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CORRECTIONS IN MONEY DEMAND
DURING HIGH INFLATION: A CASE
STUDY OF SUDAN**

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**ADJUSTMENTS AND ERROR CORRECTIONS IN MONEY DEMAND
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A-M. M. Abdel-Rahman

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Abstract

In this paper an attempt to derive a stable money demand function for the Sudan is undertaken. Sources of instability in money demand stem from the occurrence of a high and rapidly accelerating inflation. Traditional money demand adjustments and error corrections are compared using specification searches from general to specific to define the dynamic mechanism combining the conventional corrections and adjustments. Particular attention is paid to the possible roles of buffer stocks, budget finance and currency substitution effects as determinants of money holdings. Due to the presence of high inflation, it is observed that traditional error correction and adjustment mechanisms may not be adequate. Consequently, and in line with Cagan-type mechanisms, we stipulate that corrections and adjustments in money demand are undertaken with respect to inflationary expectations instead of income. Results obtained on these specifications substantiate the adequacy of this alternate formulation.

ملخص

تعمل هذه الورقة على تطوير دالة مستقرة للطلب على النقود في السودان. وتكمن مصادر عدم الإستقرار في حدوث تضخم مرتفع ومتسارع في البلاد. وتقارن الورقة بين الآليات المختلفة للتعديل و تصحيح الخطأ في طلب النقود وذلك بإستخدام طرق البحث القياسي عن الصيغة الملائمة تدرجاً من صيغ تتسم بالعموميه إلى صيغ تتميز بالتحديد بغية تحديد الآليات الحركيه التي تزواج بين طرق التعديل والتصحيح المعهودة في طلب النقود. وتلقى الورقة إهتماماً خاصاً بآثار المخزون العازل، تمويل الميزانيه وإحلال العملة و التي يشتد مغولها على طلب النقود إبان التضخم. وفي ظل التضخم المرتفع فإن آليات التعديل والتصحيح التقليديه تغدو غير كافيه. و تفترض الورقة بالتالي آليات تعديل و تصحيح مغايره على نمط تلك المفترضه من قبل كاقان (١٩٥٦) لحالة التضخم المفرط يستجيب فيها طلب النقود لتوقعات التضخم عوضاً عن الدخل. و تعضد النتائج التطبيقيه التي تحصلنا عليها من شأن هذه الصيغ البديله المفترضه.

ADJUSTMENTS AND ERROR CORRECTIONS IN MONEY DEMAND DURING HIGH INFLATION: A Case Study of Sudan

A-M. M. Abdel-Rahman

INTRODUCTION:

In this paper we study the demand for narrow money balances in the Sudan. Towards the end of the 1970s money demand became increasingly unstable due to the process of monetization of the economy which was accompanied by a rising and variable inflation. Due to the instability in the conventional money demand functions. The paper follows an approach leading to an Error Correction Mechanism(ECM) as its final outcome. To obtain the ECM we proceed along a systematic specification search following a general to specific Wald/Hendry procedure in order to reduce the initial specification into an ECM.

The paper is organized as follows: Section 1 examines the stability of a 'basic function' and investigates the possibility of structural breaks. The occurrence of these breaks is attributable in part to the incidence of high inflation in the economy. Consequently, section 2 extends the basic model by including inflation-specific variables in the function. Section 3 then applies the general to specific analysis within a cointegration and error correction framework. Due to an apparent failure of the resultant conventional ECM in adequately reflecting error corrections and adjustments, alternative modes of adjustment and correction are explored. A final section then concludes the study.

The emphasis throughout the paper is on the effect of the high inflation witnessed in Sudan on money demand and specifically on the mechanisms of adjustments and corrections built into the function. This is line with recent works on the monetary dynamics of high and hyperinflations¹.

§1. THE BASIC MONEY DEMAND FUNCTION:

To develop a 'basic' money demand function we note first that the domestic interest rate is often excluded from demand functions in Less Developed Countries(LDC). Financial markets are not developed and financial assets are either absent or inadequate. Holdings are mostly limited to

¹ Phylaktis and Taylor(1993) study the experiences of high inflation Latin American countries and Frenkel and Taylor(1993) apply similar concepts in the analysis of money demand in Yugoslavia where the situation changed from high into full-blown hyperinflation during their sample period.

money and real assets. Domestic interest rates usually show little variation overtime due to excessive government regulation with low ceilings and often exhibit negative real magnitudes. In the case of Sudan, organized money and capital markets simply donot exist. The banking system is the main - if not the sole - financial intermediary; and bank deposits, especially saving deposits, are the main - if not the sole - asset in financial portfolios. Interest rates were never taken seriously as viable financial instruments. Most of the time they were pegged through a direct restriction on the maximum interest paid with some variance due to size and notice of withdrawal in the case of deposits; and destination and maturity in the case of credit. Interest rates were altogether abolished within an Islamization package for the economy effected in 1984. In 1986 a compensatory rate was reinstituted to cater for inflation in money balances. For these reasons it is doubtful that the interest rate is the appropriate variable to use as a proxy for the opportunity cost of money holdings in Sudan. Empirical trials using domestic interest rates frequently resulted in incorrect and/or insignificant coefficients. Because of the above considerations, we adhere to Modigliani's 'rule of thump' and use the inflation rate as the right measure of the opportunity cost of holding money². Indeed, Domowitz and Elbadawi(1987) argued that the inflation rate is the better proxy for the opportunity cost variable in their study of Sudan. The emphasis on inflation does appear to be justified both theoretically and empirically. In the face of the rapidly accelerating inflation in Sudan, the rate of price changes reflects much more adequately the opportunity cost of narrow money holdings as compared to the administered interest rates.

Hence the starting form of our money demand function is the basic form:

$$(m - p)^* = f(y, \dot{p}) + \varepsilon$$

where:

$(m - p)^*$	the natural log of the desired stock of real balances.
y	the natural log of real income.
\dot{p}	the inflation rate.

Prior reasoning suggests that:

$$f_y > 0; \quad f_p < 0.$$

The basic function was then estimated. The data were quarterly observations over the period 1970-1991 on M1, real GDP and the inflation rate as calculated from the Consumer Price

² Modigliani suggested choosing the higher of the interest rate or inflation rate as the appropriate cost variable. Domowitz and Elbadawi(1987) subscribed to this convention. For more on this see, Ghatak(1981) and more recently, Babba *et al.*(1992) and Psaradakis(1993) *inter alia*.

Index(CPI). The real income data were available only in annual form³. Quarterly observations were generated by use of a Lagrangian interpolation procedure. Results of the estimation were:

$$\begin{aligned}
 m - p &= -5.321 + 1.330 y - 0.004 \dot{p} \\
 &\quad (-6.253) \quad (15.751) \quad (-2.172) \\
 R^2 &= 0.765 \quad \bar{R}^2 = 0.759 \quad \hat{\sigma} = 0.147 \quad F = 125.280 \\
 &\quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad (0.000) \\
 d &= 0.284 \quad Q_{20} = 279.769 \quad AR(1) = 63.154 \quad AR(4) = 20.473 \\
 &\quad \quad \quad (0.000) \quad \quad \quad (0.000) \quad \quad \quad (0.000) \\
 AR(1-4) &= 62.559 \quad RESET = 5.179 \quad ARCH(1) = 38.947 \\
 &\quad (0.000) \quad \quad \quad (0.008) \quad \quad \quad (0.000) \\
 ARCH(1-4) &= 41.036 \quad HESC = 6.581 \\
 &\quad (0.001) \quad \quad \quad (0.037)
 \end{aligned}$$

...(1.1)

The statistics beneath the regression are the conventional model congruency statistics. R^2 is the coefficient of determination, \bar{R}^2 is its adjusted variant, $\hat{\sigma}$ is the standard error of the regression, d is the Durbin-Watson(DW) statistic, Q is the Ljung-Box statistic, $AR(.)$ are Breusch-Godfrey Lagrange Multiplier(LM) tests of serial correlation of orders specified within brackets, HESC is a modified Breusch-Pagan LM test of heteroscedasticity, RESET(.) are model specification tests and ARCH(.) are Autoregressive Conditional Heteroscedasticity tests. Bracketed terms beneath equation coefficients are t-statistics whereas those beneath test statistics are the corresponding marginal significance levels.

As far as the basic formulation is concerned, there is rampant evidence of residual autocorrelation. The RESET statistic suggests potential misspecification and the income elasticity of money demand exceeds the expected bounds.

The sample period was suspected of harboring structural breaks⁴. Inflation started to run loose in the economy during the late seventies. The eighties were a period of considerable volatility in prices and policies which may have also contributed to causing additional breaks in structure. To check for stability in the absence of *a priori* information about the exact period of break, we employed a simple method which requires the estimation of the original equation in

³ Data on the basic variables used in the study are provided in the Appendix.

⁴ Spanos(1986) prefers to keep the distinction between 'structural breaks' and 'parameter invariance' where he defines the former to apply to the case where the point of break is *a priori* known.

first difference form and choosing the points of large residuals as possible points of breaks. Residuals were judged to be large if they exceeded two equation standard errors⁵. Using this method, two time periods resulted in significantly high residuals - the first being at 1979:1 and the second being at 1987:1. In the second half of the seventies the government adopted a policy of liberalization relaxing, in due process, the exchange controls. In mid 1978 a first major devaluation was undertaken. A 'nill-value' import license system was also introduced whereby private agents could use their holdings of foreign exchange to finance imports in return for high profits. These factors may have contributed to the first structural break in 1979. The subperiod extending over 1979-1986 coincided with times of excessive instability in economic policies and consecutive devaluations. This may have had its culmination in the occurrence of the second structural break.

The next step was to reestimate the above basic equation using dummy variables in means and slopes of the income variable to account for subperiods concurring with the anticipated structural changes.

Results for this regression were:

$$m - p = - 0.141 + 5.796 D2 + 25.232 D3 + 0.802 y - 0.006 \dot{p} \\ (-0.188) \quad (2.108) \quad (3.850) \quad (10.600) \quad (-5.237) \\ - 0.537 D2 \times y - 2.420 D3 \times y \\ (-1.991) \quad (-3.797)$$

$$R^2 = 0.924 \quad \bar{R}^2 = 0.917 \quad \hat{\sigma} = 0.086 \quad F = 147.288 \\ (0.000)$$

$$d = 0.561 \quad Q_{20} = 178.127 \quad AR(1) = 44.352 \quad AR(4) = 3.768 \\ (0.000) \quad (0.000) \quad (0.000)$$

$$AR(1-4) = 44.430 \quad RESET = 4.378 \quad ARCH(1) = 6.112 \\ (0.000) \quad (0.000) \quad (0.013)$$

$$ARCH(1-4) = 11.648 \quad HESC = 5.171 \\ (0.020) \quad (0.522)$$

...(1.2)

Coefficients in the above specification corresponding to structural shifts were significant, but the overall performance of the equation still left a lot to be desired. Economically, the impact of income on money demand over the third subperiod appears to be negative and high. Statistically, there was still remaining evidence of residual autocorrelation.

⁵ For more description of the test see Lardaro(1993) for example.

But parameter instability could be a spurious phenomenon due to poor specifications as argued by Hendry and associates. Indeed, as has been shown in various studies, the log-level formulation of money demand tends to exhibit large shifts, whereas the log-differences and ECM formulation do not. Thus we proceed along a two pronged path. Economically, we look for potential causes of the breaks. Econometrically, we derive a full EC representation for the money demand function.

Potential causes of the possible 'breakdown' of conventional money demand could be traced to the emergence of 'buffer stock' and 'currency substitution' motives as a result of the high inflation. As far as the buffer stock motive is concerned⁶, an unanticipated increase in the money supply - a money surprise - would result in greater holdings of money balances as agents take time to adjust their portfolios. The price level and the interest rate, entering a standard real money demand function, do not move instantly to clear the money market. Therefore, the money surprise component affects positively real money demand.

Also, in as far as the currency substitution motive is concerned, Abel *et al.* (1979) and Blejer (1978) suggest that under conditions of very high inflation added incentives to substitute foreign for domestic assets in portfolios exist. An increase in the value of the foreign currency signals an increased demand for foreign currency denominated assets and a decrease in domestic money demand. Thus, the presence of the currency substitution phenomenon tends to destabilize domestic money demand. The high inflation environment prevailing in Sudan since the late seventies provided a major incentive for currency substitution.

In addition to the above effects money supply appears to have been largely determined by the budget deficit in the case of Sudan, hence we consider the possible role of the variable 'seigniorage'⁷ in our list of explanatories.

Equilibrium money demand is thus specified to depend on, among other things, surprise money as a buffer stock variable, seigniorage as a measure of the budget deficit variable and the foreign exchange premium as a currency substitution proxy.

§2. THE EXTENDED MONEY DEMAND FUNCTION:

As noted above, among the set of factors which might have contributed to the possible breakdown of our conventional money demand specification three variables that merit inclusion were the measure of money surprise, seigniorage and the premium. The purpose of the

⁶ On the role of buffer stocks and surprise money on the demand for money, see Carr and Darby (1981), MacKinnon and Milbourne (1984), Cuthbertson (1985), Lothian *et al.* (1990) and Frenkel and Taylor (1993) *inter alia*.

⁷ For the effects of budget deficits on the demand for money during hyperinflations, see Sargent and Wallace (1973) and Fischer and Easterly (1990) for example.

introduction of these variables was to try to account for the above noted regime shifts attributable to the increasing degree of monetization in the economy and the frequent changes of economic policies. The extended function thus becomes:

$$(m - p)^* = f(y, \dot{p}, \text{Prem}, \text{Msurp}, \text{Seign}) + \varepsilon$$

where:

Msurp	the surprise money.
Seign	seigniorage.
Prem	the premium.

Prior reasoning now suggests that:

$$0 < f_{\text{Msurp}} < 1; \quad f_{\text{Seign}} > 0.$$

The sign on the Prem variable is *a priori* indeterminate and remains an empirical question. For, on one hand, an increase in the premium - being a signal of expected exchange rate depreciation - could induce agents via the currency substitution effect to substitute foreign currencies and real assets in place of domestic securities in portfolios. Hence, the response of money demand would tend to be negative. But on the other hand, the same increase in premium may reflect an increase in the black market and hidden economy effects where agents require more balances to finance the increase in parallel operations. In this latter case the response of money demand would tend to be positive.

Before empirically estimating the extended regression, a series for the money surprise variable has to be constructed. Following Carr and Darby(1981), MacKinnon and Milbourne(1984) and Carr, Darby and Thornton(1985) we estimated a parsimonious Autoregressive predictor of the form:

$$m_t = f(m_{t-1}, m_{t-2}, m_{t-3}, m_{t-4})$$

The residuals from this equation were used as the Msurp variable. Seigniorage was calculated according to its definition of $\dot{M}1 \times m$; $\dot{M}1$ being in first-difference log form. A log form of the premium of the black market exchange rate over the official rate was taken as the proxy for currency substitution⁸.

⁸ There is no consensus on measuring the degree of currency substitution. Some use the exchange rate as a proxy; see for example, Bordo and Choudri(1982), Domowitz and Elbadawi(1987) and Arize and Shwiff(1993) or the forward premium; see for example, Abel *et al.*(1979) and Daniel and Fried(1983). Simmons(1993) uses the expected exchange rate depreciation. Taylor(1991) uses the actual rate of depreciation as a proxy for the expected rate whilst

The estimated model after the inclusion of the variables assumed the following form⁹ :

$$\begin{aligned}
 m - p = & -0.183 + 0.796 y - 0.003 \dot{p} - 4.279 \text{ Msurp} \\
 & (-0.181) \quad (7.724) \quad (-1.744) \quad (-6.335) \\
 & + 0.115 \text{ Seign} - 0.016 \text{ Prem} \\
 & (7.134) \quad (-1.624)
 \end{aligned}$$

$$\begin{aligned}
 R^2 &= 0.848 & \bar{R}^2 &= 0.837 & \hat{\sigma} &= 0.116 & F &= 79.209 \\
 & & & & & & & (0.000)
 \end{aligned}$$

$$\begin{aligned}
 d &= 0.699 & Q_{19} &= 104.781 & \text{AR}(1) &= 38.128 & \text{AR}(4) &= 9.950 \\
 & & (0.000) & & (0.000) & & (0.002)
 \end{aligned}$$

$$\begin{aligned}
 \text{AR}(1-4) &= 40.074 & \text{RESET} &= 0.843 & \text{ARCH}(1) &= 3.734 \\
 & (0.000) & (0.362) & & (0.053)
 \end{aligned}$$

$$\begin{aligned}
 \text{ARCH}(1-6) &= 8.455 & \text{HESC} &= 12.009 \\
 & (0.207) & (0.035)
 \end{aligned}$$

...(2.1)

The elasticity of real money balances on real income is less than one and close to the conventional Goldfeld estimates. Inflation - being only significant at 8.3% level - was negative indicating an acceleration effect on money demand. The money surprise variable had an unexpectedly high magnitude and incorrect sign attached to it. The coefficient of the seigniorage variable was highly significant and remained robust across many alternatively tried specifications. The premium variable was negative and only significant at 8.6% level. Currency substitution didnot exert a clear-cut and significant influence with its premium measure and hence was subsequently suppressed from the specification. The insignificance of the currency substitution effect is in line with previous findings by other authors - see for example Arango and Nadiri(1981), Cuddington(1983), Daniel and Fried(1983), Taylor(1991), Bahmani-Oskoe(1991), Bahmani-Oskoe and Pourheydarian(1990), Leventakis(1993) and Frenkel and Taylor(1993) *inter alia*. In particular, a similar rationalization to that advanced by Frenkel and Taylor(1993) in the study of the Yugoslavian money demand function could be invoked here. For given the anecdotal evidence of currency substitution in the country, we think that the effect started to materialize in the second half of the sample period , i.e. the period of the eighties, after liberalization was firstly attempted in 1979. The effect was subdued at the outstart but gathered momentum when inflation

Phylaktis and Taylor(1993) and Frenkel and Taylor(1993) follow Blejer's(1978) suit in adding the expected rate of foreign inflation as a determinant of currency substitution.

⁹ In these models, as before, seasonal dummy variables were used to approximate stochastic seasonality. Results obtained didnot support their use.

started to run amok in the economy. Thus the full sample set may have been incapable of revealing the extent of the impact and the influence of the return to foreign assets tended to be dominated by that of the domestic inflation rate.

Dropping the insignificant premium variable and rerunning the regression we obtained the following estimated equation:

$$m - p = - 0.091 + 0.785 y - 0.003 \dot{p} - 4.130 \text{ Msurp} + 0.110 \text{ Seign}$$

$$(-0.089) \quad (7.549) \quad (-2.002) \quad (-6.102) \quad (6.873)$$

$$R^2 = 0.842 \quad \bar{R}^2 = 0.834 \quad \hat{\sigma} = 0.117 \quad F = 96.163$$

$$(0.000)$$

$$d = 0.612 \quad Q_{19} = 112.391 \quad AR(1) = 41.656 \quad AR(4) = 12.988$$

$$(0.000) \quad (0.000) \quad (0.000)$$

$$AR(1-6) = 42.351 \quad RESET = 0.080 \quad ARCH(1) = 5.088$$

$$(0.000) \quad (0.779) \quad (0.024)$$

$$ARCH(1-4) = 9.757 \quad HESC = 9.645$$

$$(0.045) \quad (0.047)$$

...(2.2)

The results are largely similar to the preceding specification in terms of magnitudes and fits but with an added significance for the inflation variable. Money surprises still remained of an unexpectedly large magnitude and wrong sign. A recurrent problem in the two specifications is the low magnitude of the DW d statistic indicative of possible misspecifications still ailing the function. One way to improve the equation performance is to further till along the lines necessary for the development of an adequate dynamics of the model. An attempt on this is conducted in the next section.

§3. COINTEGRATION AND THE ECM:

In this section the issues of nonstationarity, cointegration and error correction(EC) are explored by conducting tests firstly of unit roots in individual series and later on of cointegrating relationships between combinations of variables. In due process we obtain EC and cointegrating representations of the money demand function.

To determine the order of integration, we use the Augmented Dickey-Fuller(ADF) and Phillips-Perron(PP) tests. Results obtained with differing lag specifications to purge autocorrelated contaminations were:

Table(3.1)
Unit Root Tests*

	m	p	m-p	y	\dot{p}	Msurp	Seign
Levels:							
ADF	0.899	1.490	-2.234	-2.127	-1.338	-71.006	-12.221
PP	1.033	1.721	-3.408	-3.225	-14.921	-81.054	-77.253
Differences:							
ADF	-24.407	-17.658	-82.073	-21.183			
PP	-74.445	-83.248	-67.556	-22.920			

* Tests were mostly conducted with 4 period lags.

Asymptotic 5% critical values for the sample were -3.41. Hence we do not reject the existence of unit roots in the principal variables *m*, *p*, *m-p* and *y*. All these series are *I*(1) as judged by the ADF and PP results on first differences. Real balances in particular are *I*(1), meaning that the cointegrating property between prices and money which usually holds during hyperinflations is supported by the data in our case of high inflation. Similar results were obtained recently by Taylor(1991), Phylaktis and Taylor(1993) and Frenkel and Taylor(1993). Inflation, \dot{p} , provided conflicting ADF evidence with stationarity at low lags and nonstationarity at lags of higher order. The PP test, which accounts for heteroscedasticity and autocorrelation, was mostly significant with different lags. We took this conflict as evidence of nonstationarity¹⁰. The rest of the independent variables are *I*(0) which is not surprising in view of their forms. *Msurp* is a residual and *Seign* uses the growth rate of money $\dot{M1}$ in first-log difference form in its calculation.

To cater for the dynamics, we follow Hendry's approach of general to specific modeling which starts from a general dynamic Autoregressive distributed lag(ADL) class of models in the shape of:

$$\omega(L)(m - p) = \text{const} + \alpha(L)y + \beta(L)\dot{p} + \gamma(L)\text{Msurp} + \delta(L)\text{Seign} + \varepsilon$$

The approach followed here is to specify a *k*th quarterly period dynamic distributed lag model from which an ECM of the form:

¹⁰ Banerjee *et al.*(1993) indicates that the tests have notoriously weak power when the process is close to but not at stationarity.

$$\begin{aligned}\Delta(m-p)_t = & k + \psi(m-p-y)_{t-1} + \alpha_0 \Delta y_t + \sum_1^k \alpha_i y_{t-i} + \beta_0 \Delta \dot{p}_t + \sum_1^k \beta_i \dot{p}_{t-i} \\ & + \gamma_0 \Delta \text{Msurp}_t + \sum_1^k \gamma_i \text{Msurp}_{t-i} + \delta_0 \Delta \text{Seign}_t + \sum_1^k \delta_i \text{Seign}_{t-i} \\ & + \omega_0 \Delta(m-p)_{t-1} + \varepsilon_t\end{aligned}$$

is derived. In this form level variables provide information on long-run equilibrium properties while difference terms show short-run dynamic adjustments. The term $(m-p-y)_{t-1}$ is the conventional ECM in money demand functions. Its coefficient ψ shows the extent of short-run disequilibrium.

The model above was estimated with an appropriate number of lags chosen after some experimentation. Based on coefficient estimates, the model was reduced through a search procedure to a more parsimonious specification potentially combining levels and differences, *i.e.* an ECM.

The following conventional ECMs of money demand where corrections are undertaken with regards to income, were thus generated:

$$\begin{aligned}\Delta(m-p)_t = & -0.233 - 0.014(m-p-y)_{t-1} + 0.088 \Delta y_t + 0.024 y_{t-4} \\ & (-2.533) \quad (-1.341) \quad (1.803) \quad (2.605) \\ & - 0.009 \Delta \dot{p}_t - 0.009 \dot{p}_{t-1} + 0.564 \text{Msurp}_t \\ & (-62.408) \quad (-42.035) \quad (8.053) \\ & + 0.011 \text{Seign}_t \\ & (6.667)\end{aligned}$$

$$R^2 = 0.991 \quad \bar{R}^2 = 0.991 \quad \hat{\sigma} = 0.010 \quad F = 1146.039$$

(0.000)

$$d = 1.522 R^2 \quad Q_{19} = 39.534 \quad AR(1) = 4.294 \quad AR(4) = 12.410$$

(0.004) \quad (0.038) \quad (0.000)

$$AR(1-4) = 17.631 \quad RESET = 0.341 \quad ARCH(1-4) = 5.881$$

(0.001) \quad (0.561) \quad (0.053)

$$\text{HESC} = 20.249$$

(0.005)

...(3.1)

The EC term was low in magnitude and insignificant. Adding more dynamics in the shape of real partial adjustments in accordance with Fair's(1987) suggestion and using first differences

on some of the inflation set variables resulted sometimes in significant EC terms but at the cost of insignificant other variables occurring with unexpected negative responses. For example we obtain:

$$\begin{aligned}
 \Delta(m-p)_t = & 0.041 - 0.021(m-p-y)_{t-1} + 0.003\Delta y_t - 0.008y_{t-4} \\
 & (0.619) \quad (-2.809) \quad (0.089) \quad (-1.269) \\
 & - 0.009\Delta\dot{p}_t - 0.002\dot{p}_{t-1} + 0.823\Delta\text{Msurp}_t \\
 & (-80.257) \quad (-3.478) \quad (11.963) \\
 & + 0.114\text{Msurp}_{t-3} + 0.004\Delta\text{Seign}_t + 0.007\text{Seign}_{t-1} \\
 & (5.931) \quad (2.569) \quad (3.605) \\
 & + 0.696\Delta(m-p)_{t-1} \\
 & (9.191)
 \end{aligned}$$

$$\begin{aligned}
 R^2 = 0.996 \quad \bar{R}^2 = 0.995 \quad \hat{\sigma} = 0.007 \quad F = 1511.856 \\
 (0.000) \\
 d = 2.352 \quad Q_{18} = 23.071 \quad \text{AR}(1) = 7.216 \quad \text{AR}(1-4) = 7.900 \\
 (0.188) \quad (0.007) \quad (0.095) \\
 \text{RESET} = 6.661 \quad \text{ARCH}(1-4) = 5.006 \\
 (0.012) \quad (0.287) \\
 \text{HESC} = 9.255 \\
 (0.508)
 \end{aligned}$$

...(3.2)

The EC term, though still small in magnitude, is significant showing that the current change in real balances is related to its past level but with low speeds of adjustment and time lags in the partial adjustments of money balances. The main shortcoming in (3.2) lies in the fact that the income variables assumed a negative sign in their level and lost their significance. Further trials revealed that when the income variables were significant the ECM was insignificant with incorrect signs and magnitudes and vice versa. This served to cast doubt on the conventional ECM in a situation of high inflation and during hyperinflations. For in this latter case, and as Cagan(1956) noted, the adjustment of real balances are towards the expected rate of change of prices, \dot{p}^e , rather than being towards income. Taylor(1993), Phylaktis and Taylor(1993), Frenkel and Taylor(1993) and Engsted(1993,1994) obtained results supporting the Cagan hypothesis. Under hyperinflation and rational expectations, Engsted(1993,1994) proved that real balances cointegrate - and hence have an EC representation - with money growth. Since the situation is slightly different in our case where the inflation rate didnot assume hyper proportions over the sample period, we use expected inflation as the variable with which real balances may cointegrate

- much in line with the Taylor works. Assuming as the proxy for expected inflation the one period lagged actual inflation, the EC term becomes:

$$(m - p - \dot{p}^e)_{-j} = (m - p - \dot{p}_{-1})_{-j}, \quad j = 1, 2, \dots$$

and since the responses of money balances to expected inflation are expected to be rapid in order for agents to avoid paying the 'inflation tax', the magnitude of the disequilibrium error terms is expected to be extremely small. Moreover, and because of the appearance of the inflation set variables including money surprises and seigniorage, we expect insignificant partial adjustments in our estimated equations. For, if the effects of high inflation are reasonably accounted for in the money demand function, then there should be no fundamental disequilibria and adjustments should be completed relatively fast. Indeed, basing our general model on this reformulation we obtained, after various model reduction steps, the following preferred specification:

$$\begin{aligned} \Delta(m - p)_t = & -0.139 - 0.0006(m - p - \dot{p}_{t-1})_{t-1} + 0.132 \Delta y_{t-1} + 0.018 y_{t-4} \\ & (-1.779) \quad (-4.645) \quad (3.107) \quad (2.215) \\ & - 0.009 \Delta \dot{p}_t - 0.008 \dot{p}_{t-1} + 0.597 \text{Msurp}_t \\ & (-71.866) \quad (-44.524) \quad (12.103) \\ & + 0.009 \text{Seign}_t \\ & (7.771) \end{aligned}$$

$$\begin{aligned} R^2 &= 0.993 & \bar{R}^2 &= 0.993 & \hat{\sigma} &= 0.008 & F &= 1493.296 \\ & & & & & & & (0.000) \\ d &= 1.493 & Q_{19} &= 24.111 & \text{AR}(1) &= 4.492 & \text{AR}(1-4) &= 8.443 \\ & & & (0.192) & & (0.034) & & (0.077) \\ & & \text{RESET} &= 0.220 & \text{ARCH}(1-4) &= 0.097 \\ & & & (0.641) & & (0.953) \\ & & \text{HESC} &= 15.607 \\ & & & (0.029) \end{aligned}$$

...(3.1)'

and a dynamic variant incorporating real partial adjustment mechanisms produced the following results:

$$\begin{aligned}\Delta(m-p)_t = & -0.128 - 0.00005(m-p-\dot{p}_{t-1})_{t-1} + 0.009 \Delta y_t + 0.017 y_{t-4} \\ & (-1.498) \quad (-3.935) \quad (1.890) \quad (2.127) \\ & - 0.009 \Delta \dot{p}_t - 0.008 \dot{p}_{t-1} + 0.604 \text{Msurp}_t \\ & (-69.203) \quad (-27.200) \quad (11.582) \\ & + 0.009 \text{Seign}_t + 0.017 \Delta(m-p)_{t-1} \\ & (7.417) \quad (0.820)\end{aligned}$$

$$\begin{aligned}R^2 &= 0.993 & \bar{R}^2 &= 0.992 & \hat{\sigma} &= 0.009 & F &= 1212.461 \\ & & & & & & & (0.000) \\ d &= 1.455 & Q_{19} &= 27.198 & AR(1) &= 5.346 & AR(1-4) &= 12.225 \\ & & & (0.100) & & (0.021) & & (0.016) \\ RESET &= 0.116 & ARCH(1-4) &= 18.639 \\ & (0.735) & & (0.001) \\ HESC &= 19.660 \\ & (0.012)\end{aligned}$$

...(3.2)'

The partial adjustment term turned out to be insignificant whereas the EC term retained its significance but with a more diminished magnitude as expected.

Since the expectation hypothesis used above in the EC term is a rather simple and extreme way to describe the evolution of expectations, we investigated the impact of the choice of the expectational mechanism on corrections and adjustments by using firstly a distributed lag on past inflation rates and then of a suitable ARIMA on the variable. Using fitted values from the adaptive expectation distributed lag:

$$\hat{p}_{AE,t}^e = \sum_0^n \hat{\theta}_i \dot{p}_{t-i}$$

where n was fixed at 8 after experimentation with different horizons and application of the necessary model selection criteria in choice. This term was then substituted in the EC term and the static runs yielded the following results after model reduction steps were undertaken:

$$\begin{aligned}\Delta(m-p)_t = & -0.148 - 0.0008(m-p - \hat{p}_{AE}^e)_{t-2} + 0.114 \Delta y_{t-1} + 0.018 y_{t-4} \\ & (-1.641) \quad (-3.311) \quad (2.550) \quad (2.014) \\ & - 0.009 \Delta \dot{p}_t - 0.008 \dot{p}_{t-1} + 0.574 \text{Msurp}_t \\ & (-66.848) \quad (-39.862) \quad (10.411) \\ & + 0.011 \text{Seign}_t \\ & (7.339)\end{aligned}$$

$$\begin{aligned}R^2 &= 0.993 & \bar{R}^2 &= 0.992 & \hat{\sigma} &= 0.009 & F &= 1288.628 \\ & & & & & & & (0.000) \\ d &= 1.456 & Q_{17} &= 23.600 & AR(1) &= 5.375 & AR(1-4) &= 9.054 \\ & & (0.131) & & (0.020) & & (0.060) \\ & & RESET &= 2.175 & ARCH(1-4) &= 3.336 \\ & & (0.145) & & (0.503) \\ & & HESC &= 10.091 \\ & & (0.183)\end{aligned}$$

...(3.1)''

The dynamic partial adjustment variant incorporating real partial adjustment mechanisms produced the following results:

$$\begin{aligned}\Delta(m-p)_t = & -0.157 - 0.0008(m-p - \hat{p}_{AE}^e)_{t-2} + 0.110 \Delta y_t + 0.019 y_{t-4} \\ & (-1.640) \quad (-3.417) \quad (2.325) \quad (1.977) \\ & - 0.009 \Delta \dot{p}_t - 0.008 \dot{p}_{t-1} + 0.596 \text{Msurp}_t \\ & (-65.152) \quad (-24.380) \quad (10.355) \\ & + 0.009 \text{Seign}_t + 0.026 \Delta(m-p)_{t-1} \\ & (6.790) \quad (1.216)\end{aligned}$$

$$\begin{aligned}R^2 &= 0.993 & \bar{R}^2 &= 0.992 & \hat{\sigma} &= 0.009 & F &= 1107.590 \\ & & & & & & & (0.000) \\ d &= 1.434 & Q_{17} &= 21.328 & AR(1) &= 6.581 & AR(1-4) &= 11.614 \\ & & (0.212) & & (0.010) & & (0.020) \\ & & RESET &= 1.905 & ARCH(1-4) &= 4.790 \\ & & (0.173) & & (0.310) \\ & & HESC &= 15.668 \\ & & (0.047)\end{aligned}$$

...(3.2)''

A similar pattern of results to that noticed for the previous EC specification emerges. The EC term - though significant - kept its low magnitude indicative of extremely low disequilibria and hence rapid responses to expected inflation during high inflation episodes. From the dynamic

run the partial adjustments were also insignificant indicating the success of the inflation set variables in accounting for the adjustment and correction mechanisms stipulated to be working under high inflation.

Expectations generated from a seasonal ARIMA(2,0,1) × (0,1,0) chosen after proper inspection of auto and partial correlation functions with AR lags of order 4 and 8 consecutively and an MA component at lag 4 were also used. The resultant ARIMA was:

$$\Delta_4 \dot{p}_t = 0.530 - 0.253 \Delta_4 \dot{p}_{t-4} - 0.335 \Delta_4 \dot{p}_{t-8} - 0.664 \varepsilon_{\dot{p}_{t-4}}$$

(3.032) (-1.581) (-2.280) (-4.382)

$$R^2 = 0.459 \quad \hat{\sigma} = 6.085$$

$$d = 1.835 \quad Q_{17} = 8.982$$

(0.830)

Fitted values of \dot{p}_t were obtained from the ARIMA model and used in the ECM. The model yielded a similar picture to that obtained above indicative of the robustness of the results regardless of the type of inflationary mechanism deployed to reflect inflation expectations. Results from these trials were:

$$\Delta(m-p)_t = 0.034 - 0.0004(m-p - \hat{p}_{ARIMA}^e)_{t-1} + 0.101 \Delta y_{t-1} - 0.009 \Delta \dot{p}_t$$

(12.286) (-3.882) (2.341) (-69.342)

$$- 0.008 \dot{p}_{t-1} + 0.528 \text{Msurp}_t$$

(-32.472) (13.018)

$$+ 0.0001 \text{Seign}_t$$

(12.241)

$$R^2 = 0.993 \quad \bar{R}^2 = 0.992 \quad \hat{\sigma} = 0.009 \quad F = 1522.671$$

(0.000)

$$d = 1.544 \quad Q_{18} = 160.015 \quad AR(1) = 4.362 \quad AR(1-4) = 6.512$$

(0.591) (0.037) (0.164)

$$\text{RESET} = 0.781 \quad \text{ARCH}(1-4) = 5.801$$

(0.380) (0.215)

...(3.1)'''

The dynamic variant incorporating real partial adjustments produced the following:

$$\begin{aligned}\Delta(m-p)_t = & 0.033 - 0.0004(m-p-\hat{p}_{ARIMA}^e)_{t-1} + 0.103 \Delta y_{t-1} - 0.009 \Delta \dot{p}_t \\ & (10.615) \quad (-3.519) \quad (2.366) \quad (-68.100) \\ & - 0.008 \dot{p}_{t-1} + 0.533 \text{Msurp}_t \\ & (-24.322) \quad (12.764) \\ & + 0.0001 \text{Seign}_t + 0.012 \Delta(m-p)_{t-1} \\ & (11.887) \quad (0.545)\end{aligned}$$

$$R^2 = 0.993 \quad \bar{R}^2 = 0.992 \quad \hat{\sigma} = 0.009 \quad F = 1291.064 \\ (0.000)$$

$$\begin{aligned}d = 1.523 \quad Q_{18} = 16.874 \quad AR(1) = 4.615 \quad AR(1-4) = 7.899 \\ (0.532) \quad (0.032) \quad (0.095) \\ RESET = 0.800 \quad ARCH(1-4) = 6.403 \\ (0.374) \quad (0.171)\end{aligned}$$

...(3.2)'''

Thus, the overall picture remained the same regardless of the nature of the ECM. Across the expectational mechanisms used in the correction terms there were no significant differences between specifications or in coefficients.

The choice of a preferred specification between the above competing models was rather difficult. But based on model selection criteria, we elected to choose (3.1)' as the preferred one. For as noted above, the equation is acceptable in relation to the standard range of statistical and economic diagnostics.

To investigate the possibility of joint endogeneity in (3.1)' of inflation and money leading to biased estimates, we reestimated the chosen equation by a weighted Instrumental Variables(WIV) technique using a set of instruments consisting of two period lagged values of variables appearing in (3.1)'. Results were:

$$\begin{aligned}\Delta(m-p)_t = & -0.319 - 0.0008(m-p-\dot{p}_{t-1})_{t-1} + 0.181 \Delta y_{t-1} + 0.036 y_{t-4} \\ & (-1.181) \quad (-2.254) \quad (1.656) \quad (1.283) \\ & - 0.009 \Delta \dot{p}_t - 0.009 \dot{p}_{t-1} + 0.530 \text{Msurp}_t \\ & (-30.188) \quad (-23.147) \quad (5.965) \\ & + 0.007 \text{Seign}_t \\ & (1.080)\end{aligned}$$

$$R^2 = 0.985 \quad \bar{R}^2 = 0.984 \quad \hat{\sigma} = 0.013 \quad d = 1.668$$

The WIV coefficients didnot change much in comparison to their OLS counterparts. To be more precise on this count, we conducted some formal tests on the endo-exogeneity issue. A Hausman test for the presence of simultaneous equation bias yielded a $\chi^2_{(8)}$ value of 3.298 with a level of significance of 0.915 entailing nonrejection of the null of no difference between OLS and WIV estimates. A variant of a Hansen test which goes through the process of computing an optimal weight matrix allowing for one period lagged autocorrelation after an WIV run, resulted in a $\chi^2_{(8)}$ value of 13.340 with a level of significance of 0.101. This led to nonrejection of the null at 5% level. One can therefore conclude that simultaneity is not a serious problem in our preferred EC model.

To check for cointegration of (3.1)', we applied the ADF and PP tests for the residuals and EC term, both being at 4th order lags. Results for the residuals of the regression were -20.483 for the ADF and -65.293 for the PP tests. Results for the EC term were -23.483 and -80.243 respectively. The cointegrating DW(CRDW) test statistic of 1.493 value exceeded the R^2 value, hence satisfying the Banerjee *et al.*(1986) 'rule of thumb' for cointegration to occur. The results point to the fact that the error mechanisms comprising the EC term and the residuals of the equation, are stationary. Hence the principal variables are cointegrated *i.e.* real balances and inflation cointegrate.

The multivariate cointegrating technique of Johansen and Juselius(1990) was also deployed to investigate the long-run properties of the model and as a further check on the validity of the endo-exogenous variable decomposition scheme. The technique is superior to the simple regression based techniques of CRDW and ADF as it captures more fully the underlying time-series properties of the data, provide estimates of all the cointegrating vectors that may exist among the variables and offers test statistics for the number of cointegrating vectors which have an exact limiting distribution.

Results obtained using a 5 period lagged Vector Autoregression(VAR) reported in table(3.2) below demonstrate that at 5% level the null of zero cointegrating vectors is rejected while that of at most one vector is not, *i.e.* there is a unique statistically significant cointegrating vector relating the variables.

Table(3.2)
Johansen Cointegration

H_0	LR	5% VALUE
$r \leq 4$	0.114	3.84
$r \leq 3$	5.952	12.53
$r \leq 2$	16.249	21.63
$r \leq 1$	39.762	39.82
$r=0$	69.284	59.46

** r is the number of cointegrating vectors. LR is the sequential Likelihood Ratio trace test statistic. Critical values are from Osterwald-Lenum(1992) table(0).*

The unconstrained cointegrating regression obtained from the procedure normalized around m is:

$$m = 0.611y - 0.134p + 0.127M_{surp} + 0.356Seign$$

This resembles a conventional money demand function with long-run positive and less than unity income elasticity. The semi-elasticity of the demand for real money balances with respect to inflation equals -0.134. Based on this we can infer that the implied optimal rate of seigniorage is $\sigma = 7.463$ which is high in comparison to low inflation economies. The buffer stock motive is pronounced and the budget effect assumes a powerful role in determining long-run behavior of real money. There is also no need to suspect our initial endo-exogenous division.

Overall then, our preferred equation (3.1)' and its long-run cointegrating relative reveal that real narrow money balances are negatively related to the inflation opportunity cost rate but positively so to the buffer stock and seigniorage variables. The buffer stock motive was strong and in conformity with Cagan's stylized fact that during hyperinflations accelerations in the growth of money are followed in the short-run by a rise in the level of real money as agents temporarily hold buffers till times of adjustment, *i.e.* they are temporarily off of their Cagan's schedules.

The equation had a simple dynamic structure with no lagged dependent variables. During high inflation eras, agents base their expectations of future inflations on the most recent period's rates instead of adapting as far back as 8 periods or using complex ARIMA mechanisms. This is slightly different from Frenkel and Taylor's(1993) results where the performance of the Cagan model when coupled with an adaptive expectational mechanism was superior to that which was coupled with simple last period schemes.

The EC magnitude, as expected, was extremely small indicative of the absence of fundamental errors of disequilibrium in money holdings during high inflations - else that agents

will be forced to pay a heavy toll in the form of the inflation tax. Similar magnitudes of EC were obtained recently by Frenkel and Taylor(1993) where a value of -0.00004 was reported in their equation(24) of the study on the Yugoslavian money demand. Our value of -0.0006 implies an estimated parameter on lagged balances in a conventional partial adjustment which is approximately equal to one. The implied speed of adjustment is thus extremely high.

The implications drawn from the present model are a bit different from those of Domowitz and Elbadawi(1987) who argued on basis of their ECM for the Sudan that " ... The performance of the ECM in the [LDCs] cases bodes well for its continued use The EC framework is a likely replacement for the partial adjustment specification which has dominated the money demand literature... ". We carry their conclusion a bit further by arguing that in the presence of high inflation, the conventional ECM itself where adjustments and corrections are effected with respect to income, may be unsuitable for policy purpose and hence alternative formulations where adjustments and corrections are undertaken with respect to inflation and its expectations should be investigated and incorporated. The explicit use of the inflation variables in the money demand function would allow then the computation of the optimal rates of seigniorage and inflation taxes which are based on the inflation elasticity of money demand coefficient; and the investigation of whether the particular economy lies on the "efficient" side of its Laffer curve or not.

CONCLUSION:

The main objective of this paper was to investigate the effects of high inflation on the formulation of adjustment and error correction mechanisms governing basic money demand functions in Sudan. The country suffered from an accelerating bout of inflation during the previous two decades and hence considerable instability in the basic money demand formulations ensued. Motives for holding money appearing during high inflation epochs in the shape of currency substitution and buffer stocks were investigated in addition to fiscal effects in the form of budget finance. The introduction of these elements - in particular, the buffer stock motive and the deficit seigniorage variables - considerably improved the performance of the basic money demand equation. Currency substitution didnot prove a good choice. During high inflation, errors - indicative of disequilibria - were small in magnitude. Corrections in real balances were undertaken with respect to inflation expectations, not income. Adjustments towards and corrections for inflation swamped other types of adjustments and corrections - in particular those towards real income. There were small, though statistically significant, essential errors of fundamental disequilibria. Partial adjustments were extremely swift and tended to be completed within a short period of time.

As such, the results are much in line with Cagan type mechanisms where demand for real money balances is predominantly explained by inflation, its attendant variables and its expectations.

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Data Appendix

period	M1	Y	CPI	Prem
70:01	109.55	16843.7	5.0	1.924
70:02	105.10	17152.0	5.3	1.924
70:03	106.54	17460.2	5.7	1.924
70:04	109.58	17768.4	5.1	1.924
71:01	116.18	18076.6	4.9	1.752
71:02	111.66	18384.9	5.1	1.637
71:03	114.20	18693.1	5.6	1.551
71:04	115.21	19001.3	5.2	1.522
72:01	114.79	19309.5	5.3	1.493
72:02	114.27	18934.6	5.3	1.493
72:03	122.49	18798.8	6.3	1.522
72:04	137.73	18594.6	6.0	1.608
73:01	145.58	18322.1	6.0	1.694
73:02	151.24	17981.3	6.5	1.694
73:03	158.85	17572.2	7.6	1.694
73:04	168.48	17094.8	7.2	1.723
74:01	182.58	17223.8	8.0	1.752
74:02	192.86	17554.4	8.4	1.780
74:03	204.59	18086.6	9.0	1.838
74:04	219.73	18820.3	9.0	1.867
75:01	233.97	17695.0	9.8	1.924
75:02	230.02	18100.8	10.5	1.838
75:03	232.01	19511.4	11.7	1.809
75:04	251.58	21205.4	10.5	1.752
76:01	269.63	22660.3	9.8	1.723
76:02	258.94	23699.9	10.5	1.694
76:03	279.12	24436.9	11.5	1.694
76:04	306.66	25109.8	11.0	1.694
77:01	334.04	25915.7	11.4	1.723
77:02	365.33	26907.9	12.3	1.780
77:03	395.35	27980.1	13.3	1.838
77:04	423.77	28923.9	12.9	1.867

78:01	452.18	29521.4	12.7	1.924
78:02	482.07	29632.2	14.4	1.725
78:03	510.55	29243.9	16.6	1.775
78:04	570.60	28472.7	16.1	1.800
79:01	752.46	27520.9	16.2	1.850
79:02	738.88	26610.0	17.9	2.100
79:03	776.73	25915.0	21.4	2.199
79:04	836.51	25519.8	22.8	1.920
80:01	903.49	25408.2	23.1	1.960
80:02	874.97	25488.1	23.5	1.960
80:03	988.73	25638.7	25.4	1.900
80:04	1097.41	25763.1	26.1	1.800
81:01	1221.10	25827.1	27.1	2.020
81:02	1254.80	25871.2	30.0	2.140
81:03	1396.40	25992.4	35.0	2.180
81:04	1530.90	26301.5	30.1	1.728
82:01	1580.20	26871.6	32.5	1.465
82:02	1677.90	27696.6	36.9	1.587
82:03	1715.40	28676.2	41.9	1.598
82:04	2091.00	29635.3	42.4	1.570
83:01	2039.30	30374.7	44.3	1.392
83:02	2025.70	30737.8	47.5	1.569
83:03	2146.20	30670.0	54.9	1.415
83:04	2303.90	30246.2	54.1	1.538
84:01	2341.10	29650.9	56.7	1.646
84:02	2376.80	29110.0	60.9	1.823
84:03	2514.30	28794.5	74.0	1.785
84:04	2752.10	28732.0	77.6	2.146
85:01	3195.70	28012.3	86.6	1.984
85:02	3305.80	27471.7	100.2	1.408
85:03	3676.90	27110.2	105.6	1.508
85:04	4144.60	26927.8	103.7	1.688
86:01	4695.30	26924.6	114.4	1.860
86:02	4972.60	27100.5	122.5	1.872

86:03	5415.30	27455.5	134.4	1.720
86:04	5848.80	27989.6	126.3	2.140
87:01	6744.20	28168.8	128.3	2.592
87:02	7129.90	28331.1	134.6	3.080
87:03	7395.20	28476.5	156.8	3.608
87:04	7768.30	28605.0	162.0	2.315
88:01	8661.30	28716.6	190.9	2.646
88:02	9129.60	28811.4	226.8	2.364
88:03	9860.80	28889.3	297.8	2.466
88:04	11218.00	28950.3	272.9	2.951
89:01	12665.00	29968.6	335.4	3.817
89:02	14774.00	30687.6	401.4	5.066
89:03	17553.00	31107.3	439.5	6.699
89:04	18899.00	31227.7	439.4	8.712
90:01	21069.00	31048.7	514.2	11.110
90:02	23245.00	30570.4	605.8	13.890
90:03	25497.00	29792.8	774.8	17.052
90:04	27659.00	28715.9	817.9	20.596
91:01	26220.00	31064.7	1189.0	24.524
91:02	37728.00	33413.5	1504.4	28.837
91:03	40445.00	35762.3	1694.7	33.528

Sources: *International Monetary Fund(IMF)*, *International Financial Statistics(IFS)*, various issues.

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