Is the Investment-Uncertainty Link Really Elusive? The Harmful Effects of Inflation Uncertainty in Brazil

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Motivation (1)

- Until the 1970s Brazil was one of the **fastest growing** countries in the world.
  - During 1940–1980 average growth reached 6.8%.
- However, after the 1970s inflation began to rise sharply and the economy began to experience a **sizeable economic slowdown**.
  - During 1980–1990 average growth was 2.25%.
  - During 1990–2000 average growth was 1.99%, **despite pro-growth reforms**!
    - Trade liberalisation began in 1990.
    - Privatisation began in early 1990s and was intensified after 1994.
    - Economic stabilisation began in 1994 with Plano Real.
- Real investment rates have also **fallen sharply** since 1980.
  - Total investment to GDP ratio fell by 9 percentage points during the 1980–1989 period (at 1999 prices);
  - And continued to fall during from 1990 onwards, despite the reforms above, being unable to reach the 1989 level ever since;

Motivation (2)

- **Striking feature:** the failure of investment rates to show any consistent sign of recovery even **more than ten years after the stabilisation of the economy** [see Pindyck and Solimano (1993) on Bolívia, Chile and Israel experiences].
  - In the ten years after stabilisation took place (1995–2004) the average real rate reached its **lowest value for, at least, half a century**. (i.e. lower than in the 1950s, …, 1990s).
  - Note that after the securitisation of Brazilian external debt in 1994, the supply of external financing to Brazilian firms increased sharply, making this behaviour harder to explain!

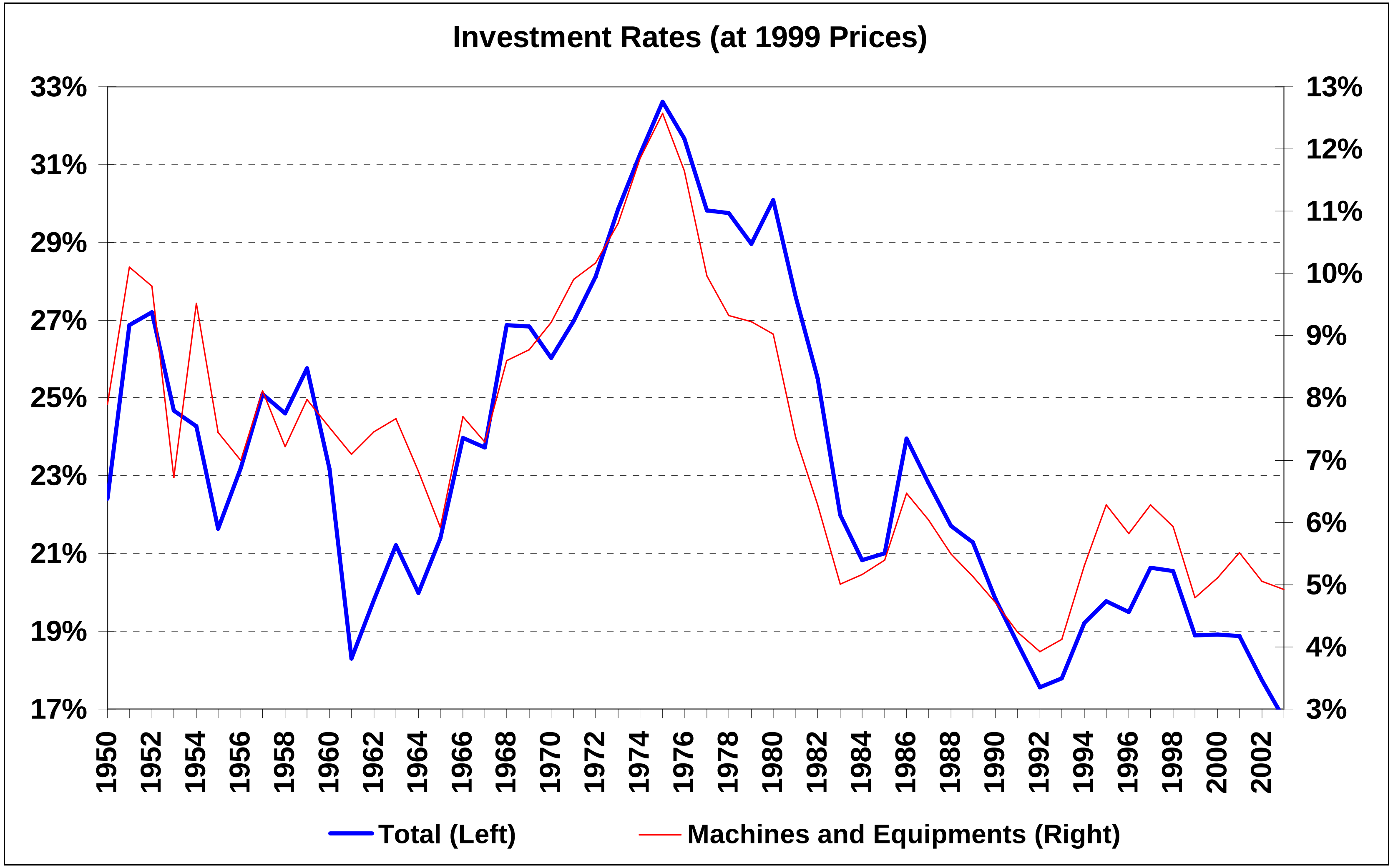
- One major candidate for such a dismal result is **inflation uncertainty**, which not only was very high throughout the high inflation period but also remains high despite much lower inflation rates since 1994.

► What drives capital accumulation in Brazil?

► Is inflation uncertainty harmful to M&E investment, or is it just a nuisance (e.g. Lucas' island model, certainty equivalence results)?

- Are there any long-run effects?
- Are there asymmetric effects?

Investment in Brazil: a Dismal Picture



Investment and Uncertainty: a First Look

- Firms face uncertainty over **many dimensions**.
  - Costs
  - Demand
  - Output price
  - Success of newly created products
  - Their competitors strategies
- Even though some types of uncertainties are bound to be more relevant to some firms than to others (e.g. exchange rate uncertainty to exporters and importers)…
- And firm-specific uncertainty plays a major role in investment decisions…
- Note that uncertainty about **inflation is at the root of many uncertainties**.

Inflation Uncertainty and Investment: Some Links

- Since tax systems are not perfectly indexed to inflation, inflation uncertainty also means uncertainty about (see Feldstein, 1982)
  - Effective **tax rates**.
  - **Depreciation** allowances.
- Uncertainty about inflation means that future **real wages** are uncertain;
- For a given nominal rate, inflation uncertainty means uncertainty about **real interest rates**;
- Under inflation uncertainty risk averse agents require a **risk premium** to buy nominal bonds.
  - Higher real interest rates $\Rightarrow$ **raise the cost of capital**.
- Inflation uncertainty means uncertainty about the **future stance of monetary policy** and, therefore, about future demand and prices.
  - Inflation is a **summary indicator** of how well managed is a given economy.

$\Rightarrow$ **Hence, there are several reasons why inflation uncertainty should rank very high on entrepreneurs' concerns.**

Inflation Uncertainty and Investment: Informal Evidence

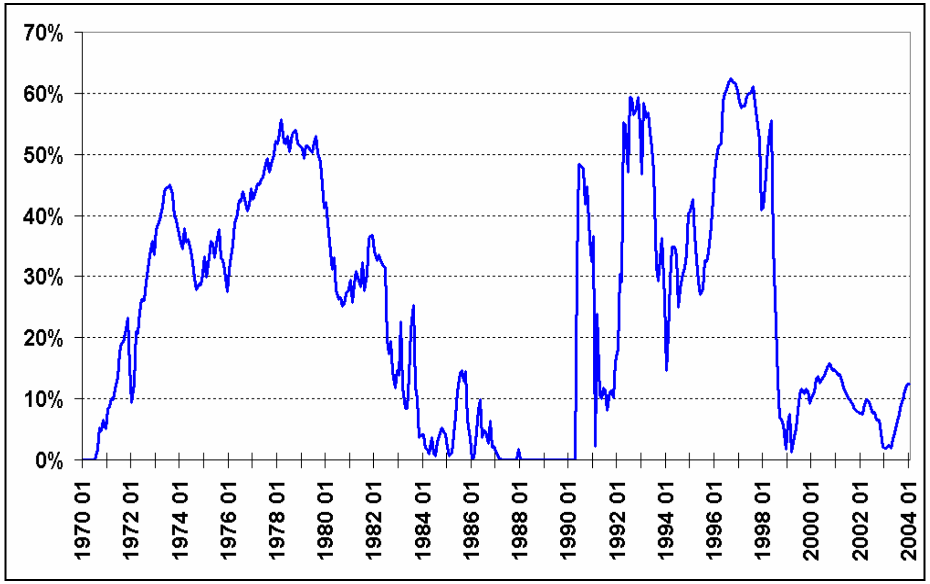
"Thus, low inflation may stimulate investment by **reducing risk premia**. As a result, low inflation makes it easier for firms to **finance entrepreneurial projects**. For example, low inflation is correlated with a narrow spread between high-risk securities and U.S. Treasury Bonds."

"The low inflation that we have seen in this expansion, for example, has been associated with less inflation volatility than in earlier, higher inflation periods. The associated **reduction in inflation uncertainty** has surely been a positive factor for **investment in plant and equipment**."

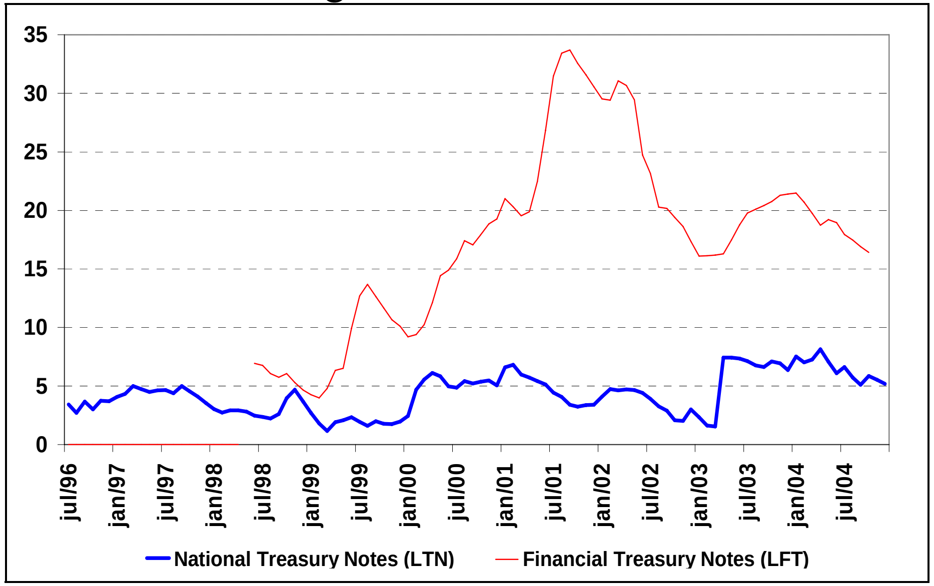
Thomas. M. Hoenig (1998)
FRB of Kansas City President

Some of the Costs of Inflation Uncertainty in Brazil

Share of Nominal Bonds in Public Bonds



Nominal and Real Treasury Bonds:
Average Duration in Months



- Shocking **low maturity** attached to nominal bonds.

- **Hysteresis:** very long memory ⇒ **inflation uncertainty remains high.**

  – **Higher inflationary past** in Canada and New Zealand vis-à-vis the U.S. and Australia, explained **higher long-term interest rates** observed in the former countries despite lower inflation rates than their neighbours in the previous five years (Gagnon, 1997).

The Elusive Investment-Uncertainty Link (1)

- **Hartman(1972) and Abel (1983):** the marginal revenue of capital is convex on price, so due to Jensen's inequality a mean preserving increase in uncertainty **raises** investment;

- **Bernanke (1983) and Pindyck (1988):** <u>option value</u> of waiting when investment expenditures are irreversible $\Rightarrow$ the bad news principle $\Rightarrow$ uncertainty **decreases** investment;

- **Caballero (1991):** negative link due to <u>decreasing returns</u> or <u>imperfect competition</u> and not due to asymmetric adjustment costs (i.e. irreversibility) $\Rightarrow$ depending on **market structure** and **technology** convexity not only can be offset but actually overturned.

The Elusive Investment-Uncertainty Link (2)

- **Pindyck (1993):** Cabbalero's results treats the firm in isolation, ignoring industry-wide uncertainty. No ambiguity arises when industry's negative sloped curve is considered.

- **Abel and Eberly (1994):** very general model of investment, having irreversibility and convex adjustment costs as special cases
  - Optimal policy involves **discontinuity** depending on the shadow price of capital (adds, sells or inaction).
  - For a price taking firm the marginal profitability of capital remains an increasing function of price uncertainty $\Rightarrow$ **decreases** investment.
  - Irreversibility and lumpiness are not enough to give negative link.

- **Abel *et al.* (1994):** disinvestment and expansions are costly $\Rightarrow$ call option and put option
  - Both very bad and very good news matter.
  - Effect of uncertainty depends on both options values $\Rightarrow$ **ambiguous.**

Measuring Inflation Uncertainty: Some Key Issues

Challenge: trying to replicate the economic environment forecasters faced at each point in time when out-of-sample forecast were being

Crucial: Use only **historical available data** to make forecasts.

- Avoid a temporal inconsistent information set;
- Does not impose the zero-mean forecast errors embedded in in-sample forecasts;
- Does not imply that auto-correlated errors are the result of mis-specified models, as it happens when in-sample forecasts are generated.

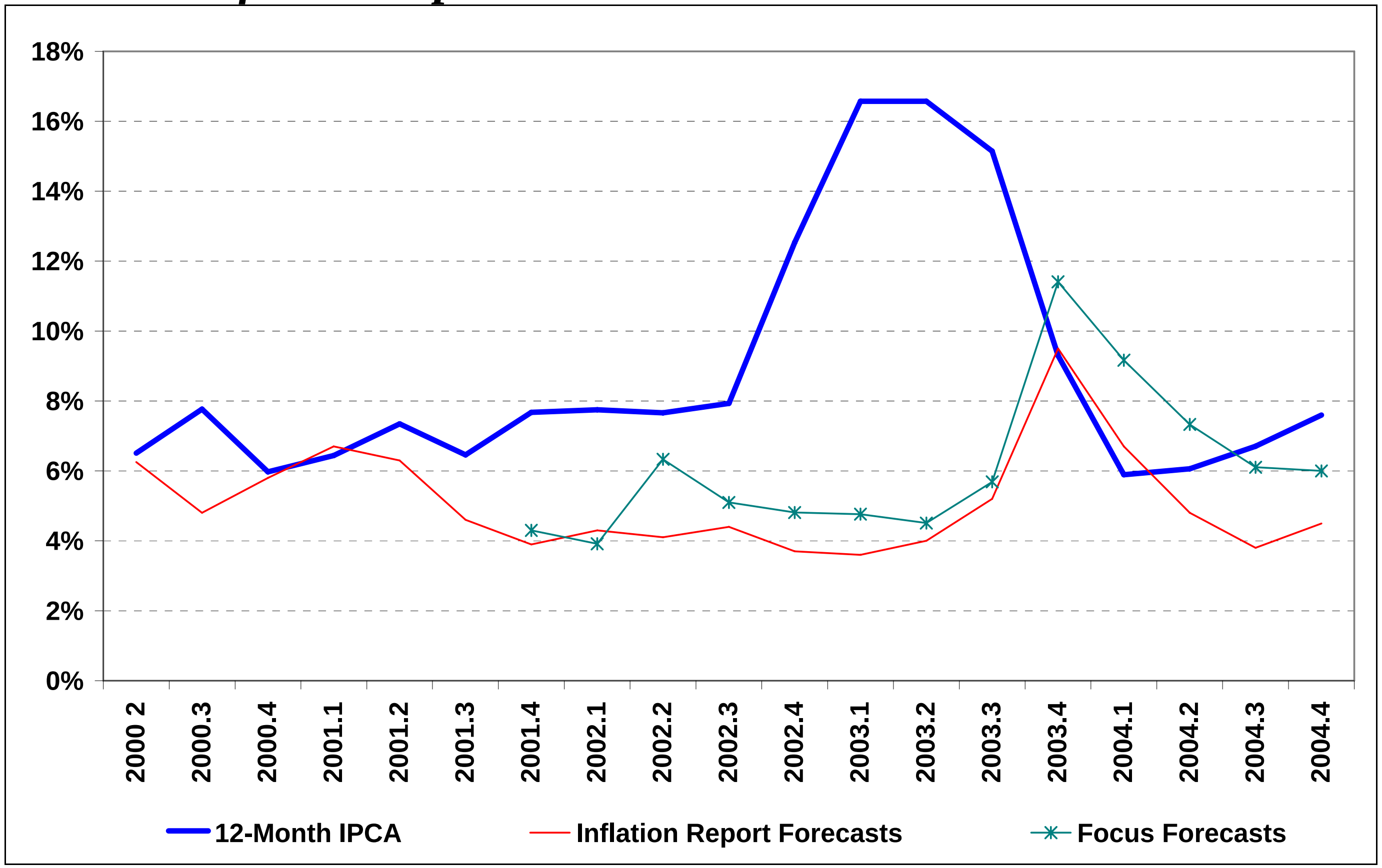
- However, the literature is plagued by proxies derived using future information, specially from (G)ARCH models.
  - Bound to underestimate uncertainty.
  - Results are unreliable, and potentially wrong.
- Economists have systematically overlooked the measurement of the variable that is at the heart of the debate!

⇒ Da Silva Filho (2006a) carries out a pseudo real time forecasting simulation exercise, in order to obtain inflation uncertainty proxies for Brazil.

  - Resulting forecasts resemble very much the pattern of actual inflation forecasts

Brazil:
How Do Inflation Forecasts Look Like in Practice? (1)

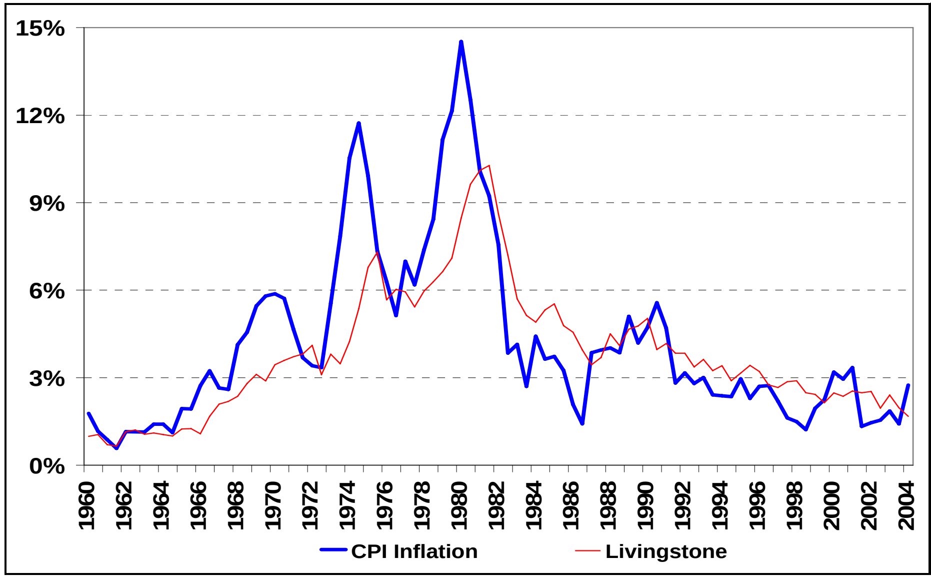
BCB *Inflation Report* and Focus One-Year Ahead Forecasts



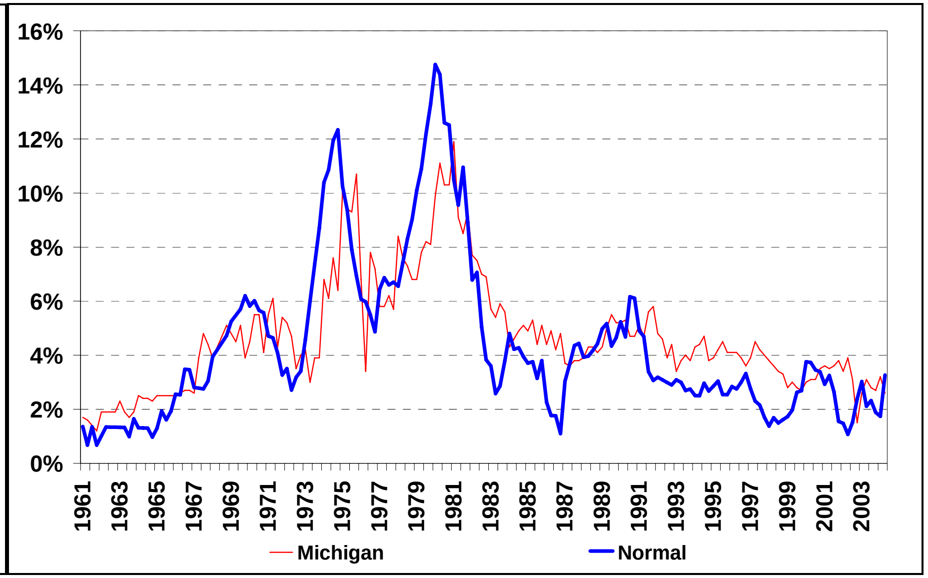
- Systematic **under-prediction** during most of the sample.

U.S.
How Do Inflation Forecasts Look Like in Practice? (2)

Livingstone Survey
One-Year Ahead Forecasts vs. CPI Inflation



Michigan Survey
One-Year Ahead Forecasts Vs. CPI Inflation



- **Systematic** **under-prediction** when inflation is rising.
- **Systematic** **over-prediction** when inflation is falling.

How Do Inflation Forecasts Look Like in Practice? (3)

"Forecasts of <u>inflation</u> and of <u>growth</u> in real activity for the United States, including those of the Federal Open Market Committee, have been generally off for several years. Inflation has been **<u>chronically</u> overpredicted** and real GDP growth underpredicted"

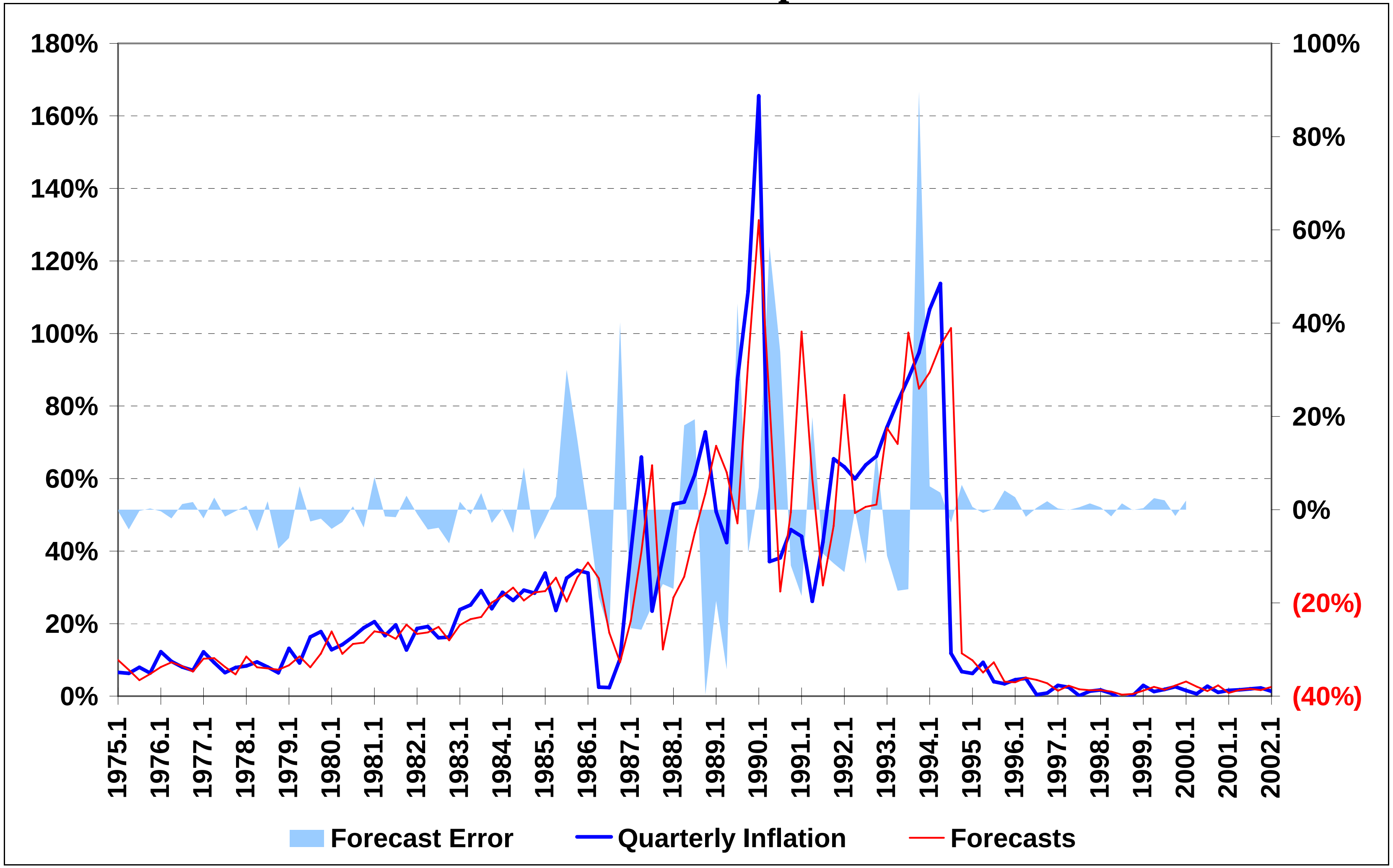
Greenspan (1998)

"**Problems in predicting inflation** have been a worldwide problem in the mid to late 1990s and it seems that quite new perspectives may be required in order to produce good predictions of it from a model."

Pagan (2001)

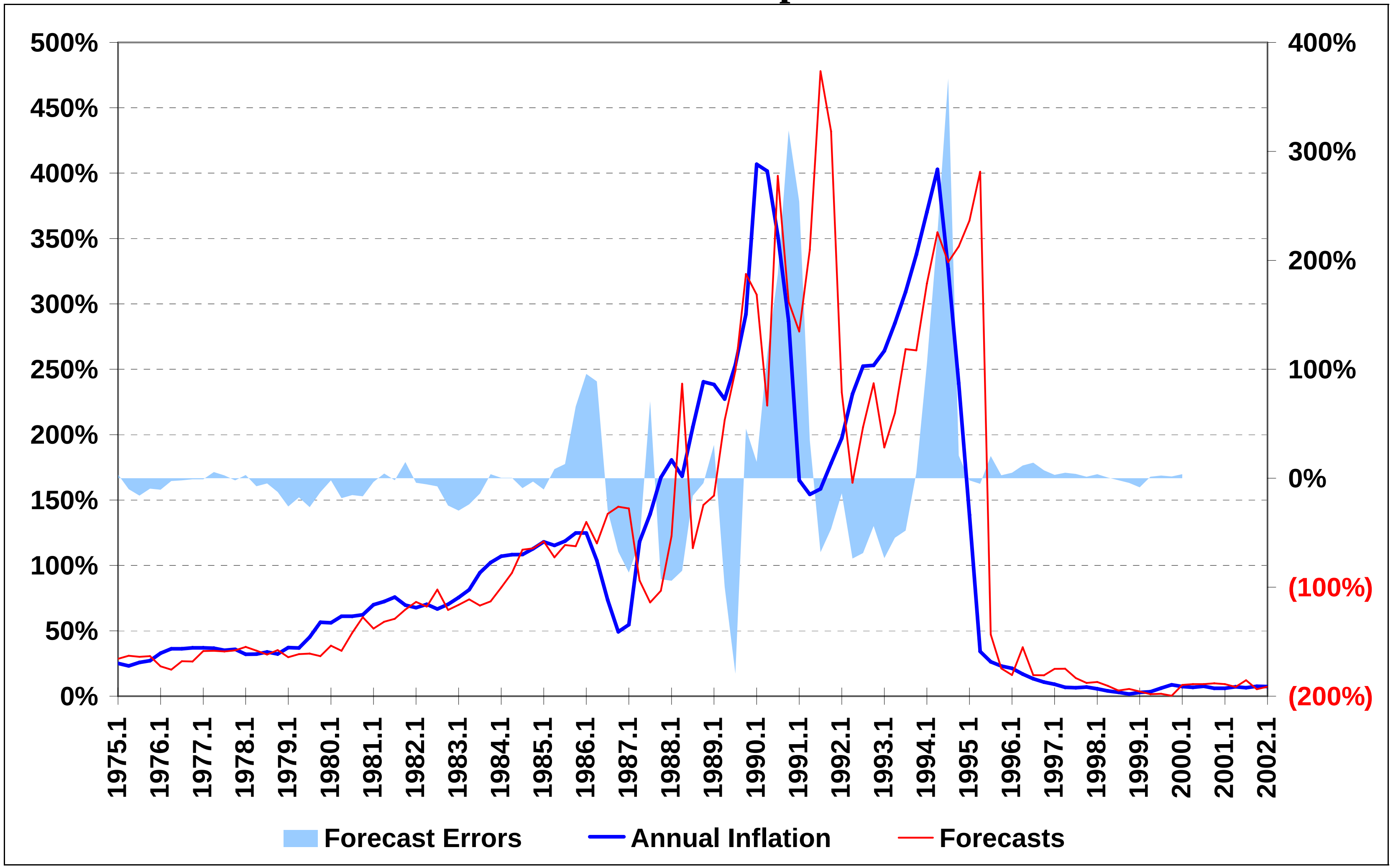
Estimating Inflation Uncertainty for Brazil (1)

Quarterly CPI Inflation and One-Quarter Ahead Simulated Out-of-Sample Forecasts



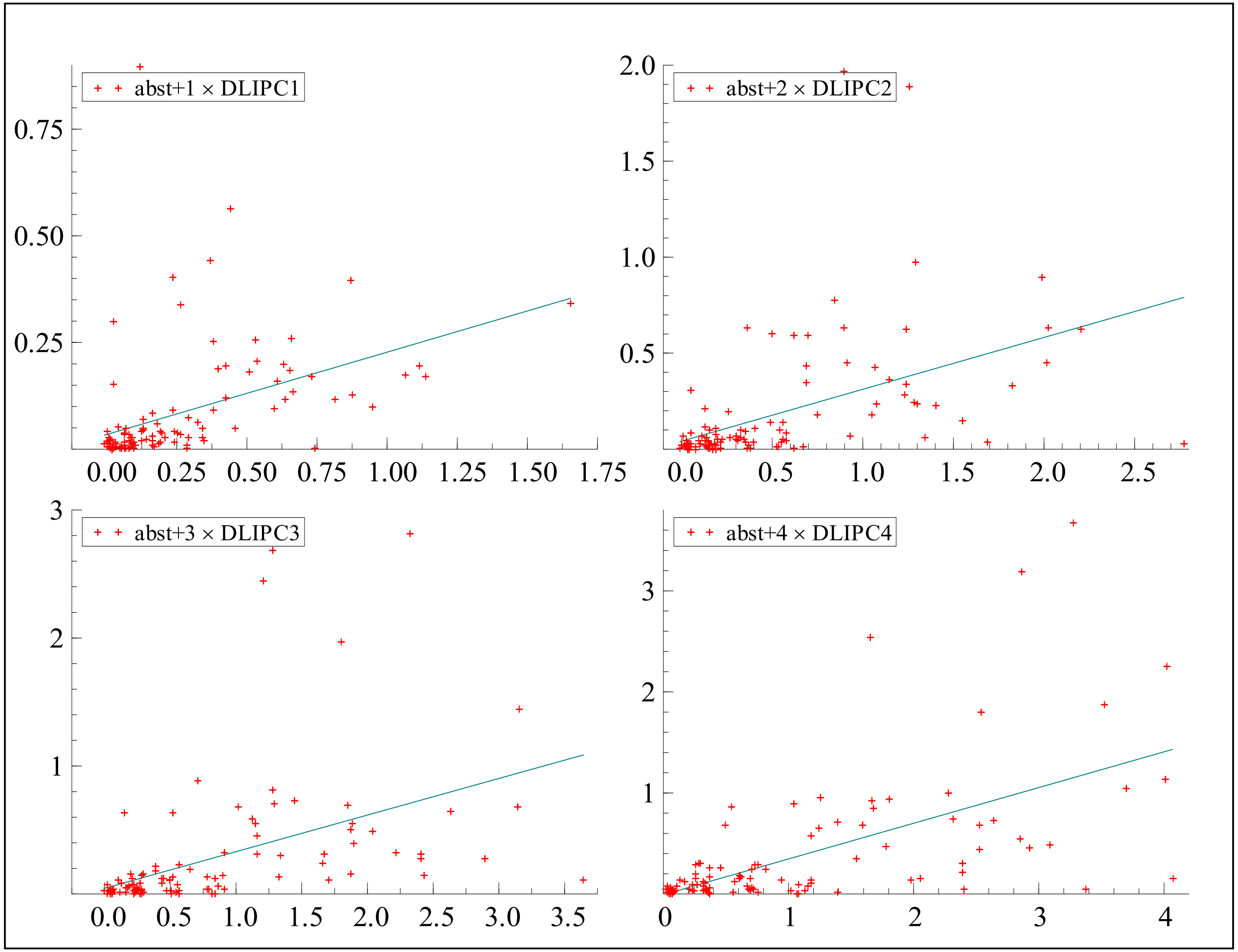
Estimating Inflation Uncertainty for Brazil (2)

Annual CPI Inflation and One-Year Ahead Simulated Out-of-Sample Forecasts



The Inflation Uncertainty-Inflation Level Link for Brazil

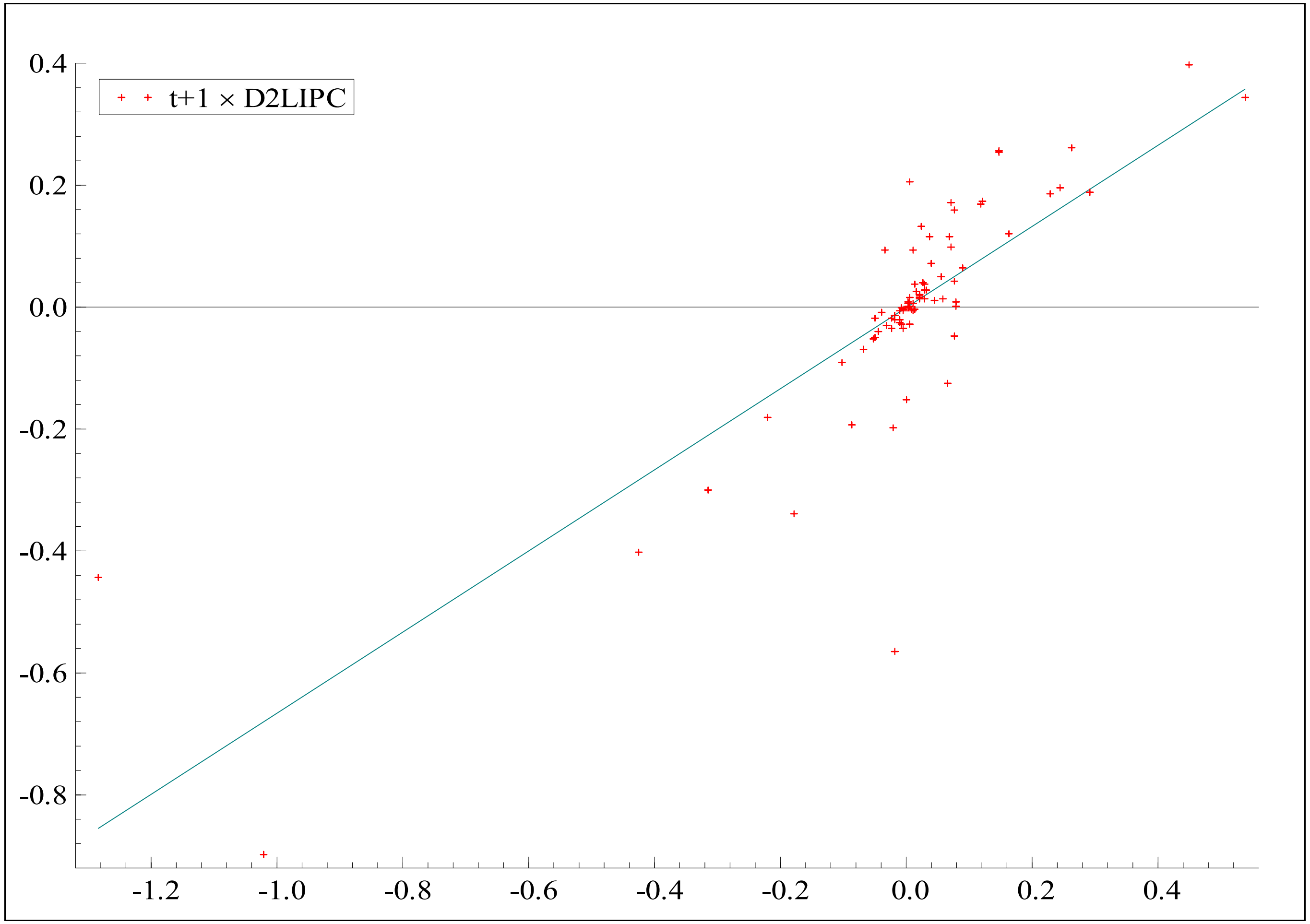
Pseudo Real Time Absolute Inflation Forecasts Errors and the Inflation Level



Obs: $\text{DLIPCi} = \Delta_i \ln P_t$, $\text{abst+i} = \left|\Delta_i \ln P_t - E_{t-i}(\Delta_i \ln P_t)\right|$, i = 1,…,4.

Random Walk and One-Quarter Ahead Inflation Forecast Errors

Simulated Real Time One-Quarter Ahead Out-of-Sample Inflation Forecasts Errors and Random-Walk Errors



Obs: $\mathrm{D2LIPC} = \Delta^2 \ln P_t$, $\mathrm{t{+}i} = \Delta \ln P_t - E_{t-1}\left(\Delta \ln P_t\right)$.

Model 1
One-Quarter Ahead (RW) Proxy

$$\Delta k = \underset{(7.51)}{0.020} - \underset{(-7.36)}{0.000077}\,T + \underset{(3.05)}{0.0024}\,D82.1 + \underset{(5.12)}{0.0067}\,D90.2 + \underset{(3.76)}{0.0030}\,D94.2$$

$$- \underset{(-3.82)}{0.0030}\,D99.2 - \underset{(13.5)}{0.61}\,\Delta k_{t-1} + \underset{(2.97)}{0.0067}\,\Delta y_{t-2} - \underset{(-3.39)}{0.0061}\,\Delta y_{t-3} + \underset{(3.80)}{0.0037}\,\Delta_4 w_{t-1}$$

$$- \underset{(-6.60)}{0.014}\,k^{*}_{t-1} + \underset{(4.94)}{0.013}\,\Delta_2 uci_t + \underset{(4.06)}{0.013}\,uci_{t-3} - \underset{(-4.28)}{0.014}\,r_{t-2} + \underset{(4.17)}{0.0086}\,\Delta r_{t-2}$$

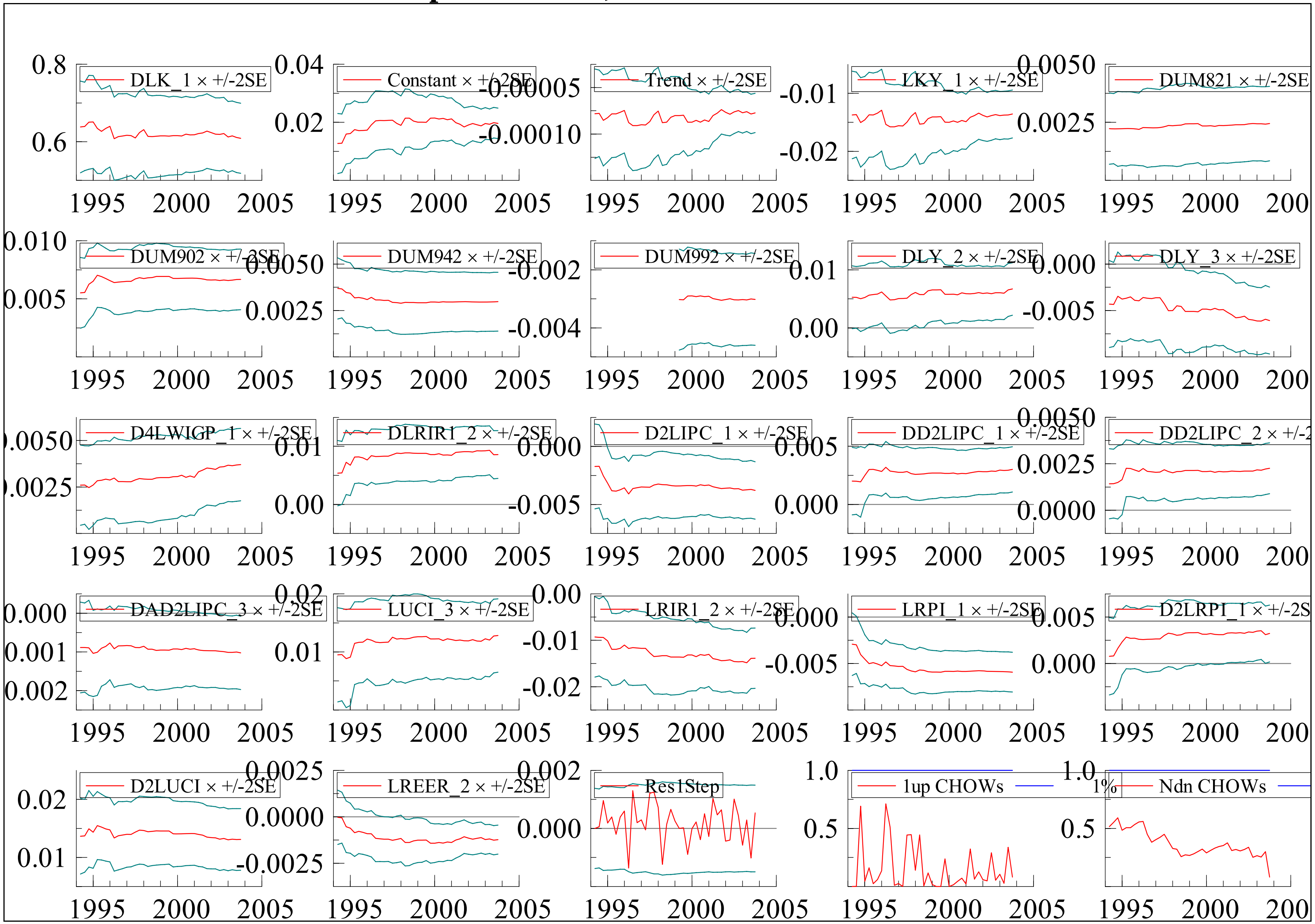
$$- \underset{(-5.55)}{0.0060}\,rpi_{t-1} + \underset{(2.12)}{0.0032}\,\Delta_2 rpi_{t-1} - \underset{(-3.16)}{0.0012}\,reer_{t-2} - \underset{(-3.07)}{0.0038}\,s^{rw}_{1,t-1} + \underset{(3.11)}{0.0030}\,\Delta s^{rw}_{1,t-1}$$

$$+ \underset{(3.31)}{0.0023}\,\Delta s^{rw}_{1,t-2} - \underset{(-2.17)}{0.0010}\,\Delta\left|s^{rw}_{1,t-3}\right|$$

T = 89 (1981.4–2003.4); $\hat{\sigma} = 0.075\%$; R^2 = 0.97; DW = 2.29;
AR 1–5: F(5, 62) = 1.59 (0.18); ARCH 1–4: F(4, 59) = 1.15 (0.34); Hetero: F(38, 28) = 0.43 (0.99); Normality: $\chi^2(2)$ = 2.33 (0.31); RESET: F(1, 66) = 0.14 (0.71).

Long run elasticities: *uci* = 1; *r* = –1; *rpi* = –0.4; *rer* = –0.09; $\boxed{s_1^{rw} = 0.27}$.

Recursive estimates, 1-Step Residuals +/- 2 S.E.,
1-Step Chow Test, Break-Point Chow Test



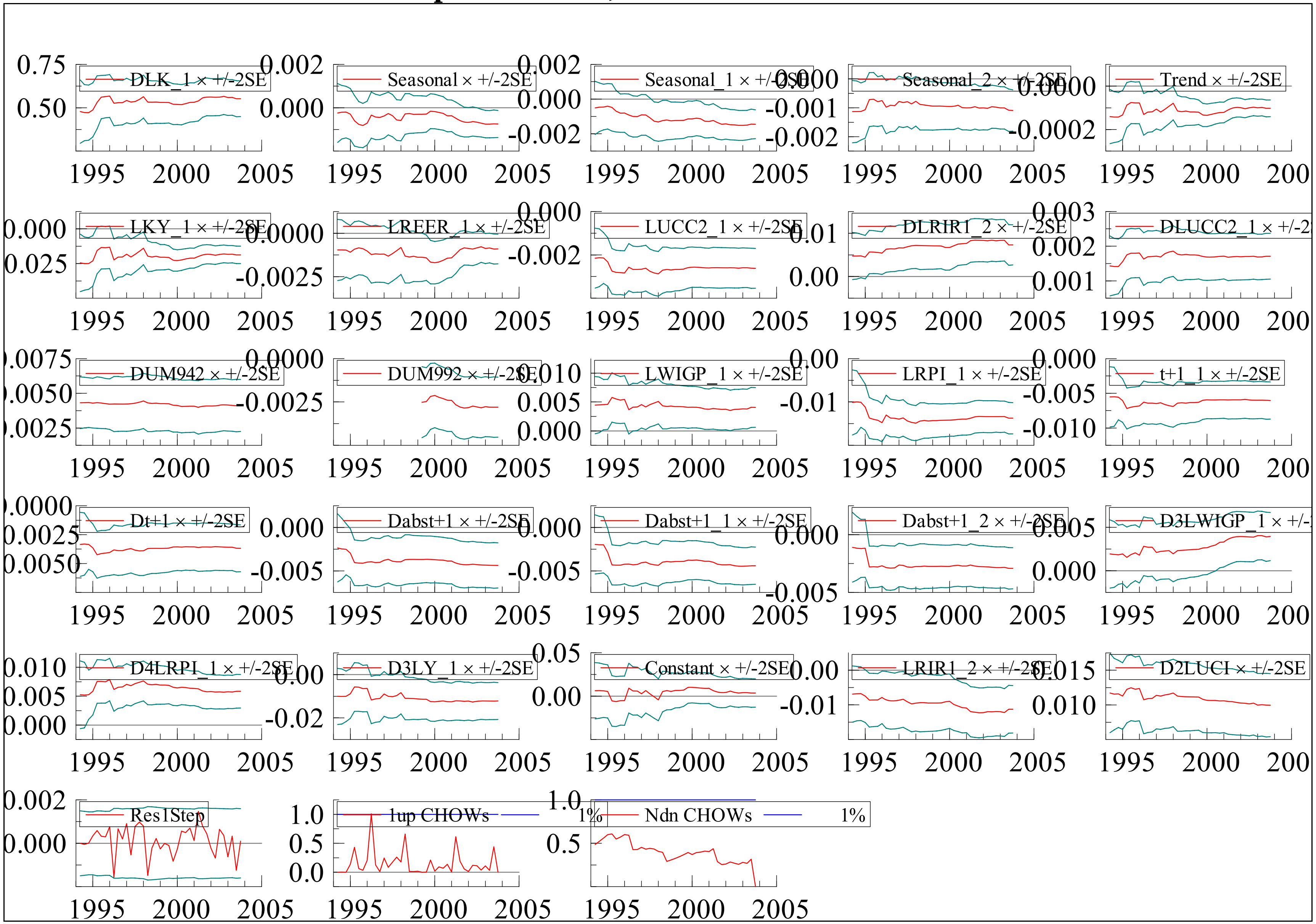
Model 2
One-Quarter Ahead (AR) Proxy

$$\begin{aligned}\Delta k =& \underset{(0.453)}{0.0037} - \underset{(-2.40)}{0.00075}\,S_0 - \underset{(-3.48)}{0.0014}\,S_1 - \underset{(-3.06)}{0.0011}\,S_2 - \underset{(-5.31)}{0.00010}\,T + \underset{(4.40)}{0.0041}\,D94.2 \\ & - \underset{(-3.23)}{0.0028}\,D99.2 + \underset{(10.7)}{0.55}\,\Delta k_{t-1} - \underset{(-2.88)}{0.012}\,\Delta_3 y_{t-1} - \underset{(-5.96)}{0.019}\,k^*_{t-1} + \underset{(4.38)}{0.010}\,\Delta_2 uci_t \\ & - \underset{(-3.30)}{0.011}\,r_{t-2} + \underset{(3.16)}{0.0073}\,\Delta r_{t-2} - \underset{(-5.72)}{0.0026}\,ucc_{t-1} + \underset{(5.20)}{0.0017}\,\Delta ucc_{t-1} - \underset{(-7.63)}{0.014}\,rpi_{t-1} \\ & + \underset{(4.04)}{0.0059}\,\Delta_4 rpi_{t-1} + \underset{(2.37)}{0.0041}\,w_{t-1} + \underset{(2.84)}{0.0039}\,\Delta_3 w_{t-1} - \underset{(-2.11)}{0.00091}\,reer_{t-1} \\ & - \underset{(-4.51)}{0.0060}\,s^{ar}_{1,t-1} - \underset{(-3.63)}{0.0037}\,\Delta s^{ar}_{1,t-1} - \underset{(-3.36)}{0.0044}\,\Delta\left|s^{ar}_{1,t}\right| - \underset{(-4.11)}{0.0044}\,\Delta\left|s^{ar}_{1,t-1}\right| - \underset{(-3.27)}{0.0029}\,\Delta\left|s^{ar}_{1,t-2}\right|\end{aligned}$$

T = 91 (1981.2–2003.4); $\hat{\sigma} = 0.080\%$; $R^2 = 0.97$; DW = 2.12;
AR: F(5, 61) = 1.30 (0.28); ARCH: F(4, 58) = 0.22 (0.93); Hetero: F(43, 22) = 0.37 (0.997); Normality: $\chi^2(2) = 0.73$ (0.70); RESET: F(1, 65) = 1.66 (0.20).

Long run elasticities: r = –0.6; ucc = 0.1; rpi = –0.7; rer = –0.05; w = 0.2; $\boxed{s_1^{ar} = 0.32}$.

Recursive estimates, 1-Step Residuals +/- 2 S.E., 1-Step Chow Test, Break-Point Chow Test



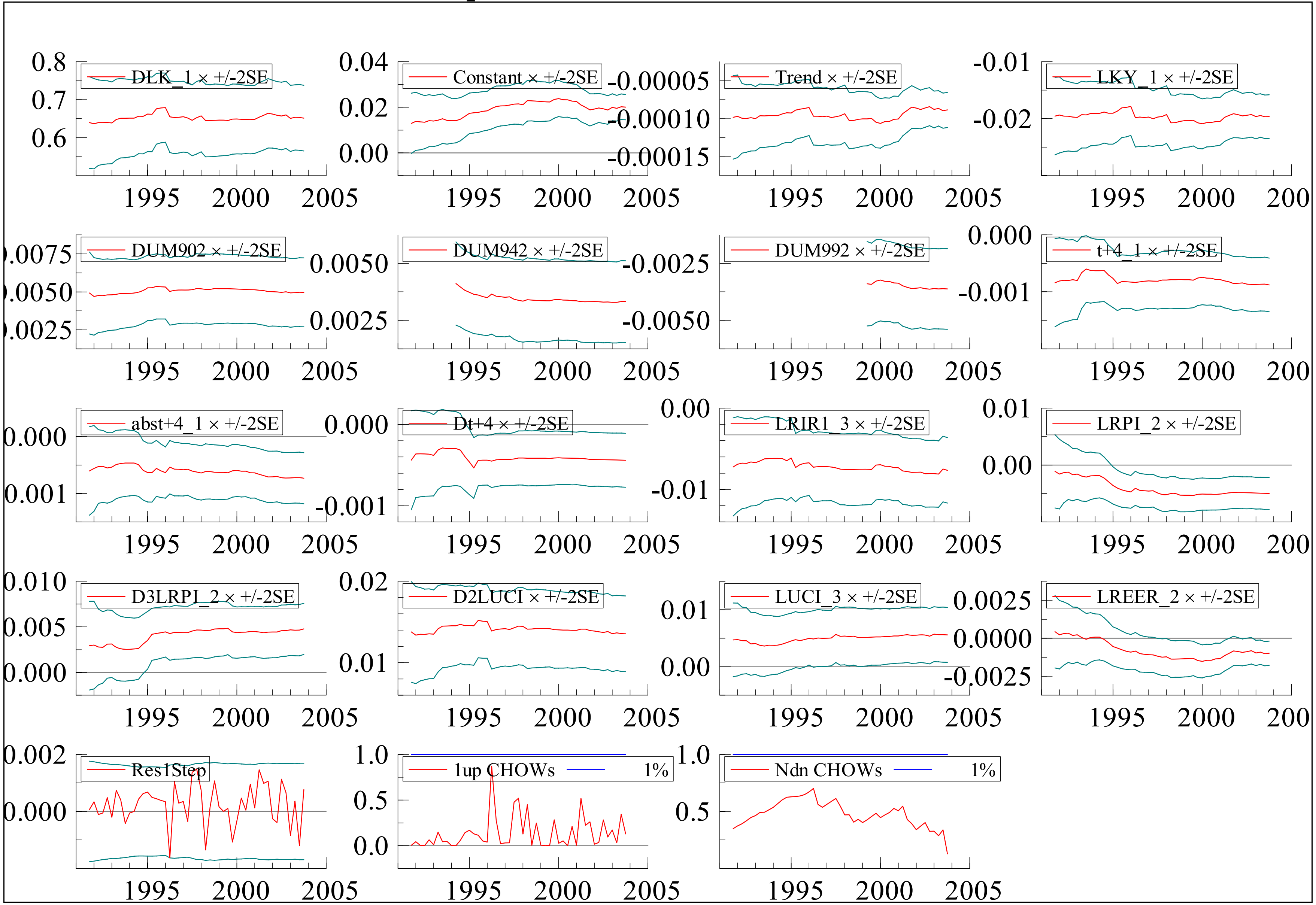
Model 3
One-Year Ahead (AR) Proxy

$$\Delta k = \underset{(7.19)}{0.020} - \underset{(-7.68)}{0.000088}T + \underset{(4.38)}{0.0050}D90.2 + \underset{(3.71)}{0.0033}D94.2 - \underset{(-4.10)}{0.0036}D99.2 + \underset{(15.1)}{0.65}\Delta k_{t-1}$$
$$- \underset{(-10.3)}{0.020}k^{*}_{t-1} + \underset{(5.83)}{0.014}\Delta_2 uci_t + \underset{(2.32)}{0.0056}uci_{t-3} - \underset{(-3.81)}{0.0076}r_{t-3} - \underset{(-3.55)}{0.0050}rpi_{t-2}$$
$$+ \underset{(3.41)}{0.0048}\Delta_3 rpi_{t-2} - \underset{(-2.47)}{0.00098}reer_{t-2} - \underset{(-3.73)}{0.00088}s^{ar}_{4,t-1} - \underset{(-3.27)}{0.00073}\left|s^{ar}_{4,t-1}\right| - \underset{(-2.66)}{0.00044}\Delta s^{ar}_{4,t-1}$$

T = 91 (1981.2–2003.4); $\hat{\sigma} = 0.085\%$; $R^2 = 0.96$; DW = 2.02;
AR: F(5, 70) = 1.57 (0.18); ARCH: F(4, 67) = 0.20 (0.93); Hetero: F(26, 48) = 0.55 (0.95); Normality: $\chi^2(2) = 1.73$ (0.42); RESET: F(1, 74) = 0.098 (0.75).

Long run elasticities: *uci* = –0.3; *r* = –0.4; *rpi* = –0.3; *rer* = –0.05; $\boxed{s^{ar}_4 = 0.04}$.

Recursive estimates, 1-Step Residuals +/- 2 S.E., 1'-Step Chow Test, Break-Point Chow Test



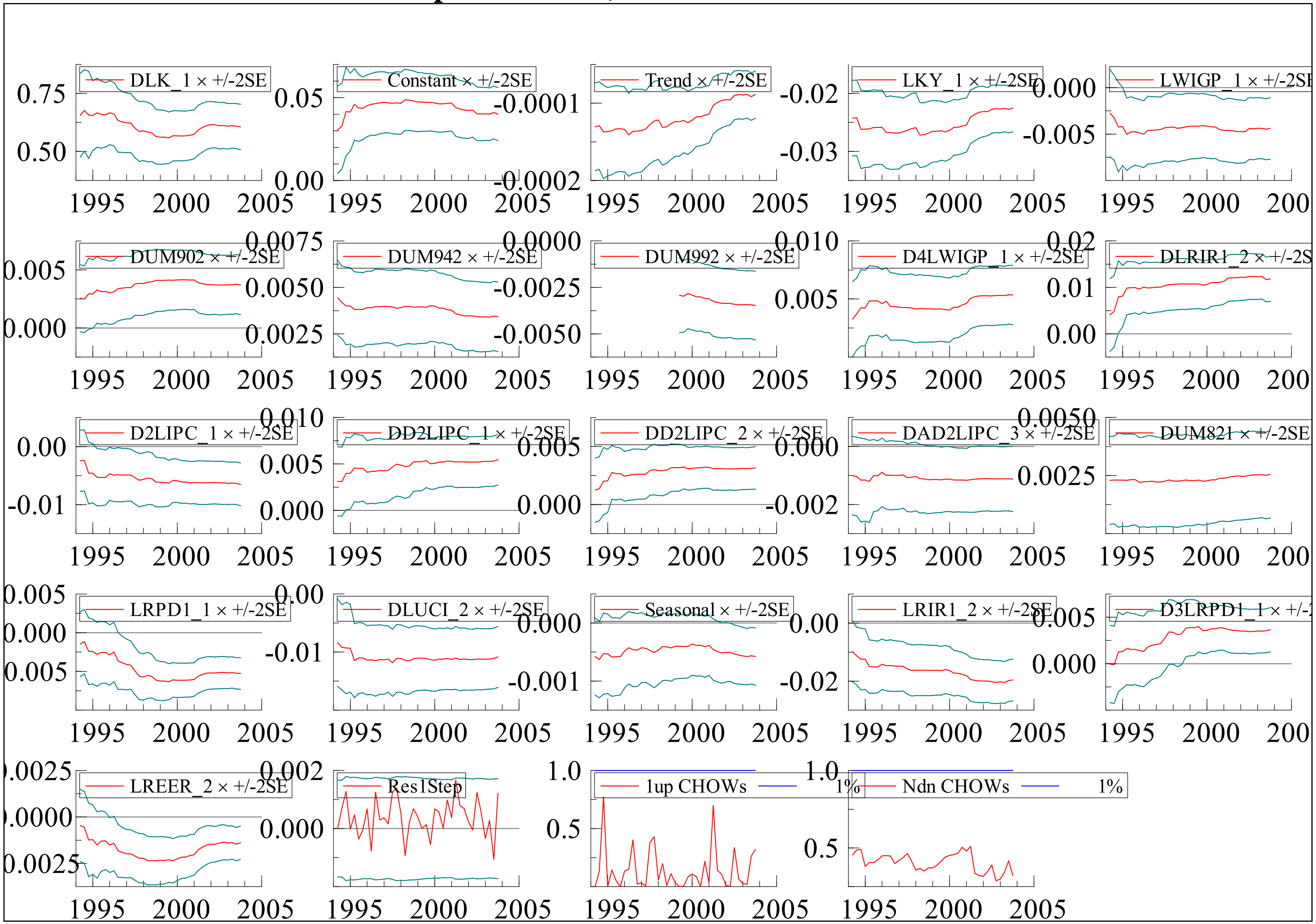
Model 4 (using the RPD)
One-Quarter Ahead (AR) Proxy

$$\Delta k = \underset{(5.01)}{0.040} - \underset{(-2.35)}{0.00058} S_0 - \underset{(-5.82)}{0.000089} T + \underset{(2.72)}{0.0026} D82.1 + \underset{(2.90)}{0.0037} D90.2 + \underset{(3.65)}{0.0034} D94.2$$
$$- \underset{(-3.76)}{0.0035} D99.2 + \underset{(12.4)}{0.61} \Delta k_{t-1} - \underset{(-11.1)}{0.023} k^*_{t-1} - \underset{(4.11)}{0.011} \Delta_2 uci_t - \underset{(-5.43)}{0.020} r_{t-2} + \underset{(4.89)}{0.012} \Delta r_{t-2}$$
$$- \underset{(-5.17)}{0.0053} rpd_{t-1} + \underset{(3.07)}{0.0037} \Delta_3 rpd_{t-1} - \underset{(-3.10)}{0.0014} reer_{t-2} - \underset{(-2.65)}{0.0044} w_{t-1} + \underset{(4.19)}{0.0054} \Delta_4 w_{t-1}$$
$$- \underset{(-3.55)}{0.0065} s^{rw}_{1,t-1} + \underset{(4.01)}{0.0054} \Delta s^{rw}_{1,t-1} + \underset{(3.45)}{0.0032} \Delta s^{rw}_{1,t-2} - \underset{(-2.00)}{0.0011} \Delta \left| s^{ar}_{1,t-1} \right|$$

T = 89 (1981.4–2003.4); $\hat{\sigma} = 0.086\%$; $R^2 = 0.97$; DW = 2.16;
AR: F(5, 63) = 0.91 (0.48); ARCH: F(4, 60) = 0.37 (0.83); Hetero: F(35, 32) = 0.54 (0.96); Normality: $\chi^2(2) = 2.59$ (0.27); RESET: F(1, 67) = 0.53 (0.47).

Long run elasticities: $r = -0.9$; $rp = -0.2$; $rer = -0.06$; $w = 0.2$; $s_1^{rw} = 0.28$.

Recursive estimates, 1-Step Residuals +/- 2 S.E., 1-Step Chow Test, Break-Point Chow Test



Conclusions (1)

- The paper provides strong evidence that **inflation uncertainty has been a powerful investment deterrent** in Brazil.
  - Uncertainty proxies are highly significant across specifications.
  - All types of proxies are highly significant
  - Magnitude of the effect is economically relevant

- Uncertainty is harmful both in the **short and long run** (i.e. not a nuisance!).

- Inflation uncertainty effects seems to be **asymmetric**:
  - Positive inflation errors are harmful to capital accumulation.
  - Negative errors actually act like good news.

Conclusions (2)

- The **real interest rate** was found to play a major role in investment decisions.
  - Could be due to the modelling strategy used.
  - Could be due to its high variability in Brazil.
- A fall in the **real exchange rate** (i.e. appreciation) increases M&E investment in Brazil.
- Inflation uncertainty effects are likely to be **much bigger** than those shown in this paper, since it can affect investment **indirectly** via other channels (e.g. credit constraints, risk premium).
- Results show the **large potential gains** that the economy can accrue if inflation is kept low and stable for extended periods of time.