly high frequencies as inflation accelerates.

[15]Author will provide evidence of this timing misalignment and its relative importance to the CPI quality issue on request.

[16]This shows a moving average annual rate of change based on 12 monthly log difference growth rates.

inflation peaked at around 700% per year (when using log differences) before declining significantly in mid 2005. Almost immediately after this decline the inflation rate began a rapid acceleration however which has not as yet peaked. This acceleration stalled briefly in 2006 and again in 2007 but rapidly moved the country to a state of hyperinflation (as measured by the CPI) in March 2007. Figure 1 also indicates that inflation (based on the CPI) has not been low or stable for much of Zimbabwe's history, even prior to the large increase in the inflation rate post-2000.

Figure 1: *Annual Inflation*



4.3 Alternative Price Series

In recent years a variety of price indices have emerged as alternatives to the Zimbabwean CPI. Table 2 records monthly inflation rates for six price series available for the last part of 2008, briefly described below. These are available daily.

There are three series relating to the price of US dollars: the 'Inter-Bank Rate' is the rate of foreign exchange available through the banks, this is higher than the official exchange rate and available only in certain circumstances, for example to some exporters for the purchase of inputs, Robertson (2008); the

'Old Mutual Implied Rate' (OMIR) is the implied exchange rate given the price of an Old Mutual Share dual listed on the Harare and London stock exchanges (adjusted by the USD/GBP exchange rate); and the 'Parallel Rate' is the rate paid by businesses for foreign currency on the parallel market. The final two series relate to the price of goods and services when paid for by cash, 'Cash Value' or via the banks' payment systems, the Real Time Gross Settlement ('RTGS') rate.[17] Finally the 'Hard-Boiled Egg Index' measures the daily price of a hard-boiled egg. This represents prices of basic goods purchased in small quantities by low income families in Zimbabwe, Robertson (2008).

The range of alternate series available at the end of 2008 reinforces the idea of the requirement for a price series other than the domestic CPI.

Table 2: *Alternate Price Series*

2008	Inter-Bank Rate	Old Mutual Implied Rate	Hard-Boiled Egg Index	Cash Value	RTGS Rate	Parallel Rate
August 1	7.15	67.6	35.0	14.9	89.9	90.0
September 1	37.15	1,810.3	350.0	199.1	3,000.6	3,000.0
October 1	138.14	5.9E+05	3,500.0	2,500.0	9.2E+05	1.0E+06
October 21	290.12	3.07E+08	70,000.0	31,000.0	1.01E+08	3.00E+08

John Robertson, Robertson Economic Services.

4.3.1 Establishing a New Price Index

Use of alternate deflators for the construction of the real money balance variable is common in the literature. For example, Bernholtz (2003) suggests that using the exchange rate series as the money deflater may improve on the domestic price series available, especially during periods of very high inflation. This may be applicable to Zimbabwe, where price pass-through from imports to domestic prices may be rapid. This strengthens the information content of the parallel market exchange rate series in forming inflation expectations since 2000 as transactions increasingly occur on the 'parallel' or black market and are thus not captured by the CPI.

The following criteria have been established to rank the various alternate price and parallel market exchange rate variables in an attempt to locate the most appropriate price series for use in this paper. These criteria comprise:

[17] this price series is higher than the 'cash value' as the RTGS system took several days to clear, and so the currency's devaluation in the intervening time is priced into the cost of using this method.

high frequency availability, available for a long time period, limited delays in publication, 'basket' of goods updated regularly,[18] wide availability, wide use, and can be seen in Table 3. Of the price series listed only Parallel Rate, and WCY (World Currency Yearbook) fulfill all of the six criteria. These are both measures of foreign exchange on the 'parallel' market. The merging (details below) of these series comprises the new price index for Zimbabwe, the Composite Exchange Rate series (CER) is established. The new series is available monthly from January 1980 to January 2008.

Table 3: *New Index Quality Criteria*

	High Frequency	Time Period	Publication Delays	Regularly Updated Basket	Represent ative Basket	Widely Available
CPI	y	y	y	n	n	y
Interbank	y	n	n	y	y	n
OMI	y	y	n	y	y	y
Hard-Boiled Egg	y	n	n	y	n	n
Cash	y	n	n	y	n	y
RTGS	y	n	n	y	n	y
Parallel Rate	y	n	y	y	y	y
Farm Comp	y	n	n	y	y	n
WCY	y	y	n	y	y	n

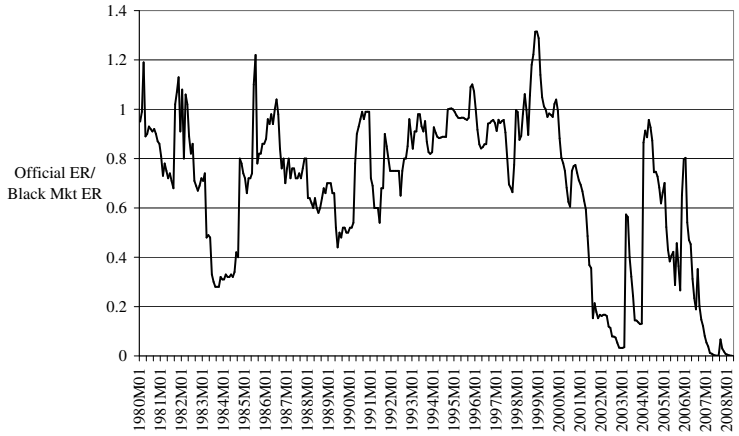
The official rate has diverged from the CER significantly at many points in the last 28 years, except during the mid-1990s when the government maintained the real value of of the ZWD at the level of the USD (between April 1995 and January 1997) Mabugu (2001). Figure 2 shows the parallel market premium (Official ER/CER) for 1980-2008. A dramatic divergence occurred between the official and parallel market exchange rates several times prior to the dramatic divergence volatility in this series since 1999, as the series approaches zero.

4.3.2 Merging Three Series

Having established a set of quality criteria, which the the new price index meets, there remain three issues surrounding the overall validity of the CER. First there is a gap between December 1993 and January 2000 for which neither series records observations. This is addressed by using the Farm Compensation (FC) series to fill this gap. Second, neither series runs for the entire time period 1980-2008, the two series must then be merged in order to obtain a single price index for the entire period of interest. This addressed by merging the over-lapping

[18]The basket of goods relevant to the non-CPI series relates to those products for which the price series is applicable to.

Figure 2: *Parallel Market Premium*



periods of each series using monthly log growth rates, $\frac{dlnX_t}{dt}$.[19] The CER is then a function of three series: the Parallel rate (1999-2008), the WCY rate (1980-1993) and the FC rate (1993-1999).

The FC series is unpublished (therefore not widely available) and quarterly (rather than monthly).[20] To test whether this series is a good summary of the parallel exchange rate information between 1993 and 2000 the following is carried out. First where the series overlaps with the WCY (1990-1993) and Parallel (1999-2006) series the correlation coefficients are reported. These can be found in the data appendix, Table A1 and show high correlation between the Parallel and FC measures (0.928) and low correlation (0.281) between the FC measure and the WCY measure. This may in part be due to their short overlapping time-period. Figures A1 and A2[21] show that FC follows the Parallel rate and the WCY follows the broad trends of the FC measure, respectively. Second, an error correction model is estimated between WCY and FC and

[19]Or rather $Parallel\ mkt\ ER(-1) * e^{(gr)}$ where gr is the log difference of the ER series when computing the series.

[20]Cubic spline interpolation is carried out to obtain a monthly series, details in Eviews, version 6.

[21]These exchange rates are ZWD/USD where we have re-based the Zimbabwe dollar to reflect the currency used between August 2006 (when three zeros were removed from the currency) and August 2008 (after which 10 more zeros were removed from the currency)

between the Parallel rate and FC. The results, reported in Table A2, indicate a significant long-run relationship between the variables of interest with large adjustment coefficients and long-run coefficients approaching one.

In light of the above discussion we adopt the novel merged series as our alternative price index and deflate M1 by this series in the main regression.

Deflating M1 by the CER, is compared to deflation by the domestic CPI in Figure 3.[22] The CER deflated series follows the trends of the CPI deflated series between 1980 and 1997. The CER series captures a decline in RMB starting in late 1999 and continuing to 2003. The CPI deflated series records stable holdings of RMB at this time despite the significant increase in inflation over these years (as measured by both CPI and CER derived inflation rates). The CER deflated series picks up an increase in RMB holdings at the end of 2003 and on-going until 2005, also noted in Munoz (2006). This coincides with the introduction of an auction system for the purchase of foreign exchange (January 2004), recall Section 3. This auction system was abandoned late in 2005, Munoz (2006). By November 2006 the level of RMB Zimbabweans were willing to hold had slipped to below 1983 levels (the lowest level prior to this date). The recent decline in RMB is consistent with our priors on the behaviour of agents holdings of money balances during periods of high inflation. The series in these years is based on the 'parallel exchange rate' from Techfin which records the actual parallel market rates paid by businesses and individuals each day for foreign currency in Harare.

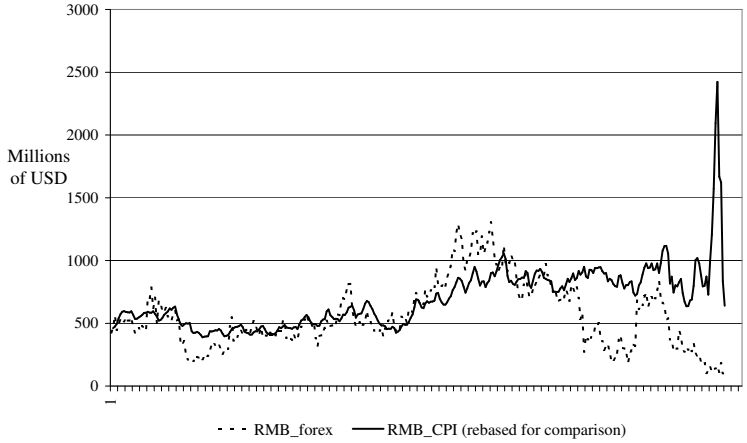
The Hanke Hyperinflation Index for Zimbabwe (HHIZ),[23] has been widely quoted in the press since the series was published in the summer of 2008. Although similar to the HHIZ, as seen in Figure 4, our series runs monthly from 1980 to late 2008, and is based on a merging on three parallel market exchange rate indices whereas the HHIZ Hanke's index is based on 'market based' price data and the authors calculation,[24] and runs for only 23 months between 2007 and 2008. The two series overlap for just 21 months and follow the same trend over this time period. The Hanke index appears to have a higher volatility than

[22]The RMB series is now denoted in millions of USD (as the nominal money data have been deflated by an exchange rate). The comparable CPI deflated series has been rebased so that the CPI=100 in July 1994.

[23]Cato Institute, http://www.cato.org/zimbabwe.

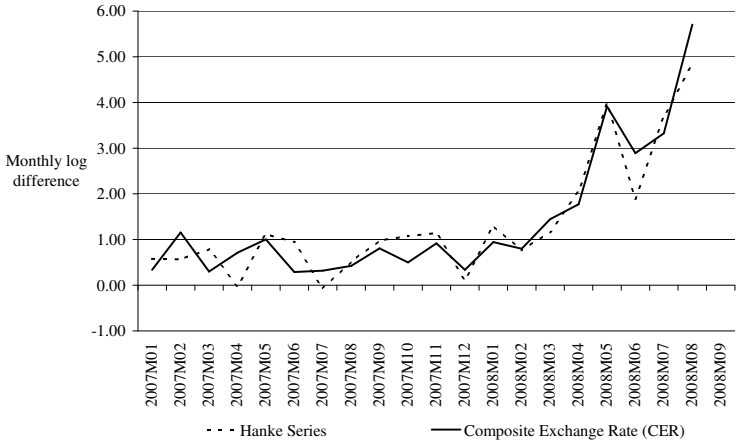
[24]The exact nature of which is not specified on the author's website or accompanying papers.

Figure 3: *RMB - Comparison*



the CER, registering more pronounced declines in the series in April, July and December 2007 as well as June 2008 than the CER.[25]

Figure 4: *CER comparison with Hanke Hyperinflation Index*



[25]This may, of course, be attributable to the limited data available on the HHIZ from http://www.cato.org/zimbabwe

5 Money Demand Estimation

In this section we estimate a money demand function for the Zimbabwean economy. This allows us to test the reasons put forward by authorities there for the hyperinflation in recent years.

5.1 OLS Results

Table 4 shows the baseline OLS results on a log-levels equation with and without an autoregressive component and control variables measuring returns on wealth held as time deposits (3 months deposit rate), stocks (stock market returns) and cash (inflation rate). The dependent variables is log(RMB). The AR(1) term is required as the macroeconomic variables display a degree of persistence over time. As such the AR(1) term is large and significant when included in columns (2-5)

As the CER is a substitute for the CPI specifications (1) and (2) exclude the CPI while (3) and (5) exclude the CER. Although of the correct sign, the inflation rate is not significant in (3) and weakly significant in (5).

Specification (4) comprises a conventional, baseline money demand function. Here the CER is interpreted as the opportunity cost of holding domestic currency instead of foreign currency while CPI measures the opportunity of cost of holding cash over goods.[26] The 3-month deposit rate is not significant and the stock market returns variable is weakly significant only in (4), although it displays the correct sign. The CER inflation rate is highly significant and of the correct sign in all specifications.

Table 5 shows results on inclusion of six dummy variables relating to environmental and policy shocks affecting the Zimbabwean economy. The coefficient on the CER inflation rate is robust (in size, sign and significance) to alteration of the time-periods used and to the introduction of various other control variables. In Zimbabwe the level of real money balances depends negatively on the inflation rate (proxied by the price of foreign currency on the parallel market). This is highly significant and accounts for most of the explained variation in RMBs over the period.

[26] In most instances CPI and CER are interpreted as substitutes and thus not included in the same regressions.

Table 4: *Demand for Money: Zimbabwe, Conventional Specification*

Dependent variable: RMB	(1) Pars	(2) AR(1)	(3) CPI	(4) Controls	(5) Controls/CPI
Inflation rate	-0.26***	-0.47***		-0.51***	
(CER)	(0.01)	(0.06)		(0.07)	
Inflation rate			-0.22	0.21*	-0.23*
(CPI)			(0.13)	(0.12)	(0.13)
3mnth				0.00	-0.00
deposit rate				(0.00)	(0.00)
Stock market				0.07*	-0.02
returns				(0.04)	(0.06)
Constant	6.39***	7.15***	6.36***	6.45***	6.36***
	(0.03)	(1.34)	(0.15)	(0.16)	(0.16)
AR(1)		0.98***	0.94***	0.96***	0.94***
		(0.02)	(0.02)	(0.01)	(0.02)
Adjusted R squared	0.40	0.95	0.92	0.95	0.92
Durbin-Watson statistic	0.10	2.20	2.28	2.06	2.18
F-statistic	214.11	2838.84	1817.77	1222.18	903.33
Number of observations	325	324	324	320	320
Sample	1981M01	1981M02	1981M02	1981M02	1981M02
	2008M01	2008M01	2008M01	2007M09	2007M09

White Heteroskedasticity-Consistent Standard Errors and Covariance

Specification (1) introduces the dummy variables while assuming no autocorrelation in the error term. All the dummy variables display the correct signs and several are significant. Drought, post-independence boom, civil war, exchange rate appreciation and the judicial crisis also display large coefficients, of the same magnitude to that on the primary variable of interest, the inflation rate. The DRC War and Elections dummies are excluded from specifications going forward given their insignificance here. The low Durbin-Watson statistic in (1) indicates however that the errors in this initial model are correlated. Despite this the model display good fit.

On introduction of the AR(1) term some of these dummy variables lose significance and drought and the ER auction no longer display the correct sign. Specification (5) introduces the alternate inflation measure, the interest rate and the stock market returns variable. Only the stock market returns variable is significantand of the correct sign with a small coefficient. A very tight fit now achieved, as we argue above that this is to the detriment of the explanatory power of important shock variables.

Table 5: *OLS results, controlling for large, sustained shocks*

Dependent variable: RMB	(1) Shocks	(2) AR(1)	(3) 1981-1999	(4) 2000-2008	(5) Controls
Inflation rate	-0.43***	-0.46***	-0.48***	-0.46***	-0.52***
(CER)	(0.03)	(0.06)	(0.07)	-0.08	(0.06)
Inflation rate					0.12
(CPI)					(0.12)
3mnth					0.00
deposit rate					(0.00)
Stock market					0.07*
returns					(0.04)
Drought	-0.19***	0.02	0.06***	-0.06	0.03
	(0.03)	(0.02)	(0.02)	-0.05	(0.02)
Post-independence	0.49***	0.06**	0.09*		0.06*
boom	(0.04)	(0.03)	(0.05)		(0.03)
Civil war	-0.23***	-0.08**	-0.09*		-0.10**
	(0.05)	(0.04)	(0.04)		(0.04)
ER peg period	0.41***	-0.01	-0.01		-0.01
	(0.04)	(0.02)	(0.02)		(0.02)
Judicial crisis	-0.61***	-0.21*		-0.20	-0.23*
	(0.07)	(0.11)		-0.11	(0.13)
ER auction	0.08**	-0.27		0.28	0.24
	(0.03)	(0.17)		0.18	(0.18)
DRC War	-0.03				
	(0.04)				
Elections	-0.04				
	(0.05)				
Trend	0.004***	0.005***	0.006***	0.02	0.003**
	(0.000)	(0.002)	(0.001)	0.02	(0.001)
Constant	5.83***	5.69***	5.64***	2.01	5.92***
	(0.03)	(0.29)	(0.21)	-4.56	(0.23)
AR(1)		0.95***	0.93***	0.91***	0.94***
		(0.03)	(0.03)	-0.07	(0.02)
Adjusted R squared	0.81	0.95	0.96	0.92	0.95
Durbin-Watson statistic	0.38	2.13	2.09	2.15	2.00
F-statistic	179.94	670.45	723.03	193.56	540.06
Number of observations	325	324	227	97	320
Sample	1981M01 2008M01	1981M02 2008M01	1981M01 1999M12	2000M01 2008M01	1981M02 2007M09

White Heteroskedasticity-Consistent Standard Errors & Covariance

As 2000 marks the onset of severe economic deterioration and the onset of high inflation there are concerns that a linear regression spanning 1980-2008 may not be able to capture potential non-linearities between the pre- and post-2000 time periods. Specification (3) uses only pre-2000 observations while (4) uses only post-2000 observations. the coefficient on the CER term is remarkably consistent, although the significance and sign on the dummies of interest do not perform well under these specifications. Similar concerns regarding difficulties in fitting the last few observations of the hyperinflation in 2008 result in the estimation being truncated at the start of 2008.[27]

These regression results are an improvement on previous empirical investigations of the money demand function in Zimbabwe. We have established a robust (in size and sign, over time) coefficient on the variable proxying for the increase in the price level (the cost associated with holding RMBs). A 1% increase in the price level results in a 0.48% decrease in holdings of RMB. In contrast the elasticity found by Munoz (2006) was -0.12 (for the time period 1998-2004), and -0.66 for Kovanen (2004) (for the time period 1980-2001). The coefficient in this paper thus falls between the 2 estimates previously found.[28]

5.2 Cointegration

Using Equation (2.4), we estimate the ARDL error correction model. First we test the Pesaran F-statistic against the appropriate bounding critical values with a 12 period lag structure (appropriate to the monthly data in this model). The ARDL model accepts cointegration between the inflation rate and RMBs. The F-statistic for the specification in Equation (2.4) is 10.74, above the relevant 1% band of 6.84-7.84. The null of no-cointegration is rejected. This rejection is robust to a reduction in the lag structure to 1 lags, see Table 6.

For completeness augmented Dickey-Fuller tests are also carried out on the inflation rate and RMB variables. The results, in Table A4, show that the levels of these variables do not reject the null of a unit-root while the differenced variables are stationary.

[27] This eliminates any requirement for measurement of the barter-exchange that emerged in Zimbabwe only after January 2008.

[28] Estimates on the elasticity of the exchange rate (measured by the change in the parallel market exchange rate) are -1.28 to -1.25 for these authors, respectively. These are larger numbers than the coefficients this (slightly different) model has produced.

Table 6: *Pesaran bounds test*

Dependent variable	F Statistics	
	Lag order 1	Lag order 12
RMB	6.12	10.74
Critical	Pesaran et al (2001)[1]	
value	Lower bound value	upper bound value
1%	6.84	7.84
5%	4.94	5.73
10%	4.04	4.78

[1] Critical values are obtained from Pesaran et al (2001), Table CI (iii): Unrestricted intercept and no trend (indicates linear trend in levels equation and intercept for both CE and independent variables).

Table 7 shows the ARDL results. Using SIC, Microfit estiamtes an ARDL(1,1). Column (1) shows the short-run parameters prior to estimating for an error-correction relationship, this specification differs from that in Column (2), Table5 in number of observations and AR(1) techniques. However the coefficients are of broadly similar size and signs as those in the AR(1) model (in Table 5). Drought and the ER auction have regained the correct signs; however drought, post-independence boom and the judicial crisis are not significant in this specification. Specification (2) displays the long-run coefficients, the elasticity on the inflation rate variable is about 40% smaller than in the short-run ARDL model or the AR(1) model, but similar in size to the original OLS specification, without controls and is still within the -0.12 and -0.66 range reported by Munoz (2006) and Kovanen (2004), respectively.

Specification (3) shows the error-correction model. Crucially the error-correction (ecm) term is significant and negative, indicating a long-run corrective process between RMBs and price movements in this model. The implied convergence rate, 0.11, means that a shock of 1% to the RMB-inflation levels equilibrium is halved in about 7 months. This half-life seems reasonable for the case-study in this paper and falls between the convergence rates in the Asian countries Bahmani-Oskooee & Rehman (2005) examine using the same methodology.[29]

Table 8 shows the stationarity of the ECM residuals and the mean-reverting behaviour of the ECM relationship over time, respectively.

[29] In that paper India's rate of convergence in -0.47 whilst that of -0.01 for Thailand. These estimates are for periods of relatively low inflation but are still indicative of the range of estimates we might expect to find for money demand functions estimated in this way.

Table 7: *Long-run Money Demand Estimation, Zimbabwe*

Dependent variable: RMB	(1) Short-run	(2) Long-run	(3) ARDL
Inflation rate	-0.48***	-0.24***	-0.48***
(CER)	(0.04)	(0.09)	(0.04)
Drought	-0.02	-0.22	-0.02
	(0.017)	(0.14)	(0.02)
Post-independence	0.02	0.18	0.02
boom	(0.04)	(0.29)	(0.04)
Civil war	-0.06**	-0.55**	-0.06**
	(0.03)	(0.26)	(0.03)
ER peg period	0.07**	0.58**	0.07**
	(0.03)	(0.23)	(0.03)
Judicial crisis	-0.04	-0.39	-0.04
	(0.05)	(0.37)	(0.05)
ER auction	0.49***	4.30***	0.49***
	(0.12)	(1.60)	(0.12)
Trend	0.003	0.002*	0.003
	(0.002)	(0.001)	(0.002)
Constant	0.70***	6.15***	0.70***
	(0.17)	(0.20)	(0.17)
Log(RMB) - lag	0.89***		
	(0.03)		
Inflation rate	0.45***		
(CER) - lag	(0.04)		
ECM(-1)			-0.11***
			(0.03)
Adjusted R squared	0.95		0.43
Durbin-Watson statistic	2.16		2.16
F-statistic	641.87		27.72
Number of observations	313		313
Sample	1982M1		1982M1
	2008M1		2008M1

ARDL(1,1) selected, based on Schwarz Bayseian Criterion
(1) ARDL estimates
(2) Estimated long-run coefficients
(3) Error correction representation for the selected ARDL (1,1) model (level variables all differenced)

Table 8: *Stationarity of ECM Residuals*

	Level		Difference	
	1982m01-2008m01			
	ADF test statistic	MacKinnon one-sided p-value	ADF test statistic	MacKinnon one-sided p-value
Residuals from ARDL ECM	*-19.12*	*0*	*-33.17*	*0*

Italics: reject unit root at 1% level

Table 9: *Test for Price Speculation*

Dependent variable	Differenced log RMB	
	(1)	(2)
Constant	0.039***	0.69***
	(0.10)	(0.14)
Inflation rate	-0.03***	-0.04***
(CER)	(0.01)	(0.01)
Log RMB - lag	-0.06***	-0.11***
	(0.02)	(0.02)
Dummy controls	No	Yes
AR(1)	-0.17***	0.16***
	(0.07)	(0.07)
Implied alpha	0.41	3.36
Implied beta	0.06	0.11
Implied alpha*beta	0.03	0.37
Adjusted R squared	0.07	0.14
Durbin-Watson statistic	1.96	1.97
F-statistic	9.45	8.22
Number of observations	324	324
Sample	1981M02 2008M01	1981M02 2008M01

White Heteroskedasticity-Consistent Standard Errors and Covariance

5.3 Stability and Exogeneity

Recall Equation (2.5) in Section 2. This provides a test for the stability of the inflation rate over time by examination of a continuous time Cagan model, approximated by a discrete time model which is empirically testable. Table 9 shows the results from estimation of Equation (2.5) as an AR(1) process, we include a trend and the exogenous dummy variables in specification (2) (as in previous specifications of this model). Given the three estimated coefficients on the constant, inflation rate and lagged RMB variable we can solve for the α and β parameters as seen at the bottom of Table 9. The stability test, as derived in Cagan (1956) and Khan (1980) amounts to a necesary and sufficient condition of $\alpha\beta < 1$. This is accepted for both model specifications and provides some evidence to reject the claim that the private sector has been bidding up prices speculatively in Zimbabwe.

The first stage of a Granger-causality test is carried out in the Appendix, Table A5. This test for weak-exogeneity indicates that there is a feedback process between money and prices, weakening the above rejection of speculation. In fact weak exogeneity cannot be accepted for money or prices, the error-correction terms in both specifications are significant and negative. Until an appropriate instrument is found to test for exogeneity of money explicitly in this model it is difficult to conclude that speculation did or did not exist during the high inflation period in Zimbabwe in recent years.

6 Aid Shocks

In Section 5 a long-run, stable relationship between real money balances and prices is estimated and evidence is advanced suggesting that prices are not self-perpetuating. This indicates that price increases may be driven by increases in the money-supply. We maintain this hypothesis in the following discussion.

We follow Cagan in calculating the equilibrium seigniorage that the government is able to raise, should it embark on a policy of printing large quantities of money to finance part of the domestic expenditure requirements. This is something the authorities allude to when they state that international sanctions are to blame for the economic woes of the country.[30]

This section also examines aid flows to Zimbabwe since 1980. We show that although aid levels have declined in recent years, the real story is around the large reduction in domestic revenue (largely taxes) raised by the authorities since 2001. This has been caused in the main part by a steep fall off in the domestic economy, Zimbabwe having been in a severe recession since the early 2000s.

6.1 Seigniorage Maximising Inflation

Recall Section 2: when assuming a steady-state money-supply increase maximum inflation is the coefficient on the inflation rate. As we use an annual moving average for the inflation rate variable this will be an annual rate.[31]

For the period 1981-2008 the rate of inflation that would maximise the revenue from printing cash is 420 per cent (1/0.24 - the long-run elasticity on inflation as estimated in the ECM) per year (0.35 per month). The actual rates of inflation during the hyperinflationary period September 2006 to January 2008 vs the average for 1980-2006 are 71 and 0.6, respectively. This means that before hyperinflation the government was not achieving the rate of inflation needed to maximise seigniorage revenue (35% per month). After September 2006 however the government actually over-shoots this 'optimum' number and is thus printing

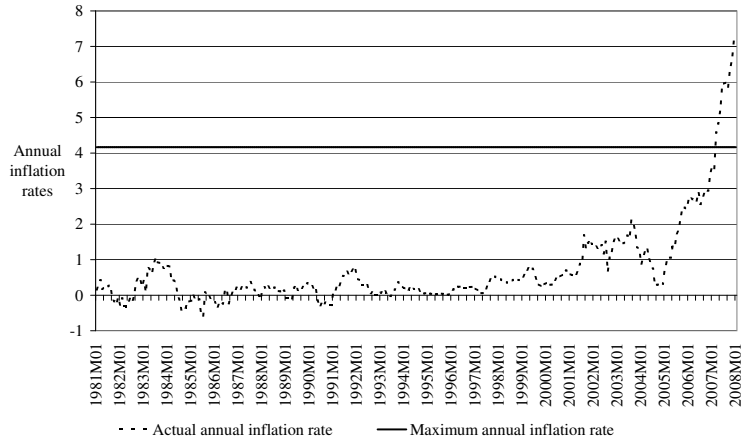
[30] 'Faced therefore with the circumstances of sanctions and lack of international financial supportthe Central Bank's quasifiscal interventions have served the people of this country as a survival kit against total economic collapse.' (RBZ 2006, p.6)

[31] Use of log difference growth rates means that dividing $\frac{1}{\alpha}$ by 12 yields the average monthly inflation rate.

money too quickly (592% per month) to maximise seigniorage revenue in the steady state.

Figure 5[32] shows the level of seigniorage maximising inflation relative to the actual level of annual inflation (using our parallel market exchange rate data as the price series). Prior to early 2007 authorities kept price increases well below those needed to maximise seigniorage. After March 2007 there was much less inclination to keep below the rate of 420% per year.

Figure 5: *Seigniorage maximising and actual annual inflation, 1980-2008*



6.2 Revenue Decomposition

The domestic authorities are able to finance government spending according to the following:

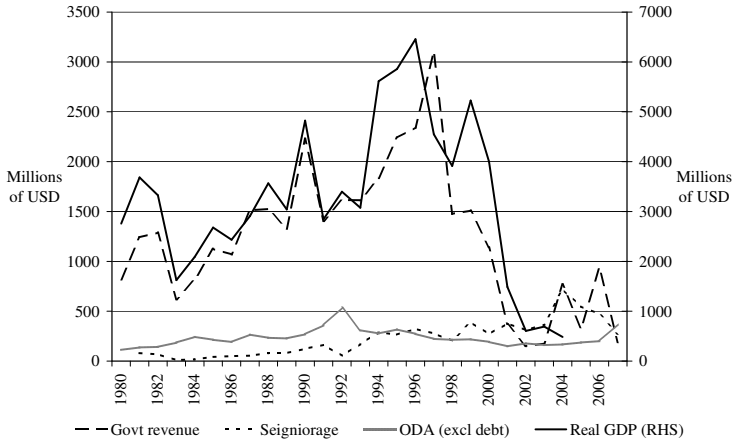
$$G_t = tY_t + A_t + S_t \tag{6.1}$$

where G is total government spending, tY is domestically raised tax revenue, A is external financing (ODA etc.) and S is domestically raised seigniorage

[32]Note: the CER inflation rate shows volatile and occasionally negative inflation between 1980 and 1990. This is to be expected with the exchange rate series and does not affect estimation or inference here.

revenue.[33] Figure 6 shows the profile of actual tY, A and S as well as real GDP, in millions of USD. The drop in real GDP is stark and is matched by a large decline in domestic tax revenue. There is an increase in S post-1999 and although aid levels are lower in the 2000s than they were in 1993/94 (high aid levels due in part to the severe drought experienced by the country in 1991/92) they have maintained their post 1994 trend throughout the 2000s.

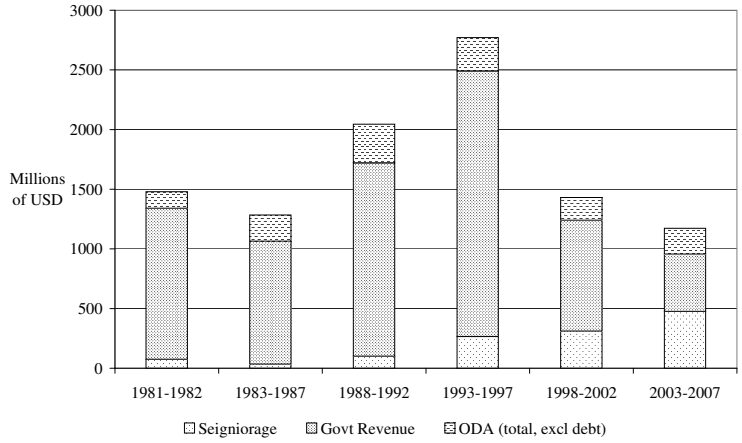
Figure 6: *Revenue and Real GDP Profile, 1980-2008*



ODA peaked between 1983 and 1988, making up 17% of total government revenue. Since 1998 aid has declined in absolute terms but still makes up 18% of total revenue. Seigniorage comprises 10% of total revenue between 1993 and 1997, rising to 22% between 1998 and 2002 and almost 41% of total revenue between 2003 and 2007. Strikingly the period 1998-2002 is characterised by a sharp and sustained decline in domestic tax revenue as the economy collapses in Zimbabwe. From making up 80% of total revenue between 1993 and 1997, by 2006 tax revenue was contributing only around 23% to overall revenue available for public spending requirements.

[33]Note: tax revenue is proportional in Zimbabwe. As long as the tax base is not altered inflation should raise increasing amounts of tax. Thus Tanzi effects are not pertinent to this discussion. Although this is clearly a partial equilibrium story: we would expect given the other large shocks in the economy that domestic financing options become limited as the productive capacity of the economy declines.

Figure 7: *Government Revenue Profile, 5-year averages*



Monthly domestic government revenue statistics, both non-seigniorage and seigniorage revenue, are available from 2006-2007, see Figure A3. These show that in mid-2006 seigniorage surpassed tax revenue as the government's most important domestic revenue source.

Finally, Figure A4[34] decomposes aid disbursements into technical assistance (proxying for non-humanitarian aid) and humanitarian aid. This addresses the alternate hypothesis that the Zimbabwean authorities had expected (based on past trends) that they would receive a particular level of non-humanitarian aid to assist in their domestic financing requirements. Humanitarian aid is still flowing into the country.[35] If non-humanitarian aid were to decline sharply post-2000 seigniorage financing might have been used to plug this gap. The data available show that although technical assistance to the country has declined and humanitarian assistance has increased, that these changes in the ODA profile available to the country are relatively small, especially when contrasted to the large decline in GDP.

Although ODA to Zimbabwe peaked in 1992,[36] post-2000 levels of total ODA

[34]Data from OECD, DAC.

[35]This is being channelled through non-governmental agencies rather than through the government.

[36]This particular year shows a large increase in ODA, possibly due to the severe drought in

have been in line with previous broad trends. The technical assistance component is fairly steady from 2000, though there is an increase in humanitarian aid from 2006. Aid remains a significant but not dominant aspect of government financing in Zimbabwe, see Figure 7. Similarly aid has not been extremely volatile, relative to total output and domestic financing.

A large financing deficit has occurred in Zimbabwe since the late 1990s. This has been increasingly funded by seigniorage. Total aid has declined somewhat, but the collapse in tax revenue is quantitavely more important.

6.3 Alternate Explanations

Alternatively the government may have been relying on payments from the UK government (or other international donors) to finance domestic expenditure requirements post 1999 (namely land-resettlement). On embarking on the Fast Track Land Reform Process (FTLRP) and in the absence of these funds authorities may have anticipated a spending profile that they were unable to meet without resorting to seigniorage financing. It is difficult to quantify this argument with existing data. Although planned aid may have declined, actual aid disbursements have not diverged from their long-run trend.

1991/92 and the emergency assistance needed in these years.

7 Conclusions

This paper has set out to address two potential (and conflicting) reasons for the hyperinflation currently seen in the Zimbabwean economy. First whether private sector price speculation is driving the hyperinflation and second whether large reductions in external (aid) financing have led to authorities resorting to seigniorage financing of the domestic deficit.

To test these we estimate a demand for money function for the country over the time period 1980-2008 and find that real money balances are cointegrated with the change in the price level with plausible convergence rates and long-run elasticities.

Our ARDL model establishes a long-run money demand relationship for Zimbabwe for the first time in the literature. This estimation relies on deflating the money variables by a newly constructed price series: the exchange rate for US dollars on the parallel market.

Second the paper uses the estimated model to test for self-perpetuating prices and feed-back mechanisms between nominal money and prices. We find evidence to suggest that although feed-back mechanisms do exist between money and prices, that prices are not themselve self-perpetuating in the sample period.

Finally the paper uses the estimated elasticity on the price variable to calculate the revenue maximising level of seigniorage given constant rates of money supply growth. Seigniorage levels have increased dramatically in recent years as other sources of (domestic and international) financing have declined. Whereas the decline in international financing (ODA) has not been as dramatic as the loss in domestic financing as the domestic tax base has collapsed, due to the country's economic decline. Even when external financing (aid) is decomposed into humanitarian and non-humanitarian assistance the decline in external assistance to the government is far from dramatic.

That component of domestic revenue raised from purchasing export earnings at cheap rates of exchange may have further been used to plug the financing gap, although this is difficult to quantify with exisiting data. Seigniorage financing (and export earnings financing through differing rates of foreign exchange) must be considered when attemtping to address the financing imbalances currently present in the economy. Thus the second potential reason for hyperinflation,

printing money to alleviate financing losses is accepted, but it is noted that financing losses are due to the collapse of the domestic tax base rather than the decline in external financing.

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A1 Data

A1.1 Data sources

Data is monthly from January 1980 to early 2008.[37] The variables of interest are drawn from:

- The consumer price index (CPI), money (M1) and three-month time deposit rate:
  - IMF International Financial Statistics (IFS), 1980-2007 and
  - Reserve Bank of Zimbabwe (RBZ) Monthly Statistics, 2007-2008.
- Composite exchange rate (CER) data:
  - World Currency Yearbooks, 1980-1993;
  - Professor A. Hawkins[38] (this data is quarterly), 1994-1999 and
  - Techfin (Zimbabwe), Parallel Market Rate, 2000-2008.[39]
- Government budget[40] and overseas development assistance data[41] (ODA):
  - OECD, Development Assistance Committee (DAC), 1980-2008;
  - The Economics Intelligence Unit, 'Country Reports' and 'Country Profile' series, 1980-2007 and
  - RBZ, 2006-2007.
- Stock market returns:
  - IMF's IFS, 1980-1988 & 1994-1997;
  - Datastream Advance, 1988-1994 and
  - Ecowin, 2007-2008.
- Imports:
  - IMF Direction of Trade Statistics (DOTS), trade-partner exports to Zimbabwe, 1980-2007.

A1.2 Parallel Market Exchange Rate

[37] All ZWD denominated data is transformed to reflect the 2006-2008 dollar, i.e. in August 2006 three zeros were removed from the currency and in August 2008 ten zeros were removed from the currency to allow reintroduction of lower denomination notes in order to cope with the very high rates of inflation.

[38] From an (unpublished) document compiled to establish (fair) compensation for commercial farmers affected by the Fast Track Land Reform Programme (FTLRP).

[39] This series is derived from surveying businessmen in Harare on the actual rates they used to buy and sell foreign currency on the black market, established through correspondence with Techfin, Zimbabwe and with John Robertson, an economist in Harare, summer 2008.

[40] Budget data is annual from 1980-1997, quarterly from 1998-2005Q2 and monthly from 2006-2007.

[41] Aid data is annual.

Table A1: *Exchange Rate Correlations, log-differenced*

	Time available		*Farm compensation*	*World Currency Yearbook*	Parallel rate *(Techfin)*
Farm compensation	1990m03	2006m12			
World Currency Yearbook	1980m01	1993m12	1990m03-1993m12 **0.457**		
Parallel rate (black market)	2000m01	2008m10	2000m01-2006m12 **0.549**	don't overlap	
Official rate	1980m01	2008m10	1990m03-2006m12 **0.641**	1980m01-1993m12 **0.192**	2000m01-2008m01 **0.376**

Source: IMF, Techfin (Zimbabwe), World Currency Yearbook, Hawkins (2008).
Note: All series log-differenced.

Figure A1: *Farm Compensation and World Currency Yearbook series, Log Difference*

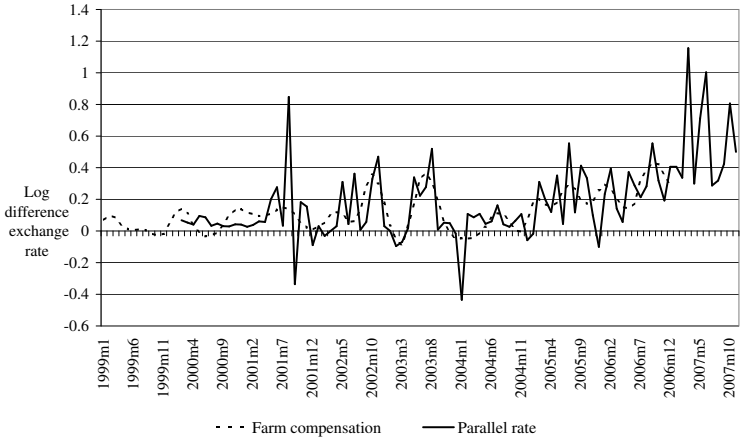


Figure A2: *Farm Compensation and Parallel Rate series, log difference*

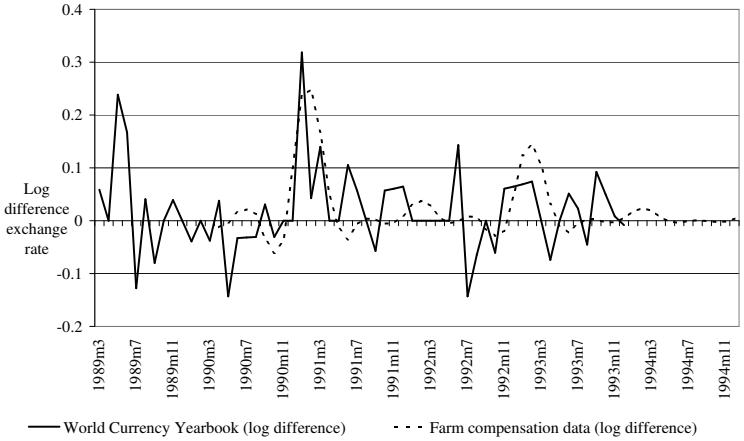


Table A2: *Merging Three Series: Error-Correction Model*

Dependent variable	(1) World Currency Year	(2) Parallel Rate
Farm Compensation	1.26***	0.94***
	(3.61)	(5.81)
Farm Compensation[1]	-0.88***	
	(-3.16)	
Constant	-0.97***	0.05*
	(-3.32)	(1.76)
ECM(-1)	-0.45***	-0.52***
	(-4.11)	(-4.89)
Adjusted R squared	0.35	0.46
Durbin-Watson statistic	1.94	2.1
F-statistic	7.27	31.48
Number of observations	34	72
Sample	1991M3	2001M1
	1993M12	2006M12

Note: level variables all differenced.

[1] Second difference.

(1) ARDL(1,2) selected, based on Schwarz Bayseian Criterion

(2) ARDL(1,1) selected, based on Schwarz Bayseian Criterion

Table A3: *Comparing Inflation Rates*

	Author		Hanke
	log difference	% change	% change
2007m1	41	50	78
2007m2	34	40	77
2007m3	116	217	56
2007m4	30	35	-2
2007m5	71	104	207
2007m6	100	173	60
2007m7	29	33	-7
2007m8	32	38	71
2007m9	42	53	165
2007m10	81	124	193
2007m11	50	65	
2007m12	92	150	62
2008m1	34	40	12
2008M02	94	157	259
2008M03	80	122	114
2008M04	145	325	222
2008M05	177	488	497
2008M06	391	4,900	5,260
2008M07	289	1,700	566
2008M08	332	2,678	3,190
2008M09	570	29,900	12,500
2008m10	1,272	33,333,233	630,000,000

Source: Authors calculations and
http://www.cato.org/zimbabwe

A1.3 Accounting for Dynamics

Table A4: *Augmented-Dickey Fuller Tests*

	Level		Difference	
	1980m01-2008m01			
	ADF test statistic	MacKinnon one-sided p-value	ADF test statistic	MacKinnon one-sided p-value
Log of RMB	-2.34	0.16	*-22.03*	*0*
Inflation rate (CER)	1.54	0.99	*-6.73*	*0*

Italics: reject unit root at 1% level

Table A5: *Granger-Causality, Weak Exogeneity*

	(1)	(2)
Dependent variable	Inflation rate	Money
Inflation rate		0.10***
		(0.01)
Money	0.39***	
	(0.10)	
Money (lagged)	0.34***	-0.14**
	(0.10)	(0.06)
Drought	-0.00	-0.03*
	(0.03)	(0.01)
Post-independence Boom	0.09*	-0.02
	(0.05)	(0.03)
Civil war	0.01	-0.02
	(0.04)	(0.02)
Fixed ER	-0.02	0.00
	(0.04)	(0.02)
Judicial crisis	-0.03	0.02
	(0.07)	(0.04)
Trend	0.00	-0.00
	(0.00)	(0.00)
Constant	-0.05	0.03
	(0.03)	(0.02)
ECM(-1)	-0.08***	-0.05***
	(0.03)	(0.02)
Adjusted R squared	0.11	0.32
Durbin-Watson Statistic	2.16	1.97
F-statistic	5.50	17.11
Number of Observations	313	313
Sample	1982M1	1982M1
	2008M1	2008M1

Note: level variables all differenced.

(1) ARDL(1,2) selected, based on Schwarz Bayseian Criterion

(2) ARDL(2,0) selected, based on Schwarz Bayseian Criterion

A1.4 Seigniorage Financing

Figure A3: *Monthly Seigniorage and Domestic (tax) Revenue, 2006-2007*

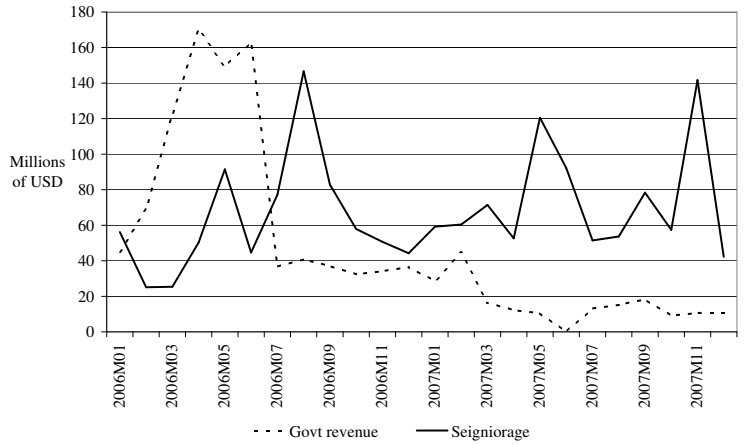
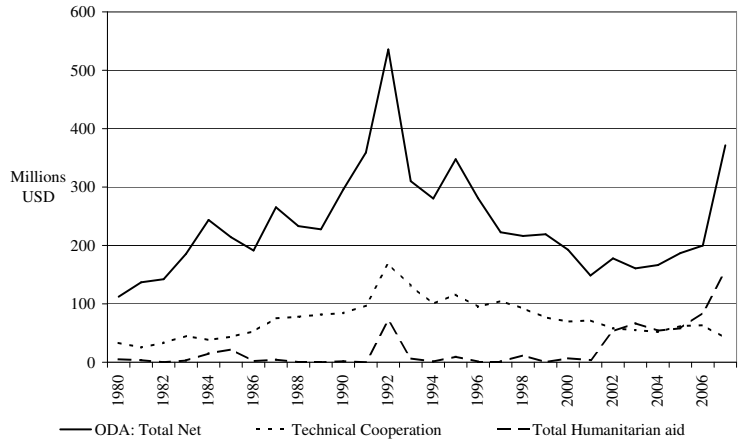


Figure A4: *Break down of Aid Disbursements, 1980-2008*



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