The Determinants of Inflation in Sudan 1970-2002

Kabbashi Suliman

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Abstract

The main objective of this paper is to explain the causes of inflation in Sudan using information during 1970, Q1 - 2002, Q4. The analytical framework views inflation as responding to disequilibria in the internal and external sectors of the economy.   Results confirm the existence of stable equilibrium relationships in the money and foreign exchange markets, which tend to govern the price level in the long run. In particular, the external sector's disequilibrium is found to matter most signifying a strong long-run impact of foreign price and exchange rate on inflation, with slow adjustment to equilibrium. Inflation is also found to be perpetuated by feedbacks from the short-run nominal exchange rate, foreign price, drought shocks and deterioration in expectations. Money growth does not appear to affect inflation in the long run, but the elasticity of inflation to the short-run money supply is significant and high. The findings suggest that a monetary-cum-exchange rule is more suitable for inflation control in Sudan while maintaining external competitiveness. Fighting inflation also depends on the ability of policy to reduce the effects of supply shocks emanating from droughts and foreign price movements, which negatively affect the costs of production inputs.

محددات التضخُم فى السودان 1970-2002

كبَاشى مدنى سليمان

ملخص

الهدف الرئيسى لهذه الورقة هو دراسة مسببات التضخم فى السودان بإستخدام معلومات ربعيَّة خلال 1970 - 2002. إفترِض الإطار التحليلى ان التضخم يستجيب للإختلالات القطاعين: الداخلى والخارجى للإقتصاد. اكدت النتائج وجود علاقات توازن فى سوقى النقد الاجنبي و النقود، والتى بدورها قد تتحكم فى مستوى الاسعار فى الامد البعيد. تحديدا؛ إتضح ان إختلالات توازن القطاع الخارجى هى الاهم فى التاثير على نمو الاسعار مما يدل على وجود اثر قوى فى الإمد البعيد للاسعار العالمية و سعر الصرف فى زيادة التضخم؛ وان التصحيحات تجاه التوازن الخارجى بطيئة جدا. إتضح ايضا ان سعر الصرف الإسمى الفعَال و للاسعار العالمية و صدمات الجفاف و التوقعات غير المواتية للاسعار قد تسببت فى ترويج التضخم فى الامد القريب. لم يثبت من النتائج ان نموعرض النقود يؤثر فى التضخم فى الامد البعيد، لكن إستجابة التضخم لعرض النقود فى الامد القريب كانت عالية و إحصائيا معنوية. تدلل النتائج على ان الإلتزام بقانون نقدى يُراعى تقلبَات سعر الصرف قد يكون اكثر ملائمة للسيطرة على التضخم فى السودان مع المحافظة على التنافسيَة الخارجيَة. وإيضا محاربة التضخم تعتمد على مقدرة السياسة الإقتصاديَة على تقليل اثر صدمات جانب العرض المرتبطة بالجفاف و تقلبات الاسعار العالميَة؛ التى بدورها يُؤثر سلباً على تكلفة مدخلات الإنتاج.

Introduction

Sudan has experienced economic instability during the 1970s through the mid 1990s characterized by high and volatile rate of inflation. The period between 1971 and early 1990s is dominated by the occurrence of double-digit inflation averaging about 29%. A series of reforms are introduced during this period including successive devaluations, price and import controls and rationing, to name a few. However, these efforts were largely unsuccessful, and triple-digit inflation persisted over 1991-1996. Sudan is included by Fischer et al (2002) as one of the 25 countries in the world that experienced episodes of very high inflation crossing 100% growth rate per annum. Among the main factors that could have contributed to inflation developments are: (a) Monetization of the fiscal deficit; (b) Successive devaluations of the domestic currency, which in turn increase the costs of imports including imported capital and intermediate inputs; and (c) Supply shocks relating to back-to-back droughts during 1984-85 and 1993-94.

It is known that very high inflation in excess of 100% per year is very disruptive and no country practically tolerates such price growth (Fischer et al, 2002). Following a period of very high inflation over 1991-96, the government initiated an economic reform in 1997 and the IMF started to help in monitoring this program in 1998. The main force behind this self-imposed reform largely relates to learning from the failures of the government-led import substitution industrialization (ISI) program and the negative macroeconomic consequences of accelerating inflation to generate more inflation tax in a bid to bridge the growing domestic resource gap. The reform emphasized the unification of foreign exchange rate and fiscal consolidation. The inflow of foreign direct investment (FDI) attracted by the advent of the oil sector, and the inflows of oil revenues helped the stabilization efforts and inflation receded to single-digit as from 2000. Real GDP growth showed strong response to these developments. Stabilization is reached mainly through fiscal retrenchment and exchange rate anchoring. However, the challenge ahead relates to the credible commitment for marinating the internal and external balances that ensure sustained low inflation and robust output growth. Hence, it is vital to improve understanding of the determinants of inflation in Sudan, which may enhance such policy endeavor.

An attempt is made in this paper to analyze the underlying sources of inflation in Sudan; which is a key factor in establishing macroeconomic stability. The intention is to provide answers to the following questions:

- What are the internal and external factors that govern the long-run and short-run processes of inflation in Sudan?
- What are the remaining bottlenecks for the success and sustainability of the ongoing stabilization efforts in fighting inflation?

Numerous studies on inflation in the developing countries draw from the monetarist and structuralist approaches to provide explanation for this event. According to the monetarist view, given a stable demand for money, inflation is purely a monetary phenomenon, and can be controlled by curbing excessive growth of money supply. Early application of the monetarist model to explain the dynamics of inflation is found in Harberger (1963) for the Chilean case. In the same vein, the monetarist hypothesis has been tested in other less developing countries as in London (1989) and Tegene (1989) for a group of African countries; Ndung'u (1994) for Kenya; Saini (1982) for Asia and Vogel (1974) for Latin America.

On the other hand, the structuralist approach distinguishes between basic or structural, inflationary pressures and the propagating mechanisms that transmit such pressures. The identified key structural sources of inflation include: distortionary government policies; foreign exchange bottlenecks; inelastic supply of food; the government budget constraint; and sectional disequilibria. Studies within this tradition include Aghevli and Khan (1978), who modeled the fiscal deficit as initiator and propagator of a cyclical process of money supply and inflation. Other studies examined the inertial factors as well as the supply side factors including cost-push elements and sectoral disequilibria as in Durevall and Ndung'u (2001), Liu and Adedji (2000), Sacerdoti and Xiao (2001), Nachega (2001), Sowa and Kwaye (1993), and Adam (1995).

Previous studies on the sources of inflation in Sudan differ in their empirical models, sample period, modeled macroeconomic variables and therefore, on their detailed results. Safi-Eldin (1976) provided an example of early attempts to study inflation in Sudan. He implemented a version of the monetarist model

using annual data over 1960-77. The model is estimated in rate of growth. His results showed that inflation is significantly explained by money supply, growth of real GDP and inflation inertia, indicating that inflation in Sudan is a monetary phenomenon. Hussian (1986) augmented the standard monetarist variables with wages and productivity as indexes measuring the cost-push element. The hybrid model is estimated over 1967-75 with annual data. The main result revealed that inflation in Sudan is of a demand-pull variety confirming earlier findings. However, failure to obtain satisfactory results on the structural proxies, as acknowledged by the author, may partly reflect data deficiencies on these proxies, and may also reflect wage control policy regime during that period aiming to ease rather than trigger inflation.

Suliman (1989) applied a methodology based on the Aghevli-Khan model to examine the effects of fiscal deficit as the originating force and propagating mechanism in the inflationary process in Sudan. The model is estimated by 3SLS with data observed annually over 1960-82. The results provided evidence on the existence of a process of self-generating inflation driven by the symbiotic relationship between government deficit, base money and price growth.

Mahran and Gangi (1996) applied the 2SLS estimation technique to a simultaneous model consisting of inflation and the free exchange rate equations over 1971-91. Their results showed that continued public sector borrowing, frequent depreciation of the free market exchange rate and imported inflation are the most important factors that contributed to price growth in Sudan. In particular, the continuous depreciation of the free exchange rate is found to be the most significant single variable contributing to inflation in Sudan. In another study, Mahran (1999) found a significant causation between the free exchange rate and the inflation rate for Sudan over 1971-91 with feedback.

Abdel-Rahman (1997) investigated the sources of instability in both the mean and variance of inflation in Sudan over 1970-94 with annual data. Shifts in means are accounted for by step dummies, while account of the variable variance is undertaken via autoregressive conditional heteroscedasticity and error correction estimation mechanisms. The results showed that inflation is highly unstable over the reviewed period. In addition, nominal money growth and inflation inertia are found to be the main drivers of price growth and volatility especially after

1982, whereas supply factors, proxied by real output growth, served to depress inflation.

Despite the differences in the empirical models developed in these studies and the sample periods, there is broad agreement on the following key factors affecting the rate of inflation in Sudan: (a) Money growth; (b) Income growth; and (c) Exchange rate developments.

This paper uses data over the years 1970, Q1 - 2002, Q4. By so doing, it updates most of the previous studies; and adds to exposition by considering the temporary and the more prolonged factors that could have affected inflation in Sudan. It is clear that some factors have short-term influence ─ for example, episodes of aggregate demand shocks. Others have medium- to long-term effects such as the convergence of the domestic price to foreign price. The empirical investigation applies Johansen's (1988) maximum likelihood cointegration testing to identify and analyze the long-term relationships that may determine the Sudanese inflation.

The study also examines whether a general inflation error correction model (ECM) incorporating those relationships as disequilibrium correction terms, may be empirically developed for Sudan. Such an approach is more general; compared to that in the previous studies. It also pays attention to aggregate demand as well as supply sides of the economy and permits a distinction between the long-run and short-run effects within a general ECM specification that embeds several hypotheses underlying the explanation of inflation. In addition, the use of quarterly data permits an in-depth analysis of the lagged effects of key economic variables on inflation adjustments.

The main results confirm the existence of long-run relationships in the foreign exchange and money markets, which govern the price level in the long run. Disequilibrium in the external market appears to exert long-run impact on prices and the adjustment of inflation to disequilibria is slow. Inflation is also found to be propagated in the short run by the deterioration in expectations, the contemporaneous and lagged money growth as well as by pass-through from the exchange rate and from foreign prices. The proxy variables included to account; respectively, for the impact of the level of economic activities and the effect

of liberalization of foreign exchange, suggest that an increase in the level of economic activity lowers inflation in the short run. On the other run, liberalization of foreign exchange rate appears to exert an immediate upward pressure on prices. The dummies entered to account for the effects of droughts during 1983-84 and 1993-94 suggest that agricultural supply is negatively affected and in turn, significantly contributed to inflation. Similar results are obtained by studies on inflation experiences of other comparator countries, (Durevall and Ndung'u, 2001; Liu and Adedji, 2000; Sacerdoti and Xiao 2001; Nachega, 2001 and Adam, 1995).

The findings suggest that the policy of defending the exchange rate reform ─ although it has contributed to bring inflation down ─ may not be sustainable in the long run due to the sluggish adjustment of the real exchange rate towards equilibrium. The authorities need to fully develop sound indirect monetary instruments to supplement the policy of exchange rate anchoring. Fighting inflation also depends on the ability of policy to reduce the effects of supply shocks emanating from droughts and foreign price movements.

Background on the Proximate Sources of Inflation in Sudan

In general, the persistence of annual inflation rate of 40% or more over two consecutive years or more, and/or negative real GDP growth over the same period, are known symptoms of macroeconomic instability. Figure 1 shows the annualized rate of inflation over 1970-2002. It suggests that inflation developments since 1970 can be roughly divided into three periods: (a) There was a period of moderate to high inflation from 1970 to 1988 with an annual inflation rate hovering around 20-30% except in 1973 and 1987 where it grew by 44 and 67%, respectively; (b) There was a process of very high inflation in excess of 100% per annum over 1989-96 and (c) Inflation receded to 17% average rate over 1997-2002.

Figure 1. Inflation developments in Sudan over 1970-2002
(annualized inflation rate as aforementioned)
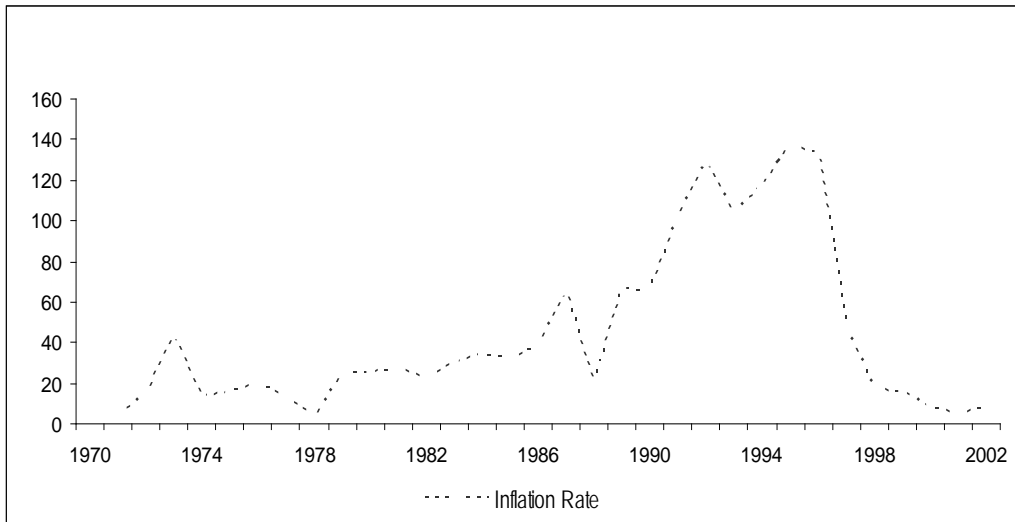
Source: Sudanese Central Bureau of Statistics (various years) and the IFS (various years). See Appendix A for the construction of this variable.

The main macroeconomic episodes and the underlying policy stance during each period of inflation development would be highlighted subsequently. Ali and Elbadawi (2002) presented a comprehensive review of how the evolution of public policies and institutions impacted economic growth in Sudan over a comparable review period. Table 1 presents a summary of the major macroeconomic variables that are likely to influence inflation during each sub-period.

Table 1. Selected Macroeconomic Indicators for Sudan (1970-2002)[a,b,c]

Period	Cons Price Infl	Real GDP Grwth	Chng in Nomnl Money (M1)	Chng in Nomnl Money ((M2)	Chng in Parallel Mrkt Exc Rate (%) /1	Chng in Prem (%)	Ratio of Fisc Def to GDP (%)	Ratio of Current Acct Def to GDP (%)	Chng in Terms of Trade Index (%)	Real Imprts Grwth	Real Exprts Grwth
1971-1988	24.0 (0.6)	1.5 (4.3)	28.5 (0.4)	29.4 (0.4)	26.6 (1.9)	9.5 (3.3)	-8.4 (0.5)	-2.9 (0.9)	6.3 (1.4)	3.0 (6.2)	-0.5 (41.3)
1989-1996	106.8 (0.3)	-3.9 (2.5)	71.0 (0.3)	76.0 (0.5)	126.3 (1.7)	1.1 (61.1)	-6.1 (0.9)	-6.3 (0.6)	-2.1 (2.0)	5.7 (4.6)	3.6 (7.0)
1997-2002	16.8 (0.9)	6.8 (0.2)	16.3 (1.3)	7..20 (0.6)	9.3 (1.3)	-2.5 (2.8)	-1.1 (0.4)	-6.0 (0.4)	0.6 (5.7)	0.9 (17.7)	23.3 (2.1)
1971-2002	43.8 (0.9)	1.2 (6.6)	39.1 (0.5)	41.3 (0.7)	36.9 (1.4)	5.2 (7.5)	-6.5 (0.8)	-4.4 (0.8)	4.8 (1.9)	3.3 (6.0)	4.9 (6.0)

[a] The parallel (or black) market exchange rate is defined as the local currency per unit of the US dollar, hence positive change implies depreciation. The series is compiled from two sources: (a) Pick Dollar Year Book over the period 1970, Q1 - 1993, Q4. The relevant pages were provided by Jantz, R.; Alexander Library, Rutgers University and (b) Bank of Sudan over 1994, Q1 - 2001, Q4.
[b] Exports and imports are deflated by the foreign price index. (See Appendix A for the definition of foreign price index).
[c] Figures in parenthesis are the coefficients of variation.

Source: Bank of Sudan Annual Reports, Pick Currency Year Book (various years) and the IFS (various years).

        The first burst of inflation during 1970-88 is associated with the oil price increases in early 1970s. However, the economy was not immediately affected by the full impact of these shocks. At that time the government managed to exploit the geopolitical position of the country and attracted substantial FDI especially from the surplus of the oil rich Arab countries in a view to promote Sudan as a breadbasket for the region. The Peace Agreement signed between the North and the South in 1972 encouraged the inflows of FDI. Most of these foreign investments are attracted to the government-led projects in agriculture and imports-substituting industries. Nonetheless, the FDI boom failed and by late 1970s, the government had neither the foreign exchange nor the domestic resources with which to meet the politico-economic demands for spending following the peace and the debt servicing obligations. Accordingly, Sudan

adopted a Structural Adjustment Program (SAP) with the support of the IMF and the World Bank over 1978-84.

Despite the adoption of the SAP, the monetary policy continued to follow the ISI strategy and is largely based on fixed exchange rate and various forms of trade and foreign exchange controls. However, in post mid-1980s, a premium exchange rate was introduced along with liberalization measures that shifted imports, and to some extent exports, from the official to the parallel market. These reforms aimed at attracting the remittances of the Sudanese nationals working abroad after having failed to attract more investments from the oil-exporting Arab countries, but these efforts were largely unsuccessful (Elbadawi, 1992a and 1992b).

The intensification of controls to repress inflation tolerated an entrenched rent seeking, black markets and smuggling. The successive devaluations of the free exchange rate in the black market led to overvaluation of the official exchange rate and inflation vicious circle and to loss of external competitiveness. Over the period, real export growth was negative averaging -0.5 and showed very high volatility, as indicated by the coefficient of variation of 41.3 (Table 1).

The parallel market premium ─ defined as the ratio of the free exchange rate to the official exchange rate ─ grew on the average by 9% during 1970-88, (Table 1). The finance for more than 80% of imports is channeled through the parallel market, (Hussian, 1986). The resulting increases in the prices of imported intermediate inputs and consumer tradables fed the inflationary process, with serious implications for capacity utilization and growth in the country.

The budget deficit as a percentage of the GDP averaged 8.4% over this sub-period. The fiscal gap is financed mainly by money creation thought to substitute external credit, which dried up in the late 1970s and by 1987, inflation stated to run loose in the economy, (Table 1).

The macroeconomic imbalances and the policy failures of the period[1] are complicated by the outbreak of the Civil War in 1983, ending ten years of peace, and aggravated by the droughts and crop failures that developed in severe food shortages during 1984-85. The pressure of the situation has not only resulted

in an economic u-turn, but has also induced massive political instability. For example, the sub-period witnessed succession of four changes of the political regimes.

The second period of inflation development over 1989-96 opened with a political change in 1989. The new government was faced with a deteriorating balance of payments due to loss in competitiveness and a large fiscal deficit. A National Economic Salvation Plan was introduced in 1990 which is a home-grown vintage of the SAP. This was largely a reflection of the severe decline of the foreign finance. The Plan consisted of the following main measures: (a) Strict control of foreign exchange, including imports and prices, and exports retention through the Central Bank surrender requirements, which furnished a base for export tax; (b) Adherence to strict cash budget system; and (c) Privatization of the non-performing public enterprises. Following these measures, the fiscal deficit as a ratio of the GDP declined by 2 percentage points on the average compared to the previous period. However, it remained high due to the burden of the Civil War. The official exchange rate is occasionally devalued, but not merged with the free market rate which depreciated on the average by 77.5% during 1989-96. The premium continued to be positive and exhibited considerable volatility (Table 1).

Notwithstanding these efforts, Sudan has experienced a bad combination of shocks that negatively affected the internal and external balances during this sub-period. These included the withdrawal of the IMF balance of payments support and the loss of seal of approval; the meat export ban in 1992; the drought and food shortages in 1993-94 and the cuts of aids from multilateral institutions. The combined effects of these internal and external shocks caused inflation to grow by phenomenal records and the economic growth was negatively hit. As seen in Table 1, during 1988-96, real output growth was negative and volatile with recorded average decline of -3.9% and a coefficient of variation of 2.53.

The government relied on money printing to finance the growing domestic resource gap, and at the same time perused a policy of maintaining the Purchasing Power Parity (PPP). This policy mix has resulted in massive parallel market premium and large real exchange rate overvaluation spells. More importantly, it could be hypothesized that the dual exchange system maintained during the

sub-period could have indirectly influenced price movements through the quasi-fiscal deficit of the Central Bank operations. The direction of change depends on whether the Central Bank is a net buyer of foreign exchange; i.e. collector of implicit tax; or a net seller; i.e. provider of implicit subsidy (Morris, 1995 and Pinto, 1991). Very few studies on Sudan, if any, analyzed the inflation-premium relation. An attempt is made in this paper to empirically evaluate this link.

The third episode of inflation development followed the reform introduced in 1997 which built on liberalization of the foreign exchange in 1992 and focused on lifting the remaining imports and prices controls as well as on fiscal consolidation and streamlining the banking system. The IMF started to monitor the reform program in 1998. Because liberalization of trade and foreign exchange are essential components of this program, the Central Bank significantly reduced the surrender requirements, and in some cases, eliminated the surrender applicable to some exports.

The 1997 reform policies coincided with a substantial inflow of FDI associated with the commercial exploitation of oil and the rise of the oil money as an important source of public revenue. The combined effects of these developments provided an enabling macroeconomic environment. Real export including oil grew on the average by 23.3% during the sub-period. The growth in broad money, M2 ─ which is M1 (narrow money) plus quasi-money ─ declined by about 55 percentage points compared to the previous period and inflation receded to a single digit as from 2000. The growth of real GDP showed a strong response to these developments. It grew on the average by 6.8% (Table 1). The fiscal consolidation is at the center of this reform effort. The large cuts in public spending has also improved the fiscal stance and significantly curbed escalation of inflation.

The preceding discussion suggests that financing of the fiscal deficit appeared as a key element determining the environment for monetary policy. Despite the introduction of Islamic financing mode in 1984, the financial market remained relatively thin and characterized by entrenched guidelines for credit allocation. The effects of the continued deficit financing on price stability is a concern for the Central Bank and started to become a cause of worry in post mid 1990s.

Following the 1997 reform, the Bank introduced the Central Bank Musharaka Certificate (CBMC) in 1998 to streamline its long-standing, cost-free lending to the government and the commercial banks (Kireye, 2001). The CBMCs are short-run liquidity papers which the Central Bank trades with banks to smooth short-term fluctuations in liquidity and hence, finish a base for open market operations. A similar Government Musharaka Certificate (GMC) was introduced in 1999. In spite of this, only recently that the sharp decline in the budget deficit due to fiscal retrenchment and the rise of oil revenues in public finance, has created space for more proactive monetary policy.

The combined size of the CBMCs and GMCs available for open market operations is small to fully neutralize the effects of deposit changes on reserves money and hence, inflation. Nevertheless, under the Islamic finance mode, without ex ante interest rate, the Central Bank may use the monetary aggregates, change the reserve requirements, pursue moral suasion as well as selective credit controls to achieve its objective of low inflation real GDP growth. Yet, to a great extent, the monetary policy in Sudan is based on the management of the exchange rate and the control of the monetary aggregates. Selecting an appropriate anchor within a comprehensive monetary framework relevant for the Central Bank's objectives, presents a challenge for the policy mix in the period ahead.

This is of crucial importance especially that the recent rise in inflows of oil revenues may lead to money supply growth, and consequently inflation ─ if the oil money is not appropriately sterilized following the developments in the real sector of the economy. Therefore, it remains important to highlight the main channels through which the behavior of the monetary aggregates could affect inflation in a small open economy like Sudan with an underdeveloped financial sector and instruments of monetary policy.

Analytical Framework and the Econometric Methodology

The paper relies on the proximate sources of inflation previously for modeling inflation process. The most important are: (a) The impact of domestic aggregate demand ─ for example, the monetization of the fiscal deficit and other causes for excessive money growth); (b) The impact of supply side that emanates from the external sector and transmitted via the price of imported capital goods and

intermediate inputs; and (c) The impact of drought shocks which are transmitted to inflation.

Theoretically, inflation process is often modeled as: (a) A mark-up pricing mechanism following the work of Duesenberry (1950); (b) An interaction of supply and demand for money, following the contribution of Harberger (1963) and (c) A response to internal domestic (expectations) disequilibria or external "equilibrium exchange rate" misalignment pressures. Other modeling strategies involve various combinations of the above factors.

The model adopted in this study assumes that inflation originates from both demand and supply sides of the economy. Various studies on inflation in developing countries represent the aggregate demand side by the demand for money relation. The influence from the supply side could be represented by the external sector. In small open economy like Sudan with underdeveloped local sources of capital goods and inputs supplies, the share of tradable inputs in production of consumer goods is large. It is more likely that changes in import prices pass-through to the consumer prices. Thus, the analytical model allows overall inflation to adjust to long-run disequilibria in the money market and the external sector as well as to short-term impact of the variables determining these equilibrium conditions including other relevant factors.

The PPP provides a representation of the long-run price formation process in an open economy. Accordingly, the overall price level P may be expressed as weighted average of the domestic price P_d and foreign price measured in domestic price $E\,P^f$, that is;

$$P = P_d^{\delta}\,(E\,P^f)^{1-\delta} \qquad \text{(Equation 1)}$$

Equation 1 in log-linear form with lower case letters denoting logarithms may be rewritten as;

$$p = \delta p_d + (1-\delta)\,(e + p^f) \qquad \text{(Equation 1')}$$

Here, (e) is the nominal effective exchange rate and δ sands for the share of the domestic component of price level, which is determined by the equilibrium condition in the money market, that is, $M^s / P_d = M^d / P_d$. Expressing this condition in logarithms denoted by lower case letters and solving for P_d gives:

$$p_d = m^s - m^d \qquad \text{(Equation 2)}$$

Where, m^d is the log of real money demand and m^s is the log of nominal stock of money. The demand for real money for Sudan may be expressed as;

$$m_t^d = \beta_1 y_t - \beta_2 \pi_t^e - \beta_3 prem_t \qquad \text{(Equation 3)}$$

Due to the distortions of the financial markets in Sudan, the long-run demand for money, in terms of Equation 3, is assumed to be affected by real income y; the expected rate of inflation π^e as well as by the exchange rate movements measured by the parallel marked premium prem; and t is time index. In this setting, a rise in the premium may lead to a decline in demand for money, reflecting currency substitution motive, due to devaluations of the parallel exchange rate. Other studies used similar equation to describe demand for real money in developing countries, (Liu and Adedji, 2000).

Suppressing the coefficients and the time index in Equation 3, substitute into Equation 2 and using the resultant expression in Equation 1', this gives:

$$p = \delta (m^s + y - \pi^e - prem) + (1 - \delta)(e + p^f) \qquad \text{(Equation 4)}$$

Equation 4 establishes a general framework for the long-term movements of the aggregate price level, where both internal disequilibria in the money market as well as changes in foreign prices measured in domestic price jointly determine such movements. However, the dependent variable and some of the independent variables in the equation may be simultaneously determined, and may be that they are non-stationary but render stationarity by first differencing[2].

In such case, Johansen (1988)'s cointegration testing method and error-correction modeling could be used. This method is particularly relevant for testing to verify if there are any cointegration relationships, or long-run equilibrium relationships; among the study variables. In addition, the ECM permits the use of a general lag structure and allows for alternative hypotheses testing. Hence, the following general unrestricted vector autoregression (VAR) of order k may be used to represent the study variables;

$$x_t = \mu + \sum_{i=1}^{k} A_i x_{t-i} + \varepsilon_t \; ; \; t=1, 2\ldots\ldots.T \qquad \text{(Equation 5)}$$

Where $x = (p, m, y, \pi, prem, e \text{ and } p^f)'$ is a column vector of 7x1 dimension containing the endogenous variables; A_i, i=1,…..k, are 7x7 matrices of unknown coefficients; μ represents 7x1 vector of unknown deterministic terms (including intercepts) and ε is IID disturbance term with zero mean and constant variance.

With I(1) variables, and using the first difference operator: $\Delta x = (x_t - x_{t-1})$, Equation 5 may be re-parameterized in the following vector error correction model:

$$\Delta x_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-1} + \varepsilon_t \; ; \; t=1, 2\ldots\ldots.T \qquad \text{(Equation 6)}$$

Where, $\Gamma_i = -\sum_{r=i+1}^{n} A_r$ and $\alpha\beta' = -(1 - \sum_{i=1}^{k} A_i)$, with I representing a (7x7) identity matrix, α and β' (7,r) are respectively full-rank matrices of the adjustment factors and cointegrating vectors; with r being the number of expected cointegrating vectors.

Ideally, cointegration estimation and analysis should be carried out through the full set of variables. However, not all the study variables are available in the required frequency to fit the estimation and analysis of the full system. The main challenge is the lack of quarterly observations on GDP. Annual data on the GDP are available for Sudan and had to be interpolated. The interpolated GDP gives

a series measuring the trend which is relevant for long-run analysis, but contains less information about the short-run changes in output. Instead, the quantity index for power consumption (pc) is included to proxy the level of economic activities in the short-run dynamic analysis. This variable is used for the following reasons. Firstly, it is widely acknowledged that there is a close link between aggregate macroeconomic activity and power consumption[3]. Secondly, it is arguable that power intensity of the real value added does not change significantly during the study period. Prior reasoning suggests that a rise in the overhead power use per unit of output due, for example to decline in capacity use, fall in maintenance investment etc., will be checked by the higher direct and indirect power costs.

The estimation of the standard PPP implied by Equation 1 poses another challenge. This version of the PPP may not hold for Sudan due to the Balassa-Samuelson (1964)[4] and other factors, including transport costs, barriers to currency conversion and the presence of non-traded goods. These factors cause market segmentations and create a wedge among prices across countries. However, if they remain constant over time, the long-run PPP can be estimated including a positive constant term. In addition, the use of price indices, as in the present paper, justifies the presence of the constant. Thus, a sectoral approach was followed for testing the existence of cointegration in the subset of variables to allow for different assumptions about the restriction of the constant in the cointegration space per subsystem.

Accordingly, the vector x_t, containing the endogenous variables in Equation 5, can be partitioned into two subsets: $(p, m, y, \pi \ and \ prem)'$ as well as $(p, \ e \ and \ p^f)'$ representing, respectively, the demand for real money and the PPP relationship. This method is equivalent to adding prior identifying restrictions to the full system. It also allows the analysis of the short-run dynamics within the entire system. Thus, rather than conducting the analysis using the system of dynamic equations, a conditional single equation framework is developed and estimated based on weak exogeneity testing. Such modeling strategy is consistent with other studies (Ndung'u, 1993; Durevall and Ndung'u, 2001; Sacerdoti and Xiao, 2001; Liu and Adedji, 2000; and Nachega, 2001).

Assuming the existence of two cointegrating relations, the following general single equation ECM; similar to the ECM representation of the variables in Equation 6; may be had after dropping ($\Delta\pi$) and replacing the first difference of the interpolated y, in the short-run part of the model, by the first difference of the of log power consumption (Δpc);

$$\Delta p_t = \gamma_0 + \sum_{i=1}^{k-1}\gamma_{1i}\Delta p_{t-i} + \sum_{i=0}^{k-1}\gamma_{2i}\Delta m_{t-i} + \sum_{i=0}^{k-1}\gamma_{3i}\Delta p_{t-i} + \sum_{i=0}^{k-1}\gamma_{4i}\Delta prem_{t-i} + \sum_{i=0}^{k-1}\gamma_{5i}\Delta e_{t-i} + \sum_{i=0}^{k-1}\gamma_{6i}\Delta p^f_{t-i} +$$

$$\alpha_1[m - \beta_1 p - \beta_2 y - \beta_3 \pi - \beta_4 prem]_{t-1} + \alpha_2[\theta_1 e + \theta_2 p^f - p - \theta_0]_{t-1} + \sum_{i=1}^{3}\gamma_{7i}\mathbf{\varsigma}_i + \gamma_8 D_t + \mu_t$$

$$\text{(Equation 7)}$$

Where μ_t is a white noise process with the usual properties; sc_{it} is a vector of seasonal centered dummies and D_t is a vector containing two dummies over 1984, Q3 - 1985, Q1 and 1993, Q3 - 1994, Q3 to account for the impact of two episodes of drought on agricultural supply and the ensuing shortages of major food staples which are expected to influence price growth. The severity of these droughts and their effects on inflation is difficult to measure with precision. However, both irrigated and rain-fed agriculture had been affected most during the specified periods (Mirghani, 1999 and Teklu et al, 1991). The other variables in the equation are defined as before.

In the case that all variables are I(1), then their respective summations in Equation 7 are all stationary, and if cointegration exist, the error correction terms, that is, the linear combinations of variables represented in the brackets, are also stationary. The short-run dynamics is captured by the summations over the first difference of the variables. The long-run impact of the right hand side variables is measured by the two error correction terms. Their coefficients show the strength of adjustment, disequilibria, transmitted into the rate of inflation each period.

Equation 7 embeds several hypotheses underlying the explanation of inflation. For example, empirical testing of the pure monetarist hypothesis would require the variables entering money demand relation be significant both in the short run and long run. However, this is equivalent to assuming closed

economy, or perfect exchange rate floating, and that imports and domestic goods are perfect substitutes. In the event that the latter assumptions do not hold for an open economy, it can be hypothesized that inflation is driven by persistent divergence from the PPP in the long run, with short-terms feedbacks. Therefore, the coefficient of the error correction term, α_2, measures the extent to which deviations of the long-run domestic price level from equilibrium in the external sector affect inflation next period. It is also hypothesized that price growth is affected by the dynamic terms on these determinants in the short run.

The premium is included in the dynamic part of the model to measure the impact of foreign exchange liberalization on inflation. The relationship between inflation and the premium is indirect and complex. Generally the inflation-premium link depends on the portion of traded goods allocated to the parallel marked and on the mechanisms of international reserves adjustment and money supply creation as well as on the inflation elasticity of money demand. However, it may be hypothesized that a decrease in the premium following the 1992 unification, might reflect a short-run positive fiscal shock ─ if it leads to increased exports directly through the enhanced incentives to exporters; and/ or indirectly through reducing the incentive for tax evasion. It is also expected that the elimination of the premium may reflect a short-run fiscal shock that through monetization of the deficit to compensate for the loss of revenues from export surrender and abolition of export tax, raises inflation. These tentative channels of influence would be tested empirically.

The following section presents the results of Johansen's (1988) cointegration testing. Based on these results, the OLS technique is used to determine the data congruent dynamic inflation model for Sudan over the review period following an approach similar to Hendry's general-to-specific modeling strategy[5].

The Empirical Model

Cointegration Analysis

The way money is defined is important in estimating the demand for money specified in Equation 3. Since the quantity theory relation is assumed to hold in the long run, M2 is included in the analysis. In addition, both measures of money are closely related in case of Sudan due to the shallow financialization of the economy, (Kireye, 2001).

The general price level (P); measured by the Consumer Price Index (CPI); is available. However, the other variables needed for the analysis of the foreign sector had to be constructed. Appendix A explains how the trade weighted nominal effective exchange rate index and the foreign price index are calculated for Sudan.

Figure 2 shows the matched means plot of log foreign price and the logarithmic difference between the CPI and the nominal effective exchange rate. As it appears, the two series roughly trend upwards and follow each other closely overtime except during the period of high inflation. This implies that the exchange rate, the CPI or both, often adjust to reduce the transitory deviations between p^f and (p-e).

Before cointegration is tested, the standard Augmented Dickey Fuller (ADF)[6] and Phillips-Perron (PP) unit root tests are used to determine the order of integration of the study variables. The results of ADF and PP testing do not uniformly agree on the choice of the order of integration of the study variables. However both tests fail to reject the null hypothesis of unit root when the variables are tested in levels. The null hypothesis is rejected for the first difference of all variables[7].

Figure 2. The log of foreign price and the mean adjusted log CPI
minus log nominal effective exchange rate 1970, Q1 - 2002, Q4.
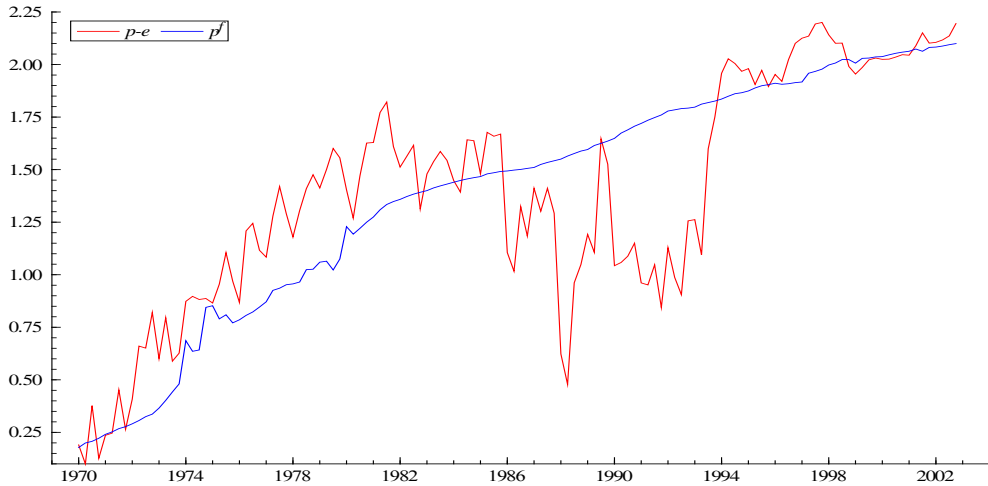
Source: See Appendix A for the construction and definitions of the variables.

Based on these results, Johansen's (1988) maximum likelihood approach to cointegration is applied to demand for money Equation 3 and a PPP relation spanning $(p, \ e \ and \ p^f)$. It is known that testing for cointegration using this approach is sensitive to the lag length of the VAR underlying the analysis and to whether or not a constant and a trend are included, restricted or otherwise. Since none of the study variables can be considered a priori as exogenous, the specification search starts with un-structural VAR per subsystem. In order to ascertain the lag length of the VAR, twelve lags are initially included. Tests for lag length selection are carried by the Akaike information criterion (AIC); Schwartz Bayesian criterion (SBC) and the log-likelihood ratio statistics (LR)[8].

The AIC selects VAR order 11 for the monetary sector, while SBC selects order 2 and LR test statistics accepts these selections. In the case of the external sector, AIC suggests VAR order 7; SBC selects order 1 and LR test statistics rejects all VAR order less than 4. Overall, the results indicate that the AIC and SBC criteria are in sharp conflict in determining the lag order of the VARs to

be used[9]. Thus, to avoid the problem of serial autocorrelation of errors of the individual equations entering the cointegration analysis, and in order not to run the risk of over-parameterization, a seventh-order VAR was used in the long-run analysis of the money market and four lags were used for the VAR of the external sector. Estimation of the first VAR included constant, seasonal centered dummies and step dummies entered unrestricted. According to the unit root testing results, (not reported), the proxy variables used to measure the purchasing power parity relationship for Sudan were not expected to form a stationary linear combination. Hence, the VAR underlying the analysis of this relationship was estimated with a constant entered restricted, seasonal centered dummies and step dummies entered as unrestricted.

The results of the Johansen procedure are reported in Tables 2 and 3 for each subsystem. As seen in Table 2, the results of testing using the money market variables indicate that there is one large and three relatively small eiginvalues. The λ-max eiginvalue statistics suggests that the null of no cointegration is rejected in favor of a single cointegrating vector at 5% level. According to the trace statistics, the hypothesis that there is at most two cointegrating vector, is not rejected with the second cointegrating vector implying that inflation forms a linear combination by itself. Detection of two cointegrating vectors in similar specification of demand for money has been found in other studies (Kuijs, 1999 and Liu and Adedji, 2000). However, the results of λ-max statistics are accepted and the subsequent analysis assumes the existence of one cointegrating relationship.

Table 2. Cointegration Testing and Analysis of the Monetary Sector[a, b, c]

Eiginvalues	0.28097	0.19173	0.15630	.091651	0.00535
Null Hypothesis, Rank $(\hat{a}\hat{a}')$ = r:	r=0	r≤1	r≤2	r≤3	r≤4
λ-max:	40.901*	26.39	21.07	11.93	.665
95% critical values[b]:	33.64	27.42	21.12	14.88	8.07
Trace-statistics:	100.95*	60.05*	31.48	12.58	.665
95% critical values:	70.49	48.88	31.54	17.86	8.07
Normalized Cointegrating Vector:	m2	p	Y	Prem	π
	1	-1.187***	-0.840	0.475	0.689**
	(0.000)	(0.134)	(0.610)	(0.319)	(0.308)
Restricted Cointegrating Vector:	1	-1.163***	-1.000	0.456	0.663**
	(0.000)	(0.093)	(0.000)	(0.300)	(0.284)
χ^2 (1): 0.۰۷۳۲ [0.۷۸۷]					
	1	-1.058	-1	-0.0000	1.001
		(0.۰٤8)	(0.000)	(0.000)	(0.262)
χ^2 (2): ۳،۱۱۱ [0.211]					
	1	-1	-1	-0.0000	0.999***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.250)
χ^2 (3): ٤،۹۳٥ [0.177]					
Weak exogeneity test statistics α_{1i}=0 for each variable[c]					
χ^2	3.950**	4.325**	2.37	2.587	3.058*
p-value	[0.047]	[0.038]	[0.123]	[0.108]	[0.080]

[a] The estimation period is 1970, Q1 - 2002, Q4. See Appendix A for the definitions of the variables. All variables are expressed in logarithms except the inflation rate (π). The VAR underlying the analysis includes seven lags of each variable, unrestricted constant, seasonal centered dummies and a step dummy for the foreign exchange liberalization taking the value of one over 1992, Q2 and zero otherwise.

Asterisks ***; ** and * denote significance at 1%; 5% and 10% level respectively. Numbers in parentheses are symptomatic standard errors and numbers in brackets are p-value of the χ^2-statistics.

[b] Testing uses the critical values at the 95 and 90% levels based on those computed by Pesaran et al (2000) rather than the original Johansen-Juselius (1990) or Osterwald-Lenum (1992) values.

[c] Weak exogeneity tests statistics are examined under the assumption that r=1 and so are asymptotically distributed as χ^2 (1) if weak exogeneity of the specified variable for the cointegrating vector is valid; significant [p-value] denotes rejection of weak exogeneity, (Engle et al, 1983).

Source: Based on long-run estimation of Equation 3. See Appendix A for definitions of the variables.

The normalized cointegrating vector corresponding to the long-run demand for money is shown in Table 2, row number 8. As it appears, the estimated coefficient for price is near unity while that of income is below unity. The estimated long-run coefficients for price level and the rate of inflation are statistically significant, whereas the other coefficients are not. Accordingly, restrictions are imposed sequentially starting with those that are most likely to accept. The imposition of unitary restriction on the income coefficient is accepted $\chi^2 = 0.0732\ (0.787)$[10]. The coefficient of the premium is negative indicating possible currency substitution influence on long-run demand for money, albeit statistically insignificant. The, imposition of zero restriction on this coefficient is accepted $\chi^2 = 3.111\ (0.211)$. Thus, the currency substitution type of argument does not seem to directly explain the long-run demand for real money. The insignificant currency substitution implies that the estimated equation reflects an average effect that misses the impact of large depreciations of the exchange rate during 1989-1996. Finally the usual homogeneity restriction between real money and real income is accepted, $\chi^2 = 4.935\ (0.177)$. The restricted cointegrating vector can be written as:

$$m - p = y - 0.999 * \pi \qquad\qquad\qquad \text{(Equation 8)}$$
$$(0.250)\ ^{[11]}$$

The demand for money relation of Equation 8 reveals that the long run income elasticity of M2 is unity in consonance with the quantity theory hypothesis. The semi-elasticity of real money with respect to inflation is, however, strongly negative. The order of magnitude is comparable to other studies (Adam 1995 and Ozmen 1998). The restricted cointegrating vector could be recognized as an extended Cagan money demand. Inflation appears to play an important long-run role in weakening the demand for real money in Sudan especially in the form of holdings in the domestic banking system. Hence, it may be argued that escalation of inflation over the review period has contributed to undermine the financial deepening process.

Feedbacks from the cointegrating relationship may be examined by weak exogeneity test[12]. The p-values of the test statistics for weak exogeneity of money, price, real income, the premium and inflation rate indicate that weak exogeneity can be rejected for money and prices at the 5% significance level and for inflation at 10% level, but not for real income and the premium (Last row, Table 2). This means that if a simultaneous system of equation is to be used, then, the error correction terms should be introduced for money and price equations only, implying no feedback from excess money to output. The result confirms the long-run neutrality of money and that there is no long-run Phillips-type trade-off between inflation and output, which is theory consistent[13].

The study period witnessed a number of structural changes, which have implications for the stability of the estimated relationship. Thus, to assess the overall performance of the estimated demand for money model, the persistence profile suggested by Pesaran and Shin (1996) is used to examine the speed of convergence of the estimated money demand vector to its long run equilibrium following a system-wide shock. The value of the profile is equal to unity on impact and should tend to zero with passage of time if the estimated cointegrating relationship is a genuine one.

Figure 3 contains the plot of the persistence profile of a system-wide shock to the estimated cointegrating vector. The plot suggests that the estimated vector responded by the full amount of the shock on impact and died out in about twenty quarters. The bulk of adjustment to the shock takes place during the first year. However, it takes about four years for the long-run money demand to completely converge to its equilibrium following a system-wide shock.

The result of cointegration analysis for the set of the variables (e, p and p^f) representing the external sector is presented in Table 3. Testing based on λ-max and trace statistics do not uniformly agree on the existence of one cointegrating vector spanned by data. The latter test accepts the existence of at most, one cointegrating vector among the included variables at 5% significance level, while the former testing procedure confirms the existence of one cointegrating vector at 10% significance level. Hence, the subsequent analysis assumes that one cointegrating vector is supported by data.

Figure 3. Persistence profile of the effect of a system-wide shock
to the estimated cointegrating vector in the monetary sector.
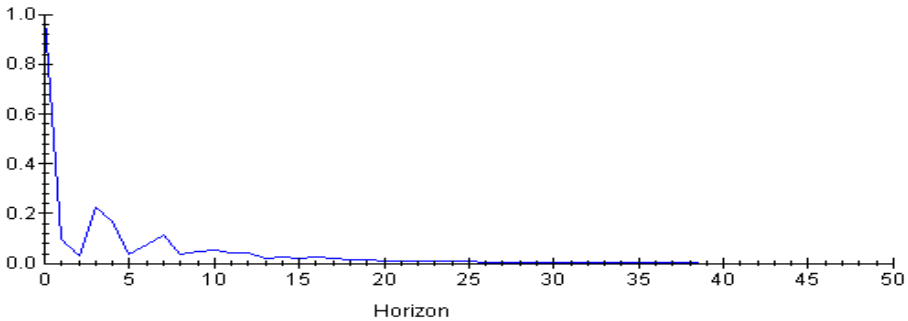
Source: Based on long-run estimation of Equation 3.

The normalized cointegrating vector is shown in row 8 in Table 3. All the estimated coefficients have the expected signs; the constant and the term on domestic price level are significant. The coefficient on foreign price is higher than unity and is statistically insignificant. Accordingly, the symmetry and homogeneity restrictions implied by the purchasing power hypothesis are imposed. The results of the validity of these restrictions are reported in rows 12 and 14. As seen, the two restrictions accepted at χ^2=0.359 (0. 54) and χ^2=4.089 (0. 129), respectively. Thus, it seems that the weaker version of the PPP is supported by data over the sample period. The restricted cointegrating vector may be written as;

$$p^f+e-p =4.021 \qquad \qquad \qquad \text{(Equation 9)}$$
$$(0.766)^{(14)}$$

Following the standard interpretation, the significant constant implies that the long-term price differential between Sudan and its trading partners is attributable to the relatively high local non-traded costs; sales taxes and transport costs. The constant may also represent the missing fundamentals and or a trend-like variable in the real exchange rate.

Table 3.   Cointegration Testing and Analysis of the Foreign Sector[a, b, c]

Eiginvalues		0.14412	11429 .0	01864 .0
:Null Hypothesis, Rank $(\acute{a}\hat{a}')$ = r		r=0	r≤1	r≤2
:λ-max		19.92	15.53	2.408
:critical values/[2] 95%		22.04	15.87	9.160
:Trace-statistics		*37.863	17.942	2.408
:critical values 95%		34.87	20.18	9.16
:Normalized Cointegrating Vectors	Constant	E	P	p[f]
	-1.464	1	***-0.963	1.679
	5.989	(0.000)	(0.114)	(1.477)
:Restricted Cointegrating Vectors	***-4.173	1	***-0.916	1.000
	(453 .0)	(0.000)	(0.046)	(0.000)
[0.540] 0.359 :(1) χ^2				
	***-4.021	1	-1	1
	(0.766)	(0.000)	(·00.0)	(0.000)
[129 .0] 4.089 :(2) χ^2				
Weak exogeneity test statistics α_{2i} =0 for each variable/[3]				
χ^2		**5.646	**3.578	1.697
p-value		[0.017]	[0.038]	[0.193]

[a] The estimation period is 1970, Q1- 2002, Q4. See Appendix A for the definitions of the variables. The VAR underlying the analysis includes four lags of each variable; restricted constant; unrestricted seasonal centered dummies and two step dummies to account for the first devaluation of the official exchange rate in 1978, Q3 and the rise in inflow of the oil revenues since 1999, Q1. Asterisks ***; ** and * denote significance at 1%; 5% and 10% level respectively. Numbers in parentheses are symptomatic standard errors and numbers in brackets are p-value of the χ^2-statistics.
[b, c] See footnotes b and c respectively, in Table 2.

Source: Based on long-run estimation of PPP (Equation 1). See Appendix A for the definitions of the variables.

      As before, the persistence profile of the estimated cointegrating vector to the effect of a system-wide shock is used to assess convergence to the equilibrium relationship. Figure 4 shows the plot. It is clear that the estimated cointegration relationship is genuine but it takes several years to converge to the equilibrium following a system-wide shock. Testing for weak exogeneity hypothesis in this sub-system suggests that foreign price is weakly exogenous, while the hypothesis

cannot be rejected for the exchange rate and domestic prices (Last row, Table 3). This implies that these two variables move together to restore the long run equilibrium following an exogenous shock which is consistent with the visual impression of Figure 2.

Figure 4. Persistence profile of the effect of a system-wide shock
to the estimated cointegrating vector in the external sector.
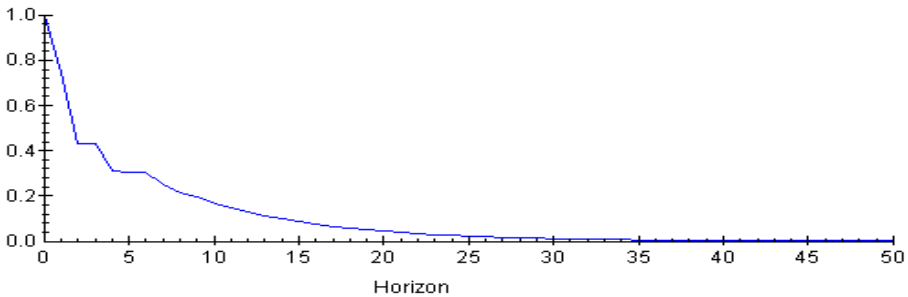
Source: Based on long-run estimation of PPP (Equation 1).

In summary, Johansen testing determined two cointegrating vectors interpreted as representing long-run real money demand and real effective exchange rate. In addition, theory based restrictions are not rejected. It should be noted that this analysis assumes that the whole system is not fully simultaneous. The restricted cointegrating vectors are stationary according to the ADF test. Figure 5 shows their plots.

In the light of Equation 7, inflation in Sudan is determined by deviations from the equilibrium conditions — defined by two error-correction terms $\alpha_1 = [m - p - y + 0.999 \ * \pi]_{t-1}$ and $\alpha_2 = [p^f + e - p - 4.021]_{t-1}$ — augmented by the dynamics of contemporaneous and lagged difference of the system and relevant non-system variables. The unrestricted model is estimated with 5 lags of each variable, constant term and seasonal centered dummies. The model also includes two dummies over 1984, Q3 - 1985, Q1 and 1993, Q3 - 1994, Q3 to account for the impact of the droughts on agricultural supply and the ensuing shortages of major food staples which are expected to increase inflation.

Figure 5. Restricted co-integrating vectors.
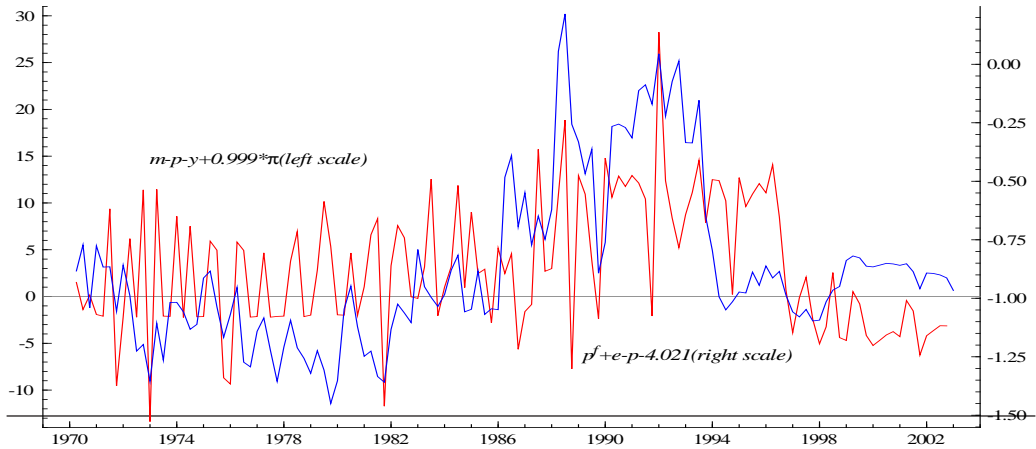
Source: Based on long-run estimation of Equation 3 and the PPP, Equation 1.

Inflation Model for Sudan

Appendix Table A.1 presents the estimation results of the general model. The misspecification tests are reported in footnotes of the table. The errors autocorrelation AR, ARCH error, non-normal error, heteroscedastic error and model misspecification are rejected. The unrestricted ECM, as an initial model, appears to perform reasonably well in terms of these tests. However, many coefficients are both economically and statistically insignificant. Therefore, exclusion restrictions are used to simplify this general model into a parsimonious, economically interpretable and statistically significant ECM. The F-test, the standard error of the regression and Schwartz criterion are used to check the model reduction process. The report on the model reduction progress did not reveal any problem implying that the simplification process is statistically viable[15].

The reduced model is reported in Table 4. The misspecification tests are reported in footnotes of the table. The errors autocorrelation AR, ARCH error, non-normal error, heteroscedastic error and model misspecification are rejected. The restricted ECM seems to perform well in terms of these diagnostic tests and

reasonably tracks the data. The estimated dynamic equation explains 61% of the variation in inflation. The coefficient on the error-correction term on the foreign sector, α_2 is statistically significant. This implies that foreign prices, measured in domestic currency, determine inflation in the long run.

Given that the error-correction term affects both the price level and its rate of change, other things being equal, a 1% increase in foreign price tends to raise domestic price by 1% in the long run. The adjustment process towards this equilibrium is very slow. About 4% disequilibrium is removed by adjustment in domestic price per quarter. In addition, a considerable short-run pass-through from exchange rate depreciation and foreign price increase affect the dynamics of inflation. The coefficient of the nominal effective exchange rate entered contemporaneously and with two lags suggesting that depreciation of the exchange rate causes inflation to rise[16] and foreign price entered with a coefficient of 0.43.

These results are consistent with those obtained by Mahran and Gangi (1996) and Mahran (1999). Other studies show that generally high inflationary environment — as in the case of Sudan — leads to high exchange rate pass-through to domestic price. For example, Choudhri and Hakura (2001) found in a cross-country panel framework that there exists a positive and significant correlation between inflation rates and the size of the pass-through. Other studies on CPI inflation also find immediate and long lasting impact of the foreign sector on inflation (Robinson, 1996 and Devereux, 2000).

Table 4. Estimation Results of the Restricted ECM for Inflation in Sudan [a, b]

Regressors	Estimated Coefficients	Regressors	Estimated Coefficients
$\Delta pt-2$	0.165** (2.17)	Δpf	0.431** (2.16)
$\Delta m2$	0.175* (1.72)	$[pf+e-p-4.021]t-1$	0.038** (2.11)
$\Delta m2t-3$	0.266** (2.61)	Constant	0.037* (1.71)
$\Delta pct-5$	-0.066** (-2.44)	sc1	0.001 (0.026)
$\Delta premt-1$	-0.078* (-1.90)	sc2	0.088** (4.67)
$\Delta premt-5$	-0.072** (-2.63)	sc3	0.105** (6.13)
Δe	0.113** (3.13)	D1	0.065* (1.70)
$\Delta et-1$	0.118** (2.02)	D2	0.082** (2.22)
$\Delta et-4$	0.067* (1.71)		

T = 126 (1970, Q1 - 2002, Q4); R^2 =0.61; σ = 0.06461and DW = 2.11
AR 1 — 5 F (5,104) = 0.54308 [0.7432]: Test for serial autocorrelation of residuals (H0: no autocorrelation)
ARCH 1—4 F(4,101) = 1.9120 [0.1142]: Test for autocorrelation conditional heteroscedasticity (H0: no heteroscedasticity).
Normality χ^2 (2) = 3.3750 [0.1850]: Test for normality of distribution of residuals (H0: normality)
Xi*Xj F(27,81) = 0.80866 [0.7283]: Test for heteroscedasticity (H0: no heteroscedasticity)
RESET F (1,108) = 0.14186 [0.7072]: Test for general misspecification of equation (H0: no misspecification)

[a] The variables sc1, sc2 sc3 are centered seasonal dummies. D1and D2 are dummies over 1984, Q3 - 1985, Q1 and 1993, Q3 - 1994, Q3 respectively, taking the value of one over the specified quarters and zero otherwise.
[b] Figures enclosed in parenthesis are t-statistics. Asterisks* and ** denote significance at 10% and 5% level, respectively.

Source: Based on Appendix Table A.1.

Excessive money does not appear to determine inflation in the long run as the lagged error correction term on money market, α_1, does not enter the restricted model. However, there may be three reasons for the failure to find significant impact of monetary disequilibrium on short-run inflation dynamics. Firstly, the monetary shocks appear to be more related to shifts in the velocity. Secondly, with a large rural sector and great deal of barter trade, there is a belief that Sudan has been undergoing a process of monetization during the review period.[17]

Finally, the Sudanese monetary authority seems to be limited on the use of the indirect instrument of monetary policy, due to a long-standing accumulation of large excessive reserves in banking sector. All these counts may allow for more accommodative stance without serious long-lasting effects of money growth. Nevertheless, the short-run money growth contemporaneously and lagged, has significant negative effects on inflation, with the sum of elasticities of inflation to money of 0.44%. This finding is consistent with a wide range of literature within the monetarist tradition. The standard explanation of high inflation is expansionary monetary policy.

Independent from the direct effect of money growth, excessive money is also transmitted through the foreign exchange market (Mahran and Gangi 1996). The liberalization of the foreign exchange which is reflected by reduced premium, hence negative Δprem, temporarily increased inflation (Table 4). The expected positive effects of the exchange rates unification in terms of expansion of the export tax base and the enhanced incentives for exporters' tax-compliance, may have happened late in the sample, as from 1999, which may explain the failure to find evidence on the pleasant fiscal consequences of unification. Thus, decontrols of foreign exchange seem to contribute to revenue losses because of the removal of implicit export taxes rather than to revenue gains due to removal of importers subsidies from over-valued exchange rate.

This finding provides evidence on excessive short-run money growth related to the quasi-fiscal deficit of the Central Bank operations driven by the attempts of the authorities to compensate for fall in revenue by an increase in monetary financing. Similar result is reported by Pinto (1991) for other comparators countries. Short-run money growth may also be explained by the attempts of the monetary authority to maintain constant real exchange rate in the face of the continually deprecating nominal exchange rate.

Inflation inertia is found significant, lagged inflation entered with a coefficient of 0.17. The extent of inflation inertia is usually taken as measuring the consequences of indexation or inflation expectations. Price indexation has not been used in Sudan, but administrative price controls were common especially before the 1992 liberalization. Hence, inertia largely reflects expectations, which in the presence of quantity and price controls, might create self-enforcing

expectations of increasing inflation. The reported evidence on deterioration in expectations implies that once inflation is initiated, it tends to have a life of its own. As noted by Calvo (1988), among others, once the public expects high inflation to continue, it may become too costly for the government not to validate the public's expectations.

An attempt is made to control for the impact of real output growth on inflation. Power consumption is entered to proxy real GDP. The result shows that an upsurge in economic activities, as reflected in the growth of power consumption, exerts downward pressure on inflation. The two dummies entered to account for the impact of back-to-back droughts over 1984-85 and 1993-94 are also significant revealing that inflation is linked to large agricultural supply shocks due to crop failures.

Overall, it is evident that inflation in Sudan during the review period, originates from the fiscal imbalances triggered by the aborted investment boom associated with the inflows of FDI in the mid 1970s and is propagated by monetary accommodation to the internal and external shocks and by its own dynamics.

The restricted ECM is estimated recursively with a default sample over 1970, Q1 - 2002, Q4 in order to examine its stability and the constancy of the estimated parameters. The results are shown in graphs.

Figure A1, Panel A, pictures the recursive estimates of the coefficients and their respective ±2 standard errors. As seen from these plots, all the estimated parameters are reasonably stable. Panel B depicts the one-step residuals and their ±2 standard errors as well as the Chow tests statistics. The plot of the one-step residuals suggests that almost all the residuals lie within the ±2 standard error bands indicating the absence of outliers. In addition, the sequence of one step ahead and the breakpoint Chow tests statistics do not reject the stability of the parameters at 1 per cent level.

Figure A2 plots the fitted inflation and actual inflation series. From this figure, it seems that the estimated ECM tracks the movements of inflation very closely even during the period of high inflation. Accordingly, it may be concluded that the estimated inflation model is reasonably stable and tracts actual price growth very well.

Conclusion and Policy Implications

This paper is an attempt to develop a simple analytical framework relevant for inflation determination in Sudan. Three main patterns of inflation developments were identified in terms of the macroeconomic performance and the underlying policy stance. The moderate inflation during the 1970s coincided with a government-led program of ISI based on tariffs, foreign exchange control and credit allocation. Thereafter, a process of very high inflation erupted during the 1980s through the mid 1990s resulting from the continued resort to inflation tax due to drop in foreign financing, the continued civil conflict and the partial failure of the ISI program. However, the reform initiated in 1997— which was further aided by the advent of the oil sector and the inflow of oil revenues— succeeded to bring inflation to single-digit as from 2000. These structural changes would make it difficult to fully gauge the impact of nominal rigidities on inflation. Nonetheless, the analysis established a parsimonious, statistically and economically viable ECM.

The following main conclusions on the proximate determinants of inflation may be formulated:

- Firstly, the analysis confirmed the existence of long-run relationships for the foreign exchange market and the money market tending to govern price level in the long-run.
- Secondly, disequilibrium in the external market appears to exert a long-run effect on inflation, and the adjustment to this disequilibrium is very slow. Moreover, the short-run feedbacks from the nominal effective exchange rate and foreign prices movements to inflation are rather rapid. Such rapid pass-through is attributable to the continuous devaluations during the review period which led to some cost-push mechanisms from imported raw materials, particularly that the consumer-industries in Sudan contain insignificant local value added. Continuous devaluations can also generate expectations of sustained future movements in the same direction. It also serves as an excuse for producers to adjust price upwards even for unconnected reasons.
- Thirdly, excess money does not seem to determine inflation in the long run. However, money growth significantly affects the dynamics of inflation. The short-run money growth may be attributed to the direct monetization of

the fiscal deficit and to the liquidity impact of the exchange rate unification working through the quasi-fiscal deficit of the Central Bank. It could also be explained by the attempts of the monetary authority to maintain constant PPP in the face of the continually deprecating nominal exchange rate.

- Finally, the consecutive large agricultural supply shocks due to droughts are found to have significant impact on the dynamics of inflation. In addition, deterioration in inflation expectations ─ within adaptive expectations/ distributed lag specification ─ is found significant.

The analysis in the paper may be further improved in a number of directions. Firstly, as the ECM shown in Table 4 is chosen from seven equations, and it is selected from eight models including the reference, still other channels of monetary transmission may be studied especially those working through the exchange rate and money supply equations. Secondly, the precise price transmission mechanism in Sudan requires further investigations, especially in the context of the structural shifts late in the sample following the advent of the oil sector, that could have influenced the process of price formation. There is also a need for the analysis of the impact of these structural changes on the choice of the monetary instruments and, more importantly, on the transmission channels of monetary policy shocks. Finally, although the paper controls for the effects of droughts through dummies, further refined measures of these effects on agricultural production and food price inflation can be more informative. Notwithstanding these limitations, the next section briefly highlights the policy implications of the findings.

Policy Implications

The existence of long-run link between exchange rate and prices and the significance of external sector disequilibrium on inflation dynamics as well as the short-run pass-through from the exchange rate on inflation, suggest that the exchange rate is a crucial transmission channel for the monetary policy to prices in Sudan. This also highlights the absence of a well functioning alternative transmission instrument such as the cost of capital. Despite the immediate inflationary effect of unification, the policy of defending the exchange rate reform, made possible by build-up of foreign reserves from oil revenues, had contributed to bring inflation down.

However, as suggested by the findings, the exchange rate-based stabilization may not be sustainable in the long run due to the sluggish adjustment of the real exchange rate towards equilibrium. Even in the face of the presence of rigidities, sectoral disequilibria and inertial factors which often result in accommodative monetary policy, the authorities need to fully develop sound indirect monetary instruments to supplement the policy of exchange rate anchoring.

The stabilization experiences in Latin America show that in situations of fiscal indiscipline ─ as the case of Sudan during most of the review period ─ flexible exchange rate provides more fiscal discipline (Tornell and Velasco, 1995). For example, under money-based anchoring of inflation, the fiscal authority pays for high deficit today by enduring high inflation both today and in the future (Sargent and Wallace, 1981). In contrast, with exchange anchoring, the bulk of the fiscal burden is pushed to the future.

Although the study does not control for the short-run transmission channels of monetary policy, it appears that money supply grows in response to exchange rate depreciation, which in turn negatively impacts inflation. If this is the case, the design of monetary plan for inflation control may be based on a hybrid regime of exchange rate and monetary targeting. This strategy can augment exchange rate flexibility─ hence leading to more fiscal discipline ─ and can lay the base for full inflation targeting. Such monetary plan could easily be adapted to keep inflation under control while maintaining external competitiveness.

The main problem with this strategy is that the authorities may have the discretion to move from one target to the other. The conflict between rule and discretion is not easy to resolve. Building and maintaining reputation and credible commitment are crucial elements for any policy. It is arguable that Sudan has a history of monetary policy errors. Developing experience in gauging the effects of monetary policy on inflation is of cardinal importance especially in the context of the currently operating Islamic banking system.

Policies for GDP growth and low inflation in Sudan need to ameliorate the impact of the supply shocks. As shown, supply shocks driven by droughts are important determinants of inflation. The agricultural sector weighs high in the economy and the source of food staples, but remains subject to the vagaries

of weather and inappropriate trade policies that compromise its competitiveness. Hence, a serious national policy of buffer stock of staple food can ensure price stability. Obviously, additional measures to enhance agricultural supply and productivity, including sound exchange rate and trade policies, are crucial for GDP growth and low inflation.

Footnotes

(1) These policy failures are not exclusively Sudanese. Similar policy failures and macro crises have been documented for the Sub Saharan African countries over the 1970s and 1980s (McKinley, 2001 and the references cited therein).

(2) In general, a variable is said to be integrated of order n if it needs differencing n times to render stationarity; i.e. to be integrated of order zero; written I(0).

(3) Elbirt and Domac, 1998 and the literature cited therein.

(4) See Balassa (1964) and Samuelson (1964).

(5) See Hendry (1993) for an overview.

(6) It is known the ADF have low power for testing in small samples, the PP is non-parametric test and robust to general forms of heteroskedasticity in the error term, (see for example Pesaran and Peseran, 1996).

(7) These testing results are not reported to conserve space.

(8) See Pesaran and Pesaran (1996) for an overview.

(9) These test results are not reported to conserve space.

(10) Henceforth, the calculated chi-square statistics is followed by the symptomatic p-value in parentheses.

(11) Numbers in parenthesis are asymptotic standard errors.

(12) Testing for weak exogeneity is important in a system of error correction equations. It is known that if the error term does not enter the long term equation for one variable, then this variable is considered weakly exogenous, and therefore it can be dropped out of the system without affecting the statistical properties of the test statistics of hypotheses about the cointegrating vector (Engle et al, 1983).

(13) See for example Lucas (1973).

(14) Numbers in parenthesis are asymptotic standard errors.

(15) These testing results are not reported to conserve space.

(16) From the definition of the nominal effective exchange rate used in the paper, positive sign indicates depreciation.

(17) World Bank, 2003, Chapter 2.

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Appendix: Definitions of Variables and Data Sources

Y: is income measured by Gross Domestic Product. Source: The Sudanese Statistical Bureau

P: is the general price level measured by the Consumer price index, the weighted average indices of the lower middle and upper income groups, 1990 = 100 Source: IFS and the Sudanese Statistical Bureau.

M1: is nominal narrow money. Source: IFS.

M2: is nominal broad money. Source: IFS.

Parallel exchange rate: is period average, defined as a unit of the domestic currency per US dollar. Source: Pick Currency Year Book during the period 1970, Q1 - 1993, Q4. The relevant pages were provided by Jantz, R.; Alexander Library, Rutgers University and over 1994, Q1 - 2001, Q4 compiled from Bank of Sudan.

Official exchange rate: is period average, defined as a unit of the domestic currency per US dollar. Source: Bank of Sudan.

PREM: is the parallel market premium for foreign exchange rate, defined as the ratio of the parallel exchange rate to the official exchange rate.

E: is the author's calculation of the nominal effective exchange rate index:

computed as; $E_{it} = \sum_{j=1}^{n} w_j \dfrac{E_{ijt} * 100}{E_j\, 1985}$, where wij is the trade share of Sudan (denoted by country i) with respect to its jth trading partners, with $\sum_{j=1}^{n} w_{ij} = 1$, and Eit is the index of effective exchange rate of country i. Eijt is the market rate of exchange of the ith currency in terms of the jth currency, with the dollar being used as a numeraire currency. Eij1985 is the average value of Eij over the quarters in 1985 and n is the number of trading partners. From this definition, it follows that an increase in the index records depreciation. The main trading partners for Sudan considered were: United Kingdom, Japan, Slovak Republic, Thailand, Turkey, Saudi Arabia, India, Singapore, Egypt and USA. Source: IFS. The parallel exchange rate for Sudan is obtained from various editions of the Pick Currency Year Book and the Bank of Sudan.

Pf : is the author's calculation of the foreign price index of Sudan, (denoted by country i), defined as the weighted average of the CPIs of its main trading partners computed as $P_{it}^{f} = \sum_{j=1}^{n} w_j\, p_j$. The same weights and trading

partners, used in the calculation of E are applied in the computation of this index.

PC: is an index of power consumption measured by the quantity consumed of dezil, gasoline, Benzene and gas (in thousand metric tons of oil equivalent). Source: The Sudanese Ministry of Energy and Mining.

π: is constructed as: $100*(P – P(-1))/P(-1)$.

Table A.1. Estimation Results of the General (EC) Model for Inflation in Sudan [a]

Regressors	Estimated Coefficients	Regressors	Estimated Coefficients
Δp_{t-1}	-0.225 (-0.747)	Δe	0.123* (1.74)
Δp_{t-2}	0.194* (1.71)	Δe_{t-1}	0.220** 2.71
Δp_{t-3}	0.020 (0.180)	Δe_{t-2}	0.0168 (0.203)
Δp_{t-4}	-0.059 (-0.521)	Δe_{t-3}	-0.112 (-1.43)
Δp_{t-5}	0.067 (0.594)	Δe_{t-4}	0.127 (1.45)
$\Delta m2$	0.0767 (0.556)	Δe_{t-5}	0.115 (1.38)
$\Delta m2_{t-1}$	-0.0298 (-0.212)	Δp^f	0.316 (1.23)
$\Delta m2_{t-2}$	0.182 (1.24)	Δp^f_{t-1}	-0.083 (-0.330)
$\Delta m2_{t-3}$	0.309** (1.96)	Δp^f_{t-2}	0.226 (0.887)
$\Delta m2_{t-4}$	-0.157 (-0.987)	Δp^f_{t-3}	0.127 (0.491)
$\Delta m2_{t-5}$	-0.111 (-0.766)	Δp^f_{t-4}	-0.088 (-0.366)
Δpc	0.029 (0.900)	Δp^f_{t-5}	-0.140 (-0.582)
Δpc_{t-1}	-0.044 (-1.30)	$[m-p-y+0.999*\pi]_{t-1}$	0.002 (0.506)
Δpc_{t-2}	-0.007 (-0.178)	$[p^f+e-p-4.021]_{t-1}$	0.024 1.02

Regressors	Estimated Coefficients	Regressors	Estimated Coefficients
Δpc_{t-3}	0.005 (0.127)	Constant	0.035 (1.06)
Δpc_{t-4}	-0.005 (-0.155)	sc1	-0.014 (-0.477)
Δpc_{t-5}	-0.059* (-1.68)	sc2	0.078** (2.66)
$\Delta prem$	-0.015 (-0.254)	sc3	0.097** (3.86)
$\Delta prem_{t-1}$	-0.127** (-2.05)	D1	0.060 (1.43)
$\Delta prem_{t-2}$	0.043 (0.685)	D2	0.089* (1.80)
$\Delta prem_{t-3}$	0.105* (1.70)		
$\Delta prem_{t-4}$	-0.074 (-1.10)		
$\Delta prem_{t-5}$	-0.129** (-2.03)		

continue.....

T = 126 (1970, Q1 - 2002, Q4); R^2 = 0.67; σ = 0.0675 and DW = 1.9.
AR 1─ 5 F(5,78) = 1.8561 [0.1117]: Test for serial autocorrelation of residuals (H_0: no autocorrelation)
ARCH 1 ─ 4 F (4,75) = 0.66589 [0.6177]: Test for autocorrelation conditional heteroscedasticity (H_0: no heteroscedasticity)
Normality χ^2 (2) = 1.6869 [0.4302]: Test for normality of distribution of residuals (H_0: normality)
Xi*Xj   F(79,3) = 0.062995 [1.0000]: Test for heteroscedasticity (H_0: no heteroscedasticity)
RESET F (1,82) = 0.027521 [0.8686]: Test for general misspecification of equation (H_0: no misspecification)

[a] The variables sc1, sc2 sc3 are centered seasonal dummies. D1and D2 are dummies over 1984, Q3 - 1985, Q1 and 1993, Q3 - 1994, Q3 respectively, taking the value of one over the specified quarters and zero otherwise. And t-statistics are in parentheses. Asterisks ** and * denote significance at 5% and 10% level respectively.
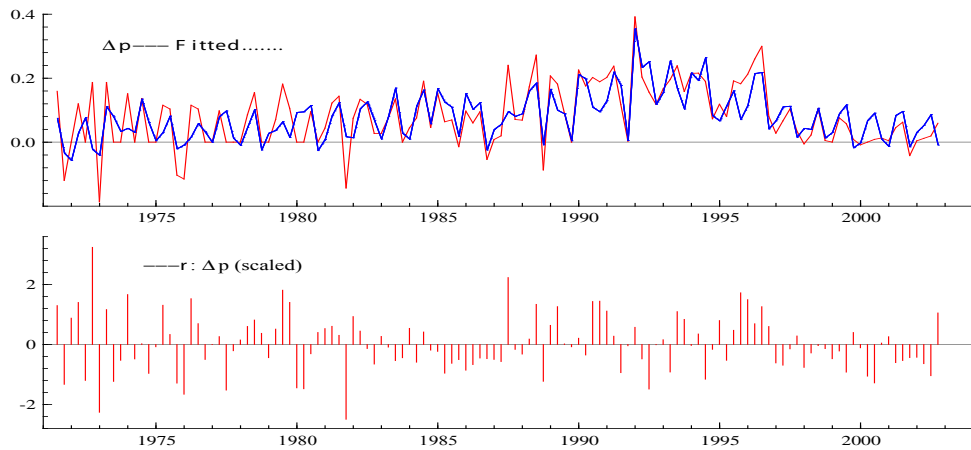
Source: Based on estimation of Equation 7. See Appendix A for variables definitions.

Figure A1. Recursive residuals; 1-step Chow Tests and Break-Point Chow Test
(1980, Q1 - 2002, Q4).
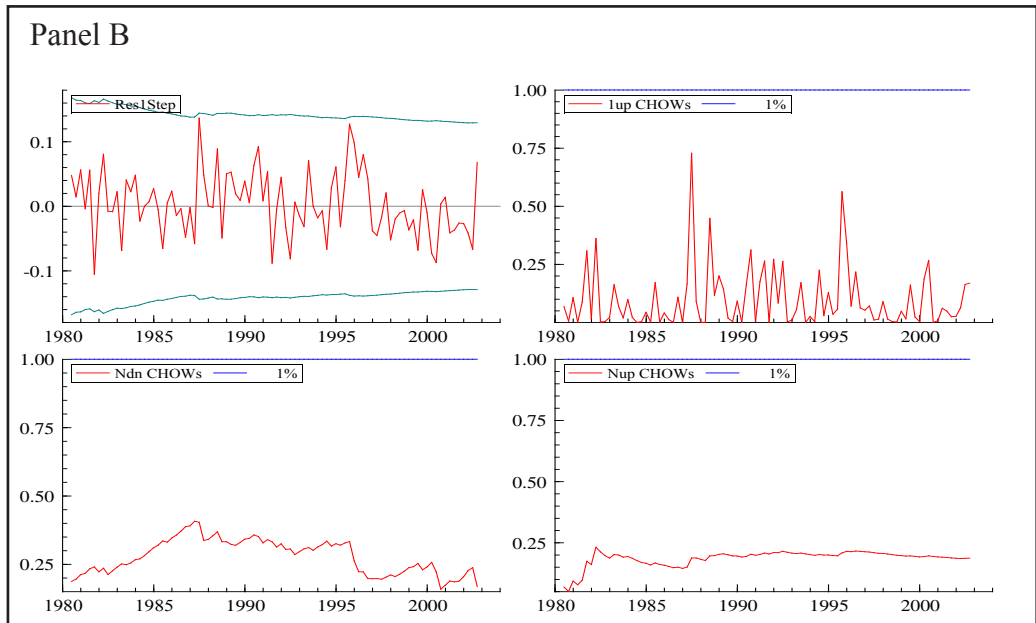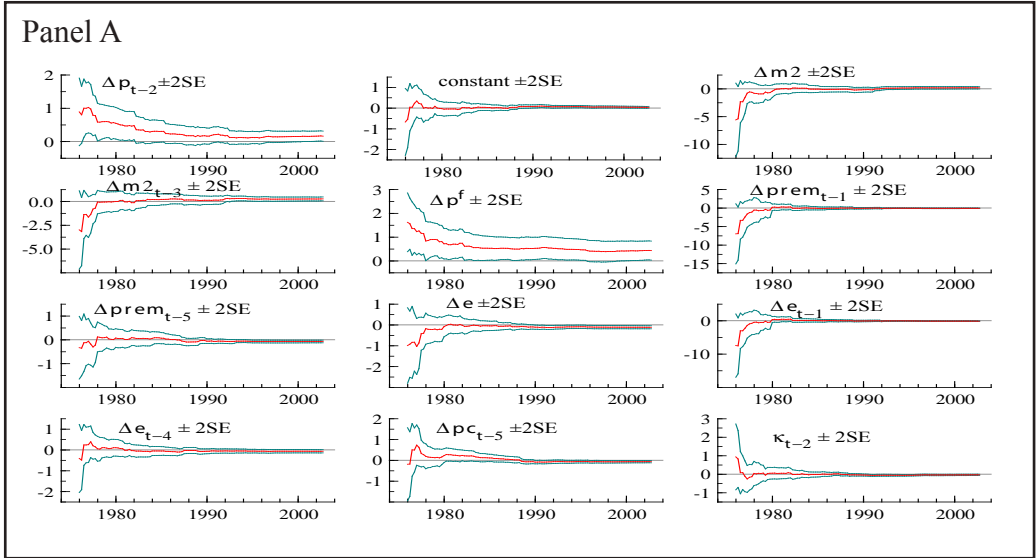
Source: Based on recursive estimation of the reduced model of Equation 7.

Figure A2. Fitted and actual inflation (1970, Q1 – 2002, Q4).

Source: Based on recursive estimation of the reduced model of Equation 7.