Challenges for Macroeconomic Theory and Econometrics

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The major challenge in macroeconomics

- To better understand
  - the 2-way interdependence of the financial sector and the real economy
  - financial fragility and how and when a financial crisis can develop into an economic crisis.

- Financial crises are the norm rather than the rare exception (Reinhart and Rogoff, 2009). Since eighties close to 60 of them.

- Idealized theoretical norms in finance and economics are largely inconsistent with the possibility of such crises.

A vision for future research

- Theoretical models that can
  - capture the full dynamics of financial market behavior and its interrelatedness with the real economy (reflexivity, Soros, 1987),
  - signal the possibility of collapse well in advance
- Empirical models that can
  - take such models to the data without compromising high scientific standards.

Close world models (Savage: small world)

The Rational Expectations, Representative Agent norm in economics:

- All possible future outcomes are known and described by one probability distribution
- Insurable risk (measured by the variance of the probability distribution)
- Inconsistent with the existence of speculative markets.

Such models are simple, mathematically tractable, but too far from the empirical reality to be useful for understanding crises.

Open world models (Savage: big word)

- The full set of possible future outcomes are not known and cannot be described by one probability distribution
- Fundamental (Knightian/Keynesian) uncertainty is the relevant concept: some future outcomes are truly unpredictable and hence uninsurable.
- Is consistent with: structural breaks, pronounced persistence from idealized norms, complex interactions and dynamics. All of them typical features of data.
- Imperfect Knowledge Economics (Frydman and Goldberg, 2007).

Imperfect Knowledge Economics: An illustration of 'Big World' Modelling

- Frydman and Goldberg (2007) model economic actors that
  - have imperfect knowledge about the functioning of the economy,
  - are endogenously risk averse,
  - are myopic,
  - use a diversity of forecasting strategies,
  - change these strategies but conservatively so,
  - recognize that future outcomes are subject to fundamental uncertainty and not just insurable risk.
- Even though all these features cannot be modelled they have testable implications on the macro level.

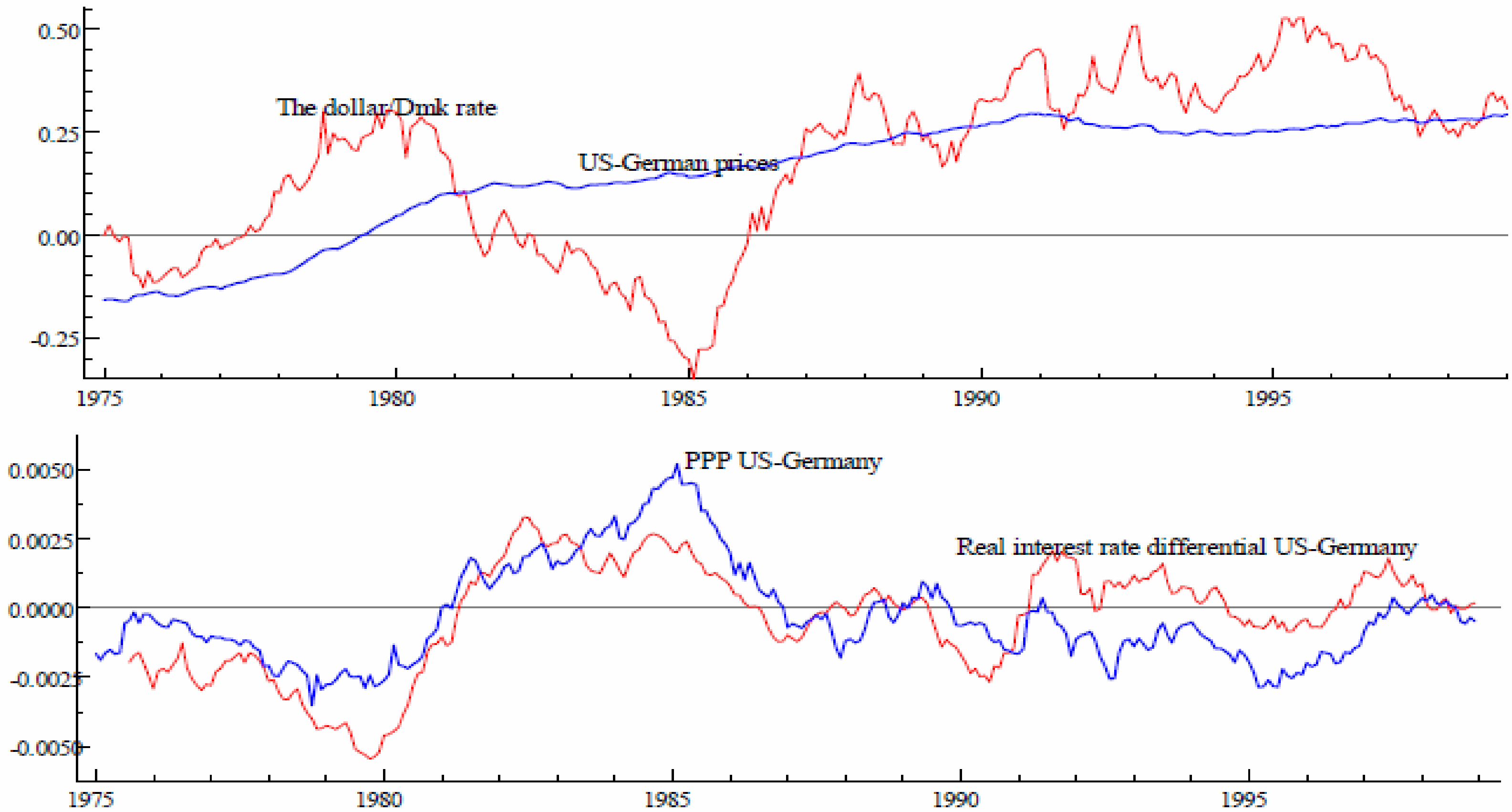
Testable implications

- Unregulated financial market behavior tends to drive asset prices persistently away from benchmark values.
- Uncertainty adjusted arbitrage trading replaces risk adjusted arbitrage trading as a description of how markets clear. Illustration: the long moderation period.
- Such long swings in asset prices (exchange rates, market interest rates, stock prices, house prices) will generally have a strong effect on our economies and can easily develop into an economic crisis

Financial market behavior in foreign currency markets

- A tendency to generate a pronounced persistence in nominal exchange rates and nominal interest rates, **but not in tradable goods prices** (unless subject to speculation). As a consequence:
- The real exchange rate, the real interest rate, the real interest rate differential, and the term spread exhibit persistent swings over time.
- These persistent swings are likely to generate persistent fluctuations in the macro economy.

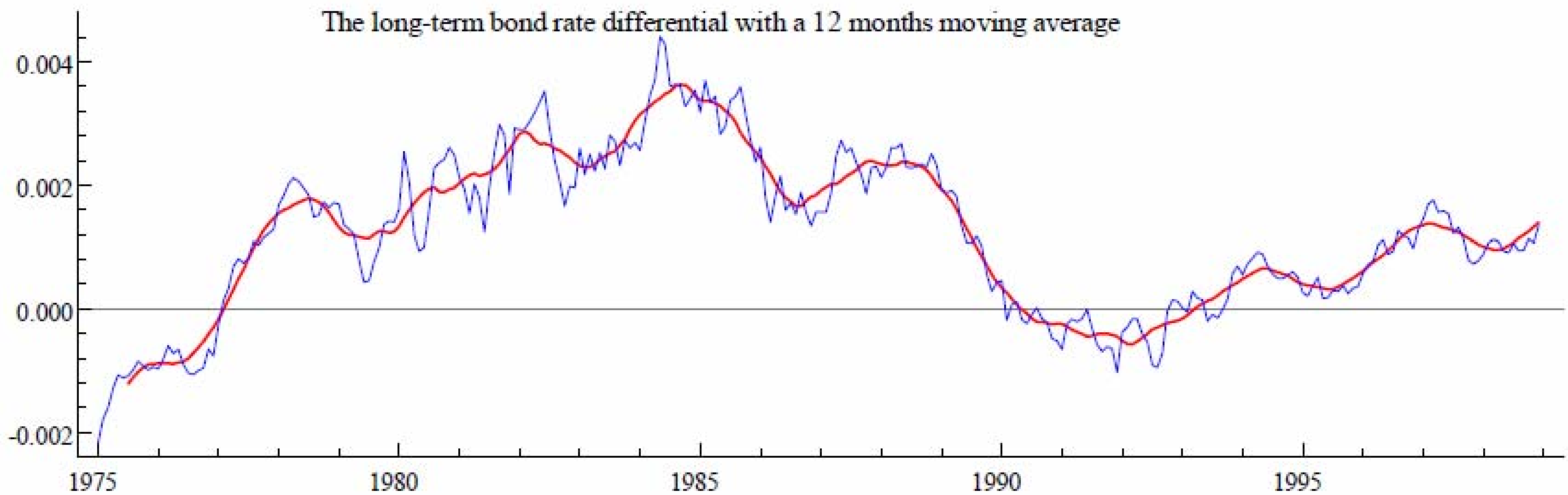
Illustrating persistence

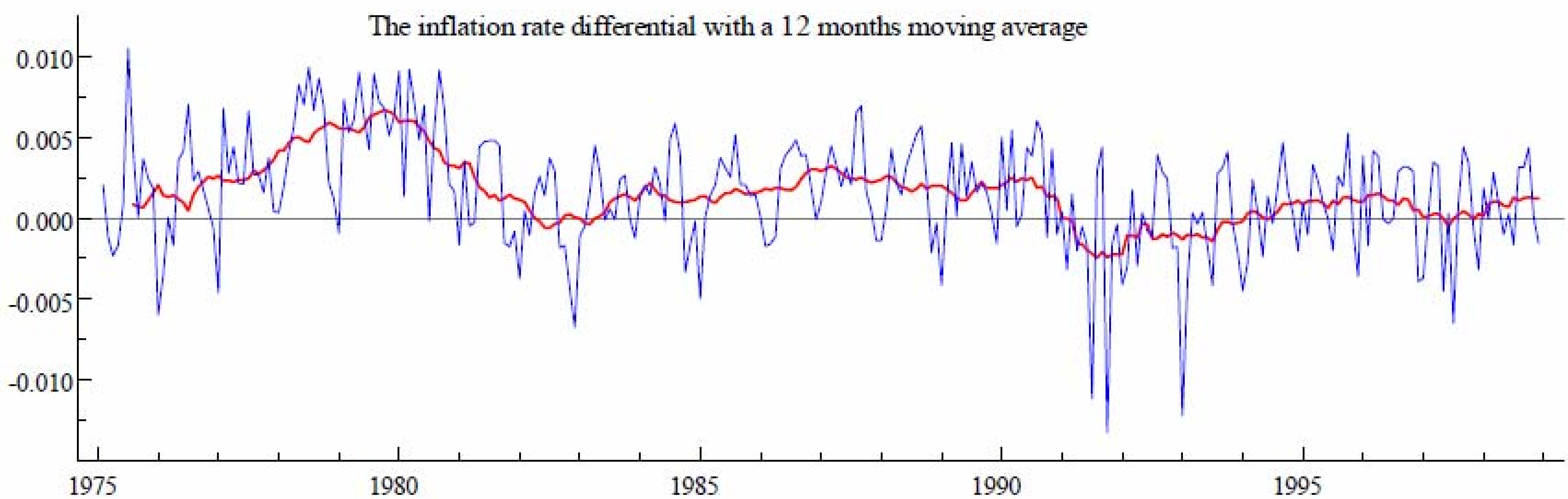


A nonstationary real exchange rate

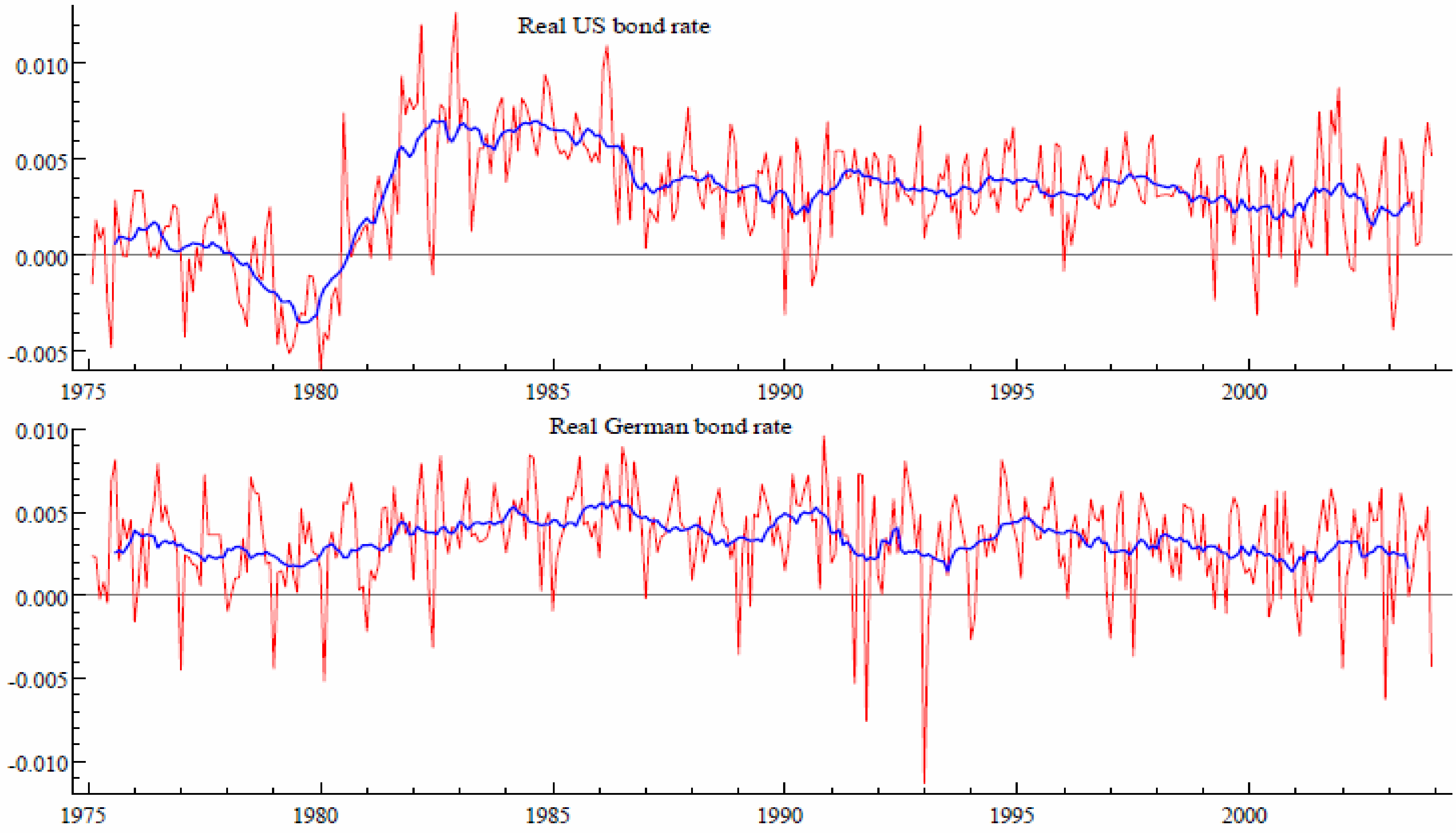
- is likely to have a strong effect on enterprises' price-setting behavior in a competitive world.
  - 'pricing-to-market' (Phelps customer markets) replaces 'constant mark-up pricing'
  - the profit share (rather than the price) is adjusting as a result of the rigidities in the real exchange rate.
- This can explain the stability of tradable goods price inflation as contrasted with the instability of asset price inflation.

Persistence in US-German interest rate, inflation rate differentials





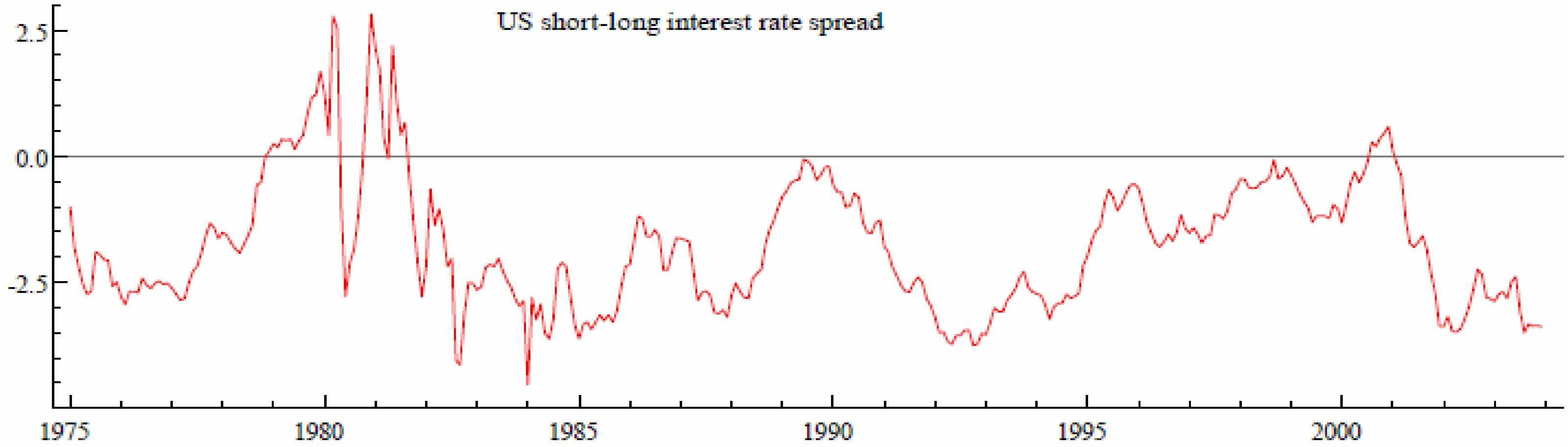
Persistence in real interest rates



A nonstationary real interest rate

- is likely to have a strong effect on unemployment, and
- the natural rate of the Phillips curve is not constant but a function of the (nonstationary) real interest rate.
- Phelps (1996): “Structural Slumps”.

Persistence in short-long interest rate spreads



Implications for monetary policy

A nonstationary interest rate spread implies that monetary policy interventions in the short end of the market may not work their way to the long end.

Instead, long-term interest rates, crucial for investment and savings decisions, are determined by uncertianty adjusted arbitrage in financial markets.

Econometric Modelling: Confronting economic theory with data

Haavelmo (1944):

1. experimental design data artificially isolated from other influences (theory-first modelling).
   - The *ceteris paribus* clause is satisfied
   - Inference is valid
2. non-experimental macrodata (data-first modelling)
   - No control over which theory model generated the data: a pre-specified true model cannot be assumed
   - Any *ceteris paribus* assumption likely to be invalid (everything else changes)

Taking small models to nonexperimental data: the scientific illusion in empirical economics

- Highly stylized economic models would require experimental design data for valid inference, but we cannot do designed experiments in macroeconomics.

- Numerous prior restrictions imposed on the model from the outset makes it hard to know the difference between an empirical fact and an assumption: The validity of inference is jeopardized.

- Illustrating our beliefs rather than finding out how we are wrong.

Taking big world theory models to non-experimental data

- There are many economic models but one economic reality.
- Hence, we should learn about which of economic models are empirically relevant by a systematic and well-structured structured data analysis.
- The design of our econometric model must allow the data to speak freely about the empirical content of these models.

General-to-Specific: some bridging principles for big world modeling and econometrics

- The econometric model must be sufficiently broad to adequately describe dominant features of economic data, such as dynamics, interaction, pronounced persistence and structural breaks.
- Basic assumptions of the economic model have to be translated into testable hypotheses on the econometric model.
- Falsification is more important than verification.
- Puzzling results are more interesting than confirmatory results.

Cointegrated VAR modelling and encompassing testing

- Formulate ’theory-consistent CVAR’ scenarios (Juselius, 2010) for relevant competing theoretical models by deriving testable implications for ”the forces that move equilibria (*pushing forces*, which give rise to stochastic trends) and forces that correct deviations from equilibrium (*pulling forces*, which give rise to long-run relations)” Hoover et al. (2008)

- Formulate a CVAR model for the set of variables representing all competing models. Control for the *ceteris paribus* assumption by conditioning on sufficiently long lags.

Encompassing testing

- By structuring the economic reality represented by the available data we can create confidence intervals within which empirically relevant models should fall. The encompassing principle. (Hendry and Mizon, 1993)
- Models that do not reproduce (even) approximately the quality of the fit of a well-specified statistical model would have to be rejected or modified.
- Many popular macroeconomic and macro finance models would not pass this test.

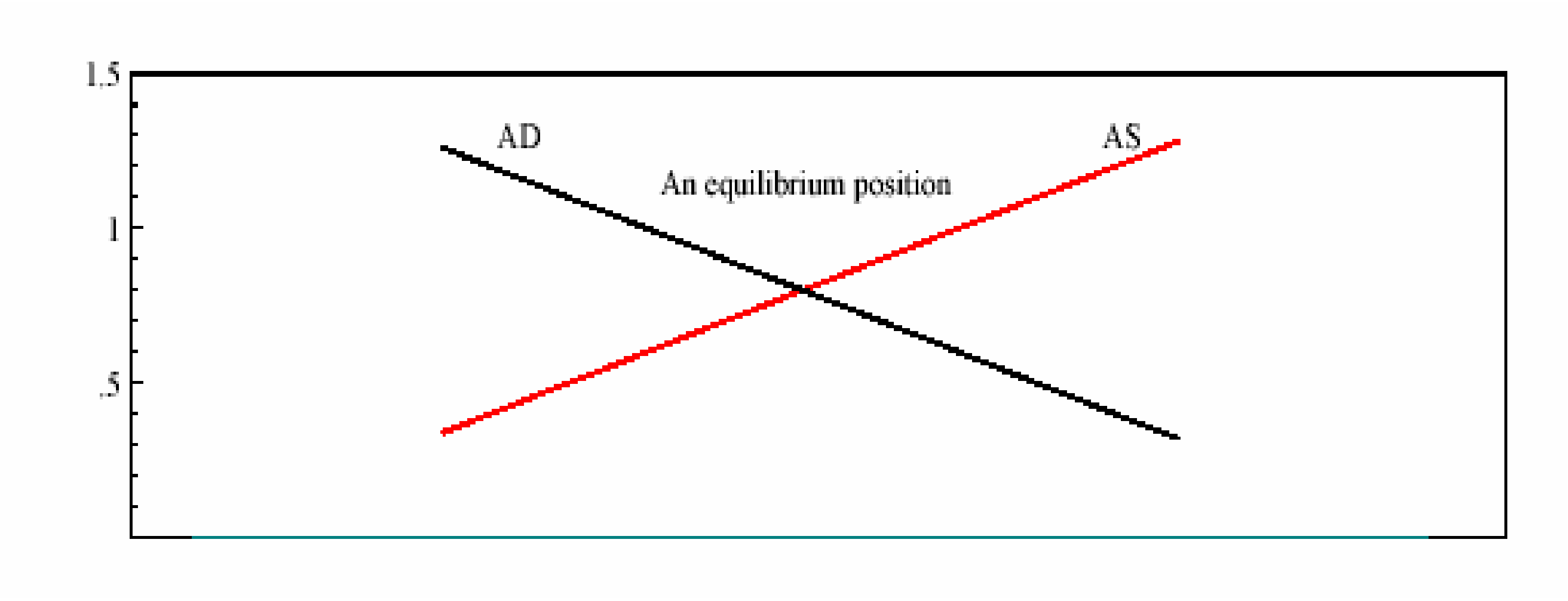
Methodological intro: concluding remarks

- Unless we take the complexity of our economic reality seriously, economic models run the risk of continuing to illustrate incorrect beliefs and will fail to predict, explain and prevent the next economic crisis.
- Adequately specified empirical models generally reject small world assumptions but are often consistent with big world assumptions such as Uncertainty and Imperfect Knowledge.
- Thus, to assume that we know from the outset what the empirical model should tell us and then insist that the results should be in accordance is a recipe for not learning what we really need to know.

Taking the theory to the data:

Romer: Advanced Macroeconomics, Chapter 9:
Inflation and Monetary Policy

What causes inflation?



Many potential causes:
Shocks shifting the AD curve to the right or the AS curve to the left leads to higher prices

Inflation and money growth

Equlilibrium in the money market:

$$M/P = L(R, Y^r), \quad L_R < 0, \quad L_y > 0.$$

Inverting the equilibrium money relation:

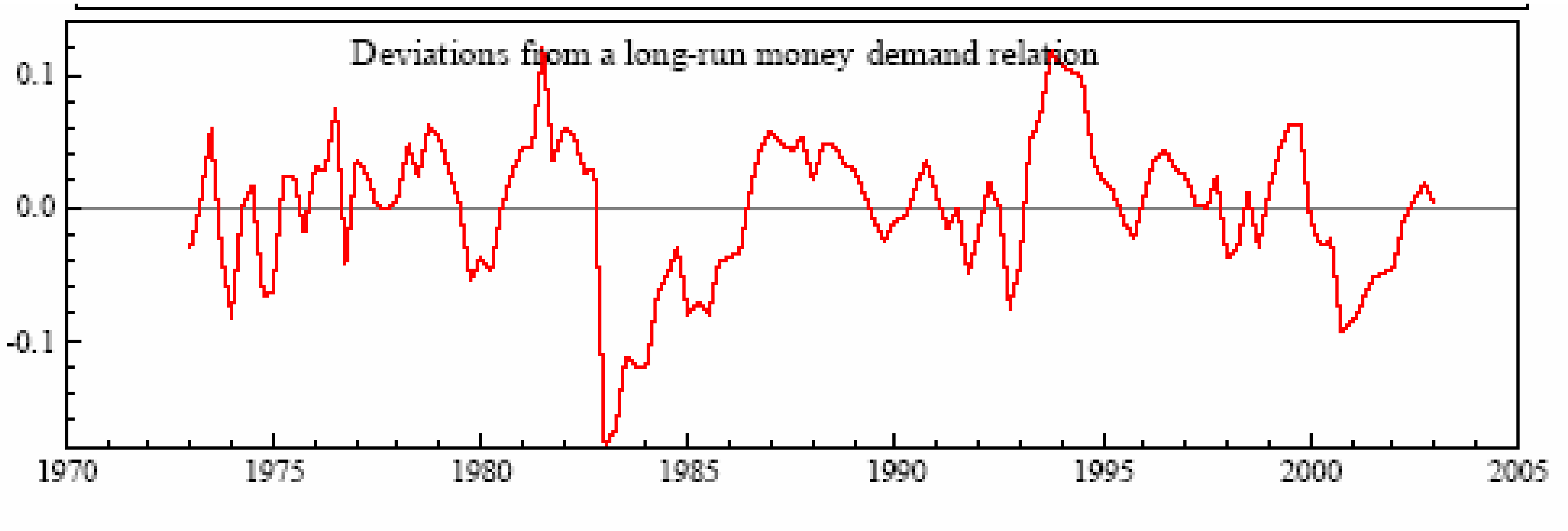
$$P = M/L(R, Y^r)$$

Endogenous, exogenous variables? Ceteris paribus assumptions?

Deviations from long-run benchmark levels:

$$\ln(M/PY^r)_t - L(R_b - R_m)_t = v_t$$

Deviations from a long-run money demand relation



Excess money measured as: m-p-y-13(Rm-Rb)

The I(2) Scenario

$$\begin{bmatrix} m_t \\ p_t \\ y_t^r \\ R_{m,t} \\ R_{b,t} \end{bmatrix} = \begin{bmatrix} c_{11} \\ c_{21} \\ 0 \\ 0 \\ 0 \end{bmatrix} [\sum \sum u_{1i}] + \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \\ d_{31} & d_{32} \\ d_{41} & d_{42} \\ d_{51} & d_{52} \end{bmatrix} \begin{bmatrix} \sum u_{1i} \\ \sum u_{2i} \end{bmatrix} + \begin{bmatrix} g_1 \\ g_2 \\ g_3 \\ 0 \\ 0 \end{bmatrix} [t] + \text{stat.comp.} \tag{2.11}$$

Defining autonomous shocks

- Theoretically
- Empirically

- Shocks shifting the AD curve
- Shocks shifting the AS curve

A theory consistent scenario under long-run price homogeneity

$$\begin{bmatrix} m_t - p_t \\ \Delta p_t \\ y_t^r \\ R_{m,t} \\ R_{b,t} \end{bmatrix} = \begin{bmatrix} 0 & d_{12} \\ c_{21} & 0 \\ 0 & d_{12} \\ c_{21} & 0 \\ c_{21} & 0 \end{bmatrix} \begin{bmatrix} \sum u_{1i} \\ \sum u_{2i} \end{bmatrix} + \ldots$$

Inflation I(1) ?

Why does nonstationarity matter for the statistical modelling?

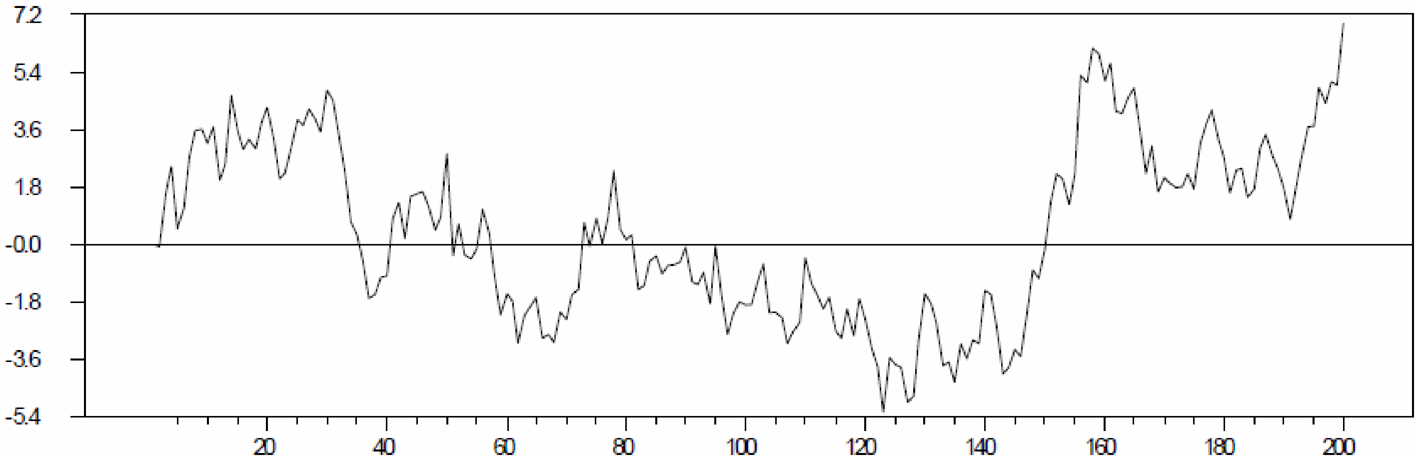
- Standard statistical inference is based on stationarity.
- Some new inferences is needed, but by transforming the data into differences and cointegration relations stationarity is recovered.
- Pulling and pushing forces

Why does nonstationarity matter for the economic modelling?

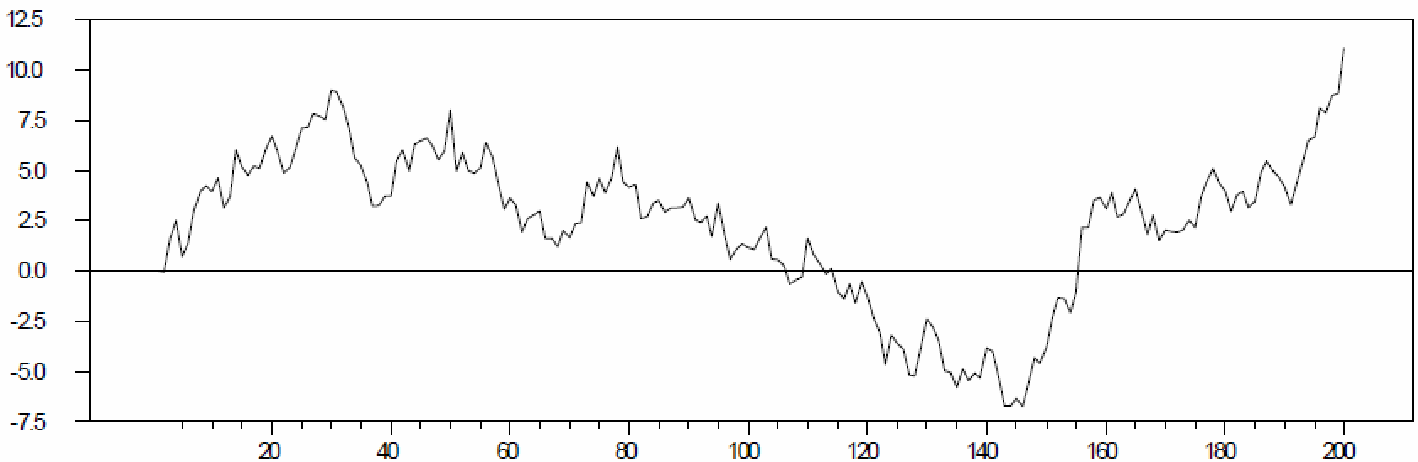
- Most economic models are developed for a stationary world
- The role of the ceteris paribus assumption
- The role of expectations
  - Model based rational expectations
  - Imperfect knowledge expectations

Persistence as a structuring device

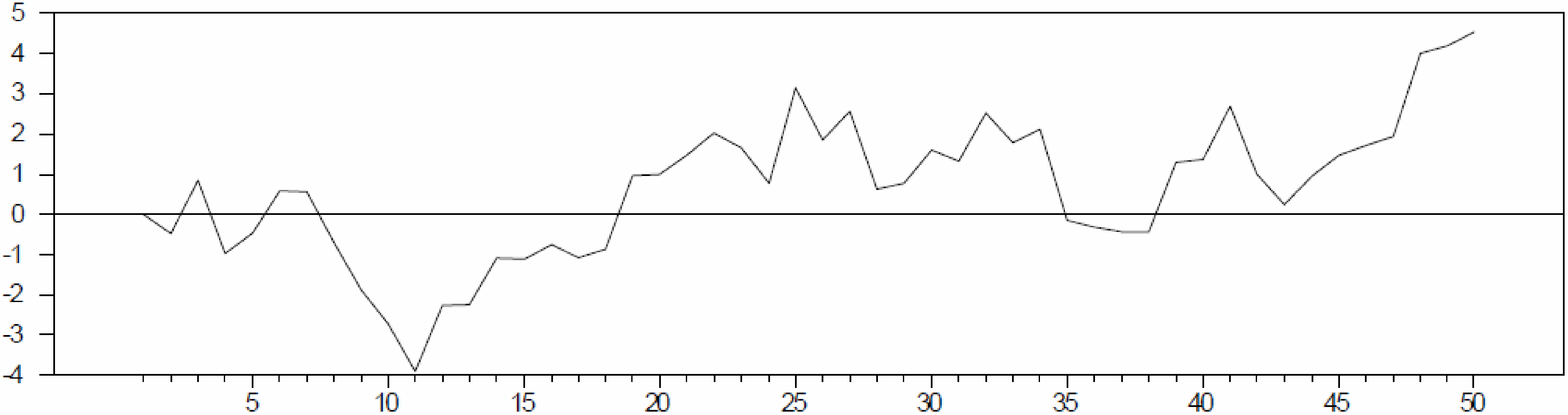
$$x_{1,t} = 0.95 * x_{1,t-1} + \varepsilon_t$$



$$x_{2,t} = x_{2,t-1} + \varepsilon_t$$



$$x_{1,t} = 0.80 * x_{1,t-1} + \varepsilon_t$$



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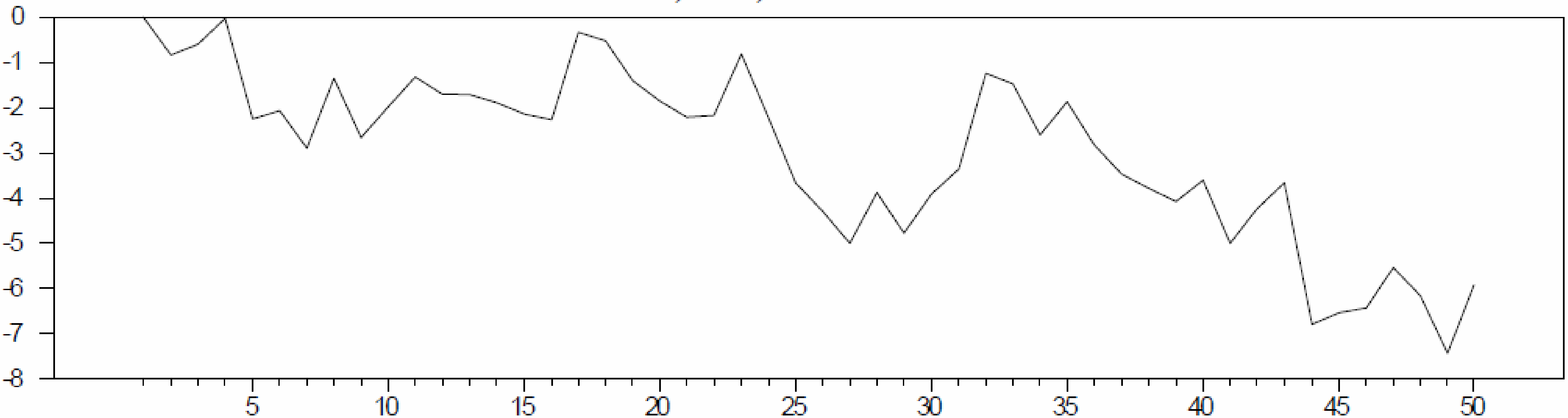

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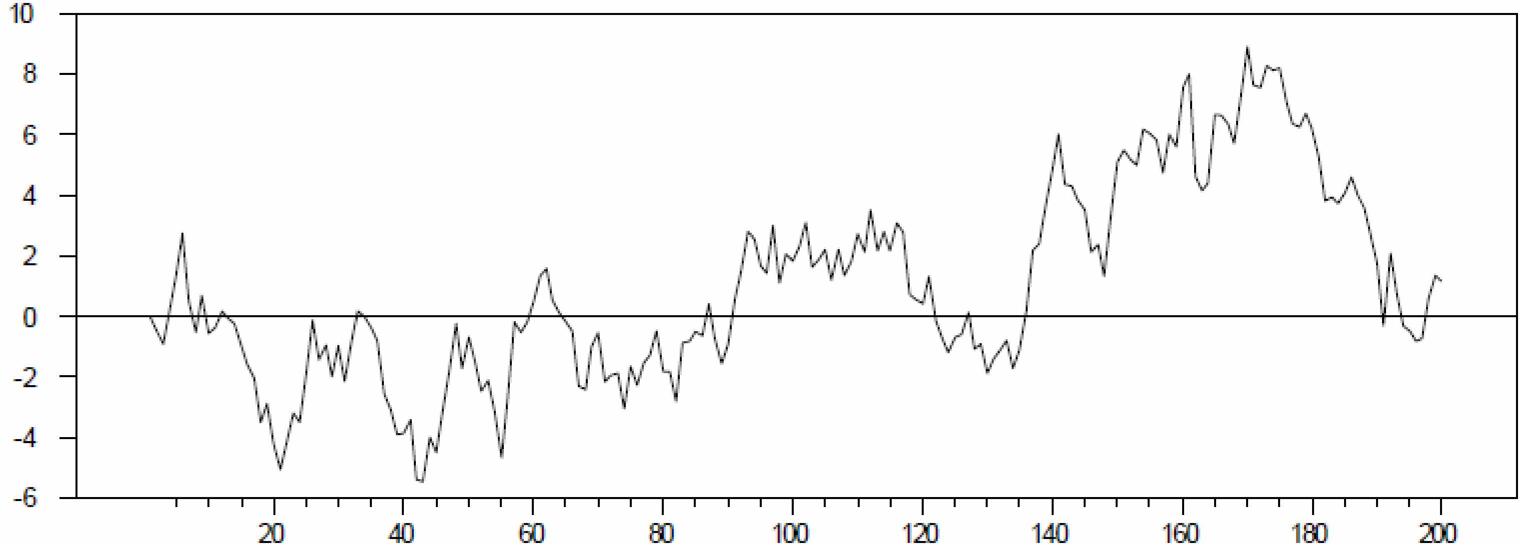
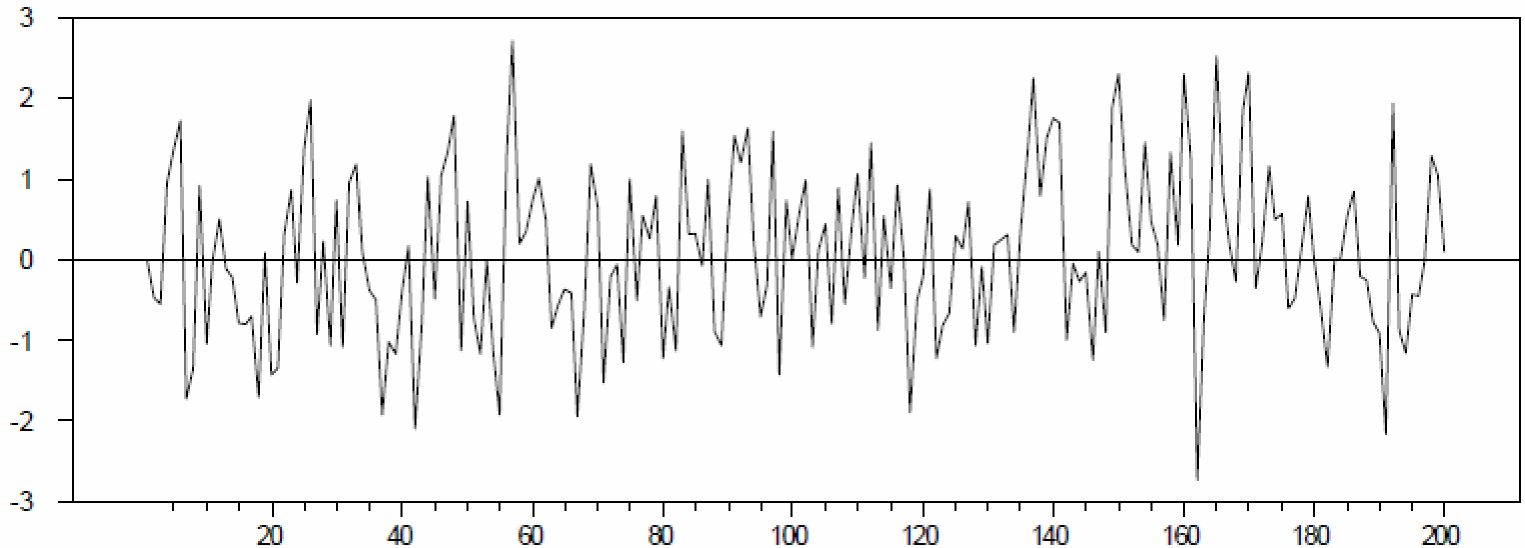


$$x_{2,t} = 0.20 * x_{2,t-1} + \varepsilon_t$$



A proposal for classification

- $I(0)$ type when the modulus of the largest root, ρ_1, satisfies $\rho_1 < \rho^*$.
- $I(1)$ type when the modulus of the largest root, ρ_1, satisfies $\rho^* < \rho_1 \leq 1.0$ and the next root $\rho_2 < \rho^*$.
- $I(2)$ type when the modulus of the largest root, $\rho_1 = 1.0$, and the next one satisfies $\rho^* < \rho_2 \leq 1.0$.

- Extension to vector processes
- Near unit root inference

Structuring persistence with the CVAR

The I(1) model:

The adjustment forces are formulated as:

$$\begin{bmatrix} \Delta x_{1,t} \\ \Delta x_{2,t} \\ \Delta x_{3,t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \beta' x_{t-1} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}$$

where $\beta' x_t$ is an equilibrium error and α_i is an adjustment coefficient describing how the system adjusts back to equilibrium when it has been pushed away. The driving forces are described by:

$$\begin{bmatrix} x_{1,t} \\ x_{2,t} \\ x_{3,t} \end{bmatrix} = \begin{bmatrix} \beta_{\perp,11} & \beta_{\perp,21} \\ \beta_{\perp,12} & \beta_{\perp,21} \\ \beta_{\perp,13} & \beta_{\perp,21} \end{bmatrix} \begin{bmatrix} \sum_{i=1}^{t} u_{1,i} \\ \sum_{i=1}^{t} u_{2,i} \end{bmatrix} + \ldots + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}$$

where $u_{1,t} = \alpha'_{\perp,1}\varepsilon_t$ and $u_{2,t} = \alpha'_{\perp,2}\varepsilon_t$ are two autonomous common shocks

The I(2) model:

The pulling forces are given by:

$$\begin{bmatrix} \Delta^2 x_{1,t} \\ \Delta^2 x_{2,t} \\ \Delta^2 x_{3,t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} (\beta' x_{t-1} + \delta' \Delta x_{t-1}) + \begin{bmatrix} \zeta_{11} & \zeta_{21} \\ \zeta_{12} & \zeta_{22} \\ \zeta_{13} & \zeta_{23} \end{bmatrix} \begin{bmatrix} \beta' \Delta x_{t-1} \\ \beta'_{\perp 1} \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}$$

where $\beta' x_{t-1} + \delta' \Delta x_{t-1}$ describes an equilibrium error from a dynamic equilibrium relation, and $\beta' \Delta x_{t-1}$ and $\beta'_{\perp 1} \Delta x_{t-1}$ describe medium-run equilibrium errors among growth rates.

The pushing forces are given by:

$$\begin{bmatrix} x_{1,t} \\ x_{2,t} \\ x_{3,t} \end{bmatrix} = \begin{bmatrix} \beta_{\perp 2,1} \\ \beta_{\perp 2,2} \\ \beta_{\perp 2,3} \end{bmatrix} \left[\sum_{i=1}^{t} \sum_{s=1}^{i} u_{1,s} \right] + \begin{bmatrix} b_{11} & b_{21} \\ b_{12} & b_{22} \\ b_{13} & b_{23} \end{bmatrix} \begin{bmatrix} \sum_{i=1}^{t} u_{1,i} \\ \sum_{i=1}^{t} u_{2,i} \end{bmatrix} + \ldots$$

where $u_{1,t} = \alpha'_{\perp 2} \varepsilon_t$ is an autonomous shock that double cumulates over time to a stochastic $I(2)$ trend and $u_{2,t} = \alpha'_{\perp 1} \varepsilon_t$ is an autonomous shocks that cumulates over time to a stochastic $I(1)$ trend. $\alpha_\perp = [\alpha_{\perp,1}, \alpha_{\perp,2}]$, is a 3×2 matrix orthogonal to α, defining the two shocks as linear combination of the VAR residuals $\hat{\varepsilon}_t$. $\beta_{\perp 2}$ is a 3×1 vector orthogonal to $\{\beta, \beta_{\perp 1}\}$ measuring how the $I(2)$ stochastic trend loads into the variables.

Research questions related to I(2) variables

- How come I (we) always find evidens of I(2) when most other people find data are I(1)?
  - The difference between multivariate and univariate testing
- Can economic variables be I(2)?
  - The order of integration is a statistical property that can be used to classify data in different persistency profiles, but not necessarily a structural economic parameter
- What about near I(2) models? Should they be analyzed as I(2) or I(1)?
  - Grayham Elliot’s Econometric paper