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Money, Meat, and Inflation: Using Price Data to Understand an Export Shock in Sudan

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Abstract

Sudanese inflation dramatically fell in 2000. But just prior to the sharp decline, an export ban was placed on Sudanese livestock. Motivated by this clue, and in the absence of any reliable income or employment data, this paper systematically develops simultaneous models of the consumer price index (CPI) and the exchange rate to assess the economic impact of the export ban. It finds that livestock exports play a large economic role as an important source of income and as a store of value. In the long run, livestock exports are positively associated with nonfood inflation. In the short run, food price movements are negatively associated with livestock exports: to help smooth income, lower food prices generate increased livestock exports. Therefore, unable to export livestock, farmers may have flooded the local market with meat, lowering food prices. Moreover, the loss of income and the decline in wealth lowered aggregate demand, leading to the decline in nonfood prices.

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I. Introduction

In the second quarter of 2000, an export ban was placed on Sudanese livestock due to an outbreak of Rift Valley Fever in the region. In Sudan the livestock sector accounts for about 20 percent of GDP and roughly 15 percent of the value of total exports. These statistics suggest that the ban may have had a substantial macroeconomic impact. But the export ban's impact may have differed significantly from a straightforward terms of trade shock. In many African countries such as Sudan, where financial markets are underdeveloped, households use livestock as an asset to smooth consumption over time. Therefore, the loss of livestock export markets may have dramatically diminished the value of household wealth denominated in livestock and significantly increased poverty. But as in many developing countries, assessing the export ban's impact is encumbered by the absence of reliable and comprehensive economic data.[2]

In a novel approach, this paper uses consumer price data to better gauge the livestock ban's economic impact. This is motivated in part by Figure 1,[3] which shows the quarterly changes in the price level from the first quarter of 1994 to the second quarter of 2001. A sudden and precipitous decline in the price level occurred in mid-2000, around the same time as the imposition of the ban. This suggests that if livestock is used as an asset to smooth consumption over time,[4] then an unexpected decline in its price—an export ban—would lower household wealth and, thus, overall aggregate demand. Because of the substitution effect, the decline in the price of livestock would also lower the relative demand for other goods. These twin effects would then lower inflation. The fall in prices would be magnified if agents expecting high livestock prices, held a large amount of wealth in livestock. The surprise decline in the world price would then have a much larger negative effect on wealth and demand, and thus on inflation. These ideas are formalized in a simple analytical framework.

Empirically, the paper investigates the impact of livestock export revenue on prices within a vector autoregressive framework (VAR). It finds very compelling statistical evidence that the decline in inflation was directly related to the livestock export ban. In so doing, the analysis provides a clearer understanding of livestock's role in the Sudanese economy and helps to identify the channels through which the ban may have affected the economy. In the short run, changes in livestock export revenues are negatively related to changes in food price inflation: an increase in livestock exports is associated with a general decline in food prices. Put differently, this finding suggests that when food prices are low, farmers increase livestock exports in order to supplement their incomes and smooth consumption in the short run. In contrast, there is no

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[2]As an example of poor data quality, according to sources in the ministry of agriculture the last animal census was performed in 1973, so these statistics are in many ways just best guesses.

[3]Note that all tables and figures can be found in the appendix.

[4]See Swinton (1988) for example.

short-run relationship between nonfood inflation and livestock. But there is strong evidence that livestock export earnings are an important source of household income. After controlling for other factors, there is a robust positive long-run relationship between nonfood inflation and livestock, suggesting that over time, increases in livestock earnings increase aggregate demand, leading to higher nonfood inflation.

The impact of the export ban on prices highlights the significant role of livestock in the Sudanese economy and gives some rough sense of the ban's economic impact. The results are also consistent with the literature in this area, which argues that livestock can act as an important buffer commodity in largely agrarian societies without instruments to insure against the impacts of weather-related shocks. Therefore, it can serve as a store of wealth, and in times of poor harvests, livestock sales can help smooth consumption.[5] But much of the literature, with the help of micro level data, has focused on either the functioning of local livestock markets[6] or how livestock holdings affect household behavior.[7] Instead, this paper uses the extreme variation induced by the export ban to understand how livestock income affects macro variables, such as inflation and the exchange rate. In so doing, it is able to provide important macro evidence of livestock's role in determining household income. The paper is also able to make some useful guesses as to the impact of the ban despite the absence of data. In the next section, I develop a simple analytical framework that focuses on how household decisions about livestock holdings affect aggregate demand and the intertemporal behavior of prices. Section III discusses some data related issues, while in Section IV I focus on the econometric arguments.

II. Analytical Framework

This section develops a simple two period model to analyze the impact of an export ban on inflation. For simplicity, the population is distributed uniformly and discreetly over the unit interval, with each agent indexed by her endowment of livestock: $\bar{T}_i$. Agents consume a basket of goods composed of livestock (T) and nonfood items (N). Specifically, the consumption basket in period 1 for agent i is:

$$c_{i1} = T_{i1}^{\alpha} N_{i1}^{1-\alpha} \qquad (1)$$

where $\alpha \in [0,1]$ is the relative weight of livestock in the consumer basket. Ignoring discounting, consumer i's intertemporal utility over the consumption basket is defined as:

[5]See McCown et. al. (1979) and Eicher and Baker (1982) for overviews of this literature.

[6]See Barrett and Luseno (2001) for an example of this literature.

[7]For example, Fafchamps (1998) et. al. consider the extent to which households use livestock sales to smooth consumption.

$$U\left(c_{i1},c_{i2}\right)=\frac{c_{i1}^{1-\theta}}{1-\theta}+E\left\{\frac{c_{i2}^{1-\theta}}{1-\theta}\right\} \tag{2}$$

and θ^{-1} is the elasticity of intertemporal substitution, and expectations are taken over second period consumption. Livestock is the sole storable good and is not only consumed, but is also used to smooth consumption over time.[8] In the first period, livestock is domestically traded, as agents select their optimal consumption of livestock and savings, where the latter is also denominated in livestock. As a result, the first period price of livestock is endogenously determined. In period two agents sell livestock on the world market, taking the world price as given. But in period one the world price of livestock is uncertain and is drawn from a commonly known distribution $F(P)$ with support $P \in [0,\infty)$, and there are no capital or insurance markets to hedge against price uncertainty. Let $P^e = E\left(P_{T_2}|I_1\right)$ denote the expected world price of livestock, given the common information available in period one. Then agent i maximizes expected utility (2) subject to the following budget constraints.[9]

$$\frac{P_{T_1}}{P_{N_1}}\bar{T}_i + w_1 = N_{i1} + \frac{P_{T_1}}{P_{N_1}}T_{i1} + \frac{P_{T_1}}{P_{N_1}}S_{i1} \tag{3}$$

$$\frac{p^e}{P_{N_2}}S_{i1} + w_2 = N_{i2} + \frac{P^e}{P_{N_2}}T_{i2} \tag{4}$$

where $\bar{T}_i$ is agent i's initial endowment of livestock; w_1, P_{N_1} and P_{T_1} are respectively the wage, the price of nonfood and the price of livestock in period one; S_{i1} is agent i's stock of savings at the end of period of t, held in livestock; uncertainty is resolved in the second period, as agents make their second period consumption decisions after the world price of livestock is observed; the nonfood good is used as the numeriare.

The intertemporal consumption profile is determined by the expected inflation rate across both goods, and the elasticity of intertemporal substitution. And unlike nonfood inflation,

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[8]In Sudan, the large majority of the population do not have access to basic financial services, such as banks; thus although the assumption is extreme, it also approximates the experience of many Sudanese farmers.

[9]To keep the analysis as simple as possible, I ignore precautionary saving motive stemming from the uncertainty surrounding the world price. See Kimball and Mankiw (1987) and Zeldes (1989) for a discussion of these issues.

livestock inflation increases both future income and relative prices both across goods and time. To see this more clearly, let

$$R^e = \frac{P^e}{P_{T_1}} \tag{5}$$

$$\pi_N^e = \frac{P^e{}_{N_2}}{P_{N_1}} \tag{6}$$

Then, agent *i*'s intertemporal consumption tradeoff for livestock is given by:

$$T_{i1} = \left[R^e \pi_N^{e-1}\right]^{\frac{-(1-\alpha)(1-\theta)}{\theta}} T_{i2} \tag{7}$$

Result 1: *If* $\theta < 1$, *then in response to an expected increase in the world price of livestock the next period, agents shift livestock consumption to the present. Otherwise, the higher expected income in period two increases that period's consumption of livestock relative to period t.*

Building on this intuition, I derive agent *i*'s optimal savings function:

$$S_{it} = \frac{1}{1+\psi^e}\left[\bar{T}_i + \frac{w_1}{P_{T_1}} - \psi \frac{w_2}{P^e}\right], \tag{8}$$

where:

$$\psi^e = \left(R^e \pi^{e-1}_N\right)^{\frac{-(1-\alpha)(1-\theta)}{\theta}} \tag{9}$$

Thus, the amount of livestock saved is a linear function of current and future income, initial wealth, and the expected inflation rates; the impact of expected inflation on savings behavior depends on θ. For example, suppose $\theta < 1$. Then an increase in expected nonfood inflation reduces the marginal propensity to save, as agents respond to higher future prices by increasing consumption in period one. Agent *i's* demand functions are then given by:

$$T_{i1}^D = \frac{\alpha\psi}{1+\psi}\left[\bar{T}_i + \frac{w_1}{P_{T_1}} + \frac{w_2}{P^e}\right] \tag{10}$$

$$N_{i1}^D = \frac{P_{T_1}}{P_{N_1}}\frac{\psi}{1+\psi}\bar{T}_i + w_1\left[\frac{P_{N_1}(1+\psi)-1}{P_{N_1}(1+\psi)}\right] + \frac{\psi w_2}{RP_{N_1}} \tag{11}$$

$$T_{i2}^{D} = \frac{\alpha}{1+\psi}\left[\bar{T}_i + \frac{w_1}{P_{T_1}} + \psi\frac{w_2}{P^*}\right] + \alpha\frac{w_2}{P^*} \tag{12}$$

$$N_{i2}^{D} = (1-\alpha)\left[\frac{P^*}{P_{N_2}(1+\psi)}\right]\left[\bar{T}_i + \frac{w_1}{P_{T_1}} + w_2\frac{P^* - \psi}{P^*}\right] \tag{13}$$

Note that P^* is the realized world price of livestock in the second period.

To simplify the analysis, I assume that the nonfood good is produced using a competitive technology and all agents supply an inelastic unit of labor to that sector, earning a wage equal to their marginal product. Therefore, the aggregate supply of nonfood goods in period t is given by:

$N_t^s = \lambda P_{N_t}$, where $\lambda > 0$. (14)

To determine their optimal consumption and savings plan, in the first period agents trade livestock conditioned on its expected price in period 2: P^e. At the equilibrium livestock price in period one, $P_{T_t}^*$, the total demand for livestock, both for consumption and savings, equals the total available endowment of livestock in the economy.

$$\sum_{i=1}^{1} T_{i1}^{D} + \sum_{i=1}^{1} S_{i1} = \sum_{i=1}^{1} \bar{T}_i \tag{15}$$

Similarly, the equilibrium price of the nonfood good in the second period, $P_{N_1}^*$ satisfies:

$$N_1^s = \sum_{i=1}^{1} N_{i1}^{D} \tag{16}$$

Equation (17) gives the expected price of the nonfood good in period 2, $P_{N_2}^e$, as an implicit function of the expected world price of livestock, P^e, and prices in period one:

$$\lambda P_{N_2}^e \frac{(1+\psi^e)}{1-\alpha} - w_2\left[\psi^e\left(1+P_{N_2}^e\right)+1\right] = p^e \sum_{i=1}^{1} \bar{T}_i + \frac{w_1}{P_{T_1}} p^e \tag{17}$$

Likewise, equations (18) and (19) define the equilibrium prices of the nonfood good and livestock in period t.

$$\lambda P_{N_1}^2 - w_1 P_{N_1} = P_{T_1}\frac{\psi^e}{1+\psi^e}\sum_{i=1}^{1}\bar{T}_i - \frac{w_1}{1+\psi^e} + \psi^e w_2 \frac{P_{T_1}}{p^e} \tag{18}$$

$$P_{T_1} = \left[w_1 p^{e^{\sigma+1}} \left(\frac{p_{N_2}^e}{P_{N_1}}\right)^{\sigma} + p^e \alpha \right] \left[\left(p^e \sum_{i=1}^{1} \bar{T}_i + w_2 \right)(1-\alpha) \right]^{-1} \tag{19}$$

Therefore, if consumption is relatively elastic over time, then an increase in the expected world price of livestock increases all prices in the economy. Intuitively, a high expected world price of livestock increases expected income and overall demand in the second period. And because of the substitutability of the two goods, it also increases the relative demand for the nonfood good, increasing $P_{N_2}^*$. Working backwards, expecting higher prices in the second period, agents shift consumption into the first period, increasing first period prices as well. Result 2 below summarizes this result.

Result 2: *In equilibrium, if* $\theta < 1$, *then* $\frac{dP_{T_1}^*}{dp^e} > 0, \frac{dP_{N_t}^*}{dp^e} > 0$.

That said, the actual price level in period two depends exclusively on the observed world price of livestock. In period one, the savings and first period consumption decisions have already been made. In period 2, after the realization of P^*, agents face the static problem of allocating income between the two goods. Therefore, apart from the obvious increase in livestock prices, a rise in P^* also increases income, as well as the relative demand for nonfood goods, thereby increasing $P_{N_{t+1}}$. To see this more clearly, Equation (20) gives the second period price of the nonfood good, taking as given the already determined period one variables:

$$P_{N_2} = w_2(1-\alpha) + \left(w_2(1-\alpha) + 4\gamma P^* \sum_{i=0}^{1} S_{i1}\left(P^e\right) \right) \tag{20}$$

The second period consumer price index is: $P_2 = \alpha p^* + (1-\alpha) p_{N_2}\left(p^*; p^e\right)$, where the price variables have been log transformed. It then follows that $\frac{dP_2}{dp^*} > 0$.

The inflation rate positively depends on the realized world price of livestock. But the sensitivity of this relationship is determined by the impact of price expectations on savings behavior. Equation (21) defines the inflation rate, where all variables have been log transformed:

$$\Pi^* = \alpha\left[p^* - p_{T_1}\left(p^e\right)\right] + (1-\alpha)\left[p_{N_2}^*\left(p^*; p^e\right) - p_{N_t}^*\left(p^e\right)\right] \tag{21}$$

Since p^* increases the second period price level, but has no effect on first period prices, it positively effects inflation. But the magnitude of this impact depends on the first period price expectations, for that variable determines savings: the second period stock of livestock. If the elasticity of consumption is very high, then a higher expected price of livestock reduces savings, as agents bring consumption forward due to the higher expected income and to the higher expected future prices. Second period income now contains a lower fraction livestock, and thus, is less sensitive to p^*; and by extension, second period spending and aggregate demand decisions are less dependant on p^*. As a result, inflation would also be less sensitive to p^*. Result 3 summarizes this finding.

Result 3: $\frac{\partial \Pi^*}{\partial p^*} = \alpha + (1-\alpha)\frac{\partial p^*_{N_2}}{\partial p^*} > 0$, *and if* $\theta < 1$, *then* $\frac{\partial^2 \Pi^*}{\partial p^* \partial p^e} < 0$.

This simple framework has shown that the aggregate price impact of the export ban—a sharp unanticipated decline in p^*--depends on the extent to which household income is denominated in livestock at the time of the ban. In turn, the decision to hold livestock wealth depends on the expected world price and on the elasticity of intertemporal substitution. In particular, if agents expected a high world price and $\theta > 1$, then the impact of the export ban: $P^* << P^e$ on inflation would be magnified. For although first period prices would be somewhat lower as households increased savings in expectation of a high second price of livestock, in the second period, a larger fraction of income would be denominated in livestock. Thus, with the ban and the low effective p^* second period income would be much lower than expected. The ensuing large decline in overall aggregate demand and the substitution away from the nonfood good would then lower P_{N_2}, leading to large decline in inflation. Building on these simple ideas, the empirical section of this paper examines the role of livestock in determining inflation. But first, I discuss some features of the data in section 3.

III. The Data

This section describes the data available and considers some of their basic properties. Because Sudan is a low income largely agricultural economy, with a large fraction of household income spent on food, the share of food in the consumer price index (CPI) is almost 60 percent. As a result, the overall CPI displays marked seasonality. Note however that the CPI used in the analysis is only drawn from Khartoum State—the location of the capital. Although the data is not representative of the entire country, most of the commercial and trading activity in the country occurs in Khartoum. Therefore, it does offer a disproportionate level of insight into the factors that affect price behavior in the economy at large. To understand better the factors that shape the CPI, Table 1[10] looks at the weighted percent contribution of each of the CPI

[10]Unless otherwise noted, all tables and charts are in the appendix

components to the overall average annual inflation rate from 1994 to 2000. The inflation rate has been steadily declining, and most components tend to vary around their CPI weights over time; moreover, because the CPI is heavily weighted towards food, food price inflation has been the main source of overall inflation. That said, in the last two years non tradable items such as housing and power, with only an 11 percent weight in the CPI basket, have disproportionately contributed to inflation, while food price inflation has fallen to well below its weighted contribution. This may stem in part from the introduction of certain reforms in the former sectors.

To investigate the determinants of inflation (dp) in Sudan, I use the exchange rate (dx), broad money (dm), livestock export revenues (dl) and the ratio of dollars to broad money—a measure of dollarization (ra), where the latter is intended to be a measure of currency and price expectations.[11] The data is observed at quarterly intervals from 1994 Q1 to 2001 Q2, where the begin date is determined by the availability of livestock data, and all variables are log transformed. Although this interval is relatively limited, as discussed below, it incorporates much variation, as the economy moved from a period of relatively high inflation and a rapid rate of currency depreciation early in the sample to a more stable exchange rate and lower inflation in the last several quarters.

For example, Figure 2 plots the behavior of money growth, changes in the exchange rate, and changes in the rate of dollarization. Movements in all three variables tend to be quite closely linked, and from the beginning of the sample until 1997, there was much instability in the movement of the exchange rate; but in the last several quarters with the continued steadiness in money growth, the currency has been relatively stable against the dollar. That said, after a period of steady growth, the money supply has picked up in the last few quarters and so has the rate of dollarization, where it appears that these two series closely track each other over time. This close relationship suggests that rapid money growth signals some imminent change in the price of the currency, leading to the increased holdings of dollars.

From Figure 1 after several quarters of co-movement with money growth, inflation suffered its steepest decline over the entire sample, beginning in the second quarter of 2000 despite the rapid increase in the money supply, providing a clue about the impact of the livestock ban. Figure 3 plots the change in livestock revenues, food (df) and nonfood inflation (dn). The marked decline in both nonfood and food occurred at about the same time as the export ban, suggesting some relationship between the ban and the behavior of inflation.

Before formally modeling the data, Tables 3 and 4 examine the statistical properties of the series. Table 3 lists the second order adjusted Dickey—Fuller (1981) statistics for the variables dp, dm, dl, dx, ra, df and dn. All variables are $I(1)$. To provide some guidance in

[11] Variables prefixed by the letter d indicate a first differenced representation of the underlying series. Hence, inflation (dp) is the first difference of prices (p): $dp_t = p_t - p_{t-1}$

modeling, Table 4 also reports the cross correlations of these series. As expected, there are high positive correlations between *dx* and both *dm* and *dp*, with the correlation between *dm* and *dn* much higher than between *dm* and *df*, suggesting some asymmetry in the relationship between money and the food and nonfood sectors. Somewhat surprisingly, there are high negative correlations between *ra* and both *dm* and *dp*. And while *dl* is negatively correlated with food prices, it is positively correlated with nonfood prices, inviting the idea of livestock's differential impact on prices. But these correlations are only tentative, and the next section takes a more systematic approach to understanding the data.

IV. Econometric Analysis

Economic theory posits that consumer price inflation can potentially stem from any combination of an excess supply of money, excess demand and wage inflation, as well as movements in the exchange rate or trading partner inflation. And there has been much research focused on identifying the sources of inflation in developed countries.[12] But in small[13] developing countries like Sudan, the systematic modelling inflation is more difficult and has attracted much less attention.[14] Firstly, quarterly data on income do not exist. To proxy for this variable, I include livestock export revenues. This is motivated in part by a need to understand the impact of the export ban on the economy, and by the graphical evidence and high correlation with the inflation measures. But interpreting this variable is not straightforward. In many instances, it may act as a scale variable for output—an increase in livestock export revenues means an increase in livestock production, and thus is negatively correlated with inflation. On the other hand, it is an important source of income and may have a postive inflationary impact. External factors also affect inflation. In an open economy like Sudan, where the U.S. dollar functions like a parallel currency for many transactions, the exchange rate is probably an important determinant of inflation, and perhaps is itself determined by inflation. A related issue is the degree of dollarization. Changes in this variable probably signal changes in expectations about inflation or the exchange rate based on information outside the available data such as political developments or oil discoveries. Thus, including this variable augments the model's information set and increases its explanatory power.

That said, identifying the direction of causality among these variables is difficult. As mentioned before, it is difficult to be certain *a priori* whether exchange rate movements 'cause' inflation or vice versa. Simiarly, with the potential endogeneity of the policy maker's money supply response with respect to inflation and exchange rate movements, treating money growth

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[12]For example, see Juselisus (1994) for the case of Denmark, Surrey (1989) for the U.K, De Bouwer and Ericson (1998) for Australia, and Ericson (1994) for the U.S.

[13]Small is used here to indicate economic size. Sudan is one of the largest countries in Africa.

[14]Liu and Adedeji (2001) analysis of Iran's inflation is a notable exception.

as exgoneous with respect to these variables can lead to inefficient estimation. In addition, there is much valuable information in the long run behavior among these variables. For example, aside from the obvious relationship between money and prices, if livestock revenues is an important economic variable , then over time it should co-vary quite closely with the other variables. Therefore, testing for long run relationships helps in identifying the roles of particular variables.

Motivated by these considerations, I pursue a general to specific modelling approach that first specifies a statistical dynamic system that is congruent with the I(1) data.[15]

$$z_t = \sum_{j=1}^{p} \prod{}_j z_{t-j} + \Phi D_t + v_t \quad v_t \sim IN(0, \Omega) \tag{22}$$

where $z_t = (dp, dm, dl, dx)'$ is a *(4x1)* vector of the I(1) variables,[16] and $D_t = (Seasonals)'$ is a vector of deterministic seasonal dummies. Utilizing $\Delta z_t = z_t - z_{t-1}$, a convenient reformulation of (22) is:

$$\Delta z_t = \sum_{i=1}^{p-1} \Pi_i^* \Delta z_{t-j} + \Pi^* z_{t-p} + \Phi D_t + v_t \tag{23}$$

with

$$\begin{aligned} \Pi_i^* &= \sum_{j=1}^{i} \Pi_j - I \\ \Pi^* &= \sum_{j=1}^{p} \Pi_j - I \end{aligned} \tag{24}$$

This vector autoregression (VAR) approach is used to investigate the cointegration properties of the system.[17] That is, I determine whether as posited by the theory, a long run relationship exists between the inflation rate, money growth, changes in the exchange rate and changes in livestock export earnings. Although the cointegrated relationship is not identified, I

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[15]Tests for innovation of errors are only approximate in I(1) space, but provides a useful guide in practice. Note that I(1) data must be first differenced in order to achieve stationary. See Hendry and Mizon (1993)

[16]Because of degrees of freedom considerations I have excluded dollarization from the system estimation, and use it only as a conditioning variable in the modeling framework. Doing so increases the probability of inefficient estimates as the dollarization rate maybe endogenously determined.

[17]See Johansen (1988) and Johansen and Juselius (1990)

relationship exists between the inflation rate, money growth, changes in the exchange rate and changes in livestock export earnings. Although the cointegrated relationship is not identified, I am able to test various hypotheses about the economy. In particular, I consider the dual role of livestock revenues, for it can operate both as a supply varaible and as an income variable. Therefore livestock's observed impact depends on the information set on which it is conditioned. For example, in the case of non-food inflation, livestock revenues would be expected to act as an income variable, exhibting a postive long run relationship with non-food inflation; in contrast, the reverse should hold for food inflation. There are also questions about the symmetry of the long run relationship between money and food and nonfood inflation.

Testing these hypotheses relies on the idea that in equation (23) since v_t is stationary, the rank ρ of the long run matix Π^* determines how many linear combinations of z_t are stationary. And for $0 < \rho < 4$, there exists ρ cointegrating vectors or ρ stationary linear combinations of z_t. In this case, Π^* can be factored as $\alpha\beta'$ with both α and β being $(4 \times \rho)$ matrices, where the cointegrating vectors of β are the error correction mechanisms in the system, while α contains the adjustment parameters. And heureustically, a variable is weakly exogenous with respect to the model's information set if its adjustment parameter is zero.[18] Building on the exogeneity of certain variables and the stationarity of the long run relationship, I first difference the data, reducing the analysis to I(0) space. I then test for specific structural relationships: the impact of livestock on nonfood and food inflation, the role of the exchange rate and dollarization in determining inflation, as well as the impact of inflation on the exchange rate. I also consider how short run changes in these variables are affected by the deviations from their long run relationships. Moreover, this parsimonious representation of the data is useful both in forecasting and analyzing contrafactuals, thus helping to understand better the impact of the export ban. But first I analyze the factors that influence overall inflation in the long run.

A. Long-Run Structure

The cointegration results for the information set (*dp, dm, dl, dx*) in Table 5 are derived from a VAR with a lag order $p = 1$. Based on the evidence from the tests for autocorrelation and heteroscedasticity, the system does not appear to suffer from misspecification problems. And although there is some evidence of non-normality in the error terms, this statistical system is taken to be reasonably congruent with the underlying data generating process. From Table 5, there are two large eigenvalues and tests suggest that the rank of the matrix is at most two. However, the eigenvector corresponding to the largest and most robust eigenvalue has the most economically sensible interpretation, and I normalize this eigenvector with respect to inflation in Equation 4 below:

$$dp = 1.26dm + 0.39de + 0.03dl \qquad (25)$$

[18]See Engle and Granger (1987) and Hylleberg and Mizon (1989).

Tests on the cointegration space (Table 5, panel C) reject the inclusion of the livestock variable[19] in the long run relationship defined by Equation 4. These tests also support the idea that short run changes in the exchange rate and inflation respond to deviations from the equilibrium relationship in Equation (25). Lagged disequilibrium in the cointegration relation appears to increase the rate of current inflation: 0.40 is the feedback coeffıcent, reflecting in part the period of large and continually increasing inflation rate early in the sample. At the same time, lagged disequilibrium has a negative and large effect on the rate of depreciation: -1.14, indicative of a policy response that uses the rate of drepciation in order to control inflation. Thus, obtaining efficient estimates of inflation requires the simultaneous modelling of the exchange rate. But somewhat surprinsingly, money growth is weakly exogenous with respect to the long run behavior of inflation,[20] suggesting that the money supply growth is not used to target inflation, even over the long run.

Although close to the expected value of one, the long run elasticity of money growth on inflation is significantly greater than one,[21] suggesting that the exclusion of output or some other relevant variable may have biased this coefficient. But in the case of output, it is difficult to deduce the sign of the bias. While the long run relationship between output and inflation is expected to be negative, the long run relationship between money and output growth is largely unknown in Sudan. With the uncertainity surrounding actual ouput in the economy, it is hard to imagine how policy makers could adjust monetary policy to manage output. Aside from omitted variable bias, other factors maybe at work as well. Supply constraints in Khartoum would also produce the observed elastic relationship. For example, an injection of money in an economy with little consumer goods for sale may generate a greater percent change in prices, and I consider this possibility in detail using disaggregated price data. But separately, as a sign of the economy's relative openness, there is a sizable pass through effect in the long run, with a 10 percent devaluation leading to a roughly 5 percent increase in inflation.

The analysis conditioned on the use of overall inflation data offers little support for any impact of livestock revenues on prices in the long run. However, the use of overall price movements may mask the differential impact of livestock revenues and may help explain its non significance in the overall price regression. Increases in livestock exports revenues probably occur simultaneously with increases in the local of supply of livestock, as animals are brought

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[19]The asymptotic null distribution is chi squared with degrees of freedom in parenthesis and the asymptotic p-value in brackets: Chi^2(1) = 1.4461 [0.2292]. See Johansen and Juselius (1990) for the form of the test.

[20]Money growth endogeneity with respect to the system is rejected with a p-value of 0.06. However, when included in the modeling exercise, money is insignificant, with little change to other results.

[21]The hypothesis of unit elasticity between money growth an inflation is rejected with a p-value of 0.00.

to market to be selected for either export or domestic trade . Therefore, increases in livestock exports may be associated with a simultaneous decline in food prices. On the other hand, a positive livestock earnings shock, either through an increase in quantity or world prices would be expected to lead to an increase in aggregate demand. Thus, such a shock maybe inflationary, especially in the non-food sector , where supply constraints and other factors would delay any response in output.[22] And these contrasting effects maybe masked in the aggregate price series.

To better identify these possible transmission mechanisms, I analyze the long run determinants of both nonfood and food inflation. Table 6 presents the results of the food inflation case, and Equation (27) normalizes the eigenvector corresponding to the significant eigenvalue with respect to food price inflation:

$$dfp = 1.28dm + 0.37dx + 0.04dl \tag{26}$$

In many ways these results parallel the previous analysis. The livestock variable is not significantly different from zero[23] and the long run elasticity of food inflation with respect to money growth is significantly greater one.[24] Though slightly smaller, there is also a sizable relationship between exchange rate movements and food inflation; and a 10 percent increase in the rate of depreciation is associated with a 3.7 percent increase in the inflation rate. Moreover, unlike the other variables, the exchange rate is not weakly exogenous with respect to the information set. A 10 percent increase in food inflation above its long run level is associated with a 7 percent decline in the rate of depreciation (Table 6, Panel B), reinforcing the idea that instead of money growth, the exchange rate is the principal inflation fighting tool. Therefore, as in the case of overall inflation, an efficient model of short run movements in food inflation needs to simultaneously consider movements in the exchange rate.

The long run analysis of nonfood inflation generates very different results. The details of the analysis are shown in Table 7, and Equation 6 normalizes the significant eigenvector with respect to nonfood inflation:

$$dn = 4.18dm - 1.31dx + 0.21dl \tag{27}$$

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[22]Indeed, the ongoing civil war has led to the deterioration of Sudan's already limited infrastructure; and with frequent power outages, no access to international capital markets, and little administrative capacity or domestic human capital left, the country no doubt has little ability to increase nonfood production.

[23]Chi^2(1) = 1.4308 [0.2316].

[24]The null hypothesis of unit elasticity between the two variables is rejected: Chi^2(1) = 10.611 [0.0011] **.

The long run elasticity of nonfood inflation with respect to money growth is over three times as great compared to the cases of overall and food inflation. In addition, the impact of exchange rate movements is not only quite large relative to the previous cases, but it is also the opposite sign. And furthermore, this variable is now weakly exogenous given the model's information set. The livestock variable is both highly significant and endogenous, suggesting that livestock exports respond to deviations in nonfood inflation from its long run level. Specifically, the estimated feedback coefficient is quite substantial: –10.97.[25]

This result does lend support to the idea that livestock is an important source of aggregate demand . A 10 percent increase in livestock revenues raises the rate of inflation by roughly 2 percent over the quarter. However, the very large money growth coefficient and the negative sign on exchange rate movements provide some indication of omitted variable bias. The absence of either a comprehensive measure of demand forces, which may be positively correlated with money growth and negatively related to exchange rate movements, or of supply factors, which maybe negatively correlated with money growth and positively correlated with the exchange rate, may account for the observed coefficients.

However, Sudan's low level of income and institutional factors specific to the country may also be at work. Most of the items in the nonfood consumption basket are either non tradables such as housing, education and power or basic imported items like clothing and footwear. But in Sudan, with its widespread poverty, food makes up most of the family budget, and although the nonfood items are important ingredients of daily life, they are often in limited supply and unaffordable, attracting whatever income is left after food expenditures. Therefore, without access to capital markets, extra dollars may produce a variant of money illusion. An extra one dinar of income may prompt the many families who are cash constrained and unable to borrow to purchase essential nonfood items that were otherwise unaffordable,[26] leading to a greater than proportional increase in nonfood prices. In the case of the exchange rate, rapid depreciations maybe correlated with aggregate demand shocks, such as poor harvests or an increase in the intensity of the ongoing civil war, forcing a reduction in expenditures on non-necessary goods, and leading to a decline in nonfood inflation.

B. Short-Run Structure

To impose more economic structure and attain greater parsimony, I estimate a stationary representation of the system for the case of overall inflation. Without any loss of information I use money growth and livestock—weakly exogenous variables—as conditioning variables in

[25]This is significantly different from zero, with a Chi^2(1) = 9.4297 [0.0021].

[26]Suppose for instant that footwear cost 1 dinar, but income is exhausted after providing for food and shelter. If all families receive an extra 2 dinars in nominal income, it may well be possible that the price of footwear would double to dinars, as families spend the extra income of footwear.

the system estimation. In addition, I include the cointegrating vector defined by Equation (25) in order to capture the impact of inflation disequilibria on the short run behavior of the modeled data. These results are depicted in Table 8. To obtain congruence with the underlying data generating process, I estimate the system with a lag order of 2. There is some evidence that short run price movements negatively respond to disequilibrium in the long run relation. And unlike the long run case, the money price relationship in the short run is unit elastic. In the case of the exchange rate, changes in money growth appears to be the only significant determinant of exchange rate movements.

However, while these results are suggestive, restricting both equations to be identical may not be economically sensible and unnecessarily reduces the available degrees of freedom, especially given the small sample size. To this end, Table 9 presents a parsimonious model[27] that fits the data reasonably well (see Figure 4) and is stable over the period of the export shock (Figure 5).[28] Confirming the previous OLS estimates, the full information likelihood estimates show that changes in inflation are negatively related to its estimated long run relationship in Equation (25). In the previous quarter, a ten percent increase in the inflation rate above the long run level is associated with about a seven percent decline in the current change in inflation. In addition, there is also robust evidence of a short run relationship between money and prices, although this relationship is significantly less than the expected unit elasticity. But there is no evidence of a link between either dollarization—a measure of expectations— or livestock revenues and short run movements in prices. Thus, it appears that the short run behavior of prices is effectively characterized by changes in money growth, deviations in inflation from its long run equilibrium path and seasonality factors.

In contrast, both the contemporaneous growth of dollarization and changes in livestock revenues lagged by the two quarters have a positive and significant effect on the rate of depreciation. But it is not surprising that the former is positively related to the rate of depreciation. After all, an increase in the demand for foreign currency would be expected to put pressure on the exchange rate. The importance of livestock revenues to the Sudanese economy is underscored by its positive impact lagged by two quarters on the rate of depreciation. In particular, a 10 percent rise in livestock export earnings implies a 0.2 percent increase in the rate of depreciation. With livestock revenues accounting for about 15 percent of hard currency earnings, this result tentatively suggests that a positive livestock shock leads to higher income, which with some lag, precipitates a significant increase in consumption, especially of imports; the effect of which is then reflected in exchange rate movements. The long run behavior of inflation also affects exchange rate movements. A 10 percent rise in inflation above its

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[27]Note that in keeping with the general to specific methodology, this model parsimoniously encompasses its predecessors, as the LR test of over-identifying restrictions is rejected: Chi^2(24) = 32.7507 [0.1094]

[28]As a measure of model stability, Figure 5 compares the dynamic forecasts of the model with the actual series. Note that the actual series is well within the forecast error bands.

estimated long run level suggests a 3.6 percent increase in the rate of depreciation. In addition, there is also a net positive short run (two quarters) relationship between price changes and movements in the exchange rate. But independent of price movements, the analysis indicates that short run changes in money growth also positively affect the rate of depreciation. Indeed, the relationship between the two variables is unit elastic. Given that exchange rate movements tend to reflect inflation differentials, the positive association between money growth and exchange rate movements may reflect expectations about future inflation conditioned on the current behavior of the money supply.

I repeat a similar modeling exercise for disaggregated inflation data.[29] Table 11 depicts the FIML results for the case of food inflation: (*ddf, ddm, ddl, ddx*). Note that the model again fits the data well and is stable over the export ban (see Figures 6 and 7).[30] While changes in livestock revenues are unrelated to price movements in the long run, it does have a significant negative effect on short run changes in inflation. This result is consistent with the idea that changes in livestock export revenues are closely related to changes in the domestic supply of livestock. And a 10 percent rise in livestock export revenues is associated with a 0.3 percent deceleration in the movement of food prices. This helps to explain why the decline in food prices coincided with the export ban. Unable to export livestock, pastoralists may have flooded the local market with livestock, leading to the observed sharp decline in food prices.

Of course, since livestock export revenues is a nominal value, and does not only include the actual volume of animal exports, the 0.3 percent figure probably understates the true positive relationship between the export volume of meat and its domestic supply. In Sudan, farmers tend to bring their livestock to central markets, where middle men select the livestock suitable for export; the remaining livestock is sold on the local market. Therefore, it seems likely that an increase in export revenues stemming from increase in livestock volume would have a sizeable effect on the local supply of meat beyond that suggested by the coefficient. In addition to livestock effects, changes in money growth also has the expected positive effect, though the size of the impact is somewhat less than the long run effect. Moreover, short run movements in food prices are positively related to deviations in food prices from their long run relationship. While the biases due to omitted variables may explain this finding, it may also reflect the long term threats to food supply disruptions due to the frequent and sometimes long lasting droughts, as well as from the civil war. For instance, while a drought will push food prices above its long run level, the expected short run supply increase as a result of the higher prices maybe hampered by the difficulty of transporting food to the affected areas, as well as by the ongoing conflict itself, further forcing prices up in the short run as well.

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[29]LR test of over-identifying restrictions: Chi^2(12) = 14.9162 [0.2461].

[30]Note that towards the end of the sample period, the fit of the model (food inflation) deteriorates.

Movements in the exchange rate are unrelated to movements in food prices, but instead are quite strongly associated with changes in money growth. A 10 percent increase in the acceleration of the money supply is associated with a roughly 12 percent increase in the rate of depreciation. Again, rapid increase in the money supply portend inflation, as well as it may also signal political instability or budgetary problems, leading to an increased relative demand for dollars. Changes in livestock revenues has a negative effect on short run exchange rate movements, but this may mechanically reflect the price effect. That is, increases in livestock export revenues help lower food inflation, and thus may reduce the rate of depreciation. But somewhat surprisingly, conditional on food prices exchange rate movements exhibit a statistically robust seasonal pattern over the sample interval, with the rate of depreciation increasing in the first half of the year. This seasonal pattern roughly coincides with the behavior of food prices, reflecting the importance of that sector to the overall economy. Moreover, the country's lack of access to capital markets further tightens this relationship, as it is unable to either insure against food shocks, or finance their effects on the budget.

The FIML modeling of nonfood inflation and livestock export revenues are shown in the lower panel of Table 7. As Figures 8 and 9 indicate, the nonfood model fits the data well and is stable. From the cointegration analysis, the money and exchange rate variables were found to be weakly exogenous with respect to the system's information set. There is little evidence that short run movements in nonfood inflation respond to disequilibria in the long run relation. Instead, the variable appears to be autoregressive, as information both about the current economic state and expectations maybe contained in lagged inflation, rather than in long run disequilibria. Also, short run inflation movements are also very sensitive to the rate of dollarization in the economy, for consumers may increase their holdings of dollars in anticipation of higher positive shocks to core inflation. Note that this result is robust to the inclusion of the exchange rate and money growth changes, where short run movements in nonfood inflation are also largely driven by one quarter lagged changes in the rate of depreciation and the contemporaneous growth in the money supply; in fact, the money growth coefficient is not statistically different from one. Hence, the information contained in the dollarization variable may emanate from outside these channels; perhaps dollarization captures either excesses in aggregate demand side or political or budgetary weakness. Unlike the food inflation, there is no apparent seasonality in the behavior of nonfood prices.

Interpreting the livestock revenues equation is difficult. From Figure 9, the model is naturally unstable over the period of the unexpected export ban. Also, because the standard error of the regression is quite high, and the endogenous variables explain little of the short variation in livestock revenues, there is the real possibility that the significant findings may well be statistical coincidence. For example, economic and political shocks that are either the result or the cause of economic and political turbulence may disrupt shipping and transportation, and help explain livestock export revenues' large negative elasticity with respect to both inflation disequilibria and money growth. But for this interpretation of the results to be consistent, the sign of the exchange rate coefficient should be negative! Surely, economic and political shocks would also be correlated with rapid depreciations, leading to a negative association between the two variables.

V. CONCLUSION

Motivated by the need to understand the impact of the livestock export ban on the Sudanese economy, this paper has systematically developed stable models of the Sudanese overall, food and nonfood CPI, as well as models of the exchange rate. And despite data shortcomings, the models developed have been robust and encompassing, and have revealed much about the Sudanese economy. The results indicate that increases in livestock exports are associated with an increase in the local supply of meat, and a concomitant decline in food prices. Over the long run, however, increases in livestock export revenues positively affect nonfood inflation, highlighting the importance of livestock as an important consumption smoothing asset. Thus, the export ban, by increasing the local supply of meat and lowering income played a large role in the observed decline in both food and non-food inflation. Its significant negative impact on inflation, and the link between livestock and the exchange rate suggest that the ban may have had a large economic impact as well. But without household level or employment/income data, it is difficult to quantify its effects.

The models also shed some light on the workings of the Sudanese economy, providing an important framework for policy advice. In the long run, the evidence suggests that exchange rate policy, rather than the monetary policy supply, has been the principal inflation fighting tool. However, in the short run there is a clear circular relationship between the exchange rate and inflation, with both positively feeding into each other. Moreover, money supply growth appears to influence contemporaneous exchange rate movements independent of price behavior. Given the very large estimated relationship between money and prices, economic agents appear to use current money supply growth as a forecast of future inflation differentials and adjust their present holdings of foreign currency accordingly. Therefore, these findings strongly suggest that in addition to the exchange rate, monetary policy may also be a highly effective policy tool in controlling inflation.

A.1 Tables and Figures

Table 1. Sources of Average Annual Inflation, 1994 Q1–2001 Q2 (in percent)

	1994	1995	1996	1997	1998	1999	2000
Inflation	116	68	133	47	18	16	3
Food, drink, tobacco	62	57	72	56	71	41	48
Clothing, shoes	2	3	3	3	2	3	2
Housing, electricity, water, charcoal	6	17	9	14	3	30	29
Household	3	4	3	2	8	1	-3
Health care	1	1	1	1	0	1	1
Transport, communication	10	7	3	10	3	9	1
Entertainment	0	1	1	2	5	5	9
Education	2	1	2	3	0	2	3
Miscellaneous	12	9	6	10	7	10	9

Table 2. Variables Used in the Analysis

Variable	Description
dp	Overall inflation
df	Food inflation
dn	Nonfood inflation
dm	Money growth (M2)
dx	Change in the exchange rate
dl	Change in livestock export revenues
ra	Ratio of foreign currency to M2

Sources Sudanese authorities;and IMF staff estimates.

Note that all variables are log transformed, and changes are measured over quarters.

Table 3. ADF Statistics, 1995 Q2–2001 Q2

Variable	ADF Statistic
ddm	-3.16*
ddp	-4.47*
ddf	-6.77**
ddn	-2.99*
ddl	-6.10**
ddx	-3.74**
dra	-3.01*

Tests included a constant and 2 lags.
5% significance: *; 1% significance: **.

Table 4. Correlation Matrix

	dp	df	dn	dm	dx	dl	ra
dp	1	0.93	0.80	0.70	0.66	0.05	-0.04
df		1	0.52	0.50	0.53	-0.00	-0.34
dn			1	0.81	0.68	0.13	-0.49
dm				1	0.69	0.13	-0.35
dx					1	0.29	-0.47
dl						1	-0.04
ra							1

Table 5. Long-Run Analysis: Overall Prices, *dp*. 1994 Q3–2001 Q2

Panel A

Eigenvalue	0.75	0.61	0.37	0.08
Max Statistic (95% critical value)	33.37** (27.1)	22.29* (21.0)	11.04 (14.1)	2.35 (2.01)
Trace Statistic (95% critical value)	80.17** (68.71)	41.23** (29.7)	15.23 (15.4)	2.35 (3.8)

Testing for vector error autocorrelation from lags 1 to 3: Chi^2(48) = 58.217 [0.1483]and F-form(48,21) = 0.86214 [0.6736]. Testing for vector heteroscedasticity using squares: Chi^2(80) = 96.722 [0.0983]and F-form(80,21) = 0.40391 [0.9980]Testing for vector heteroscedasticity using squares and cross-products Chi^2(140)=155.07 [0.1815].
Vector normality Chi^2(8)= 22.538 [0.0040] **

Panel B

Estimated Cointegrating Vectors ($\beta' s$) and Error-Correction Coefficients $(\alpha' s)$

	β_1	β_2	β_3	β_4	α_1	α_2	α_3	α_4
dm	1.00	-0.36	-3.47	-43.14	-0.27	0.01	0.18	-0.00
dp	-0.79	1.00	0.37	1736.70	0.40	-0.05	0.03	-0.00
dx	0.31	-1.17	1.00	699.11	-1.44	0.08	-0.13	-0.00
dl	0.02	0.20	0.00	1.00	-10.97	-5.27	-1.04	-0.00

Panel C

Restrictions on the Cointegration Space

Hypothesis	Likelihood ratio	p-value
$H^1 : (b_1, b_2, b_3, 0) \in Sp(\beta)$	2.82	0.25
$H^2 : (b_1, b_2, 0, b_4) \in Sp(\beta)$	4.38	0.03*
$H^3 : (b_1, 0, b_3, b_4) \in Sp(\beta)$	11.32	0.00**
$H^4 : (0, b_2, b_3, b_4) \in Sp(\beta)$	8.04	0.00**

Table 6. Long-Run Analysis: Food Inflation, *df.* 1994 Q3–2001 Q2

Panel A

Eigenvalue	0.68	0.60	0.45	0.11
Max Statistic (95% critical value)	31.1* (27.10)	25.08* (21.00)	15.97 (14.10)	3.29 (3.80)
Trace Statistic (95% critical value)	75.44** (47.2)	44.34** (29.7)	19.26 (15.4)	3.29 (3.8)

Testing for vector error autocorrelation from lags 1 to 3 Chi^2(48) = 68.223 [0.0290] * and F-form(48,17) = 1.0512 [0.4762] Vector normality Chi^2(8)= 37.266 [0.0000] ** Testing for vector heteroscedasticity using squares Chi^2(80) = 97.88 [0.0850]and F-form(80,14) = 0.36077 [0.9979] Testing for vector heteroscedasticity using squares and cross-products Chi^2(140) = 159.3 [0.1264].

Panel B

Estimated Cointegrating Vectors ($\beta's$) and Error-Correction Coefficients $(\alpha's)$

	β_1	β_2	β_3	β_4	α_1	α_2	α_3	α_4
dm	1.00	-0.34	-2.70	-346.21	-0.25	0.02	0.17	0.00
Df	-0.78	1.00	0.34	-265.75	0.49	-0.09	-0.18	0.00
dx	0.29	-1.15	1.00	18.47	-0.71	0.08	-0.16	0.00
Dl	0.03	0.17	0.00	1.00	-8.71	-5.54	-1.31	0.00

Panel C

Restrictions on the Cointegration Space

Hypothesis	Likelihood ratio	p-value
$H^1 : (b_1, b_2, b_3, 0) \in Sp(\beta)$	1.43	0.23
$H^2 : (b_1, b_2, 0, b_4) \in Sp(\beta)$	2.47	0.11
$H^3 : (b_1, 0, b_3, b_4) \in Sp(\beta)$	10.82	0.00**
$H^4 : (0, b_2, b_3, b_4) \in Sp(\beta)$	6.34	0.01*

Table 7. Long-Run Analysis: Nonfood Inflation, *dn*. 1994 Q3-2001 Q2

Panel A

Eigenvalue	0.76	0.32	0.28	0.16
Max Statistic (95% critical value)	38.57* (27.10)	10.42 (21.00)	8.83 (14.10)	4.66* (3.80)
Trace Statistic (95% critical value)	762.49** (47.2)	23.91** (29.7)	13.49 (15.4)	4.66* (3.8)

Testing for vector error autocorrelation from lags 1 to 2 Chi^2(48) = 43.17 [0.09] * and F-form(48,17) = 0.52 [0.94]
Vector normality Chi^2(8)= 15.89 [0.04]* Testing for vector heteroscedasticity using squares Chi^2(160) = 161.42 [0.45]

Panel B

Estimated Cointegrating Vectors (β's) and Error-Correction Coefficients $(\alpha' s)$

	β_1	β_2	β_3	β_4	α_1	α_2	α_3	α_4
dm	1.00	-1.33	-0.91	-117.17	-0.72	0.02	0.21	-0.02
df	-0.24	1.00	-0.34	-26.12	0.45	-0.79	0.49	-0.02
dx	-0.31	-0.50	1.00	22.09	0.41	-0.32	-0.19	0.00
dl	0.05	0.03	0.06	1.00	-10.53	4.23	2.24	-1.48

Panel C

Restrictions on the Cointegration Space

Hypothesis	Likelihood ratio	p-value
$H^1 : (b_1, b_2, b_3, 0) \in Sp(\beta)$	23.15	0.00**
$H^2 : (b_1, b_2, 0, b_4) \in Sp(\beta)$	9.62	0.00**
$H^3 : (b_1, 0, b_3, b_4) \in Sp(\beta)$	3.65	0.05
$H^4 : (0, b_2, b_3, b_4) \in Sp(\beta)$	14.79	0.00**

Table 8. Changes In Inflation: *ddp*. OLS Estimates

URF Equation 1 for Ddp

Variable	Coefficient	Std.Error	t-value	t-prob
ddp_1	-0.18969	0.29833	-0.636	0.5426
ddp_2	-0.20572	0.26929	-0.764	0.4668
ddx_1	0.30455	0.27218	1.119	0.2956
ddx_2	-0.030049	0.18630	-0.161	0.8759
Ddl	0.011957	0.012867	0.929	0.3799
Ddl_1	0.015347	0.017677	0.868	0.4106
Ddl_2	0.020910	0.020483	1.021	0.3372
Ddm	0.93763	0.32562	2.879	0.0205
Ddm_1	-0.46814	0.50854	-0.921	0.3842
Ddm_2	0.25423	0.40114	0.634	0.5439
dRa	-0.28098	1.3274	-0.212	0.8376
dRa_1	0.45345	0.91129	0.498	0.6322
DRa_2	0.34753	0.83348	0.417	0.6877
CI_1	-0.72144	0.38008	-1.898	0.0942
Seasonal	-0.0032965	0.060371	-0.055	0.9578
Seasonal_1	0.048615	0.056286	0.864	0.4129
Seasonal_2	0.087207	0.036541	2.387	0.0441
Constant	-0.075480	0.028862	-2.615	0.0309

\sigma = 0.0392385 RSS = 0.01231727799

URF Equation 2 for ddex

Variable	Coefficient	Std.Error	t-value	t-prob
ddp_1	0.38103	0.38061	1.001	0.3461
ddp_2	-0.55575	0.34356	-1.618	0.1444
ddex_1	0.46017	0.34725	1.325	0.2217
ddex_2	0.11576	0.23768	0.487	0.6393
ddli	0.024609	0.016415	1.499	0.1722
ddli_1	0.018235	0.022551	0.809	0.4421
ddli_2	0.049900	0.026132	1.910	0.0926
ddm2	1.0889	0.41542	2.621	0.0306
ddm2_1	-0.47488	0.64879	-0.732	0.4851
ddm2_2	0.28893	0.51177	0.565	0.5878
dexp	2.9988	1.6934	1.771	0.1145
dexp_1	-0.45712	1.1626	-0.393	0.7045
dexp_2	-0.56453	1.0633	-0.531	0.6099
CI_1	0.47962	0.48490	0.989	0.3516
Seasonal	0.10112	0.077020	1.313	0.2256
Seasonal_1	-0.0021263	0.071809	-0.030	0.9771
Seasonal_2	-0.011186	0.046618	-0.240	0.8164
Constant	-0.00051338	0.036821	-0.014	0.9892

sigma = 0.0500598 RSS = 0.02004786393

Testing for vector error autocorrelation from lags1 to1 Chi^2(4) = 9.44 [0.05] and F-form(4,10) = 0.62 [0.65]

Vector normality Chi^2(4)= 3.17 [0.53]

Table 9. Changes in Inflation: *ddp*. FIML Estimates

Equation 1 for ddp					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
CI_1	-0.73147	0.12064	-6.063	0.0000	0.10617
Ddm	0.80228	0.20673	3.881	0.0009	0.27942
Seasonal_1	0.057470	0.015970	3.599	0.0018	0.013692
Seasonal_2	0.089620	0.015396	5.821	0.0000	0.011691
Constant	-0.078988	0.010706	-7.378	0.0000	0.010512
\sigma = 0.0365182					
Equation 2 for ddx					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
CI_1	0.36354	0.14313	2.540	0.0195	0.15954
Ddl_2	0.024742	0.0076091	3.252	0.0040	0.0064950
Ddm	1.0546	0.24818	4.249	0.0004	0.36482
Seasonal	0.051946	0.028310	1.835	0.0814	0.028441
Dra	2.2193	0.60109	3.692	0.0014	0.56551
Ddp_1	0.33630	0.13396	2.510	0.0208	0.12333
Ddp_2	-0.26855	0.10949	-2.453	0.0235	0.081719
\sigma = 0.0412652					

LR test of over identifying restrictions: Chi^2 (24)=32.76 [0.11]. Testing for vector error autocorrelation from lags1 to1 Chi^2(4) = 1.31[0.86] and F-form(4,34) = 0.22 [0.93]. Vector normality Chi^2(4)= 1.66 [0.80]

Table 10. Modeling Food Inflation: *ddf.* OLS Estimates

URF Equation 1 for ddf				
Variable	Coefficient	Std.Error	t-value	t-prob
Ddf_1	0.17998	0.24640	0.730	0.4772
Ddx_1	-0.18695	0.13902	-1.345	0.2001
CIF_1	1.3079	0.45266	2.889	0.0119
Seasonal_2	0.18407	0.043740	4.208	0.0009
Ddm	0.63169	0.37960	1.664	0.1183
Ddm_1	-0.39317	0.49730	-0.791	0.4424
Ddl	0.015230	0.013791	1.104	0.2881
Ddl_1	-0.020871	0.013382	-1.560	0.1411
Constant	-0.16533	0.027240	-6.069	0.0000
Seasonal	0.061320	0.060174	1.019	0.3255
Dra	-0.078019	0.98943	-0.079	0.9383
Dra_1	0.88219	1.0045	0.878	0.3946
Seasonal_1	0.12029	0.060240	1.997	0.0657
\sigma = 0.0580971	RSS = 0.04725380058			
URF Equation 2 for ddx				
Variable	Coefficient	Std.Error	t-value	t-prob
Ddp_1	0.25451	0.22185	1.147	0.2705
Ddx_1	-0.18474	0.12516	-1.476	0.1621
CIF_1	-0.19935	0.40756	-0.489	0.6323
Seasonal_2	0.018453	0.039382	0.469	0.6466
Ddm	0.98203	0.34178	2.873	0.0123
Ddm_1	0.17626	0.44775	0.394	0.6998
Ddl	-0.0014077	0.012417	-0.113	0.9114
Ddl_1	-0.013163	0.012048	-1.092	0.2931
Constant	-0.059609	0.024526	-2.430	0.0291
Seasonal	0.091623	0.054179	1.691	0.1129
Dra	0.68047	0.89085	0.764	0.4576
Dra_1	1.1670	0.90438	1.290	0.2178
Seasonal_1	0.099269	0.054238	1.830	0.0886
\sigma = 0.0523086	RSS = 0.03830671386			

Testing for vector error autocorrelation from lags1 to1 Chi^2(8) = 12.98 [0.54] and F-form(8,18) = 1.62 [0.45]. Vector normality Chi^2(4)= 2.45 [0.65]

Table 11. Modeling Food Inflation: *ddf.* FIML Estimates

Equation 1 for ddf					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
CIF_1	1.3252	0.15620	8.484	0.0000	0.13275
Seasonal_1	0.092993	0.027594	3.370	0.0028	0.024491
Seasonal_2	0.15642	0.025103	6.231	0.0000	0.020561
Ddm	0.90568	0.33782	2.681	0.0137	0.17251
Ddl_1	-0.034373	0.010056	-3.418	0.0025	0.011247
Constant	-0.13635	0.016421	-8.303	0.0000	0.019569
\sigma = 0.0580778					
Equation 2 for ddx					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
Seasonal_1	0.062052	0.023792	2.608	0.0161	0.022390
Ddm	1.2167	0.29446	4.132	0.0004	0.29496
Ddl_1	-0.019128	0.0086361	-2.215	0.0374	0.0065389
Constant	-0.029039	0.012103	-2.399	0.0253	0.012707
\sigma = 0.0540261					

LR test of over identifying restrictions: Chi^2 (16)=22.74 [0.12].Testing for vector error autocorrelation from lags1 to1 Chi^2(8) = 12.50 [0.13] and F-form(8,34) = 1.32 [0.27]. Vector normality Chi^2(4)= 10.12 [0.04]*

Table 12. Changes In Nonfood Inflation: *ddn*. OLS Estimates

URF Equation 1 for ddnp				
Variable	Coefficient	Std.Error	t-value	t-prob
Ddn_1	-0.44106	0.25453	-1.733	0.1068
Ddl_1	0.0012086	0.017757	0.068	0.9468
CIN_1	-0.10987	0.52229	-0.210	0.8366
Ddx	0.26506	0.28169	0.941	0.3639
Ddx_1	0.30173	0.18590	1.623	0.1286
Ddm	0.85370	0.51691	1.652	0.1226
Ddm_1	0.26389	0.44670	0.591	0.5648
Dra	-0.72750	1.0324	-0.705	0.4935
Dra_1	2.1701	0.87910	2.469	0.0282
Seasonal	-0.011122	0.028229	-0.394	0.7000
Seasonal_1	-0.0042360	0.032416	-0.131	0.8980
Seasonal_2	-0.0056482	0.031362	-0.180	0.8599
Constant	0.0041005	0.029810	0.138	0.8927
\sigma = 0.0474938	RSS = 0.02932361685			
URF Equation 2 for ddl				
Variable	Coefficient	Std.Error	t-value	t-prob
Ddn_1	-4.9416	4.9251	-1.003	0.3340
Ddl_1	0.50143	0.34359	1.459	0.1682
CIN_1	-36.642	10.106	-3.626	0.0031
Ddx	11.988	5.4508	2.199	0.0466
Ddx_1	-2.5808	3.5972	-0.717	0.4858
Ddm	-21.086	10.002	-2.108	0.0550
Ddm_1	13.503	8.6437	1.562	0.1422
Dra	4.6769	19.978	0.234	0.8186
Dra_1	10.534	17.011	0.619	0.5464
Seasonal	0.35612	0.54624	0.652	0.5258
Seasonal_1	-0.12947	0.62725	-0.206	0.8397
Seasonal_2	-0.021225	0.60687	-0.035	0.9726
Constant	1.2930	0.57683	2.241	0.0431
\sigma = 0.919009	RSS = 10.97951307			

Testing for vector error autocorrelation from lags1 to 1 Chi^2(8) = 13.35[0.10] and F-form(8,16) = 0.79 [0.62]. Vector normality Chi^2(4)= 3.68 [0.45]

Table 13. Changes in Nonfood Inflation: *ddn*. FIML Estimates

Equation 1 for ddn					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
Ddn_1	-0.33850	0.12368	-2.737	0.0120	0.10518
ddx_1	0.33563	0.11304	2.969	0.0071	0.11137
Ddm	1.1036	0.22762	4.848	0.0001	0.28606
Dra_1	1.9576	0.60944	3.212	0.0040	0.77185
\sigma = 0.0413236					
Equation 2 for ddli					
Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
CIN_1	-21.915	4.0818	-5.369	0.0000	4.4855
ddx	7.8138	3.2312	2.418	0.0243	2.9270
Ddm	-13.078	6.3282	-2.067	0.0507	6.2982
Constant	0.80930	0.23111	3.502	0.0020	0.20017
\sigma = 0.861174					

LR test of over identifying restrictions: Chi^2 (18)= 17.18 [0.51].Testing for vector error autocorrelation from lags1 to1 Chi^2(4) = 15.46 [0.06] and F-form(8,34) = 2.00 [0.08]. Vector normality Chi^2(4)= 2.30 [0.68]

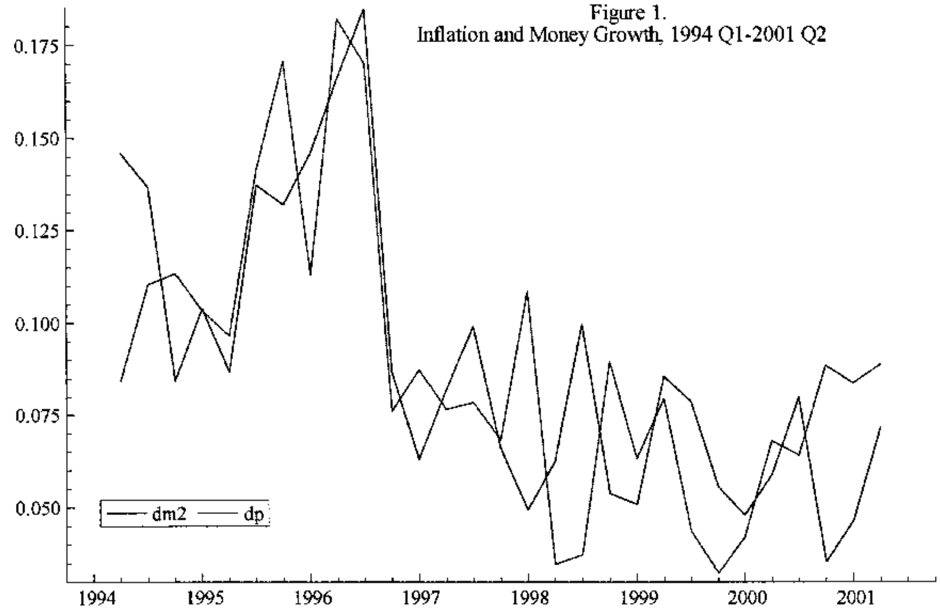


Figure 1.
Inflation and Money Growth, 1994 Q1-2001 Q2

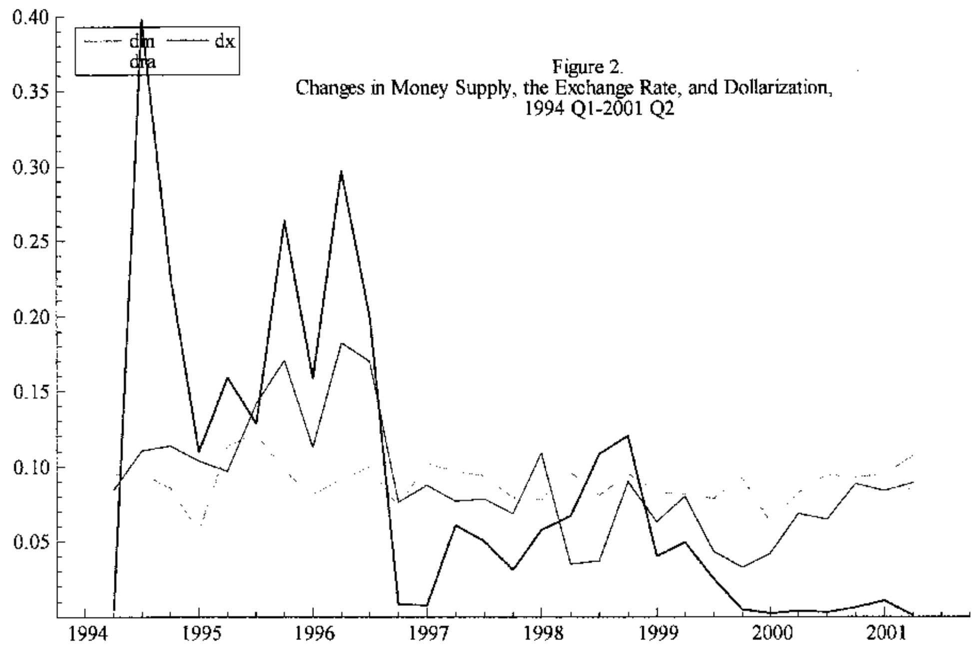


Figure 2.
Changes in Money Supply, the Exchange Rate, and Dollarization,
1994 Q1-2001 Q2

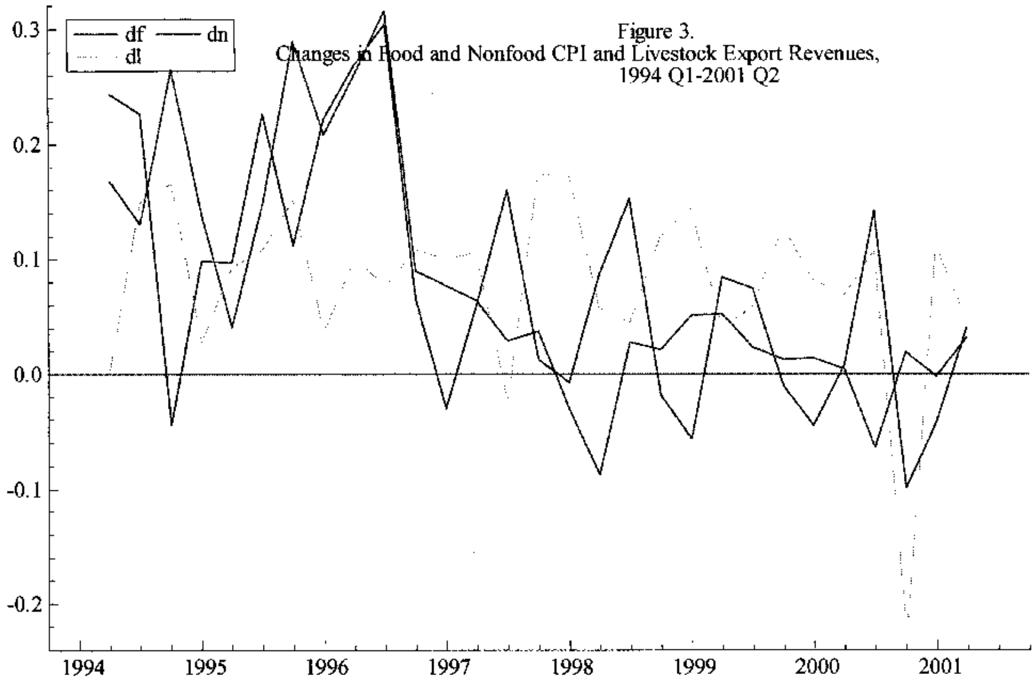


Figure 3.
Changes in Food and Nonfood CPI and Livestock Export Revenues, 1994 Q1-2001 Q2

Figure 4
Fitted and Actual Inflation and Exchange Rate Behavior
1995 Q1- 2001 Q2

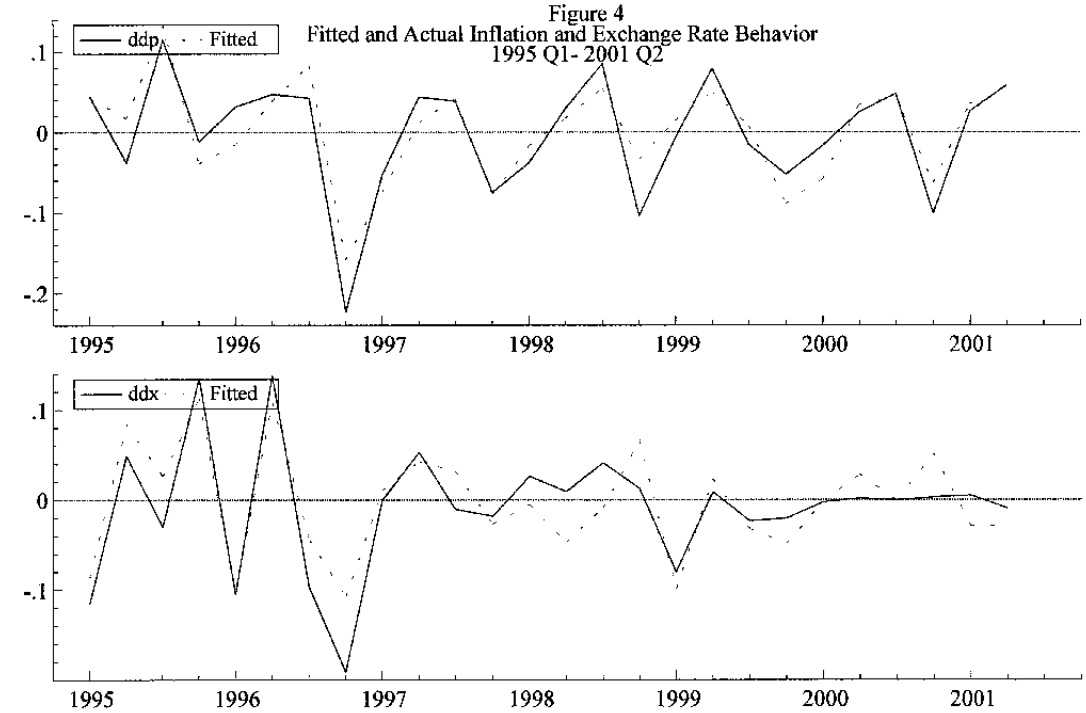


Figure 5.
Dynamic Forecasting of Overall Inflation and Exchange Rate Movements,
2000 Q2- 2001Q2

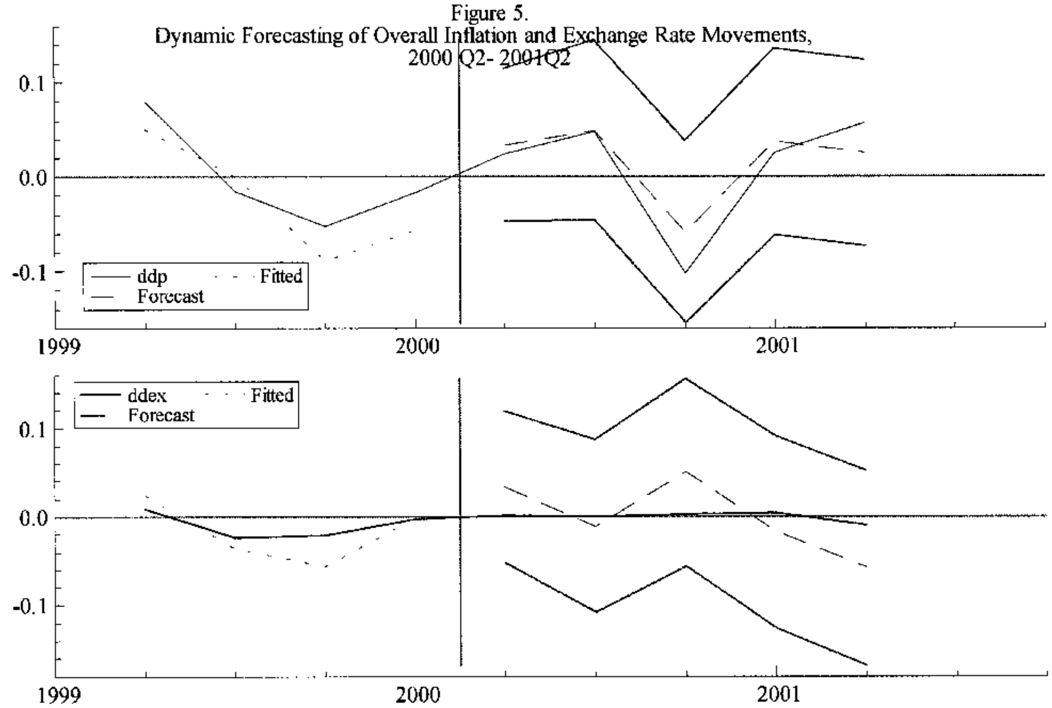


Figure 6.
Fitted and Actual Food Inflation and Exchange Rate Behavior,
1994 Q1-2001 Q2

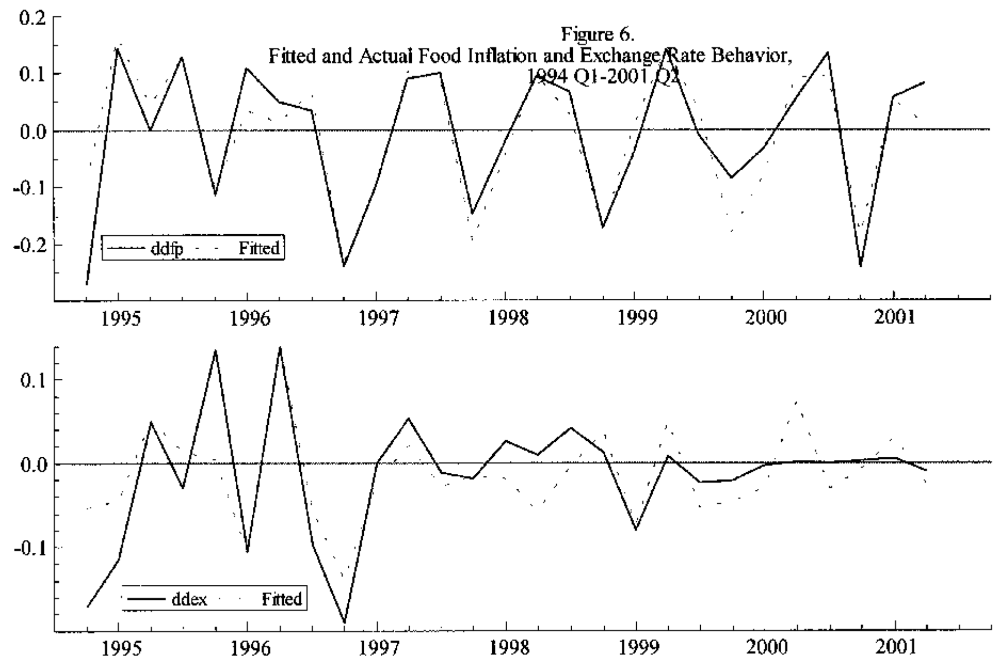


Figure 7.
Dynamic Forecasting of Food Inflation and Exchange Rate Movements,
2000 Q2- 2001Q2

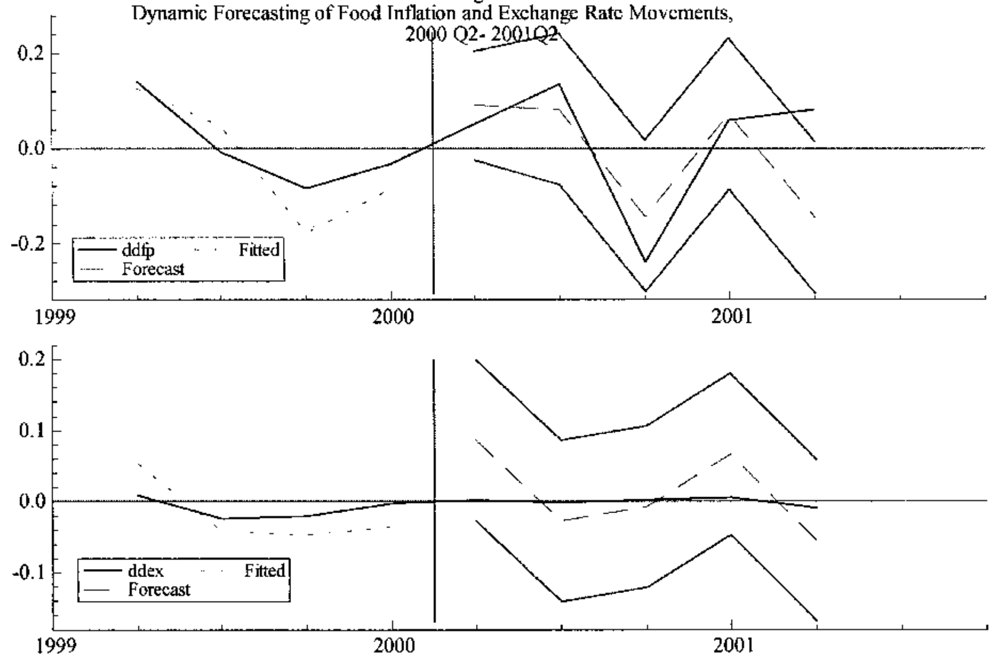


Figure 8.
Fitted and Actual Nonfood Inflation and Livestock Exports
1995 Q1-2001 Q2

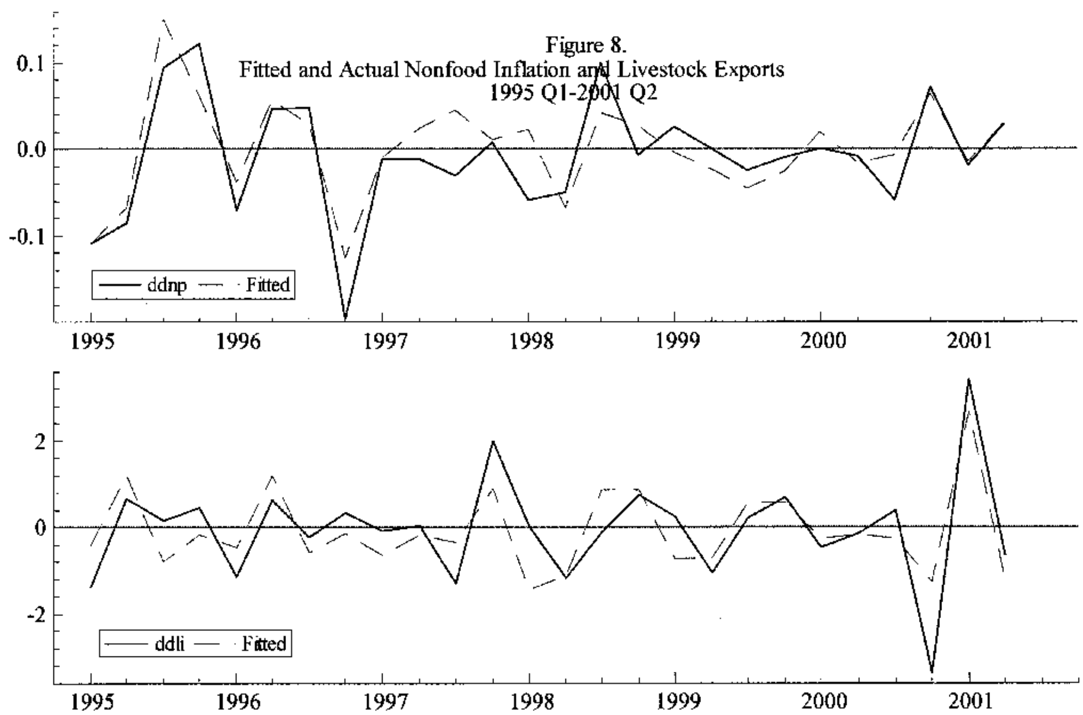
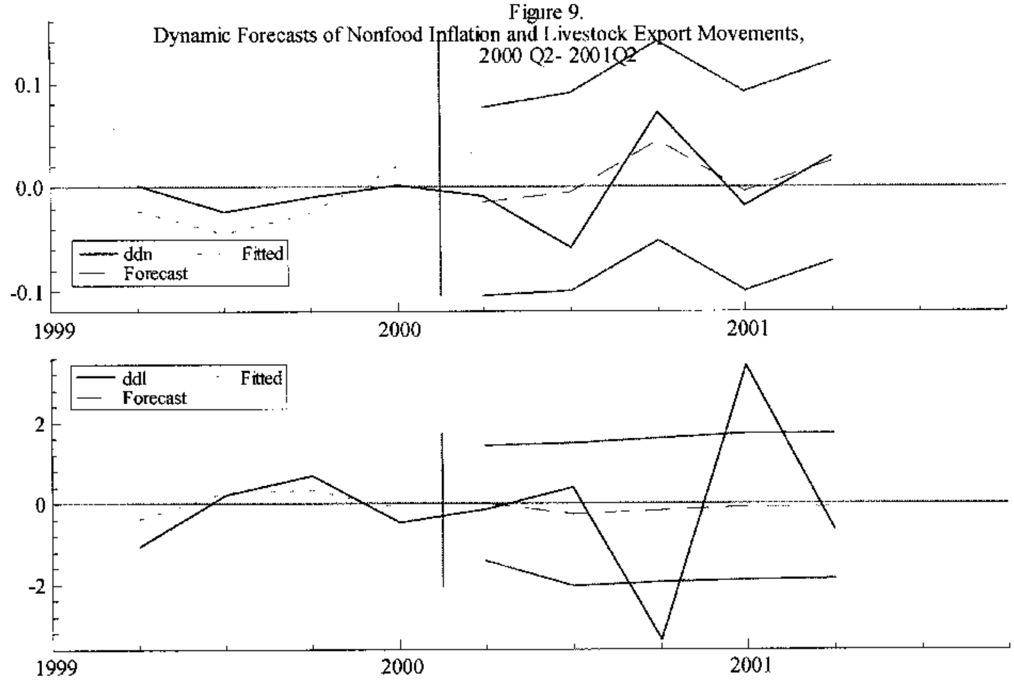


Figure 9.
Dynamic Forecasts of Nonfood Inflation and Livestock Export Movements,
2000 Q2- 2001Q2



A.2. Analytic Framework

In solving the consumer's problem, I employ the Lagrangian method:

$$L = \frac{\left[T_t^{\alpha} N_t^{1-\alpha}\right]^{1-\theta}}{1-\theta} + \frac{\left[T_{t+1}^{\alpha} N_{t+1}^{1-\alpha}\right]^{1-\theta}}{1-\theta} + \lambda_t \left[\frac{P_{T_t}}{P_{N_t}} \bar{T}_i + w_t - N_{it} - \frac{P_{T_t}}{P_{N_t}} T_{it} - \frac{P_{T_t}}{P_{N_t}} S \right] + \tag{A.2.1}$$
$$\lambda_{t+1} \left[\frac{p^e}{P_{N_{t=1}}} S_{it} + w_2 - N_{it+1} - \frac{P^e}{P_{N_{t-1}}} T_{it+1} \right]$$

where λ_t is the Lagrangian multiplier

Setting equal the marginal intertemporal utility of livestock consumption: $\frac{\partial L}{\partial L_t} = \frac{\partial L}{\partial L_{t+1}}$ and using the condition: $\frac{\lambda_t}{\lambda_{t+1}} = \frac{P^e P_{N_t}}{P_{T_1} P_{N_{t+1}}}$ gives Result 1.

Result 2: *In equilibrium, if* $\theta < 1$, *then* $\frac{dP^*_{T_1}}{dp^e} > 0, \frac{dP^*_{N_t}}{dp^e} > 0$.

To succinctly[31] show this result, I express the price system as explicit functions:

$$P^e_{N_{t+1}} = f\left(P^e, P_{N_t}, P_{T_t}\right)$$
$$P_{N_t} = h\left(P^e, P_{T_t}, P^e_{N_{t+1}}\right)$$
$$P_{T_t} = g\left(P^e, P_{N_t}, P^e_{N_{t+1}}\right)$$

The impact of a change in expectations, P^e, on P_{T_t} can be decomposed:

$$\frac{\partial P_{T_t}}{\partial P^e} = \left[\frac{\partial g}{\partial P^e} + \frac{\partial g}{\partial f}\frac{\partial f}{\partial P^e} + \frac{\partial g}{\partial h}\frac{\partial h}{\partial P^e}\right]\left[1 - \frac{\partial g}{\partial f}\frac{\partial f}{\partial P_{T_t}} - \frac{\partial g}{\partial h}\frac{\partial h}{\partial P_{T_t}}\right]^{-1}$$

If $\theta < 1$ so that consumption is relatively elastic, then the income effect is positive: $\frac{\partial g}{\partial P^e} > 0$. Moreover, since T_t and the other goods: N_t and N_{t+1} are substitutes, the other terms in the numerator are all positive. Lastly, I assume that impact of changes in P_{T_t} on the other prices are small, so the denominator is positive. A similar argument holds for the other prices.

[31]The algebraic details are available upon request.

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