Inflation forecasting models for Uganda: is mobile money relevant?

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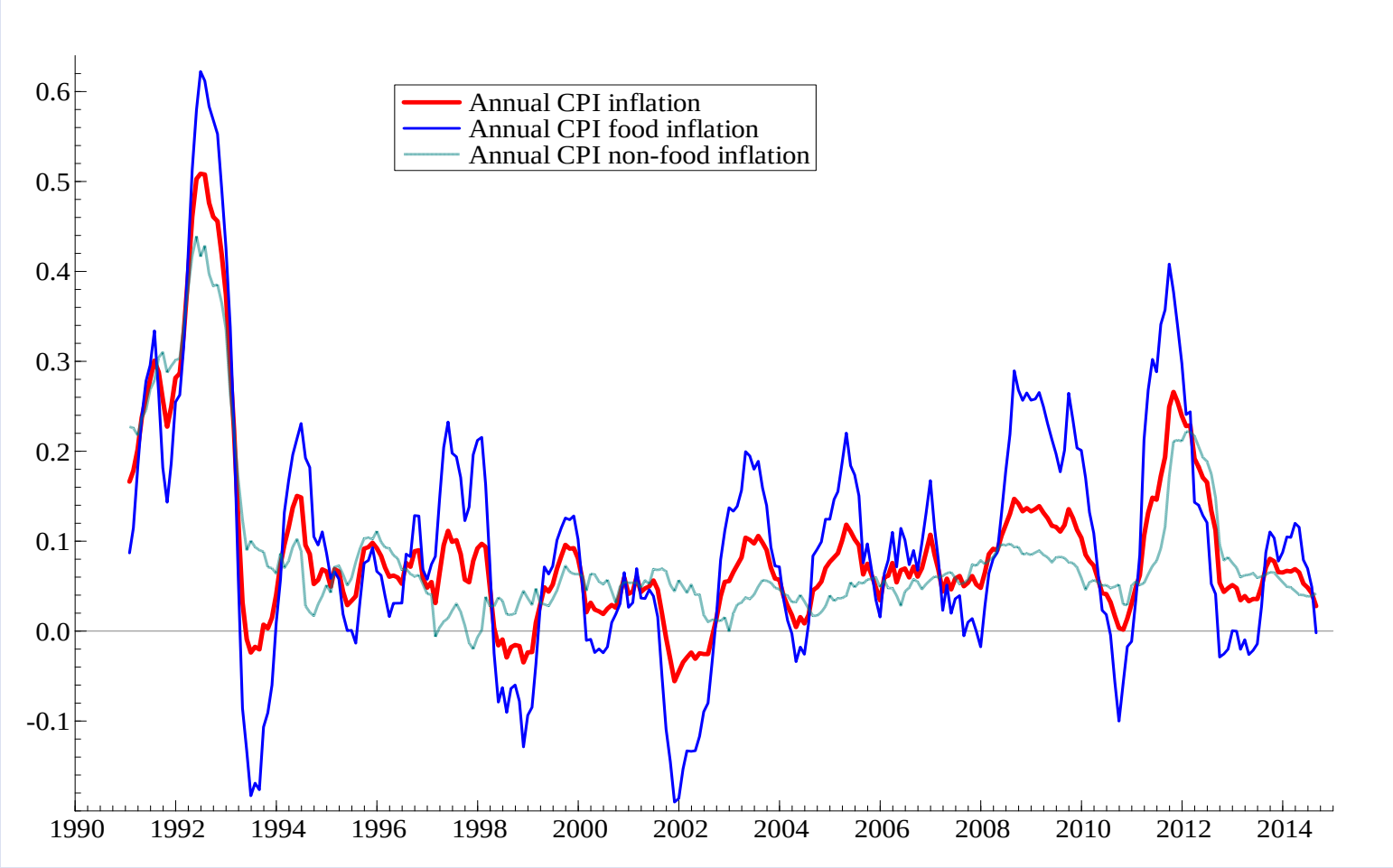
Aims

- Check for the relevance of mobile money balances and mobile transactions levels in models of inflation in Uganda.
- Develop 1-month and 3-month inflation forecasting models.
- Use best practice econometric methods on eclectic equilibrium correction models – General Unrestricted Models (GUMs) that "allow the data to speak".
- Given importance of food in the Ugandan economy, model food and non-food inflation separately.
- Take full account of supply shocks – droughts and floods.

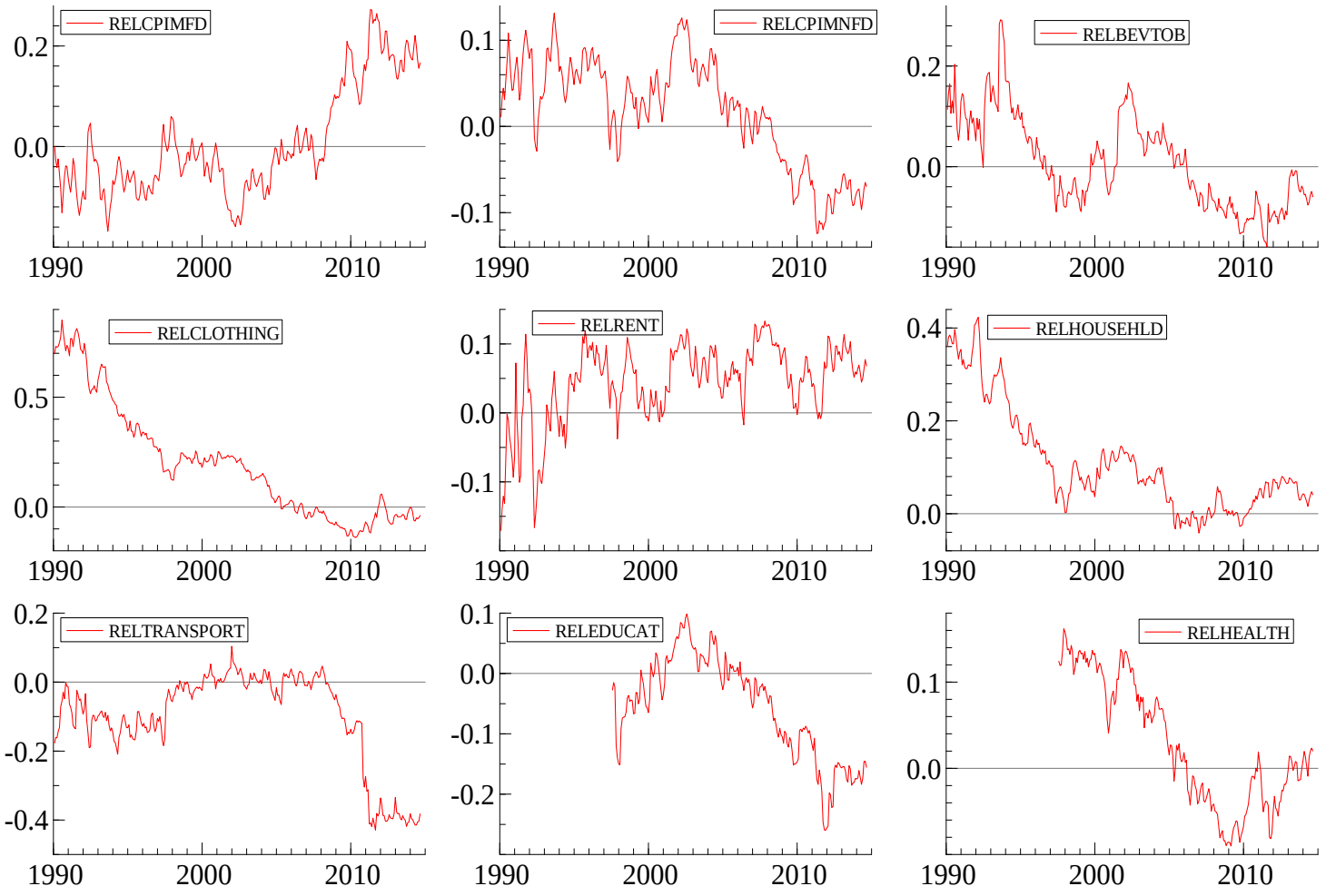
Starting hypothesis: inflation is heterogeneous, state dependent process

- Sheshinki and Weiss (1977): the probability of price changes is state dependent.
- Calvo pricing and NKPC implausible.
- RE contradicted by evidence on inflation expectations.
- Heterogeneity suggests:
  - Adjustment to relative price disturbances is part of inflation dynamics.
  - Gains from disaggregation possible as in papers by Espasa, Hubrich, ourselves for South Africa, and others.

12-month Uganda inflation rates



Trends in various relative Ugandan CPI components



Previous research on inflation in Uganda

- Kihangire & Mugyenyi (2005): 1994-2005
  - M2 and exchange rate, log rainfall, terms of trade (negative), log fiscal deficit/GDP, and measure of exchange rate mis-alignment.
- Mugume & Kasekende (2009): 1995-2008
  - money stock, foreign prices. 'Perverse' signs on output gap and interest rate. No rainfall data.
- Kabundi (2012): 1999-2011
  - key drivers money stock and foreign prices, incl. energy in dynamics. No rainfall data.
- Opolot & Kyeyune (2012): 2000-2012
  - money stock and foreign prices, terms of trade. No rainfall data.

5 key factors that influence forecasting performance

1. Clements and Hendry (1998, 2002) argue that structural breaks are key to forecast failure. Differencing can help robustify against breaks, but at cost of discarding longer run information.

2. For US data, univariate models in differences are hard to beat, claim Stock and Watson (1999, 2003), especially in stochastic parameter version, Stock and Watson (2007).

Aron and Muellbauer (2013) show this is not so, even for the US. Multivariate approaches better –especially for LDCs like Uganda.

5 key factors that influence forecasting performance

3. Include long-run trends such as trade-openness.

4. Include long-run information in equilibrium correction component (ECM) terms – better than models specified only in differences for non-stationary data.

5. Allow for non-linearities in the inflation process, when high current or recent rates of inflation are associated with disproportionately higher future inflation.

Econometric specification

- Proxy state dependence by non-linearities
  - linked to idea that time-varying second moments may matter as in Reis(2006);
  - hence include quadratic terms.

- Handle "curse of dimensionality" with *parsimonious longer lags* (PLL), and use automatic model selection methods (Autometrics).

- Instead of 12 monthly lags, PLL uses monthly changes for very recent past, then 3-month, then 6-month. Instead of 12 parameters, we use 5 to capture lags up to 12 months.

General ECM for CPI components (without PLL)

$$\Delta logCPI^{i}_{t+h}$$

$$= \alpha + \sum_{j=0}^{k} \omega_j \, \Delta logCPI^{i}_{t-j} \qquad \text{Information Set 1}$$

$$+ trends \; and \; dummies \qquad \text{Information Set 2}$$

$$+ \sum_{j=0}^{k} \gamma_j \, outgap_{t-j} \qquad \text{Information Set 3}$$

$$+ \sum_{g=1}^{m} \sum_{j=0}^{k} \varphi_{g,j} \, \Delta logOTHERPRICES_{g,t-j} + \sum_{l=1}^{n} \sum_{j=0}^{k} \beta_{l,j} \, \Delta X_{l,t-j} \qquad \text{Information Set 4}$$

$$+ \sum_{g=1}^{m} \varphi_g \, (logOTHERPRICES_{g,t} - logCPI^{i}_{t}) + \sum_{l=1}^{n} \beta_l \, X_{l,t} \qquad \text{Information Set 5}$$

$$+ non - linear \; terms \qquad \text{Information Set 6}$$

$$+ \varepsilon_{it}$$

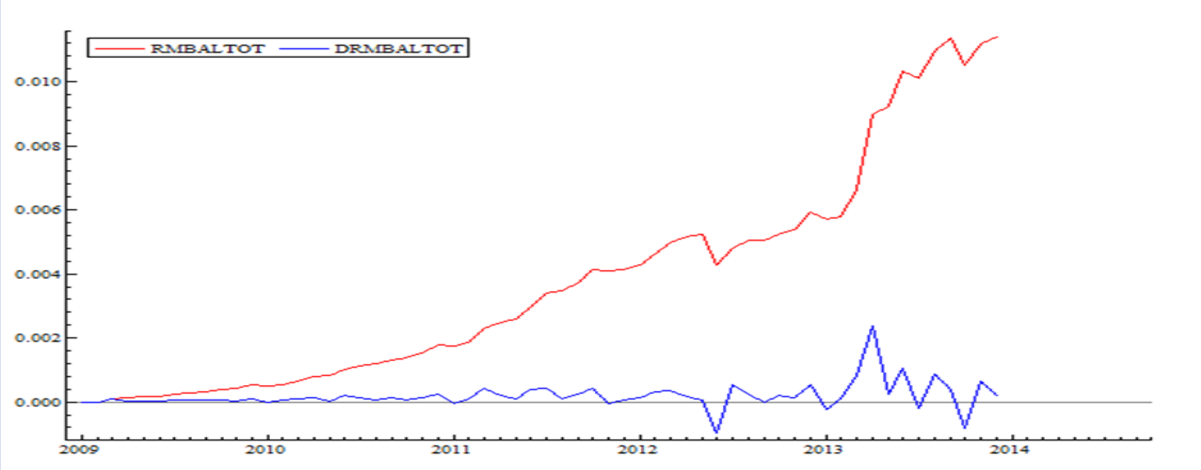
Key data

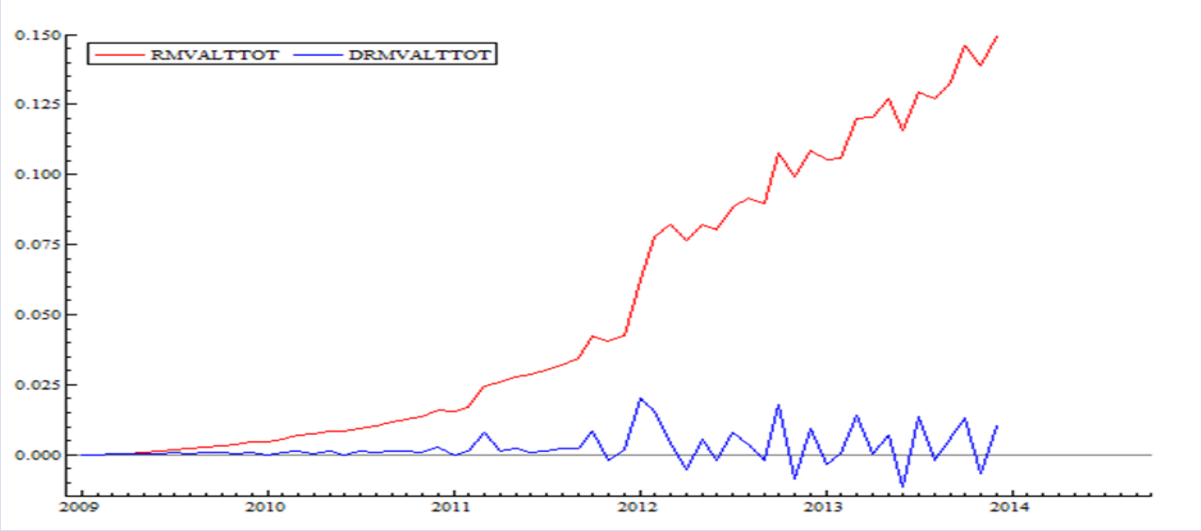
- Relative prices in logs:
  - Food and non-food components of CPI
  - Domestic fuel prices
  - Foreign prices translated at the exchange rate include oil, maize, coffee, prices in Kenya, and US PPI as proxy for global manufactured goods
  - Exchange rate
  - Terms of trade
- Supply shocks: replace output gap by deviation of rainfall from mean.
- Demand indicators: growth rates of credit and money; (log) level of real broad money relative to GDP; government deficit to GDP; and trade and current a/c to GDP.
- Interest rate differential relative to US.

Key data definitions

- Trade-openness measured by (export + import volume)/real GDP.
- One key structural break is increased regional trade integration: allowing for shift in influence of Kenyan food prices after mid-2000s.
- Check for other structural breaks with step dummies, especially around points where CPI structure changes.
- Two measures of mobile money: ratio of balances to M3; and value of transactions to M3.

Ratio of mobile balances to M3 and of mobile transactions volume to M3





Why might mobile money matter for inflation?

- ADB (2010) suggest mobile money growth increased inflation in Kenya (based on 3 data points and poor controls).
- Increased velocity of circulation increases 'effective money', and hence inflation in the monetarist view.
- Higher mobile balances might signal plans for impending spending and so proxy short-term demand increase.
- Advent of mobile money might transfer spending power to households with higher propensity to spend, so reduce saving
- But mobile money is secure and might encourage saving.
- Mobile money improves economic efficiency - not inflationary.
- Cost reductions may *not* be reflected in mis-measured CPI.

The system

- Three equations:
  - domestic fuel prices driven by Dubai oil price, domestic non-food and demand factors;
  - food price driven by domestic fuel price, non-food, international and domestic supply and demand factors;
  - non-food price driven by domestic fuel price, food, international and domestic supply and demand factors.
  - All conditional on the exchange rate.

- Hence, could solve for all three endogenous domestic prices in terms of international prices, exchange rate and domestic supply and demand factors.
  - Obvious next priority would be to add an exchange rate equation.

Non-linear proxy for state dependence of adjustment frequency

- High recent rates of inflation associated with more rapid pass-through of cost shocks
  - o suggested by time-varying frequency of information updating, Reis (2006)

- Suggests that parameters in equation (1) vary with recent inflation experience - but would be a complex model, non-linear in both variables and parameters.
- Simpler model is to include additive terms of a non-linear transformation of inflation.
- We use the residual from the regression of $(\Delta_3 \log PC)^2$ on a constant and on $(\Delta_3 \log PC)$ itself, e.g. PC is food price.

The use of Doornik-Hendry Autometrics

- This software empowers evidence-based economics – in contrast to faith-based economics' 'pretence of knowledge'.
- Since we are unsure about the truth, best to encompass all the popular theories in a general specification.
- Then test down from the General Unrestricted Model to a parsimonious specification meeting a range of test criteria: fit, parameter stability, lack of heteroscedasticity, white noise, normally distributed residuals (where feasible).
- Doing this manually is very, *very* time consuming. Autometrics goes through alternative selection paths very fast.
- But the final parsimonious model also needs to make economic sense.

Impose sign priors: for ECM terms, level effects and growth rates

- Expect + :
  - for foreign prices translated at the exchange rate including oil, maize, coffee, & prices in Kenya;
  - US PPI;
  - terms of trade (given exchange rate);
  - growth rates of credit and money;
  - (log) level of real broad money relative to GDP;
  - current a/c to GDP (measures aid flows, given trade a/c);
  - trade-openness in food eq..
- Expect - :
  - for deviation of rainfall from mean;
  - government surplus to GDP;
  - trade surplus to GDP;
  - Uganda minus US interest rate;
  - trade-openness in non-food eq..

To help parsimony, should reduce possible damage from unresolved co-linearities, particularly in short samples.

Sign priors on delta effects

- No priors on delta effects <u>where level effect present and correctly signed</u>
  - could indicate longer lags in reaction of price index to costs e.g. $+x_t$, and $-\Delta x_t$ translate into $+x_{t-1}$
  - lagged effects of a policy response to inflation

- <u>If no correctly signed level effects</u>, leading delta effects should have same sign as missing level

Key results domestic fuel: 1998-2013

- For 3-month inflation rate, 63% speed of adjustment.

- In the long-run:
  - log (price of domestic fuel)= 0.83 log non-food price index
    +0.17 log Dubai oil price + constant
  - Suggests a lot of local content and probably pricing to market.

- In the short-term dynamics, there are four factors:
  - credit growth over the previous three months;
  - the global inflation rate proxied by the US PPI inflation rate;
  - the Kenyan inflation rate over the last three months;
  - an asymmetric measure of the current month's rise in the Dubai oil price (in shillings), i.e. faster adjustment to price rises.

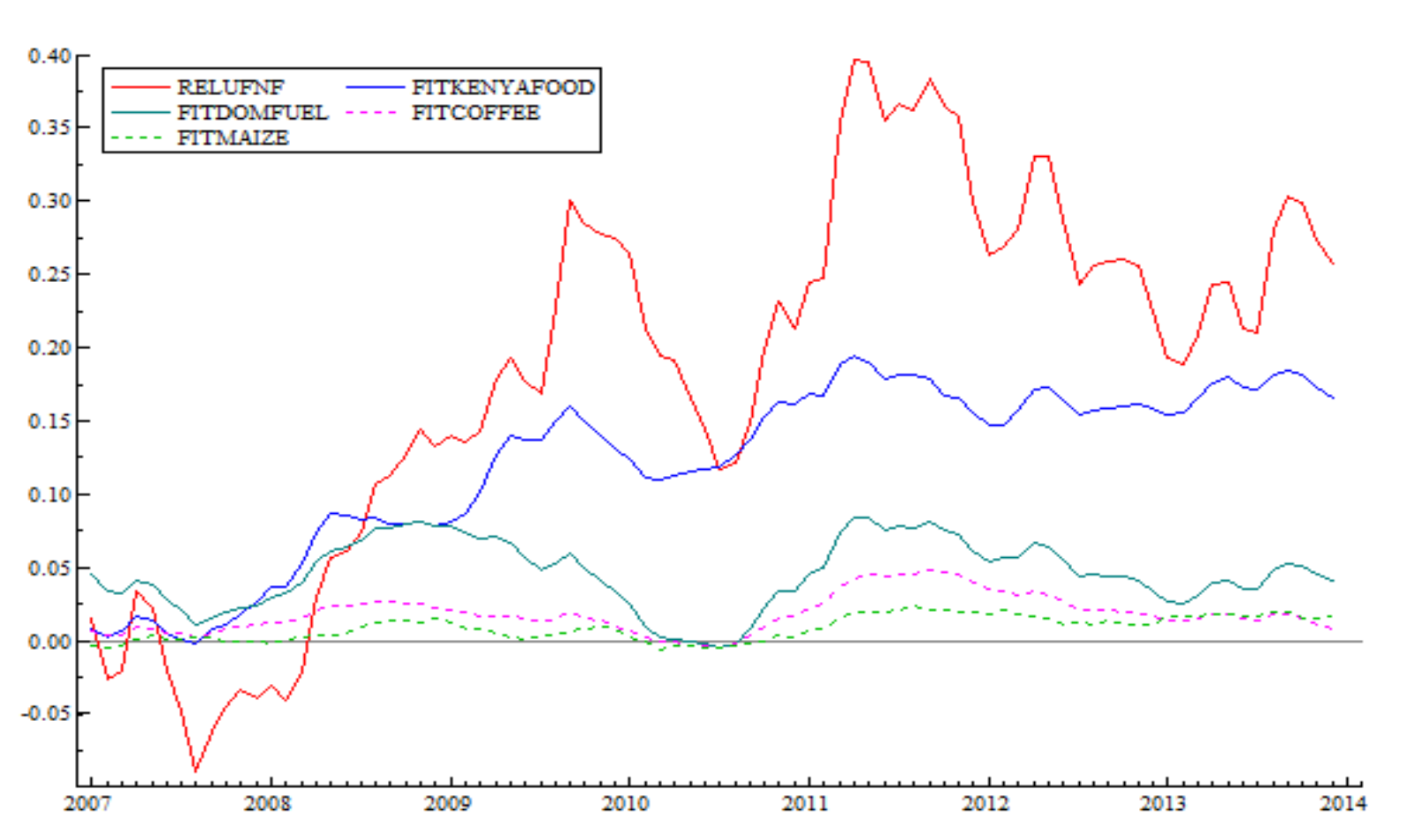
Key results for food: 1994-2013

- Important structural change due to increasing influence of Kenya food prices with greater trade integration (EAC).
- We define pos(log Kenya food/Uganda food- mean) if positive, otherwise zero. (Very similar to 2007 step dummy interaction with log price ratio.)
- From 2007: log food price index = 0.41 log non-food price index + 0.03 log foreign price of foreign maize + 0.20 log price of domestic fuel + 0.29 log price of food in Kenya + 0.07 log foreign price of coffee + 0.34 trade openness +/- (step dummies) - 0.0004 time trend - 0.14 T-bill spread vs US/100 - rainfall effects + constant
- Before 2007: both domestic fuel and Kenyan food prices drop out, and the other long-run coefficients rise to compensate.

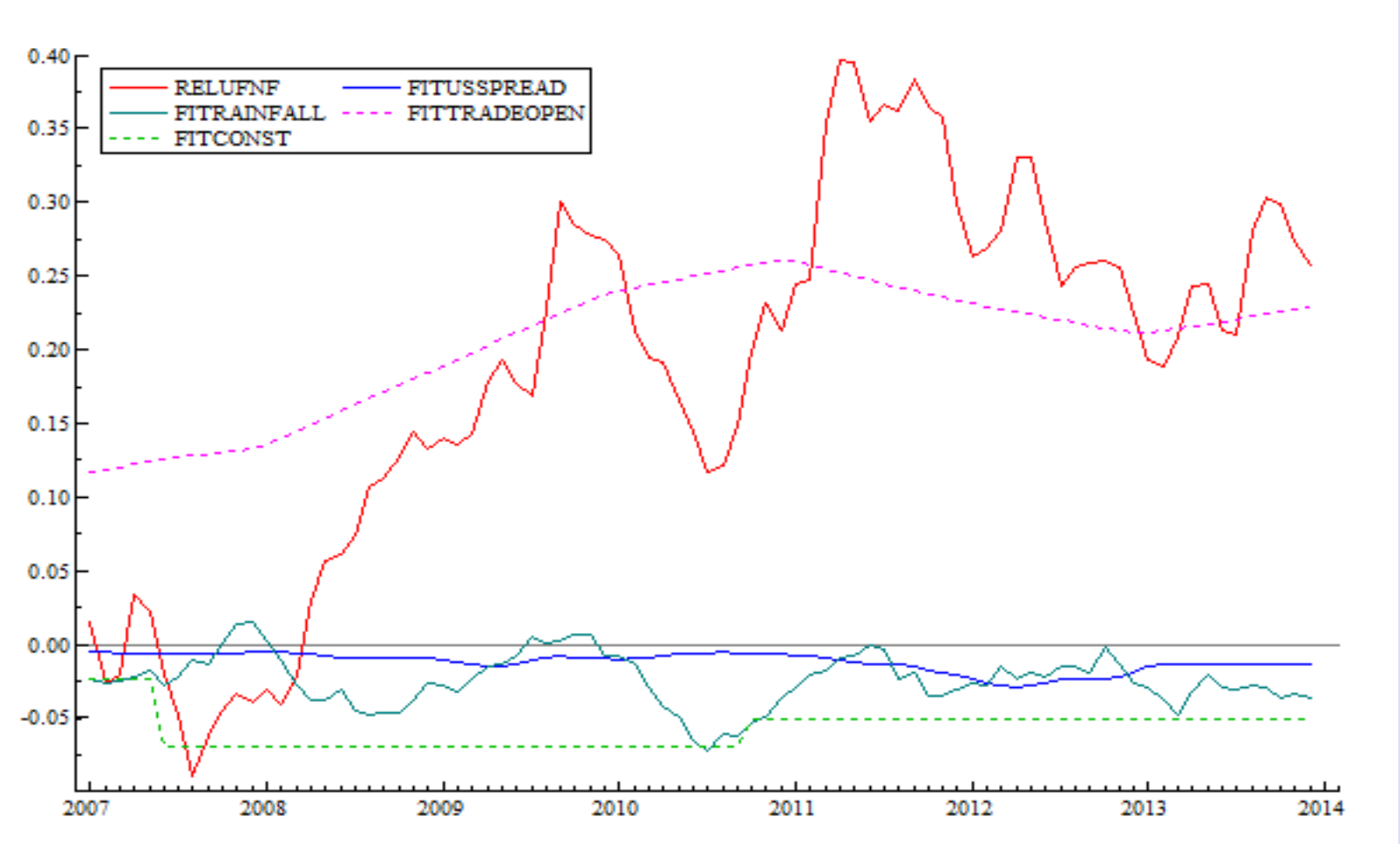
No money effects for food inflation

- GUM included: log real M3 per head – 1.5 log real GDP per head, and changes in log M3. None were retained by Autometrics. Strongly significant credit growth instead.
- GUM also included: ratio of mobile money balances/M3 (in the form of one level and 4 changes terms). None were selected. If level is forced to be retained, t-ratio is 0.3.
- Similar findings if mobile transactions/M3 is used as mobile money measure: t-ratio is -0.4 if level is forced to be retained.
- Equation s.e. for 3 month ahead change in log food price is 0.025; adj R-sq is 0.83.

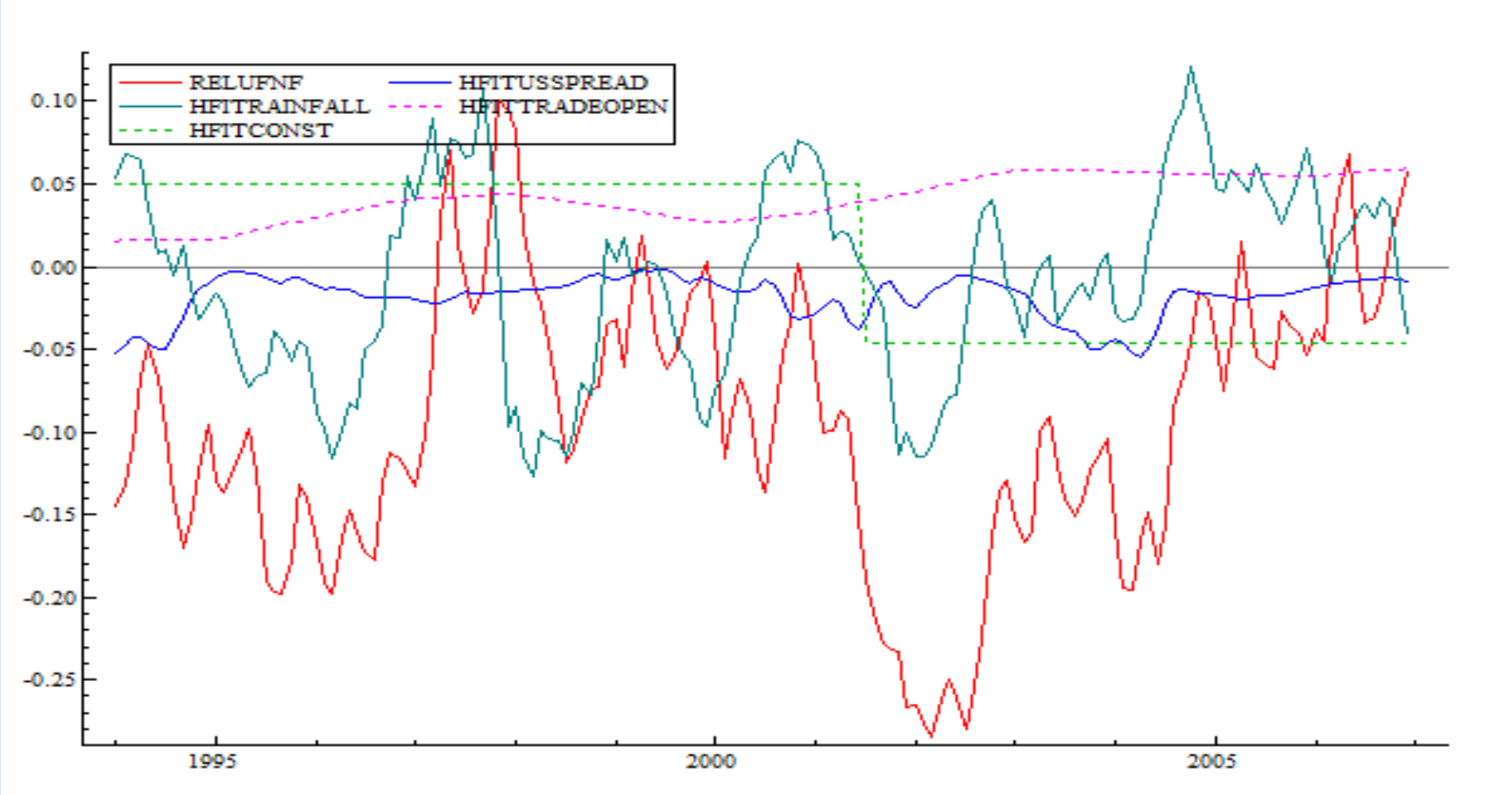
Decomposition of long-run solution for log food/non-food from 2007(1)



Decomposition of long-run solution for log food/non-food from 2007 (2)



Before 2007 impact of Uganda rainfall is even larger



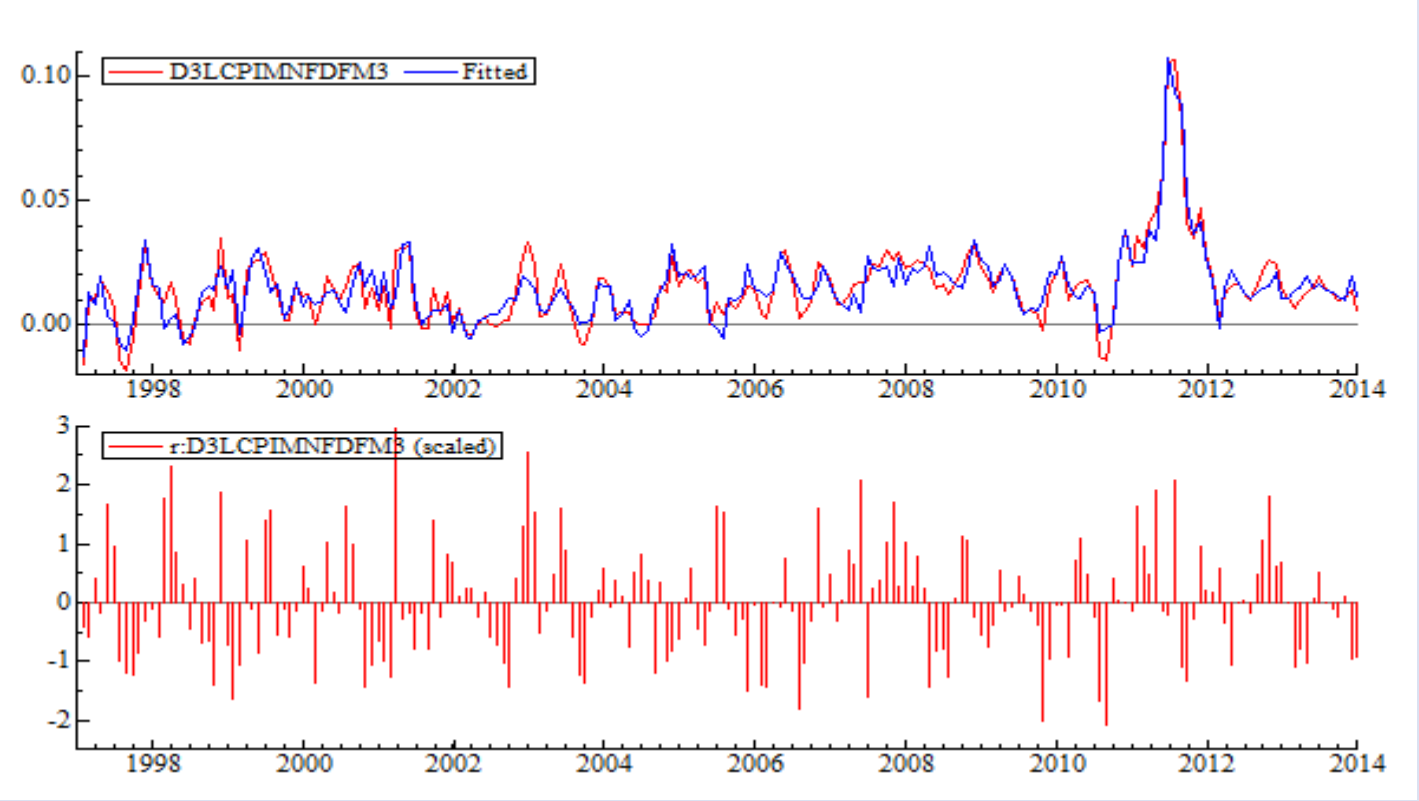
Interpreting the findings

- Note effect of variations in rainfall – even larger pre-2007, since relative price of food in Kenya from 2007 captures part of regional drought impact.
- Major effect of relative price of food in Kenya.
- Unexplained parts of LR plot mainly due to dynamic terms: credit growth, changes in the log terms of trade, Kenyan food prices, and squared lagged food price inflation
- Annual change in gov't surplus to GDP has negative effect on food price inflation.
- A trade deficit increases food inflation while there is a smaller offset in the opposite direction from the current account balance (since the latter includes aid flows and aid flows increase demand for goods).

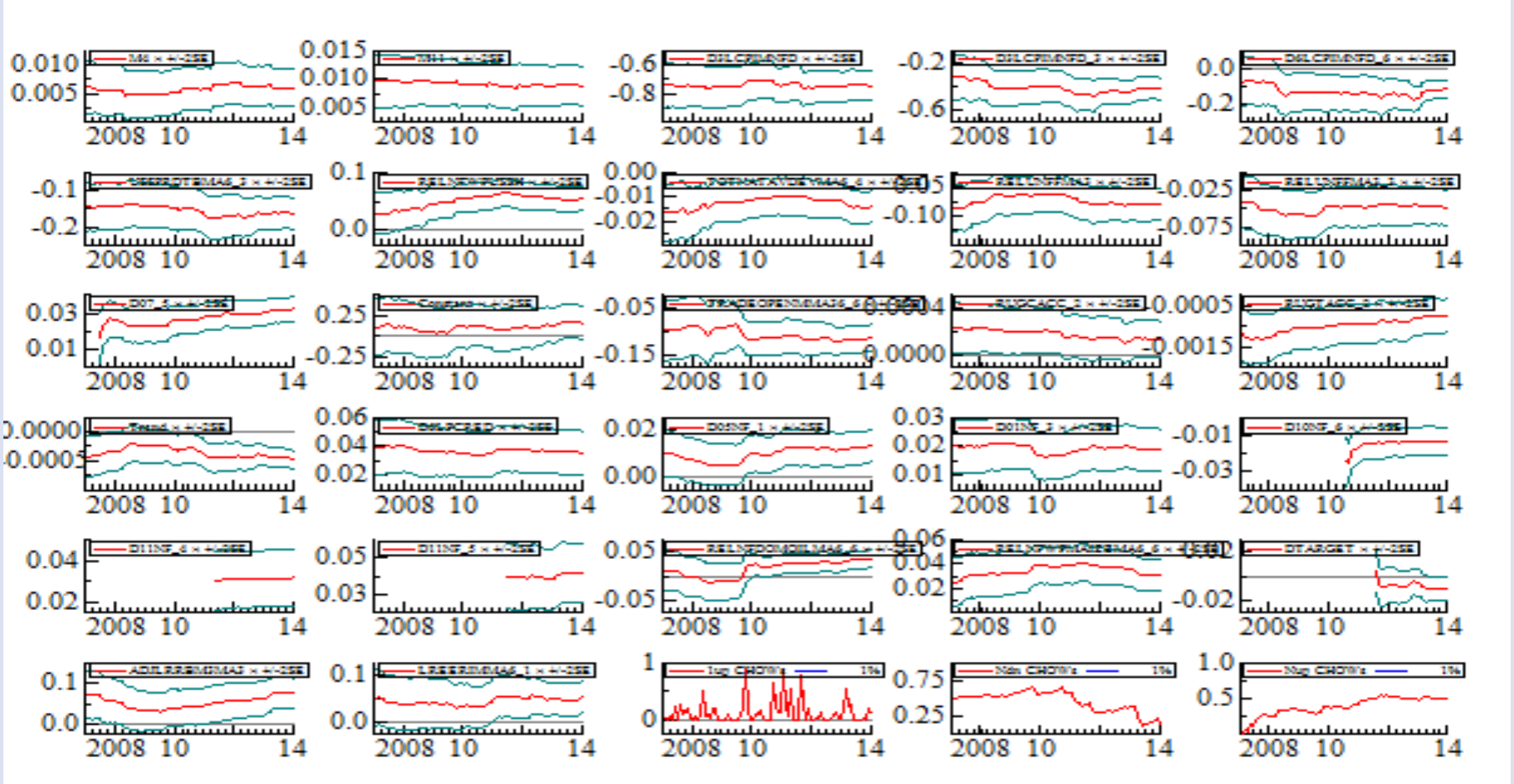
Key results for non-food: 1997-2013

- Long-run solution depends strongly on:
  food prices; US PPI as a proxy for price of manufactured goods; real exchange rate; maize price; domestic fuel prices; log real M3 per head - 1.5 log real GDP per head.
- Trade-openness and linear trend both have negative effects
- So do interest spread and trade surplus/GDP (while current a/c/GDP has positive effect, as in food equation).
- In the dynamics, credit growth is powerful.
- Rainfall also matters, via drought effects on hydro-electricity.
- No mobile money effects, on either measure. If forced to be retained, then t-ratio of -1.4 on ratio of mobile money/M3.

Residual graphics for 3-month ahead non-food, s.e. =0.0061, adjusted R-squared =0.85



Parameter stability for 3-month ahead non-food



Conclusion

- Stable 1-month and 3-month inflation forecasting equations for domestic fuel, food and non-food.
- Food equation takes account of major structural breaks and non-linearities.
- M3 is *irrelevant* for food inflation, but rainfall deviations play huge role, and domestic credit growth is important.
- Previous models put major emphasis on M3 and mostly took no account of rainfall. M3 is found *relevant* for non-food.
- International influences, via foreign prices and the exchange rate are central. Model needs extension for the exchange rate.

The role of mobile money

- For food inflation, mobile balances/M3 and transactions value/M3 have no effect, given the controls.
- For non-food inflation, effects are negative but not significant, t=-1.4 in preferred specification including (negative) dummy for onset of inflation targeting in 2011.
- If latter is omitted, mobile balances/M3 has t-ratio of -2.7.
- Suggests concern on velocity-inflation linkage is misplaced.
- More likely that productivity/efficiency gains of mobile money REDUCE inflation, even when quality improvements not fully measured in CPI.
- Considerable uncertainty with just 5 years of data.