Food Prices and Inflation in Tanzania

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Abstract

We develop an empirical representation of inflation in Tanzania for the decade from 2001, estimating 'multiple-determinant' single-equation models for headline inflation and its major components (food, energy and core inflation). Our results suggest that while supply-side factors, including yield variability and international price arbitrage, play a major role in determining domestic food and fuel inflation (which together account for almost 60 percent of the total CPI basket), demand-side factors amenable to policy intervention by the monetary authorities anchor core inflation.

Keywords: Tanzania, inflation, core inflation, error-correction, supply shocks, monetary policy

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1. Introduction

In recent years, high and volatile inflation has re-emerged as a central macroeconomic policy concern in Tanzania, as it has across East Africa. Throughout the first decade following the macroeconomic reforms implemented in the mid-1990s, strong domestic output growth coupled with favourable global economic conditions helped keep headline inflation close to the authorities' indicative target of 5 percent per annum.[1] But since the onset of the global financial crisis the economy has been buffeted by much greater volatility, both domestic and internal which has, in turn, been reflected in significantly higher and more volatile inflation. In mid-2008, year-on-year headline inflation edged above 10 percent per annum for the first time since the early 1990s, and while it dropped back to low single digits in 2009 it rose again sharply towards the end of 2010, reaching close to 20 percent per annum in the final quarter of 2011 (Figure 1).

Although it has moderated slightly since the beginning of 2012, headline inflation in Tanzania still remains high, both by historical standards and compared to other countries in East Africa. From around 2005, through the period of the global financial crisis, to the end of 2011 there was strong co-movement in inflationary patterns in Kenya, Uganda and Tanzania and by the end of 2011 inflation in each of the East African 'big three' stood at around 20 percent per annum. By September 2012, however, inflation had fallen to around 5 percent per annum in Kenya and Uganda but remained at over 13 percent in Tanzania.[2] Some of this difference reflects timing issues: the sharp acceleration of prices in Kenya and Uganda in the second half of 2011 occurred somewhat earlier than in Tanzania, so that these 'base effects' have already dropped out of current inflation calculations. But even accounting for these timing effects, the apparent downward stickiness of Tanzanian inflation, in both food and non-food components, may point to structural characteristics in the dynamics of inflation that are specific to Tanzania but which only become apparent when inflation slows down.

A substantial part of the recent rise in inflation and inflation volatility clearly reflects developments in the global economy, most obviously the sharp rise in global food and fuels prices in 2008 and again in 2011. At their recent peak, in December 2011, year-on-year inflation in the food and energy sub-indices reached 25.6% and 41.0% respectively (National Bureau of Statistics (NBS), 2011). With food accounting for 51% of the consumption basket in Tanzania and energy and transport costs accounting for a further 9 percent each, these global developments may be expected to have a

[1] There are a number of controversies surrounding the measurement of inflation throughout this period, but particularly before 2001. We avoid some of these by focusing our analysis on the period from January 2002, using the CPI series that had been revised back to that date following an IMF mission to Tanzania in 2006. On this basis, mean headline inflation from January 2002 to the eve of the global financial crisis in April 2008 averaged 5.75% per annum and did not exceed 10% per annum through the period.

[2] Given their different exchange rate regimes, direct ccomparisons with Rwanda and Burundi are not informative here, although the recent inflationary experience of Ethiopia does bear some similarities to the Tanzanian situation.

powerful impact on overall inflation, both directly and, in the case of energy prices, indirectly through the high share of transport and distribution costs in retail prices. [3]

The authorities' policy response to these developments has been broadly conventional and has involved the Bank of Tanzania accommodating the estimated initial inflationary effects of these external price shocks so as to bring about the appropriate relative price adjustment required for macroeconomic balance while at the same time seeking to ensure that second-round pressures on wages and price are resisted lest they become embedded in domestic inflation expectations. This is, however, a difficult strategy to get right and requires both a clear understanding of the relative importance of external as opposed to domestic inflation determinants and of the strength of the transmission channel from the policy instruments at the authorities disposal to those components of prices that are, in principle, responsive to policy actions.

This paper seeks to contribute to the first of these links by developing a coherent empirical framework with which to analyze recent inflationary trends in Tanzania. The paper is structured as follows: in Section 2 we document the recent history of inflation in Tanzania, highlighting in particular the dominant role played by food prices and the cost of moving food from producer to consumer. In Section 3 we develop an econometric model of the three components of headline inflation, namely food, energy and core inflation, based on an approach popularized by Hendry (2001) and others in which inflation is modeled in terms of deviations from a vector of long-run anchors reflecting demand-side and monetary determinants on the one hand and supply-side and open economy price arbitrage factors on the other.[4] Identifying restrictions are then imposed on the underlying vector error correction model in order to estimate a set of single-equation models for the components of inflation in which the cointegration relations can be interpreted as representations of these inflation anchors. Section 4 of the paper discusses the estimation results and Section 5 concludes.

2. Inflation in Tanzania

The headline price index can be defined as a geometrically-weighted average of sub-indices for food, energy and core prices, $P_t = P_{Ft}^{\beta} P_{Et}^{\gamma} P_{Ct}^{1-\beta-\gamma}$ where F, E and C denote food, energy and core prices

[3] Food accounted for 71.2% of total consumption in the 1991/92 Tanzania Household Budget Survey (HBS) and 55.9% in the 2001/02 HBS. The food share in the 2007 HBS is 44.3%, although the composition of the consumption basket has changed over time. For example, the new 2007 HBS, which is based on the UN's Classification of Individual Consumption by Purpose (COICOP), now includes non-alcoholic beverages in the 'food share' but excludes food consumed outside the home in hotels and restaurants. The current CPI, published for the first time in September 2010, defines a total food aggregate consisting of food, including food eaten outside the home, and drinks (alcoholic and non-alcoholic). This accounts for 51 percent to total CPI.

[4] Variants of this class of 'multiple determinants' model have been estimated for a number of countries in Sub-Saharan Africa in the last decade or so, including: for Mozambique by Ubide (1997); for Mali and Chad by Diouf (2007) and Kinda (2011) respectively; for Kenya by Durevall and Ndung'u (2001); and for Ethiopia by Durevall, Loening and Ayalew Birru (2013).

and β and γ the corresponding consumption weights. The core price sub-index is derived as the residual covering non-food and non-energy prices in the consumption basket. Headline inflation can then be written as a weighted average of the component inflation rates:

$$\pi_t = \beta\pi_t^F + \gamma\pi_t^E + (1-\beta-\gamma)\pi_t^C. \quad (1)$$

A conventional approach to the analysis of inflation in small open economies such as Tanzania draws a distinction between tradable goods, where the price-taking assumption ties domestic inflation to the relevant measure of world inflation rate for tradables plus the depreciation of the appropriate trade-weighted exchange rate,[5] and non-tradable goods and services, where inflation is determined by excess demand and cost-push factors in the domestic economy. In the Tanzanian context we proxy domestic demand side pressures by focusing on excess money growth, and cost-push factors by measures of the variation in agricultural output. External inflationary pressures are modeled in terms of estimates of the pass-through from world market prices for all three sub-indices, with the expectation that the pass through will be most powerful for energy prices.

Table 1 and Figure 1 summarize year-on-year inflation rates for headline inflation and its components from January 2002 to July 2012.[6] Perhaps the most striking feature of these data is the stability of headline inflation over the early part of this period. As Figure 1 highlights, however, this stability is the outcome of a remarkably strong negative correlation between food and non-food (i.e. core and energy) inflation over much of the sample, most noticeably in 2003-04 (where non-food inflation was negative) and again from early 2008 to late 2009. This negative correlation is surprising by the standards of some important strands in the literature on inflation in developing countries. Structuralist and fiscal theories of inflation, for example, would predict a positive correlation between food and non-food prices, the former in response to wage demands by urban workers and the latter via the inflationary impact of compensatory fiscal measures like food subsidies. The observed negative correlation might of course reflect a monetary policy that was designed to resist even the first-round effects of food and fuel price shocks, in a closed economy. Under such a policy, nominal income would follow real income. An adverse shock to domestic food supply would then drive down both real and nominal incomes, producing an adverse demand shock to the non-food sector (and a more powerful one as Engel's Law raised the share of income spent on food). There is no evidence from contemporaneous policy discussions or other sources, however, to suggest an unwillingness to accommodate temporary shocks. Even the strictest allegiance to the Bank of Tanzania's reserve-money programme – one that succeeded in stabilizing the growth of nominal

[5] By the small-country price-taking assumption, tradable prices are defined as $P_{Tt} = E_t(1+\phi)P^*_{Tt}$, where P^*_T denotes the world price of tradables, E is the suitably-defined nominal exchange rate and ϕ denotes relevant price wedges, including tax or tariff measures and transport costs. If this wedge is constant over time, and letting $\hat{E}_t$ denote the depreciation of the nominal effective exchange rate, the inflation rate for tradable goods is given by $\pi_t^T = \hat{E}_t + \pi_t^{*T}$.

[6] Price indices are normalized so that 2005m12 = 1. Our econometric analysis works with month-on-month growth in the log price indices, in other words monthly inflation. To better understand the underlying patterns in the data, however, the discussion in this section is framed in terms of annual inflation rates, in other words the year-on-year log differences in prices. Hence the inflation rate is calculated as 100*[ln(P_t) – ln(P_{t-12})].

aggregate demand completely – would imply partial accommodation of the first-round effects of food-supply shocks. Open-economy price linkages would of course moderate any domestically-driven relative price movements and, at the extreme, tie domestic relative price to world prices. We find some evidence in our econometric analysis that trade linkages affect Tanzanian prices in the long run, but there is nothing in the short-run movements of global prices to explain the observed negative correlation between food and non-food prices.

Two observations suggest that the reality in Tanzania may be more prosaic, at least to some degree, than any of these theories suggest. The first is that the negative correlation may in part be an artefact of serious problems in the data collection methods used by the NBS in the early part of the decade.[7] The second is that whatever its provenance, the negative correlation between food and non-food inflation disappeared around mid-2010 (around the time the CPI was re-based), after which time the food, non-food and headline prices have all moved closely together.

As a final preliminary observation, notice that by defining $\tau_{Ft} = P_{Ft}/P_{Ct}$ and $\tau_{Et} = P_{Et}/P_{Ct}$ as the real prices of food and energy relative to core prices, respectively, equation (1) can be re-written as

$$\pi_t = \pi_t^C + \alpha \Delta log \tau_t^F + \beta \Delta log \tau_t^E. \quad (2)$$

This indicates that headline inflation will deviate from core inflation only to the extent of shocks to real food and real energy prices. It follows that if the latter are stationary, headline and core-inflation will be cointegrated. Equation (2) therefore provides a link with New Keynesian perspectives on monetary policy in open economies which emphasize the primacy of targeting (sticky) core inflation in the face of short-run supply-side shocks to the natural rate of output (see, for example, Aoki, 2001 and Woodford, 2003). It is clear, however, from Figure 1 that headline and core inflation are not robustly cointegrated and that this is reflected in distinctly non-stationary behavior in real food and energy prices (Figure 2), which in turn are not cointegrated with each other.[8] Relative prices for food and energy both rose by nearly 20 percent between 2001 and 2006, and then remained at this new level before diverging in the latter half of 2008. This pattern presents a serious puzzle and may well reflect the same measurement error problems we noted above. We discuss below how we have attempted to address the implications for estimation of these trends in relative prices.

3. Estimation strategy

In this section we estimate equation (1) and its separate sub-components for the period from January 2002 to July 2011, but without imposing the restrictions across the sub-components implied

[7] This is discussed in IMF (2006) and analysed in more detail in Adam *et al.* (2012).

[8] Standard tests of the cointegration, including Engle-Granger-based bivariate cointegrating regression methods as well as Johansen's rank-based test for cointegration fail to reject the null hypothesis of non-cointegration between headline and core inflation for the full period or for relevant sub-samples.

by the weights.[9] Our empirical approach follows in a tradition of Sargan (1964) and Hendry (2001) and used recently by Loening *et al.* (2009) in their work on Ethiopia, in which we develop a generalized framework in which inflationary pressures emerge from the deviation from equilibrium in a number of different markets, including the goods market (where disequilibrium is proxied by a measure of the output gap); the money market; and the labour market. This framework therefore nests, and therefore can test the validity of, a range of alternative 'single cause' models of inflation.

In the case of Tanzania, we allow for an aggregate demand channel operating through the money market and for the pass-through from world prices (for food, fuel and manufactured goods). The key challenge is how we model the supply side of the goods market. In circumstances where potential output is highly variable on account of the prevalence of real shocks, especially in agriculture, estimates of the output gap as the deviation from a smooth trend (or even as the residual from a production function) are problematic. We therefore adopt an alternative approach. Following Loening *et al.* (2009) we focus exclusively on agricultural output, assuming implicitly that that the non-food output gap is essentially demand-determined. While Loening *et al.* (2009) proxy the agricultural output gap as the deviation of actual (interpolated) output from the Hodrick-Prescott trend in the data, we proxy for variations in agricultural output using deviations of rainfall from its long-run seasonal mean in the principal food-producing districts of the country (see below).

Ideally, we would estimate a fully-specified structural system of equations defined in terms of a full set of inflation sub-indices and the other relevant endogenous determinants such as money, output, the exchange rate and domestic interest rates. Given our short data set, however, we have doubts about the robustness of such a system of equations. We therefore adopt a two-stage, single-equation approach, modeling headline inflation and its components as stationary processes that depend on their own past values, on short-term inflation determinants, and lagged deviations from our set of pre-estimated long-run inflation anchors. In the light of the previous discussion, these anchors consist of world price arbitrage conditions for food and fuel, the 'natural rate' equilibrium in agricultural output, and money market equilibrium.

Our inflation equations therefore take the following error correction form

$$\Delta lnp_t^i = \beta_0 + \sum_i \sum_{j=1}^{k} \beta_j^i \Delta lnp_{t-j}^i + \sum_{j=1}^{k} \mathbf{\Gamma}' \mathbf{Z}_{t-j} + \alpha_1^i (m - \widehat{m})_{t-l} + \alpha_2^i \left(e^f - \hat{e}^f\right)_{t-m} + \alpha_3^i (e^e - \hat{e}^e)_{t-n} + \alpha_4^i (e^c - \hat{e}^c)_{t-p} + \alpha_5^i (y^a - \hat{y}^a)_{t-q} + \sum_{s=1}^{11} \phi_s D_t^s + \varepsilon_t, \tag{3}$$

where Δlnp_t^i is (12 times) the month-on-month change in the log of price index i , with $i = \{headline, food, energy, core\}$. The deviations from long-run anchors are: $(m - \widehat{m})$, the deviation of real money from its equilibrium value; $(e^f - \hat{e}^f)$, $(e^e - \hat{e}^e)$ and $(e^c - \hat{e}^c)$, the deviations of domestic food, energy and core prices from their relative PPP values respectively; and $(y^a - \hat{y}^a)$, a

[9] Ideally we would base our analysis on a much longer time series but for reasons of measurement error, we felt it was unwise to use the price data before 2002.

measure of 'excess supply' in agriculture. The parameter vector $\boldsymbol{\alpha^i} = (\alpha_1^i \dots \alpha_5^i)'$ denotes the feedback effects from the long-run price anchors onto the relevant inflation rates. These long run effects are defined such that we expect $\alpha_1^i \geq 0$ for all *i.* For the coefficients α_2^i, α_3^i and α_4^i we expect own effects to be negative and cross effects positive. Thus, for example, we would expect $\alpha_2^i < 0$ and α_3^i and $\alpha_4^i \geq 0$ when *i=food.* In other words, when the domestic food price exceed the exchange rate-adjusted world price, domestic food price inflation will fall to eliminate the disequilibrium but excess energy and core prices will, other things equal, increase food inflation. Likewise for energy and core prices. The vector ***Z*** consists of other exogenous short-run inflation determinants including a small number of dummy variables introduced to pick up measurement changes in the price indices. All elements of **Z** are either stationary or transformed to be so.[10] Before turning to the estimation results we consider each of the long-run anchors in more detail.

3.1 Monetary equilibrium

We proxy demand-side inflationary pressures by the excess growth of money relative to the private sector's long run demand for money, where the estimate of the latter is taken directly from earlier work on the demand for money in (Adam *et al.* 2011). In that paper, we estimated an error correction equation for real money balances of the form

$$\Delta(m-p)_t = \beta_0 + \Gamma' \Delta \boldsymbol{W}_{t-i} - \alpha[m_{t-1} - (p_{t-1} + \delta_1 y_{t-1} - \boldsymbol{\delta_2}' \boldsymbol{r_{t-1}})] + \varepsilon_t, \quad (4)$$

where m_t is log M2, p_t is log prices, and $\boldsymbol{W}_t = (y_t, \boldsymbol{r}_t)$ is a vector of conditioning variables consisting of y_t, the log of real GDP; and $\boldsymbol{r}_t'$, a vector of variables measuring the opportunity cost of holding broad money including a vector of interest rates and the rate of exchange rate depreciation. The vector $X_t = m - p, \boldsymbol{W}\}' \sim \mathrm{I}(1)$ so that under cointegration, the term in square brackets measures the deviation of real money balances from their estimated equilibrium. This term is then taken as a measure of (lagged) monetary disequilibrium in the economy to which prices (amongst other variables) respond. Figure 3, based on equation (4), plots deviations from money market equilibrium, with positive values denoting excess money supply and hence latent excess aggregate demand.[11]

3.2 Food prices: international pass-through and domestic supply conditions

With low per capita incomes and relatively high rural poverty rates placing a large proportion of the population on or close to a subsistence existence, food demand is highly inelastic with the implication that the evolution of food prices will primarily reflect variations in domestic and international supply conditions. In practice, international trade in food on both the import and

[10] Unit root tests and full details of the construction of variables are provided in Tables A2 and A3 of Adam *et al.* (2012).

[11] An alternative, and simpler, measure of money market disequilibrium can be computed as the deviation of velocity from its long-run trend. We consider this measure in Adam *et al.* (2012), but find broadly similar results.

export side accounts for a relatively small share of total consumption and production. There is some cross-border trade in maize and rice with DRC, Zambia and Kenya, but most food consumed is produced domestically.[12] Moreover, the topography of Tanzania means that food production is concentrated around the periphery of the country resulting in substantial internal trade in food from the surplus regions in the south and west to the deficit regions around Lake Victoria, in the centre of the country, and along the coast south of Tanga. Transport costs therefore play an important role in leveraging up the role of food prices in explaining overall inflation.

Though modest in aggregate, the potential for cross-border trade will nonetheless place limits on how far domestic food prices can deviate from world prices. In reality, arbitrage is weakened by constraints on trade, including high transport costs, policy barriers and monopolistic behavior in the trade and distribution sectors. As a result, the domestic price of food can move around within a potentially wide 'parity band' without triggering price-stabilizing international trade. The higher are import tariffs and per-unit transport costs, for example, the wider the bands and the more 'non-tradable' domestic food prices will be.[13] These effects may well be exacerbated in the presence of imperfect competition in trade and distribution as monopolists will tend to mark-up their prices over cost pro-cyclically with (world) food prices.

To reflect this partial tradability of food we model domestic food inflation as a function of both domestic supply factors, measured as shocks to yields, and international price arbitrage constraints operating directly through food prices and indirectly though fuel prices, in each case intermediated by movements in the exchange rate. Which of these dominates depends not just on the evolution of domestic and external conditions but also on the degree of openness to trade in food. [14]

3.3 Real exchange rates and price arbitrage in food and fuel

We measure the existence and strength of arbitrage between domestic and world markets using a conventional *relative purchasing power parity* (relative PPP) measure which states that when

[12] Back-of-the-envelope calculations based on National Accounts and Balance of Payment data for 2005-2008, food imports as a share of food consumption are in the order of 6%. See also Ng and Aksoy (2008).

[13] The parity band is defined by the export- and import-parity prices respectively such that $(1-c)(1-t_X)EP_F^{\$} \leq P_F \leq (1+c)(1+t_I)EP_F^{\$}$ where world food prices $P_F^{\$}$ are exogenous in dollar terms, *E* is the nominal exchange rate, *c* denotes the (constant) marginal transport cost of moving good from the world to the domestic market (expressed as a proportion of the landed world prices) and where t_X and t_I are the relevant trade taxes. At either boundary, with fixed ad valorem tariffs or taxes and constant proportional transport costs, domestic food inflation will be equal to the sum of exchange rate depreciation and world food inflation, $\pi_{Ft} = \hat{E}_t + \pi_{Ft}^{\$}$, but away from these bounds, food prices will behave like a non-traded good whose price is driven by variations in domestic supply and demand conditions.

[14] An alternative approach would be to model domestic food price inflation using a regime-switching framework (see Goldfeld and Quandt, 1973) which allows for switching from between tradability (quantity-adjustment via international price arbitrage) to non-tradability (price adjustment) as a function of exogenous factors such as yield determinants, transport costs, trade policy etc.

expressed in a common currency, the domestic and foreign price indexes should differ from one another by a constant proportion on average. Under this hypothesis, the relevant real exchange rate is stationary, which means that it can be expressed as the sum of a constant and a stationary variable with a mean of zero. In the case of food prices this is given as:

$$(e_t + p_{Ft}^W - p_{Ft}) = c + \varepsilon_t, \quad (5)$$

where lower-case letters denote the logs of the nominal effective exchange rate, world food prices and domestic food prices respectively. Relative PPP has the implication that whenever the real exchange rate is away from its long-run mean, at least one of these three components must adjust to bring the real exchange rate back towards *c*. Because world food prices are exogenous to developments in Tanzania, the two candidates for this error-correction behavior are the nominal effective exchange rate and the Tanzanian price level. Relative PPP says (for example) that following a period of overvaluation we would expect to observe some combination of depreciation and food price disinflation in Tanzania. A similar analysis holds for fuel prices.

We plot the domestic food and fuel price real exchange rates for Tanzania.[15] Two features are immediately apparent from Figures 4 and 5. The first is that to the extent that relative prices for food and fuel are stationary they are so only around a strongly negative trend (i.e. a real exchange rate depreciation) at least until the end of 2007.[16] In the econometric analysis presented below, we remove the trend in the food relative price to focus on a de-trended series computed by applying a Hodrick-Prescott filter to de-trend the relative prices for food and fuel.

Regardless of how we handle these trending effects, a key feature of both the food and fuel real exchange rates is that domestic prices have frequently deviated substantially from their parity values. In the case of food prices this suggests a relatively weak link on average between domestic and world food prices consistent with limited exposure to international markets arising from high transport costs and other non-tariff barriers.

We conduct a similar analysis for core inflation, looking at the potential cointegration between core prices in Tanzania and various measures of world inflation, such as US wholesale and retail prices and the IMF composite 'manufactured unit value' series. As we note below, we find no evidence in

[15] The world price series are the World Bank all-food and energy price indices for low and middle-income countries respectively expressed in US dollars: there are converted to local currency using the official bilateral exchange rate with the US dollar.

[16] These trend declines in the relative prices of food and fuel present a challenge to our analysis. In particular, the decline in relative food prices stands in contrast with other recent research on agricultural productivity and food prices in Tanzania which suggest stagnant or declining average total factor productivity in agriculture over the last decade which is inconsistent with sharply falling real (farm-gate) food prices (see Kirchberger and Mishili 2011, and Lokina *et al.* 2011). We cannot dismiss the possibility that these trends reflect the measurement errors noted earlier in the paper, but the trend may also reflect a decline in the transport cost component in domestic food prices (relative to that embodied in world food price index) leading to a depreciation of the real exchange rate for food defined in terms of consumer prices.

our econometric analysis in support of this real exchange rate playing any role in anchoring core inflation.

3.4 Domestic supply conditions and food price inflation

Finally, we turn to domestic food supply factors. As noted, a conventional approach to measuring the impact of supply variation on food prices would entail direct measurement of the agricultural output gap, in other words, the deviation of actual from potential agricultural output, where the latter is defined as output under 'normal' growing conditions:

$$y_t^a = yp_t^a + agap_t. \quad (6)$$

The output gap could be computed using standard decomposition methods such as the Hodrick-Prescott filter.[17] Doing so for agricultural output in Tanzania is problematic, however: consistent time series on agricultural output are typically not available on anything higher than annual frequency and moreover, those series that do exist are deeply contradictory. The first of these problems is beginning to be addressed with the publication of a disaggregated quarterly GDP series for Tanzania going back to 2001. This series has not yet been analyzed in detail and we remain concerned that it exhibits an implausibly large degree of seasonal variation.[18] But even so, there are major differences between real value added in agriculture from the Tanzanian national accounts and ostensibly comparable data from the Food and Agriculture Organization of the United Nations (FAO). National sources appear to show almost none of the volatility of the FAO series. In particular the sharp fluctuation in output between 2002 and 2003 reported by the FAO are completely absent in the national accounts data, as is the apparent contraction in output between 2007 and 2008.[19]

To circumvent these measurement problems we proxy for the variation in agricultural supply by using variations in monthly rainfall patterns. Food crop agriculture, particularly the production of the staple foods of maize, beans and rice, is overwhelmingly rain fed so that, conditional on planting decisions, yield variation is dependent on rainfall variation. The bulk of food production occurs in the south western and western regions of the country where the *msimu* rains from November through to April, are critical.

Using rainfall data collected by the Tanzania Meteorological Authority for each administrative district in Tanzania, we compute long-run monthly average rainfall at the district level and compute

[17] Loening *et al.* (2009) adopt this approach, first interpolating agricultural GDP in Ethiopia from annual to monthly frequency and applying a Hodrick-Prescott filter.

[18] This presumably reflects decisions on how the treatment of inventories and 'work-in-progress' which, in the context of highly seasonal agriculture will dominate the data series. The NBS has not yet released a detailed description of the methodology used to construct quarterly agricultural GDP.

[19] Narrative analysis from the United States Agency for International Development (USAID) "Famine Early Warning System Network", FEWSNET, which point to bumper crops in the key growing areas in 2002 followed by poor rainfall and incipient food security problems in 2003 and 2004, appear to support the patterns reported by FAO. FEWSNET analysis also supports weak output in late 2006 and 2007.

the deviation of actual rainfall from this long-run average in the principal growing areas. Figure 6 plots a smoothed moving average of these rainfall deviations for producing regions over the sample period. We use this measure as our basic proxy for the output gap, letting the data determine the appropriate lag between rainfall variations and output. It is reasonable to assume, however, that only rainfall variations occurring during critical times in the year such as planting and harvest will affect agricultural output while variations at other times of the year are irrelevant for the output gap. To allow for this, we examine a range of alternative specifications for this proxy, including specifications which pick out rainfall deviations for the growing season only, for the planting season only, for the harvest season only and for combinations of all three. We also computed separate measures for those districts specializing in maize, rice and beans and measures that distinguished between *msimu* (long-rains) and *vuli* (short-rains) growing seasons only. In all cases, these alternatives were dominated by the aggregate measure. As discussed below, we also allow for the possibility that deviations of rainfall from the norm are asymmetric – that 'too much' rain has a stronger effect on prices than 'too little' – as well as the possibility that the effects on prices are non-linear by examining the square of the (positive or negative) deviations from the long-run mean.

The final factor determining food prices we consider is storage. Both public and private storage should dampen within-year seasonal variation in prices. Households have an incentive to hold food stocks if they expect their marginal utility of food to be higher in the future than in the present, most obviously between harvest-time and the hungry season. These storage activities should dampen seasonal fluctuations in prices, although not entirely if storage is costly, because of carry costs or physical deterioration. Similar considerations mean that across-year private storage is unlikely to be as effective. We have no empirical evidence on private storage although the impact of within-season private smoothing will be absorbed by the monthly seasonal dummy variables used in our regression analysis (and the fact that this seasonality in prices is so powerful is evidence that price smoothing through storage is at least incomplete). Public sector storage in Tanzania is facilitated by the National Grain Reserve Authority (NGRA) whose sales and purchases can in principle be used to smooth food prices seasonally, spatially, or even across years (subject to the physical deterioration of stocks), at least when price movements lie strictly within the band between import and export parity prices. When local market prices are arbitraged fairly continuously with world grain prices via imports, intervention by the NGRA will have no effect on price unless it is large enough to drive imports to zero. Similarly, when prices in border regions are being pushed up by demand pressures from neighboring countries (e.g., along the Tanzania/Kenya border in late 2009), attempts to use grain sales to lower grain prices will tend to spill abroad as increased exports, with little effect on local prices. Data on storage activities by the NGRA are limited. We do not have access to the spatial pattern of interventions or any means to distinguish price stabilization transactions from other activities of the grain reserves. Our analysis is therefore limited to examining whether net intervention at the national level moderate food and headline inflation.

4. Results

Table 2 reports our preferred estimates of equation (3) for monthly data on headline inflation and its sub-components for the period from January 2002 to June 2011 (a total sample of T=126). These results are the outcome of an extensive search process across different dynamic specifications and so we report only the most robust results here.[20] Moreover, to facilitate interpretation of the results we report only the standardized beta coefficients rather than the raw coefficients. This allows for an assessment of the relative contribution of variations in the individual regressors to the overall variation in inflation.[21] Columns [F1] and [F2] of Table 2 report the results for food inflation, columns [E1] and [E2] and [C1] and [C2] the results for energy and core inflation (i.e. the non-energy component of the non-food index) respectively, and columns [H1] and [H2] the results for headline inflation. Each equation is estimated free of cross-equation restrictions so that lagged inflation in each sub-component can enter its own equation and those of the other sub-components. The dependent variable in each case is the annualized value of monthly inflation defined as 1200*Δlnp_t^i for *i =(food, energy, core and headline)*, and in all cases we condition the model on a set of 11 centered monthly dummy variables (for the months *Jan…Nov*). For convenience these are not reported in the tables (although see Figure 7 below). Each equation is also conditioned on three further dummy variables included to reflect un-resolved measurement concerns.[22]

The battery of diagnostic tests reported below each table suggests that the models for headline inflation and its components are suitably conditioned: equation residuals are stationary and broadly white noise. There are a small number of deviations from this benchmark, most notably error non-normality in headline inflation which, in turn, reflects non-normality in energy and core inflation, both of which exhibit a small number of extreme values across the sample. But in general the models do not exhibit generalized error autocorrelation, nor is there evidence of any significant error heteroscedasticity, although we report heteroscedastic-consistent standard errors throughout. The overall goodness of fit of the set of models varies substantially, with the adjusted goodness of fit ranging from approximately $\bar{R}^2 = 0.68$ in the case of food inflation to only $\bar{R}^2 = 0.15$ for core inflation; for headline inflation overall, the fit is reasonably good, with an $\bar{R}^2 = 0.63$.

A substantial share of the explanatory power of the food and, as a consequence, headline inflation equations resides in the estimated seasonal pattern in inflation (conditional on controlling for other inflation determinants), which is driven almost entirely by the seasonality in food inflation (see Figure 7). The pattern of seasonality accords with the dynamics of the food cycle in Tanzania and is consistent with an environment in which neither international trade in food nor private and public food storage is sufficiently powerful to eliminate within-year seasonal volatility in food prices. Thus,

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[20] More complete results are available in Adam *et al.* (2012).

[21] Letting the raw parameters be defined by the vector $\boldsymbol{\beta} = \{\beta_1, \beta_2, \dots, \beta_k\}'$, the 'beta coefficients' are defined as $\widetilde{\boldsymbol{\beta}} = \{\beta_1 \left(\frac{\sigma_{X1}}{\sigma_Y}\right), \beta_2 \left(\frac{\sigma_{X2}}{\sigma_Y}\right), \dots, \beta_k \left(\frac{\sigma_{Xk}}{\sigma_Y}\right)\}'$ where σ_{Xk} and σ_Y are the sample standard deviations of regressor *k* and the dependent variable respectively.

[22] Specifically, these consist of, first, an 'intercept correction' designed to pick up what appears to be a levels adjustment in the food price series which saw food prices drop by around 5% in one month; and second, a 'pulse dummy' to pick up an atypical movement in non-food prices at the very beginning of our sample period. In this instance non-food inflation dropped very sharply in March 2002 but spiked by the same amount in April of the same year. The final dummy variable, d10m9 controls for the introduction of a new CPI series from September 2010. This takes the form of an 'intercept correction' to the price levels for headline inflation and each of the sub-components.

other things equal, food inflation picks up from the third quarter of each year, peaking around planting time in December and January – the 'hunger season' in Tanzania – and falling sharply in June and July following harvest. Given the food share in total consumption, this pattern is repeated in overall inflation although is slightly moderated by a countervailing but statistically insignificant non-food seasonality. It is notable that, other things equal, non-food prices fall relative to their mean at the time of highest seasonal food prices, consistent with the negative demand-side transmission discussed in Section 2.

4.1 Food price inflation

Our results for the food inflation equation highlight the interplay of demand-side and supply side factors and distinguish between short-run and long-run or error-correction effects. Column [F1] presents a basic specification in which food inflation is restricted to respond symmetrically to positive and negative deviations from the long-run inflation anchors while column [F2] accommodates potential asymmetries and non-linearities in the food inflation equation. Consistent with our priors, column [F1] indicates that food inflation is driven primarily by supply-side determinants: we find a weak but statistically insignificant positive effect of excess money growth on food inflation and a direct short-run effect from the growth rate of broad money, both acting with a one-quarter lag, but these effects are substantially outweighed by supply-side determinants. First, the negative coefficient on the error correction term on the food real exchange rate indicates price-stabilizing international trade in food: if domestic food prices rise above the relevant world price, adjusted for the exchange rate, food imports will increase, augmenting domestic supply and returning domestic prices back towards their long-run PPP value. Although this effect is statistically significant, it is relatively weak compared to other inflation determinants and operates with a substantial lag: the error correction coefficient suggests that for the economy as a whole it takes around 5 months for this stabilizing effect to start to take effect.

Second, our rainfall-based proxy for the agricultural output gap is statistically significant and plausibly signed: other things equal, good rains (i.e. positive excess rainfall) dampen food price inflation with a lag of about one quarter (again conditional on the regular seasonal variation in prices) and *vice versa* for deficient rainfall. The effect is modest in scale with the (un-standardized) coefficient indicating that when rainfall is 10 percent above its seasonal mean, food inflation drops by around three quarters of one percent.

Finally, domestic food prices are also significantly influenced by energy price inflation, both directly (lagged energy inflation is significant in the food inflation equation) and indirectly through deviations of domestic energy prices from their long-run relative PPP value. As we note below, we find a conventional error correction effect tying domestic to world energy prices so that excess domestic energy prices adjust back towards their long run PPP value. However, for the duration of this disequilibrium, there is positive spill-over onto domestic food prices. This strong transmission reflects the energy intensity of food production, both through the high transport cost component in domestic retail food and the cost of intermediate inputs to food production such as fertilizer.

Two other features emerge from this first set of results. The most striking is that food price inflation displays very little persistence. We find a positive effect from the second lag of food prices but this exactly offset and neutralized by the effect at four lags, with the consequence that there is no 'memory' in food price inflation beyond four months, conditional, of course, on other determinants including the seasonal pattern of prices. And secondly, we find that net grain purchases by the strategic grain reserves (i.e. actions to reduce aggregate food supply, *ceteris paribus*) operate in the expected direction but the measured effect on food inflation is nugatory and not statistically significant. This is consistent with the narrative evidence on the grain reserve whose net interventions appear to be determined by factors other than aggregate price stabilization.

The results in column [F2] suggest that there are important asymmetries in these supply-side effects suggesting differential domestic inflation responses to positive as opposed to negative deviations of domestic food prices from world food prices and of domestic energy prices from world energy prices. These asymmetries appear to be decisive: we find food price inflation *rises* much more rapidly when world prices exceed domestic prices than it falls when world prices are below domestic prices. The pattern for energy prices is less dramatic but nonetheless suggests that the spillover to food prices is about twice as strong, and twice a significant in response to positive energy price shocks (i.e. when domestic energy prices exceed their PPP level) as it is to negative energy price shocks.

These results are consistent with much of the anecdotal evidence that monopoly power amongst food importers and distributors generates significant downward stickiness in food inflation in Tanzania. To see this, assume for convenience that domestic supply is at its equilibrium or normal value (i.e. $(r - \bar{r}) = 0$). In this case, our results indicate that a spike in world food prices which implies $\left(p_f - p_f^*\right) < 0$, has a strong positive effect on domestic food inflation (since the coefficient on $\left(p_f - p_f^*\right) < 0$ is -0.16 the product of the variable and the coefficient is positive), whilst a decline in world food prices has a much weaker and less significant dampening effect on domestic food inflation (because the coefficient is only one third as large at -0.03). In other words, adverse world conditions are transmitted to the domestic economy more powerfully than benign ones, so that while domestic food prices are anchored by relative PPP in the long run, short run domestic food inflation follows world food price accelerations quite rapidly but will significantly lag world food price decelerations.

The results on rainfall deviations also suggest asymmetric adjustments although in this case the dynamics are rather different. In this case it appears that price adjustments are stronger in times of domestic surplus ($(r - \bar{r}) > 0$) than at times of domestic deficit, suggesting that the trade regime operates in a way that liberalizes food imports in the face of adverse domestic supply conditions, so as to prevent domestic prices from rising; while simultaneously displaying a reluctance to allow food surpluses to be exported, so that favourable supply shocks drive down domestic prices, other things equal.

4.2 Energy price inflation

The dynamics of non-food inflation are also broadly consistent with our priors. Columns [E1] and [E2] on energy inflation tell a relatively simple story in which domestic energy prices are anchored to and hence primarily determined by developments in world markets. This correspondence, while statistically significant, is not particularly tight in part because the domestic energy sub-aggregate covers both the tradable fuels that appear in the world energy price index, albeit with different weights, and energy components that do not (most notably charcoal and a substantial share of hydroelectric generation). Nevertheless, the dominant feature of the energy price regressions is the significance of the error correction coefficient which, at around -0.32, suggests a powerful and rapid adjustment of domestic to world energy prices (see column [E1]). As with food price inflation, we observe an asymmetry: as shown in [E2], starting from equilibrium, domestic energy prices adjust (downwards) more rapidly to a fall in world energy prices than to a rise in world prices. Beyond this anchor effect, the evolution of energy prices is relatively poorly explained. We can exclude any effects coming from the money market disequilibrium, although there is a weak short-run effect from the growth in broad money, and we find no conventional persistence in energy inflation (as with the food price inflation, we find an 'acceleration' specification fits the data). One small and unresolved puzzle with the energy equation is the unexpected positive feedback from food prices onto energy prices. One possible but un-tested explanation is that both prices are driven in part by rainfall, with poor rainfall both directly increasing food prices and reducing the share of relatively cheap hydroelectric electricity in the total energy mix.[23]

4.3 Core inflation

Finally we turn to core inflation. Although the model explains a relatively small share of the variation in core inflation, the results in Columns [C1] and [C2] conform to the textbook description of core inflation being determined essentially on the demand side. Monetary factors, both the deviation for money market equilibrium and in particular short-run monetary growth matter significantly for core inflation. In contrast to food and energy prices, however, there is some stickiness in core inflation operating through the first and second lags, although in quantitative terms the implied persistence in core inflation is minimal. In addition we find that lagged food price inflation (and to a much milder extent, lagged energy inflation) exert a weak negative effect on core inflation, consistent with the transmission mechanism described in Section 2 above where rising food and fuel prices squeeze the non-food share of consumers' budgets transmitting a negative demand impulse onto core inflation. The absence of supply-side factors in determining core inflation is surprising, although this may be due to deficiencies in measurement. It is plausible that at least the tradable share of core prices would be tied through arbitrage to their corresponding world prices, but for the core prices sub-aggregate as a whole we have been unable to identify a robust stationary real exchange rate relationship with conventional real effective exchange rate measures based on world price indices such as US or OECD wholesale price indices or measures of the manufactured unit value index reported by the IMF. We have also not yet succeeded in identifying a robust measure of an output gap for core inflation (beyond that working through the money demand error correction term). Addressing these supply-side issues is a priority for future work and may go some way to improving the explanatory power of the core inflation equation.[24]

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[23] In Adam *et al.* (2012) we seek to control for the composition effects of the energy index by examining fuel prices after stripping our domestically generated energy, including hydroelectric generation. Doing so, we recover a well-defined and much more powerful error-correction description of fuel price inflation and, in contrast with the overall energy index, we find that domestic prices return to their equilibrium significantly more rapidly when domestic prices are below their equilibrium than when they are above.

[24] Neither NBS nor the Bank of Tanzania currently report monthly output indicators of non-agricultural economic activity, although recent efforts by the Bank to develop leading indicators of real economic activity is

4.4 Headline inflation

Pulling together the main features from the sub-components, the final columns [H1] and [H2] present results for headline inflation. These results contain no surprises, reflecting the dominant features from the models for the principal sub-components more or less in proportion to the relative weight of each component in the consumption basket. Thus the drivers of food price inflation, including the powerful seasonality in food prices, remain significant in the equation for headline inflation and broadly proportional to the relative weight of food in the basket, while the strong impact of excess money growth on non-food inflation also carries over. And although we do not report the results here, the key asymmetries noted for food and energy inflation, both in terms of pass-through effects and rainfall variations carry through to headline inflation although without quite the same level of statistical significance. Finally, the dynamic patterns observed earlier also carry through to headline inflation: beyond the seasonal pattern, the only source of persistence in headline inflation comes from some mild stickiness in core inflation.

5. Conclusions

The analysis in this paper offers a set of inflation equations that identify, with varying degrees of precision, a plausible characterization of the main determinants of inflation in headline prices and its principal components in Tanzania over the last decade. A number of puzzles remain with the analysis and in particular with the underlying data with the consequence that some of the results are undeniably fragile. Nonetheless, the analysis offers a coherent post-estimation interpretation of the inflation experience in Tanzania for the year following the sample period and generates a number of reasonably robust conclusions which have direct implications for policy. We draw five main conclusions from our analysis.

First, money growth and hence the stance of monetary policy matters for inflation both in the long run and in the short run. The transmission from the monetary stance, through aggregate demand, to headline inflation is principally through core inflation but not exclusively so; monetary or demand-side effects also feed food and fuel price inflation, particularly in the short run. Second, however, the largest component of overall inflation -- food price inflation -- is predominantly driven by supply-side factors including both domestic agricultural output shocks and the pass-through from world prices for food and fuel. Though statistically significant, the inflation transmission from world food prices is relatively weak and attenuated, and is much stronger when world prices rise than when they fall. Third, the effect of domestic supply conditions on food price inflation points to the asymmetric effects of trade policy in Tanzania: while food imports appear to respond reasonably rapidly to domestic production shortfalls, the capacity to export surplus food production is much more muted so that market adjustment in this case occurs through falling prices, other things equal. This result has important implications for trade policy and production incentives in agriculture although, as noted below, a much closer analysis of cross-border prices is required before firm policy conclusions

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an encouraging development. These may be used, in the context of factor-augmented models to develop a robust output gap for core inflation.

can be drawn. Fourth, headline inflation exhibits strong seasonality, consistent with weak price-stabilizing effects of trade and incomplete storage. Non-food inflation is, by contrast, broadly non-seasonal. Finally, prices in Tanzania in general are flexible, more so for the food and energy sub-components but even in the traditionally sticky-price domain of core inflation there is little evidence of persistence. Some of the adjustments to equilibrium are somewhat prolonged, but conditional on these error-correction effects, inflationary shocks dissipate rapidly with half-live being little more than one month.

These conclusions need to be tempered by three further considerations. Most urgently, further work is required on the supply-side and pass-through effects operating on core inflation as and when better high frequency data on economic activity become available. Second, and related, once we have controlled for exchange rate effects operating through the pass-through from world food and fuel prices – and for the role of the exchange rate in determining the equilibrium demand for money -- we find only a surprisingly weak independent short-run role for the nominal exchange in any of the inflation equations, even the core inflation equations (see [C1] and [C2]).[25] Finally, the concept of 'world food prices' used throughout this analysis needs to be revisited to reflect cross-border food prices, particularly in Kenya to the north and Zambia and Malawi to the southwest of the country. At present, our models include measures of the deviation of domestic food and fuel prices from world price indices derived from the World Bank global commodities database. These are clearly not the relevant external price for food in Tanzania and may not even correlate with the relevant region prices. No such regional food price measure is readily available but could and should probably be constructed from the national data of neighbouring countries.

[25] The point estimates of the exchange rate (semi-)elasticity are low; a month-to-month depreciation of the nominal exchange rate of 10 percent would increase the annualized inflation rate by around 0.5 percentage points.

References

Adam, C. S., P. J. Kessy, J. J. Nyella and S. A. O'Connell (2011) 'The Demand for Money in Tanzania', IGC Working Paper 11/0336.

Adam, C. S., D. Kwimbere, W. Mbowe and S. O'Connell (2012) 'Food Prices and Inflation in Tanzania', IGC Working Paper 12/0459.

Aoki, K. (2001) 'Optimal Monetary Policy Responses to Relative Price Changes', Journal of Monetary Economics, 48: 55-80.

Diouf, M. A. (2007) 'Modelling Inflation in Mali', IMF Working Paper WP/07/295.

Durevall, D., J. L. Loening, and Y. Ayalew Birru (2013) 'Inflation Dynamics and Food Prices in Ethiopia' Journal of Development Economics 104: 89-106.

Durevall, D. and N. Ndung'u (2001) 'A Dynamic Model of Inflation of Kenya, 1974-96", Journal of African Economies, 10: 92-125.

Goldfeld, S. M. and R. E. Quandt (1973) 'A Markov Model for Switching Regressions' Journal of Econometrics, 1: 3-16.

Hendry, D. (2001) 'Modelling UK Inflation, 1875-1991' Journal of Applied Econometrics, 16**:** 255-75.

IMF East Afritac (2006) 'Evaluation of CPI compilation', unpublished paper.

Kinda, T. (2011) 'Modeling Inflation in Chad', IMF Working Paper WP/11/57.

Kirchberger, M. and F. Mishili (2011) 'Agricultural Productivity Growth in Kagera between 1991 and 2004', IGC Working Paper 11/0897.

Lokina, R., M. Nerman and J. Sandefur (2011) 'Poverty and Productivity: Small Scale Farming in Tanzania, 1991-2007', IGC Working Paper, April.

National Bureau of Statistics (NBS), Tanzania (2011) Rebased National Consumer Price Index Press Release, November 2010.

Ng, F. and M. A. Aksoy (2008) 'Who Are the Net Food Importing Countries?', World Bank Policy Research Working Paper 4457.

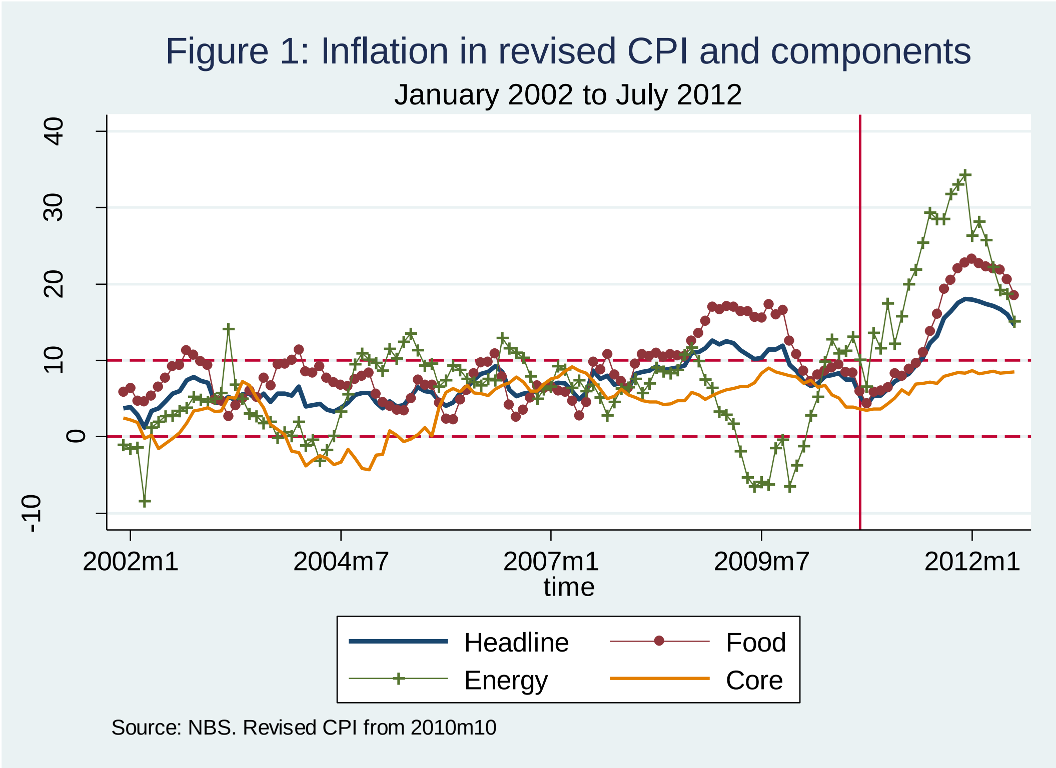
Ubide, A.J. (1997) 'Determinants of Inflation in Mozambique', IMF Working Paper WP/97/145.

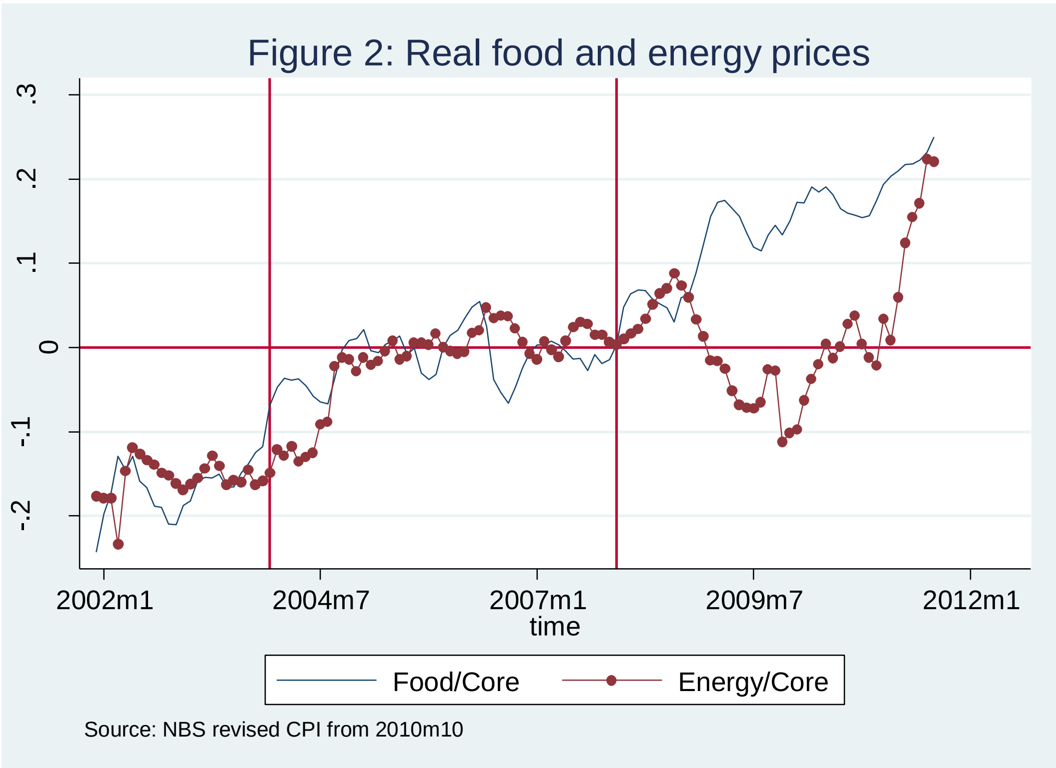
Sargan, D. (1964) 'Wages and prices in the United Kingdom: A study in econometric methodology' in Hart, P. E., G. Mills, and J. K. Whitaker (eds), Econometric Analysis for National Economic Planning. London: Butterworth.

USAID Famine Early Warning System Network (FEWSNET), www.fews/net/tanzania.

Woodford, M. (2003) Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton: Princeton University Press.

Figures and Tables





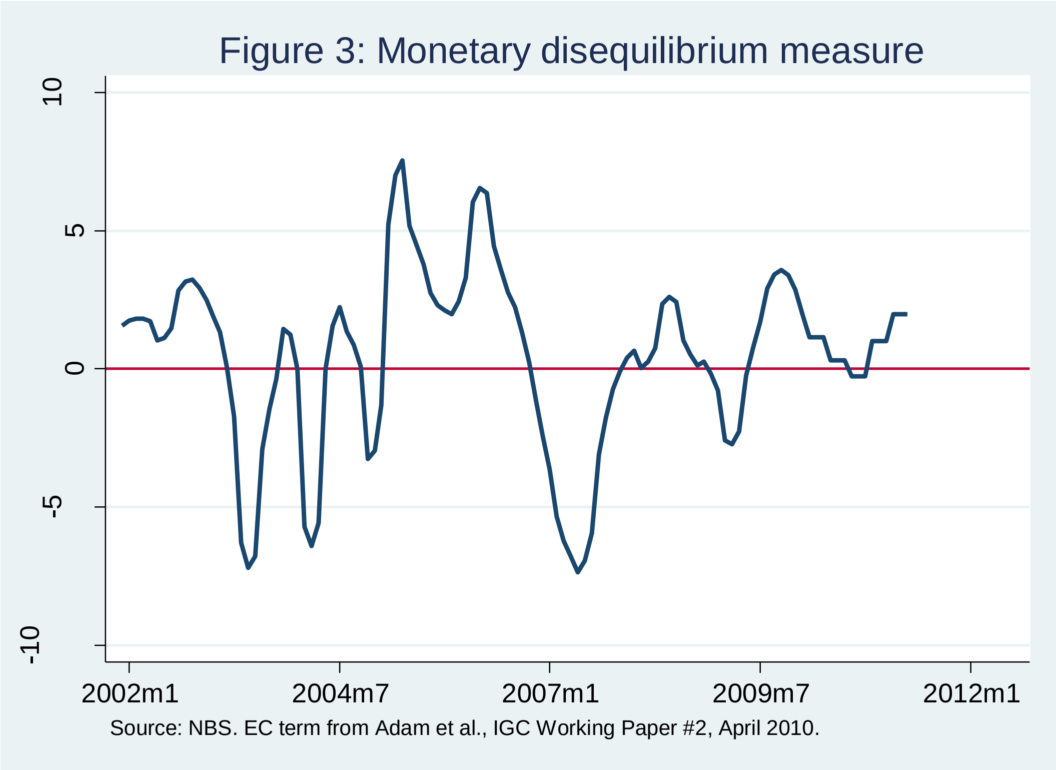


Figure 3: Monetary disequilibrium measure
10
5
0
-5
-10
2002m1
2004m7
2007m1
2009m7
2012m1
Source: NBS. EC term from Adam et al., IGC Working Paper #2, April 2010.

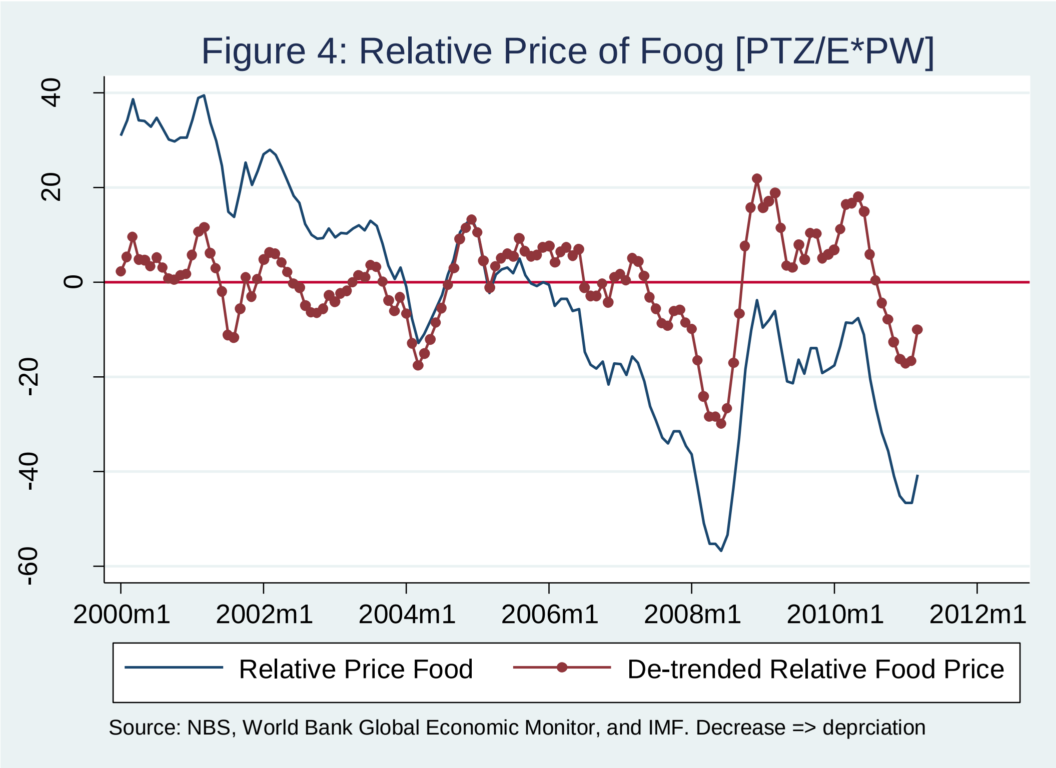
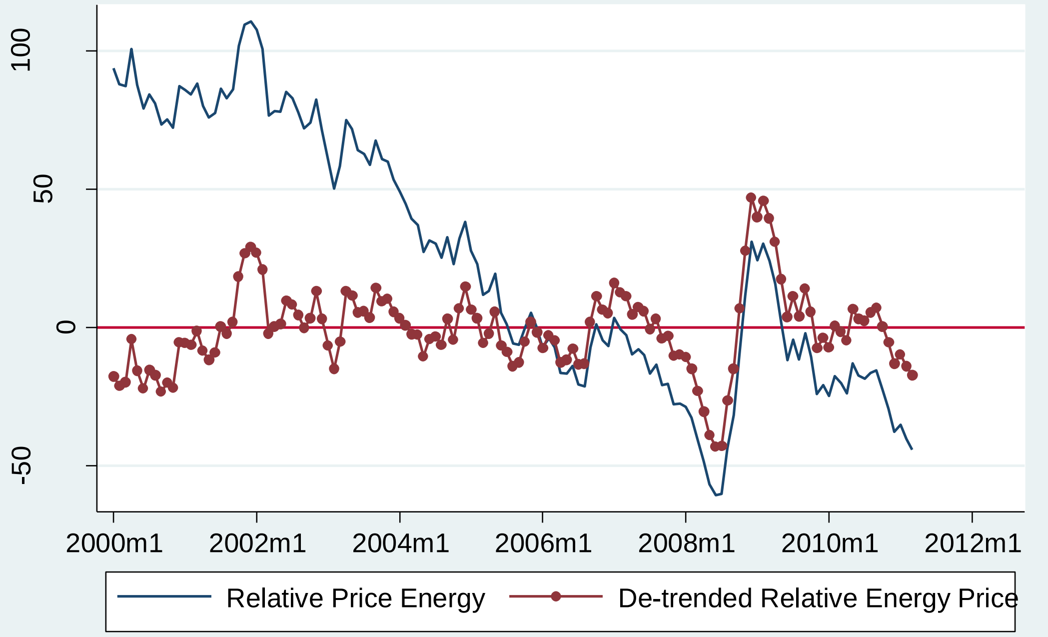


Figure 4: Relative Price of Foog [PTZ/E*PW]
40
20
0
-20
-40
-60
2000m1
2002m1
2004m1
2006m1
2008m1
2010m1
2012m1
Relative Price Food
De-trended Relative Food Price
Source: NBS, World Bank Global Economic Monitor, and IMF. Decrease => deprciation

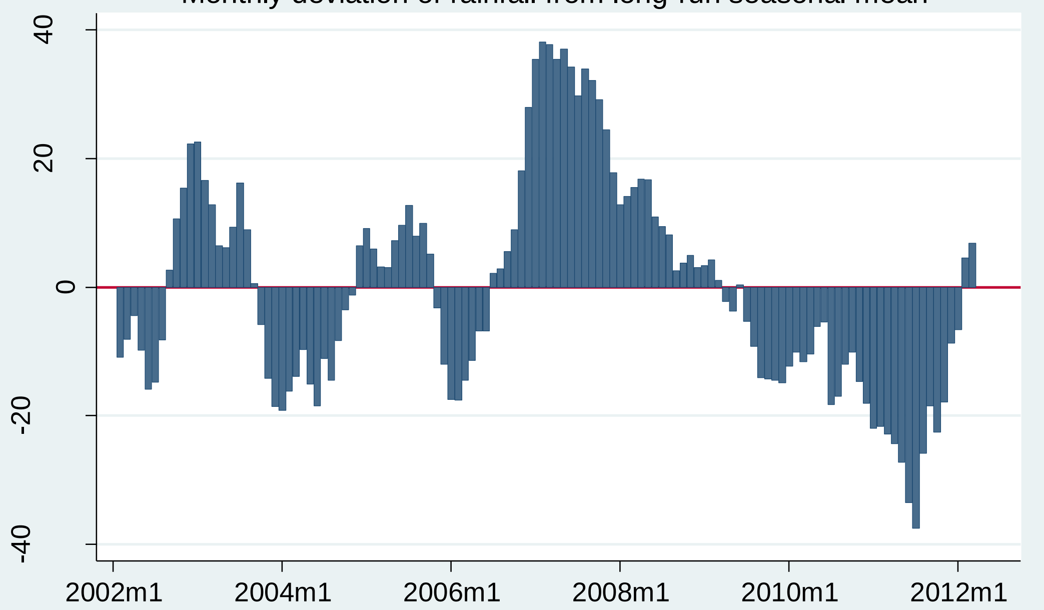
Figure 5: Relative Price of energy [PTZ/E*PW]



Source: NBS, World Bank Global Economic Monitor, and IMF. Decrease => deprciation

Figure 6: Rainfall proxy for agricultural output gap

Monthly deviation of rainfall from long-run seasonal mean



Source: Tanzania Meterological Authority

Table 1. Summary Statistics on Inflation, January 2002 to June 2011 [1]

Inflation measure	Weight [2]	Unconditional full sample		Controlling for measurement adjustments [3]		Pre-Lehman/Global Financial Crisis [Sept 2008]		Post-Lehman [Sept 2008]	
		Mean (%)	Standard deviation (%)	Mean (%)	Standard deviation (%)	Mean (%)	Standard deviation (%)	Mean (%)	Standard deviation (%)
Headline	1.000	6.96	2.53	6.19	3.16	5.84	1.87	7.01	5.00
Food	0.510	8.51	3.75	7.71	4.44	7.06	2.64	9.24	6.88
Core	0.433	3.96	3.53	3.41	3.69	2.91	3.74	4.59	3.31
Energy	0.057	6.49	6.5	4.66	5.27	5.77	4.19	2.06	6.59

Notes: [1] Inflation measured as twelve-month difference in log prices; [2] Weights based on new CPI series released by NBS October 2010, where food is defined as food and non-alcoholic beverages including restaurant-consumed food; [3] These consist of an intercept correction to pick up an atypical movement in the food price series in July 2006; a pulse dummy to pick up an atypical movement in non-food prices between March and April 2002; and an intercept correction to account for the introduction of the new CPI series from September 2009.
Source: Tanzania National Bureau of Statistics.

Table 2, part 1. Inflation equations, Jan 2002 – June 2011 (dependent variable: 12-monthly change in log price index)

Standardized beta coefficients (t-statistics in parentheses)		**Food** CPI weight 0.51		**Energy** CPI weight 0.057		**Core** CPI weight 0.433		**Headline** CPI weight 1.00	
		F1	**F2**	**E1**	**E2**	**C1**	**C2**	**H1**	**H2**
Headline inflation and components									
Headline inflation	Δ2(t-2)							0.23	
								(2.63)	
Food inflation	(t-2)	0.20	0.22						
		(3.08)	(3.16)						
	(t-4)	-0.20	-0.23						
		(2.90)	(3.25)						
	Δ2(t-2)					-0.22	-0.23		0.20
						(2.16)	(1.98)		(2.55)
	Σ(t-1)+(t-3)			0.17	0.20				
				(2.31)	(2.39)				
Energy inflation	(t-1)	0.14	0.15	0.14	0.15		-0.08		
		(2.79)	(2.98)	(1.94)	(2.03)		(0.86)		
	(t-3)						-0.12		
							(1.29)		
	Δ3(t-1)								0.20
									(3.30)
Core inflation	(t-2)								0.15
									(2.62)
	(t-3)	0.22	0.14						
		(1.26)	(0.76)						
	Σ(t-1)+(t-2)					0.30	0.29		
						(2.69)	(3.29)		
Deviations from long-run anchors									
Money									
(m-m*)	(t-3)	0.08	0.08					0.14	0.12
		(1.34)	(1.12)					(2.25)	(1.93)
	(t-5)					0.13	0.17		
						(1.59)	(1.98)		

(table continued as part 2 below)

Table 2, part 2. Inflation equations (continued from Table 1, part 1)

Standardized beta coefficients (t-statistics in parentheses)		**Food** CPI weight 0.51		**Energy** CPI weight 0.057		**Core** CPI weight 0.433		**Headline** CPI weight 1.00	
		F1	**F2**	**E1**	**E2**	**C1**	**C2**	**H1**	**H2**
Food									
(pf-pf*)	(t-5)	-0.21						-0.22	-0.22
		(3.21)						(3.22)	(3.36)
(pf-pf*) > 0	(t-5)		-0.03						
			(0.48)						
(pf-pf*)<0	(t-5)		-0.16						
			(2.40)						
Energy									
(pe-pe*)	(t-1)	0.17		-0.32				0.06	0.07
		(2.82)		(3.84)				(0.92)	(1.02)
(pe-pe*)>0	(t-1)		0.14		-0.27				
			(2.18)		(3.33)				
(pe-pe*)<0	(t-1)		0.07		-0.12				
			(0.90)		(1.45)				
Rainfall									
(r-rbar)	(t-2)	-0.14						-0.13	-0.12
		(2.52)						(2.03)	(2.11)
(r-rbar)>0	(t-2)		-0.18						
			(2.94)						
(r-rbar)<0	(t-2)		0.02						
			(0.27)						
Short-run factors									
Growth in M2	(t-3)	0.10	0.13					0.09	
		(1.53)	(2.02)					(1.32)	
	Δ2(t-2)			0.12	0.12	0.27	0.24		
				(1.65)	(1.66)	(2.25)	(2.19)		
Net SGR purchases	(t-3)	0.07	0.09						
		(1.00)	(1.56)						
Lagged ER depreciation	(t-1)			0.05	0.05				
				(0.75)	(0.75)				
	(t-2)					0.13			
						(1.34)			

N	119	119	120	120	120	120	119	119
R2	0.74	0.76	0.47	0.48	0.29	0.31	0.65	0.69
Adjusted R2	0.68	0.69	0.37	0.37	0.16	0.15	0.58	0.63
Diagnostics								
J-B Normality	0.34	0.28	0.00	0.00	0.01	0.01	0.06	0.04
LM 1	0.80	0.82	0.99	0.83	0.37	0.51	0.04	0.48
LM 4	0.22	0.36	0.73	0.92	0.78	0.66	0.25	0.73
ARCH 1	0.43	0.51	0.45	0.38	0.40	0.36	0.82	0.74
ARCH4	0.34	0.19	0.00	0.00	0.72	0.73	0.78	0.47
BP Hettest	0.14	0.16	0.03	0.03	0.08	0.04	0.95	0.86
F-seasonal	0.00	0.00	0.47	0.42	0.53	0.51	0.00	0.00

Notes: Variable definitions are in Appendix Table A.1. **[1]** Beta coefficients defined as betaβ(i)=β(i)(σx/σy) where β(i) is the estimated coefficient, σy is the standard deviation of the dependent variable and σx the standard deviation of the regressor; [2] t-statistics are based on heteroscedasticity-consistent standard errors; [3] Δx = x(t)-x(t-1) and Δ2x = x(t)-x(t-2); [4] AR[x] denotes LM test of zero autocorrelation at lag 1 to x; ARCH[x] denotes LM test of zero autoregressive conditional heteroscedasticity of lag 1 to x; BP-HETTEST denotes Breusch-Pagan test of absence of heteroscedasticity; SK-TEST tests the null of error normality. [5] All regression include 11 centred seasonal dummy variables (coefficients not reported). F-SEASONAL denotes F-test against joint significance of seasonals; [6] estimates conditional on additional dummy variables included to account for apparent measurement errors (in July 2007, March/April 2002) and re-basing of CPI in October 2010.

APPENDIX

Table A.1. Variable definitions, transformations, and sources

Variable	Definition	Source
lph	log headline price index	NBS
lpf	log food price index	
dlpn	log non-food price index	
lpe	log energy price index	
lpc	log core price index	
lpfuel	log fuel price index	
leu	log nominal exchange rate index	BOT
lm2	log money M2	
lsgr	log net sales from Strategic Grain Reserve	
lpwf	log world food price index	World Bank Commodity Price Data (Pink Sheet) from World Bank online Global Economic Monitoring database.
lpwe	log world energy price index	
lpwfuel	log world fuel price index	
	Error correction terms	
ecm2d	Money (M2) market equilibrium	Adam *et al.* (2010)
lrerf_hpc	log real exchange rate for food (lpf-leu-lpwf)	See text
lrere_hpc	log real exchange rate for energy (lpe-leu-lpwe)	See text
anomun	deviation of rainfall from seasonal mean in production regions	Tanzania Meterological Agency