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Monetary Growth and Exchange Rate Depreciation as Causes of Inflation in African Countries

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Abstract

A common issue in adjustment programs in Africa is whether inflation is due primarily to excessive monetary growth or to exchange rate depreciation. In this paper, vector autoregression analysis is used to separate the influence of monetary growth from exchange rate changes on prevailing and predicted rates of inflation. Granger casuality tests were conducted to determine direction and significance levels for key variables, and lag lengths were set based on the Schwarz criterion. The sample covers ten countries: The Gambia, Ghana, Kenya, Nigeria, Sierra Leone, Somalia, Tanzania, Uganda, Zaïre, and Zambia. Variance decompositions suggest that monetary dynamics dominate inflation levels in four countries, while in three countries, exchange rate depreciations are the dominant factor. While clearer separation of the relative effects may be due to the use of VAR analysis, changes in policy stances over the sample period complicate the resolution of relative effects. Developing a variable to measure policy shifts in a country's policy stance may be difficult.

I. Introduction

Inflation has become a significant problem for Africa during the past fifteen years. Since the first oil shock in the mid-1970s, African inflation rates have averaged more than 15 percent a year. For Sub-Saharan Africa, the average inflation rate has been closer to 20 percent a year. A few Sub-Saharan countries have even experienced inflation rates of 50 or even 100 percent a year.

The emergence of substantial inflation in Africa has led to widespread debate about its causes. Many economists that favor traditional adjustment strategies contend that monetary growth, arlsing particularly from the domestic bank financing of large budget deficits, is the major source of inflationary pressures. By contrast, some critics of the traditional approach, such as the United Nations' Economic Commission on Africa (UNECA) in its "African Alternative Framework for Structural Adjustment Programmes" (UNECA, 1989), have identified exchange rate depreciations as a major factor.

Controversy between these two viewpoints has led to differing prescriptions about the appropriate policy response. Those focusing on monetary factors have emphasized reducing government budget deficits and restraining credit to public enterprises, while advocating exchange rate depreciation to offset any overvaluation resulting from past inflation and deterioration in the terms of trade. Those emphasizing the role of exchange rate depreciation, by comparison, have argued against further exchange rate adjustments, preferring instead a combination of incomes policies, price controls, and demand reduction measures. In addition, the recent literature has begun to emphasize more the linkages between exchange rate policy and other tools for macroeconomic management, noting that a fixed exchange rate can serve as a "nominal anchor" to an economy and thus limit inflation if supported by appropriate monetary and fiscal policies .[1]

Despite its importance, there has been surprisingly little research on the causes of inflation in African countries. As described in this paper, the few empirical studies on this issue have used traditional econometric techniques best suited to identifying whether individual variables are related to inflation. Thus, the relative importance of different factors as causes of inflation remains to be determined.

The purpose of this paper is to explore further the relative importance of monetary growth and exchange rate depreciation as causes of inflation in African countries. To do so, the techniques of vector autoregression (VAR) analysis, which have become popular

1. See, for example, Aghevli and others (1991).

in economic analysis during the last decade, are used. By eliminating the need to develop explicit economic models and thus impose *a priori* restrictions on the relationships among variables, VAR analysis permits a more general test of causation among different economic variables than is possible in conventional econometric analysis[2].

This feature also enables VAR analysis to provide a way for comparing the relative importance of different factors identified as causes of a particular variable. By decomposing the forecast error variance in the dependent variable into portions arising from innovations in different explanatory variables, the relative weight of each factor as an influence on the variable of interest can be determined. Finally, VAR analysis provides a method for comparing the relative power of unit changes in innovatioons of each predetermined variable on the dependent variable, by estimating impulise response functions.

Together, these three components of VAR analysis -- causality tests, the decomposition of forecast error variance, and impulse response functions -- can identify the relative importance of monetary growth and exchange rate depreciation as causes of inflation within individual countries[3]. By searching for long-term relationships between each of these variables and inflation, however, this approach necessarily abstracts from the effects of interactions between these and other components of macroeconomic policy that may themselves have a major bearing on inflation in individual countries. To the extent that changes in the stance of macroeconomic policy, encompassing not only adjustments in monetary and exchange rate policy, but also structural measures, significantly affect inflation rates, long-term empirical relationships between monetary growth or exchange rate adjustment and inflation in individual countries may be less stable. However, if monetary or exchange rate adjustments are the main components of macroeconomic policy, shifts in the policy stance should not obscure underlying relationships between these two variables and inflation.

The plan of the paper is as follows. Section II provides a brief review of trends in inflation, monetary expansion, and exchange rate movements in Africa since the mid-1970s. Section III reviews recent research on the causes of inflation in Africa. Section IV

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2. However, the causality testing normally done within VAR analysis is Granger causality, which has a precise definition and thus some limitations as a standard for determining whether one variable "causes" another (see Cooley and LeRoy, 1985).

3. For further discussion of the use of VAR's to analyze the inflationary process, see Montiel (1989).

presents the paper's empirical findings for 10 countries in Sub-Saharan Africa during the period 1978-89. The first part of this section discusses the results of the Granger causality testing. The next subsection presents the results of the decomposition of forecast error variance in the domestic inflation variable, while the final subsection describes the estimated impulse response functions for each of the explanatory variables. Section V contains a summary of the paper and the main conclusions. An appendix gives details on the tests for unit roots and cointegration of the data, as well as the impulse response functions for each country in the sample.

II. Recent Trends in Inflation, Monetary Growth, and Exchange Rate Movements in Africa

Although data on prices in most African countries must be treated with caution because of limitations in coverage and widespread price controls, the available information suggests that African countries have experienced considerable inflation during the past two decades. As shown in Table 1, the average annual inflation rate for all of Africa, as measured by changes in consumer price indices, averaged 15 percent during 1971-80 and 17 percent during 1981-88[4]. For Sub-Saharan Africa, the rates were somewhat higher: the comparable values for the two sub-periods were 17 and 20 percent, respectively. The average inflation rates for all African countries during the past two decades were larger than for developing countries in Asia and the Middle East and far exceeded those for the industrial countries. Only for developing countries in the Western Hemisphere and, during the 1980s, for those in Europe were average inflation rates higher than those in Africa.

Disaggregating the data on African inflation by countries suggests that African countries can reasonably be subdivided into two groups from the standpoint of inflation performance: a group of 12 countries for which annual inflation rates averaged roughly 20 percent or more during 1975-88, and a second group of 35 countries in which average inflation rates during the period were roughly 10 percent a year (Greene, 1989)[5]. This disaggregation reveals some interesting relationships among trends in inflation, monetary expansion, and exchange rates in African countries.

As shown in Table 2, which is also taken from Greene (1989), average rates of monetary growth, the average percentage change in net domestic bank credit to

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4. The data in this table are taken from Greene (1989).

5. The 12 high-inflation countries are Ghana, Guinea, Guinea-Bissau, Mozambique, Nigeria, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Zaïre, and Zambia.

government (measured relative to the broad money stock at the start of the year), and the average depreciation in the nominal effective exchange rate were all significantly higher in the 12 high-inflation African countries than in the remaining African countries with more moderate inflation rates. The growth rate of broad money in the high-inflation countries averaged more than 10 percentage points above that in the more moderate inflation countries. However, both groups of countries exhibited significant rates of monetary expansion, averaging more than 13 percent a year even for the countries with lower inflation rates.

Table 2 also reveals relatively more exchange rate depreciation in the higher-inflation African countries, where the nominal effective exchange rate depreciated on average by 18.5 percent a year during 1981-88, compared to 0.7 percent for the countries with more moderate inflation rates. There was little difference between the two groups of countries in average government budget deficits, measured as a ratio to gross domestic product (GDP), or in import unit values measured in U.S. dollars[6]. However, the average growth rate of net domestic bank credit to government was 9 percentage points higher during 1975-80, and 11 percentage points higher in 1981-88, in the high inflation African countries than in the African countries with lower inflation rates. The implication is that fiscal imbalances generate inflation mainly through their effect on monetary expansion (i.e., to the extent they are financed by domestic bank borrowing), rather than through the size of the deficit *per se* relative to GDP.

The foregoing observations suggest there may be a close connection among monetary growth, exchange rate depreciation, and inflation performance in Africa. Indeed, regressions of inflation rates in these two groups of African countries suggest that both monetary growth and exchange rate depreciation are positively and significantly related to the inflation rate (Greene, 1989). However, because in some countries changes in monetary growth and exchange rate adjustments may have occurred in response to past inflation, such evidence does not indicate clearly whether these developments can be said to have caused inflation in African countries.

III. Recent Research on Inflation in African Countries

In addition to Greene (1989), a number of other empirical studies of inflation in Africa have appeared in the last few years. Most of these, however, have succeeded only

6. The lack of significant difference in import unit values among countries may be because of a basic similarity in the composition (mainly fuel and manufactured goods), and geographic origin (mostly from Europe) of imports in most Sub-Saharan countries.

in confirming the role of monetary growth and/or exchange rate depreciation as being among the causes of inflation, rather than testing which of these variables appears to have had more impact on African inflation rates.

London (1989), analyzing the experience of 23 African countries for the period 1974-85, found considerable support for the role of exchange rate adjustments as well as monetary growth in explaining inflationary developments. In this study, both cross-section and time-series regressions indicate that models of inflation based solely on monetary expansion and real income growth (which is related negatively to the inflation rate) leave sizable portions of the inflationary process unexplained. Moreover, the addition of a bilateral exchange rate variable appears significantly relate to the rate of domestic inflation during the period 1980-85. Chhibber and others (1989), looking specifically at Zimbabwe, where data on wage costs and interest rates were also available, identified unit labor costs and interest rates in addition to the exchange rate, foreign prices, monetary growth, and real income growth as factors explaining inflation. Tegene (1989), using Granger and Pierce causality tests, found evidence of causation running from monetary expansion to inflation in six African countries. Finally, Agenor (1989), examining trends in inflation in four African countries, has identified an important role for parallel market exchange rates, as compared to official rates, and monetary expansion in explaining both the decomposition of the forecast error variance of inflation rates and in estimating the response of the inflation rate to unit shocks to each of these variables.

Except for Tegene and Agenor, the studies thus far have all employed traditional econometric techniques, which involve estimating structural economic models and are therefore subject to the usual problems of invalid restrictions and specification error. The Tegene and Agenor studies, which use VAR analysis, in principle avoid some these difficulties. But Tegene has examined only the basic causal relationships between monetary growth and inflation, while Agenor's paper focuses on the decomposition of forecast error variance in inflation, and then only for a very few countries. In addition, the variable in Agenor's paper that appears most important in explaining variations in the forecast error of inflation, the parallel market exchange rate, is not one over which policy makers have a direct influence. Rather, it is determined by, among other factors, anticipated devaluation and actual and projected rates of monetary growth. None of these studies thus provides conclusive evidence of whether monetary expansion or devaluation matters more as a cause of inflation in Africa.

IV. Empirical Results

To examine the relative importance of monetary growth and exchange rate depreciation in Africa, Granger causality tests and a decomposition of the forecast error variance in inflation rates were performed and impulse response functions were estimated using quarterly data for a representative sample of 10 Sub-Saharan African countries -- the Gambia, Ghana, Kenya, Nigeria, Sierra Leone, Somalia, Tanzania, Uganda, Zaïre, and Zambia--over the period 1978-89, with the exception of Uganda, for which published data for all three variables were only available for the years 1981-86[7]. These 10 countries were chosen to represent a range of African experience with inflation, with the Gambia and Kenya exhibiting more moderate rates of inflation, generally ranging from 5 to 15 percent annually, and the other eight experiencing considerably higher inflation rates.

Domestic inflation in this study was defined as the percentage change in each country's major consumer price index (CPI), this being the only price series available for all ten countries. The bilateral exchange rate vis-a-vis the U.S. dollar was used as the exchange rate variable, to reduce the recording of depreciation from changes in cross-rates between the dollar and other currencies rather than from discrete devaluations[8]. For the monetary variable, Ml was chosen as a good compromise between an aggregate subject to direct policy control, such as the monetary base, and one sufficiently broad to be a reasonable measure of monetary holdings in the economy, such as M2- In three countries, however, unit root tests revealed that domestic credit, but not Ml, was stationary at the level of first differencing. Accordingly, in these countries (Somalia, Tanzania, and Zaire) domestic credit was used in place of Ml.

To obtain stationary data on which to perform the analysis, the various price, money, and exchange rate series were tested for unit roots and cointegration. Vector autoregressions were estimated on the various series in both log level and in log first difference form, and the resulting VARs indicated unit roots for virtually all the series in the former but not the latter, with the exception of Zambia (Appendix Table A -1)[9].

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7. The data were taken from the Fund's **International Financial Statistics** data bank.

8. Most of the ten countries were pegged to the U.S. dollar for large portions of the observation period and made discrete exchange rate adjustments vis-à-vis the dollar.

9. As shown in Appendix Table A-1, at the 1 percent significance level, unit roots could be ruled out for log level data only in the case of Nigeria for the price level and Kenya for the exchange rate. At the level of first log differences, except for Zambia, unit roots could be eliminated for all variables except the price level in Sierra Leone. Thus, there is some risk of

In the case of Zambia, the data proved stationary only at the level of second differencing (i.e., the change in the change of the log of the price level, etc.). Accordingly, the subsequent analysis was performed on data in log first differences for nine of the ten countries, and for log second differences in the case of Zambia. As shown in Appendix Table A-2, cointegration among variables could be ruled out at the 1 percent level for all but one combination of variables (between prices and exchange rates in Somalia), based on tests with a null hypothesis of no cointegration[10], although at lower levels of significance cointegration between a few pairs of variables and, in the case of Sierra Leone, among all three variables, could not be ruled out[11]. Thus, it did not seem necessary to include error correction terms in the subsequent analysis.

In addition to stationarity and cointegration, it was also important to correct for seasonality, which is characteristic of price series in most countries and monetary data in many African countries, because of fluctuations in credit associated with crop financing cycles. To avoid introducing serial correlation, the data were not transformed by taking fourth-quarter differences. Instead, the following method was used. The price data were de-seasonalized by introducing seasonal dummies wherever an F-test indicated that they were jointly significant at the 10 percent level or greater. Because the same procedure cannot be used for predetermined (i.e., right-hand-side) variables, the monetary data were de-seasonalized into log level form (i.e., before differencing) using the exponential smoothing technique in the RATS computer program. This procedure requires choosing a deterministic trend in the series to be smoothed. For this exercise, the trend was assumed to be linear, and seasonality was assumed to be additive.

1. Granger causality analysis

Granger causality tests were performed on the data in two ways: bivariate tests, involving either a monetary aggregate and consumer prices or an exchange rate variable and consumer prices; and trivariate tests, involving a monetary aggregate, an exchange rate variable, and consumer prices simultaneously. Of these two tests the trivariate

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overdifferencing in the case of Kenya and Nigeria, and nonstationarity in the case of Sierra Leone.

[10]. These tests have relatively little power, however, so in some circumstances, analysts also test using the null hypothesis that cointegration is present.

[11]. Cointegration could not be reuled out at the 10 percent level or better between prices and money in Ghana, prices and the exchange rate in Nigeria, Sierra Leone, and Somalia, or between money and the exchange rate in Nigeria and Sierra Leone.

analysis is probably more useful, because only in trivariate regressions can the relative effects of monetary and exchange rate variables be compared.

The number of lags used in the analysis was determined in the following way, using the Schwarz criterion[12]. Because the sample contained a number of high inflation countries in which exchange rate and monetary shocks were likely to affect prices fairly quickly, lags were assumed to fall between 1 and 4 quarters. Early experimentation with longer lag lengths (of up to 8 quarters) yielded results that may have reflected the greater likelihood of outliers and quirks in the data[13] .

Both the bivariate and trivariate analyses were performed using uniform lag lengths for each variable within a regression (i.e., the same number of lags for all explanatory variables appearing in the equation). However, in the bivariate regressions different lag lengths were used in the regressions of prices on the exchange rate and of prices on the monetary variable in all but three of the countries (Ghana, Nigeria, and Uganda). In addition, the number of lags was permitted to vary across countries, to allow for differences in structural characteristics. To test for causality the Granger F-test, which is the most widely-recognized approach, was used, although experimentation with two alternatives (the Sims test and the Sims-Geweke-Dent test)[14] revealed that results may be sensitive to the type of test used (Doan, 1988). The final lag lengths are reported in Table 3 (bivariate VARs) and Table 4 (trivariate VARs).

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12. The Schwarz criterion is very similar to the more common Akaike information criterion, both of which are asymptotically equivalent to a procedure in which one starts with a maximum lag length and then reduces the length until the coefficient on the last lag is found to be significant. The Schwarz criterion tends to select shorter lag lenghts than the Akaike, which was useful for the present analysis because of the relatively short sample period of the data. However, using the Akaike criterion would have led to longer lag lengths in only 4 of the 20 bivariate regressions, and only 2 of the 10 trivariate regressions. In only 1 of these 6 instances would more than one additional lag have been added. For further discussion of the Schwarz criterion, see Doan (1988).

13. Longer lag lengths could cause a regression to reflect coincicdences such as a large devaluation occurring, for example, two years before an unrelated inflationary surge. This could lead to a spuriously significant coefficient on the eighth lag of the exchange rate in a regression with the CPI as the dependent variable.

14. For a comparison of these three tests, see Griliches and Intriligator (1984, pp. 1122-33).

a. Bivariate tests

Table 3 summarizes the results of the bivariate Granger analysis. Entries indicate at which lags the hypothesis of no Granger causality can be rejected at various significance levels. As indicated in Table 3, Granger causality from the exchange rate to prices cannot be rejected for three of the 10 countries (Kenya, Sierra Leone, and Zaire) at the 5 percent significance level, and at roughly the 10 percent level for a fourth country (Tanzania). Granger causality from prices to the exchange rate, by comparison, appears to hold at the 5 percent significance level in the case of Ghana. In 5 countries Granger causality can be ruled out in either direction between the exchange rate and prices at the 10 percent level: the Gambia, Nigeria, Somalia, Uganda, and Zambia.

As regards money, Granger causality cannot be rejected at the 5 percent significance level for three of the 10 countries (Sierra Leone, Somalia, and Uganda), and at about the 10 percent level for a fourth country (the Gambia). Causality from prices to money cannot be rejected at the 10 percent level for two of the 10 countries (Ghana and Uganda). One country exhibits two-way causality between money and prices at the 10 percent level or better (Uganda). Overall, causality between money and prices in either direction can be ruled out at the 10 percent level for 5 countries (Kenya, Nigeria, Tanzania, and Zambia).

Except for Sierra Leone, in countries where money appeared to cause prices, exchange rates did not, and vice versa. Thus, money, but not exchange rates, appeared to be a significant cause of prices in the Gambia, Somalia, and Uganda, while exchange rates but not money were a significant cause of prices in Kenya, Tanzania, and Zaïre. These results are not surprising in view of the history and policy choices of some of these countries. For example, in Somalia the official exchange rate remained unchanged from the mid-1970s through 1981, while monetary aggregates increased enormously. By comparison, during most of the sample period Kenya's authorities had a deliberate policy of depreciating the real exchange rate, while Zaïre's exchange rate has been determined through a floatlng interbank market. The case of Zaïre is particularly interesting, however because bilateral tests indicate that monetary impulses appear to cause exchange rate changes, which suggests that the ultimate cause of price changes may be monetary impulses after all.

In two countries Nigeria and Zambia, bivariate Granger tests indicate causation neither between prices nor exchange rates and money, and in neither direction, at the 10 percent significance level, although causation from money to prices could not be ruled out at the 15 percent level in the case of Nigeria. In both these countries the lack of significant relationships may reflect the relatively moderate rate of inflation during much of the sample period and the absence of maior exchange rate changes during the first half of the sample period. In Zambia, the need to use second differences to obtain stationary data may also have reduced the chances of finding Granger causality, if the underlying causal relationship is from monetary or exchange rate developments to the inflation rate, rather than to the rate of change in the inflation rate.

b. Trivariate tests

Table 4, which summarizes the results of the trivariate Granger causality tests, yields similar indications of causality between money or exchange rates and consumer prices in these countries. In four countries Granger causality cannot be rejected between the exchange rate and prices (the Gambia, Sierra Leone, Tanzania, and Zaïre) at the 10 percent level or better. A fifth country (Ghana) exhibits causality from prices to exchange rates. Regarding money, three countries show evidence of causality from money to prices (the Gambia, Sierra Leone, and Uganda). In two countries (Ghana and Kenya causality from prices to money cannot be rejected. In addition, in Zaïre, there is evidence that causality may run from money to exchange rates as well as from exchange rates to prices, suggesting an underlying causality from money to prices not picked up in the direct Granger causality test. Three countries show no causality either way between money and prices (Nigeria, Somalia, and Zaïre) at the 10 percent significance level.

Overall these results are quite similar to those of the bivariate analysis. The main differences are that in these tests exchange rates significantly cause prices in the Gambia rather than in Kenya, while causality from money to prices is no longer significant at the 10 percent level in Somalia. At the same time, there is indication of possible causality between exchange rates and prices in the case of Zambia, althougl the results are not significant at the 10 percent level. This may be consistent with the observation that inflation began to accelerate in Zambia during the mid-1980s, after the exchange rate was depreciated more often.

2. Decomposition of Variance in the Forecast Error of Inflation

Another way of examining the relative importance of monetary variables and exchange rate movements on inflation involves decomposing the variance of the forecast error of inflation (the difference between actual values of inflation and those forecast from the known values of the predetermined variables) into the shares explained by innovations in the price level, money, and exchange rates[15]..This involves (l) transforming the trivariate VARs described in the previous section into moving average representations and (2) orthogonalizing the residuals to eliminate the covariances among the shocks to each explanatory variable, thereby isolating the relative impacts of each variable.

Because many orthogonalizations are possible, and each one attributes any correlation between two residuals to the one appearing first in the orthogonalization, the ordering of the explanatory variables may affect their apparent impact. Accordingly, the results, based on the standard Choleski procedure and shown in Table 5, are reported with two possible orthogonalizations (using the orderings Money Exchange Rates-Prices, or M-E-P, and Exchange Rates-Money-Prices, or E-M-P)[16]..Orderings beginning with the inflation variable (P), which by definition is considered the most endogenous of the three variables, are not reported. The orderings are reported at the 40th step ahead, well after the results appear to have stabilized (in most countries the results approached their final values after 3 or 4 steps). As noted in Table 5, only for 1 country (Sierra Leone) did the ordering of variables noticeably affect the results.

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15. For a further discussion of this procedure, see Sims (1980). Montiel (1989, pp. 535-37) provides an example of its application to the analysis of inflation.

16. The Choleski procedure seems appropriate in this case because the small number of variables under consideration makes it less risky to overlook elements that do not appear in the lower triangle of the transformation matrix and would be considered under other procedures, such as thos in Bernanke (1986).

Table 5

Percentage of Variance in Consumer Prices Explained by Innovations in Money (M), Exchange Rates (E), and Prices (P) at the 40th Step Ahead

	Ordering of Variables						
Country	**M**	**E**	**P**	**E**	**M**	**P**	Dominant Variable or Variables
Gambia	26	13	61	12	27	61	P, M
Ghana	15	6	79	4	17	79	P, M
Kenya	8	23	69	23	8	69	P, E
Nigeria	21	1	78	1	21	78	P, M
Sierra Leone	43	27	30	49	21	30	E or M[1]
Somalia	22	4	74	4	22	74	P, M
Tanzania	4	7	89	7	4	89	P
Uganda	65	5	30	6	64	30	M, P
Zaire	12	31	57	35	8	57	P, E
Zambia	5	25	70	25	5	70	P, E

1. Depends on ordering of variables

The variance decompositions suggest that for most of the 10 countries, inflation is explained largely by its own innovations, with some assistance from either innovations in exchange rates or monetary expansion. In all but two countries (Sierra Leone and Uganda), innovations in prices themselves explained over half the decomposition in variance of consumer prices. In four of these countries (the Gambia, Ghana, Nigeria, and Somalia), innovations in money represented the second largest component of the decomposition, generally contributing 17 to 27 percent of the variance in the forecast error in inflation. In three countries (Kenya, Zaïre, and Zambia), exchange rates explain the second largest component of the variance, accounting for about 25 to 35 percent. Each of these countries is one in which exchange rates, but not monetary growth, had a significant impact on prices in the Granger causality analysis. In one county, Tanzania, the contributions of money and exchange rates to the variance in the forecast error of prices were both very small, less than 10 percent.

For one country in the sample, Uganda, monetary innovations explained more than 60 percent of the variance in consumer prices. This result is consistent with theobserved close relationship between rapid monetary expansion and high inflation in Uganda. In the case of Sierra Leone prices were subordinate to money or the exchange rate as a source of forecast error variance in inflation, with the most important variable depending on the ordering in the orthogonalization.

That innovations in prices might explain the bulk of the forecast error variance in inflation in a country is not a unique observation. Leiderman (1984), for example, found a similar result for his analyses of Colombia and Mexico, although in the case of Mexico monetary innovations explained more than 40 percent of the overall forecast error. The exclusion of certain variables from the VARs, such as output growth or wage changes, the latter of which is not readily available in most African countries, may have contributed to the high percentage of variance attributable to innovations in prices themselves. At the same time, an index of import unit values (measured in U.S. dollars) for all of Africa did not provide a significant contribution to the VAR's[17] .

Finally, the short lag lengths that proved optimal in most of the trivariate VARS -- l quarter, except in the cases of Ghana (3) and Zaïre (2) -- may also have contributed to the small percentage of the variance decompositions represented by money and exchange rates. The reason is that exogenous factors may play a heavier role in the variance of inflation over a short period. One such factor may be short-term climatic variations, which have a significant effect on domestic food prices that, in turn, represent a major component of the overall consumer price index in most African countries. Over a longer number of lags, the variance in prices is more likely to be correlated with the aggregate impact of monetary growth and exchange rate adjustments.

3. Impulse response functions

As a further indication of the effects of monetary growth and exchange rate changes on inflation in these countries, impulse response functions were estimated, based on the same trivariate regressions used to perform Granger causality tests and the variance decomposition analysis described above. These functions show the effect of a 1 standard deviation shock to the orthogonalized residual of the monetary, exchange rate, and inflation variables on the future path of the inflation rate in each country. A summary of the results appears in Table 6, and diagrams of the impulse response functions themselves appear in the appendix.

As shown in Table 6, the results generally show a large initial response to a one standard deviation shock in the consumer price index that very quickly dropped off, with smaller responses to exchange rate and monetary shocks that took somewhat longer to decay. In 6 of the countries the responses decayed fully after about 10 quarters. In three

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[17]. Import unit values for individual countries, which might have differed from the aggregate for all of Africa, might have made a contriburtion to the VAR's, but were not available for every country in the sample.

countries (Ghana, Somalia, and Tanzania) the functions needed about 13 quarters to return to the baseline. Only in one country (Uganda) had the functions not fully decayed after 16 quarters. However, in virtually all countries the impulse response functions displayed a tendency to move in an unexpected direction, with positive shocks to money, exchange rates, and sometimes consumer prices triggering temporary reductions in prices at certain lag lengths. In three countries (Ghana, Uganda, and particularly Zambia) the impulse response functions exhibited noticeable cycling, with the response of prices to shocks in the predetermined variables shifting from positive to negative and back again before the functions fully decayed. Milder cycling was evident in the response functions for most of the other countries.

Table 6.

Dominant Variable (Money or Exchange Rate) in Impulse Response Functions of Money (M), Exchange Rates (E), and Prices (P) on Prices

	Ordering of Variables	
Country	M - E - P	E - M - P
Gambia	M [1.]	M [1.]
Ghana	E [2.]	E [2.]
Kenya	P [3.]	P [3.]
Nigeria	P [4.]	P [4.]
Sierra Leone	M [5.]	M [5.]
Somalia	E [6.]	E [6.]
Tanzania	P	P
Uganda	M [7.]	M [7.]
Zaïre	E [2.]	E [2.]
Zambia	M [8.]	M [8.]

1. P has the most impact initially; M, at 2 quarters; and E, thereafter.
2. P has the greatest impact initially and E, thereafter. Direction of impact cycles for all variables.
3. P has the greatest impact for the first 2 quarters and E, thereafter. Impact of E is negative after quarter l; for M, after quarter 2.
4. P has the greatest impact through the third quarter and E, thereafter. Impact of E is negative for quarters 2 through 8.

5. P has the greatest impact initially and E, during the next two quarters. Direction of impact cycles for all variables through quarter 8.
6. P has the greatest initially and E, from quarters 3 through 16.
7. P has the greatest impact initially; impact of E and M cycles.
8. P has the greatest impact for the first two quarters and M, thereafter. Impacts of all 3 variables cycle through quarter 8.

The negative movements and cycling observed in the impulse response functions are hard to interpret and may suggest some instability in the underlying VAR's. The failure of Uganda's impulse response functions for exchange rates to decay fully within four years may reflect the limited data available for the country and the considerable turbulence of prices, monetary aggregates, and exchange rates in Uganda during the sample period.

V. Conclusions

The results of this study support the view that both exchange rate movements and monetary expansion affected consumer price changes in a number of Sub-Saharan African countries. Both the bivariate and trivariate Granger causality tests suggest that exchange rates had a significant causal impact on prices in Sierra Leone, Tanzania, and Zaïre. The same was true in the bivariate tests for Kenya and in the trivariate tests for the Gambia. As for money, bivariate and trivariate Granger tests identified money as having a significant causal effect on prices in the Gambia, Sierra Leone, and Uganda. In addition, there was evidence of causality from money to prices in the bivariate tests for Somalia. Finally, money appeared to have a significant causal impact on exchange rates in Zaïre, suggesting that the underlying causality in that country was from money to prices, perhaps via adjustments in the exchange rate. In two countries, Nigeria and Zambia, Granger causality tests identified neither money nor exchange rates as significantly causing prices. At less-than-conventional levels of significance, however, there was some indication of causality from money to prices in Nigeria and, for trivariate analysis, from exchange rates to prices in Zambia.

The variance decompositions of inflation suggest that neither exchange rate depreciation nor monetary growth had a dominant role in explaining innovations in consumer prices in most of these countries. Except for Uganda, where money accounted for the preponderance of the decomposition variance, and in Sierra Leone, where the relative importance of exchange rates and prices depended on the ordering of the variables, prices themselves explained more than half the variance in consumer prices in the sample countries. This suggests either a shortcoming in the analytical approach, or that some variable other than monetary growth or exchange rate adjustment - perhaps structural bottlenecks generating price rises in specific sectors - served as the major cause of inflation in most of these countries.

In four of the remaining countries (the Gambia, Ghana, Nigeria and Somalia) money explained more of the remaining variance than did exchange rates, while in three (Kenya, Zaïre, and Zambia) the opposite was true. In one country, Tanzania, neither money nor exchange rates explained even 10 percent of the variance in consumer prices. These results are consistent with the Granger causality tests in identifying certain countries, such as Uganda, and perhaps the Gambia and Somalia, where money has a more definite impact than exchange rates on prices, and others (Zaïre, and, arguably, Kenya and Zambia), where exchange rates matter more. However, the failure in all but two countries for either exchange rates or monetary aggregates to explain the bulk of the variance in consumer prices makes it hard to draw general conclusions from this exercise about the roles of money and exchange rates as causes of inflation.

The faillure of this exercise to determine more about the relative importance of monetary growth and exchange rate adjustment as causes of inflation in Africa may reflect inherent methodological problems in VAR analysis. For example, the results of the analysis appear quite sensitive to the selection of monetary and exchange rate variables, the specification of the VAR equations, and even the form of diffferencing of variables to achieve stationarity. However, an earlier exercise, using a broader range of monetary and exchange rate variables different lag lengths, no time trend in the VAR equations, and four quarter percentage changes of the variables (to attain stationarity), also found that countries were more likely to exhibit causality either from exchange rates or money to inflation, with approximately the same number of countries showing causality from each of these variables to prices. In that exercise, somewhat more of the decomposition of the variance in prices was explained either by prices or by money. However, the resulting impulse response functions were considerably more unstable, exhibiting more cycling and generally failing to decay fully within a reasonable period such as four years.

The present analysis, while using a more careful approach to selecting variables and attaining stationarity, did not try to adjust the data for known changes in policy regimes, such as the introduction of substantial exchange rate changes in Ghana, Nigeria, and Zambia during the mid-1980's, or to screen out extreme observations through methods such as Kalman filtering. Adjustments such as these, which would require techniques now on the frontier of time-series analysis, might lead to still different results. Thus, the results described in this paper must be considered very tentative, pehaps only as a first step in using VAR analysis to examine this subject.

One implication of these findings is that the inflationary experience of these countries should be analyzed with econometric techniques and in greater structural detail before drawing broad policy conclusions. In view of the observation by Agenor (1989) that the parallel exchange rate has considerable impact on infiation rates in VAR analyses of some African countries, it might be useful to develop a structural model of the inflationary process that takes account of the effects of monetary shocks, expectations (as reflected in parallel exchange rates), and other, more fundamental determinants of inflation in these countries. Such a model could then be tested to see whether monetary expansion is in fact the underlying variable responsible for the perpetuation of inflation in African countries. One could in addition simulate the effects of monetary expansion and exchange rate depreciation in a country macroeconomic model such as that in Haque, Lahiri, and Montiel (l990), with parameters based on data for African countries. This exercise might also reveal something about the relative effects of monetary growth and exchange rate adjustment on inflation.

Because the exchange rate, and possibly also monetary variables, may reflect the impact of expected future events, testing for Granger causality (which is basically historical in nature) may not be sufficient to address the causation issues motivating this study. Including future values of the monetary and exchange rate variables in the Granger causality tests may help to address this problem. Even with this modification, however, it may be important to have in mind structural models as a way of isolating more clearly the relationships between monetary expansion, exchange rate movements, and the domestic inflation rate.

Finally, as noted at the outset of the paper, it is important to remember that the VAR approach is particularly useful for identifying longterm relationships among variables in an economic structure that is fundamentally stable. If, however, the underlying structure shifts over time, or if it is the combination of exchange rate and monetary policy, in conjunction with other variables, that primarily determines inflation in individual countries, VAR analyses between individual variables such as monetary or exchange rate indicators and inflation will not yield significant results. Because a number of African countries have often changed their macroeconomic stance during the past decade as a result of the implementation and interruption of adjustment programs, it would be interesting to examine whether some broader measure of overall policy stance, rather than monetary growth or excllange rate adjustment *per se*, is the main reason for shifts in inflation in these countries. Developlng a variable to measure shifts in policy stance may, however, be difficult.

Appendix

Tests of Data for Unit Roots and Cointegration

As indicated in the text, vector autoregression (VAR) arlalysis require, the use of stationa;y time series data. Under current practice, developing such data requires that observed data series be tested for unit roots, i.e., whether the coefficient in the following equation estimated via least squares is at least equal to, and not than less than one, with the former case implying unit or explosive roots[18.] .

$$\Delta y_t = \mu + \beta_t + \alpha y_{t-1} + \sum_{i=1}^{k} C_i \, \Delta y_{t-i} \quad ,$$

where the number of lags (K) is selected by identifying the highest number of K for which a coefficient of O on c_K can be rejected, beginning with the maximum number of lags used for the lnalysis (in our case, 8). In this equation, a linear time trend has been included to take into account the tendency of most of the data series to increase steadily over time. With K identified, the resulting estimate of α is analyzed via the augmented Dickey-Fuller test, whereby a value smaller than -3.41 rejects the null hypothesis of a unit root in favor of log-level stationarity, and a value larger than -.94 rejects the null hypothesis in favor of an explosive root.

The above equation, whose results appear in Table A - 1, was estimated for each of 50 data series in our sample: consumer prices, the Ml and M2 aggregates, domestic credit, and the bilateral U.S. dollar exchange rate for each of the lD countries under observation. As indicated in Table A - 1, it is difficult to reject the null hypothesis that virtually all of these time series contain unit roots, i.e., are non-stationary. With a time trend (the βt term) included in the above equation, the hypothesis of a unit or explosive root can only be rejected at the 1 percent significance level for consumer prices in Nigeria and for the bilateral exchange rate in Kenya. At the 5 percent level unit roots could be rejected for the bilateral exchange rate in Zaïre; at the 10 percent level, for the bilateral rate in Uganda. For data in log first differences, by contrast, the Dickey-Fuller test indicated stationarity in most instances. In 7 of the countries (all but Sierra Leone, Somalia, and Zambia) unit roots could be ruled out at the 10 percent significance level or better for consumer prices. The same was true for either Ml or credit in 9 of the

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18. This is equivalent to examining whether a series tends to be time invariant or to show trends over time. In the latter case, the trend must be eliminated through some adjustment of the series to attain stationarity.

countries (all but Zambia) and for the bilateral exchange rate in 8 of the countries (all but Kenya and Zambia). In view of these results, it seemed reasonable to assume the data were stationary in log first differences for every country except Zambia.

For Zambia, tests revealed no unit roots when the data were expressed as log second differences. Accordingly, the VAR analysis was performed on data in log second differences for Zambia.

Although the above tests suggested that it was most appropriate to estimate VAR's with the variables in differenced form, without the inclusion of a time trend, it was important to test for the existence of cointegrating vectors, in which case error-correction terms would be needed in the VARs. Appendix Table A - 2 reports the results of these tests, which involved the following, two-step procedure:

(l) estimating the contemporaneous cointegrating equation with the variables entered in log-level terms:

$$y_t = \mu + \beta_0 t + \beta_1 X_{1,t} + \beta_2 x_{2,t} + u_t$$

(2) using the residuals from the above regression and performing a unit-root, augmented Dickey-Fuller test on the fitted residuals from

$$\Delta\hat{u}_t = \alpha \hat{u}_{t-1} + \sum_{i=1}^{k} C_i \Delta \hat{u}_{t-1}$$

The estimate of Δ in the above equation will be distributed according to the number of variables in the previous equation (three in this case, when a time trend is included), with the null hypothesis being no cointegrating vector. In our case, we tested for cointegration not only among all three variables (prices, money, and exchange rates), but also among pairs of variables (prices and money, prices and exchange rates, and money and exchange rates).

As indicated in Appendix Table A-2, the null hypothesis of no cointegration among all three variables could not be rejected at the 1 percent level for any of the countries, although it could be rejected at the 5 percent level for Sierra Leone. Among the bivariate tests of cointegration, the null hypothesis of no cointegration could be rejected at the 1 percent level only in the case of prices and the exchange rate for Somalia, at the 5 percent level in the case of prices and the exchange rate for Sierra Leone, and at the 10 percent level in the case of prices and money for Ghana, prices and the exchange rate for Nigeria, and money and the exchange rate for Nigeria and Sierra Leone. Given these results, it seemed reasonable to difference all the data series once (except for Zambia, where the data were twice differenced), and to run all the resulting VAR's without time trends, to provide for consistency across the various series. Although this may lead to over-differencing for the few series that did not appear to have unit roots, the rejections of unit roots for these series were not particularly strong.

Table A-2.

Results of Cointegration Tests[1.]

	Trivariate	CPI-M	CPI-E	M-E
Gambia	-1 . 90	-1 . 52	-2 . 36	- 2 . 27
	4	8	7	4
Ghana	-2.59	-3 . 66 *	-1. 79	-1. 62
	2	0	1	3
Kenya	-3.44	-2.50	-1.72	3.14
	0	0	1	0
Nigeria	-3.52	2 . 83	-3 . 64 *	-3 . 48 *
	8	8	8	6
Sierra Leone	-4 . 48**	-2 . 49	-4 . 20 **	-3 . 54*
	0	6	0	0
Somalia	-2 . 81	-2. 31	-5 . 51***	-1 .69
	6	6	5	0
Tanzania	-2.16	-1.59	-2.11	-1.79
	8	8	8	6
Uganda	-2 . 29	-2 . 81	-1 . 62	0 . 17
	0	0	2	0
Zaïre	-1.10	-1.98	-1.05	-2. 01
	6	6	8	3
Zambia	- . 28	- . 93	1 . 00	-1 . 50
	6	6	8	3

1. All tests were performed on data in log levels and contained a time trend, except for Zambia, where the data were tested in 108 first difference form with no time trend. The top entry in each cell is the t-statistic on the lagged dependent variable in the unit root regression on residuals from the cointegration regression. The bottom entry in each cell is K, the number of lagged differenced residuals on right hand side of equation, chosen according to Campbell and Perron (1991). Critical values from Engle and Yoo (1987) to test for cointegration are as follows:

Number of Variables	Significance Level		
	1%	5%	10%
2	-4 . 32	-3 . 67	-3 .28
3	-4 . 84	-4 . 11	-3 .73

* = Reject hypothesis of no cointegration at the 10 percent level.

** = Reject hypothesis of no cointegration at the 5 percent level.

*** = Reject hypothesis of no cointegration at the 1 percent level.

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