Exchange rate puzzles
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Objective of the presentation

- To review recent theoretical and empirical developments in respect of the following:
  - The purchasing power parity puzzle
  - The exchange rate disconnect puzzle
  - The exchange rate determination puzzle

Please note that the presentation is based on:

Mokoena, T M, Gupta R and van Eyden, R. 2010. Exchange Rate Puzzles: A Review of the Recent Theoretical and Empirical Developments, *ICFAI Journal of Monetary Economics*.

Abstract of the paper

- This paper presents a comprehensive literature review of the theoretical and empirical developments that have taken place over the last two decades in an attempt to address the exchange rate puzzles. Specifically, we discuss linear and non-linear, as well as Bayesian econometric techniques, dynamic general equilibrium models, and the market microstructure approaches that have been designed to address three exchange rate puzzles, namely, the purchasing power parity (PPP) puzzle, the exchange rate disconnect puzzle and the exchange rate determination puzzle. We conclude that the exchange rate puzzles are likely to be less puzzling, if researchers decide to move to non-linear econometric frameworks and microfounded general equilibrium models.

PPP defined

- Let:
- P be the price level in the home country
- P* be the price level in the foreign country
- Y be the nominal exchange rate.

- The PPP relation is defined as:

$$Y_t = \frac{P_t}{P_t^*}$$

The PPP hypothesis

- Since the nominal exchange rate is the relative price of two currencies, in equilibrium it should reflect their relative purchasing powers. This implies that the following relation should hold in log form:

$$\log Y_t - \log P_t^* + \log P_t = 0$$

- Thus, any deviations, say a series Z_t, from this relation should be statistically insignificant. One should find the series Z_t to be stationary.

Is PPP important?

- PPP is used as one of the important assumptions of sticky price theories and in open economy macroeconomic theories

- PPP parities are used in the comparisons of national income levels

- When there is an unusual currency volatility, central bankers need to know the half-lives of deviations from equilibrium to avoid unnecessary departures from rationality

PPP Puzzle 1

- In PPP studies it is desirable to reject the null hypothesis of a random walk
- No mean reversion is detected when researchers use standard tests of nonstationarity
  - Dickey-Fuller and Philipps-Perron tests have low power: without using difference operators, they are generally unable to reject the null hypothesis of nonstationarity

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First strand of research to resolving the PPP puzzle 1

- **Develop new theories** of international macroeconomics that explicitly take nonlinearities into account:
  - Trade and related costs should not be assumed away. Hence, new explicitly nonlinear theoretical models are required.
  - Examples:
    - Sercu, Uppal and Van Hulle (1995):
    - Transport costs create a band for the real exchange rate within which the marginal cost of arbitrage is larger than the marginal benefit, creating a no-trade corridor.
    - **This theoretical model calls for smooth transition autoregressive (STAR) modelling approaches**

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Second strand of research

- **Develop econometric tests** with better power
  - PPP cannot hold continuously due to transaction costs and other frictions.
  - Nonlinear tests of nonstationarity/stationarity are required.
- Difficulty: In most cases, when using nonlinear tests, the parameter space is defined only under the alternative hypothesis

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Basic protocol for hypothesis testing in respect of mean-reversion hypothesis

- **Check the statistical properties of the time series** for stationarity autocorrelation, long memory, structural change, et cetera.
- Set up the null and alternative hypotheses.
- Set up a test regression to test the alternative hypothesis.
- Decide on the test statistic to be used:
  - T-stat, F-stat, Wald-stat, LM-stat, etc
  - Please note: In nonlinear analysis, usually a grid search is undertaken to calculate the supremum, the average or the infinimum of the test statistic when the limit distribution depends on nuisance parameters.
- Make inferences based on the **critical values associated with the limit distribution of the test statistic.**
  - Note: the limit distributions of nonstationary processes tend to be Brownian motion stochastic integrals. In nonlinear analysis nuisance parameters need to be integrated out of the limit distribution, if possible.

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An example of an asymptotic distribution of a nonstationary process

$$NLADF \Rightarrow \frac{\{ \frac{1}{4} B(1)^4 - \frac{3}{2}\int_0^1 B(r)^2\, dr \}}{\sqrt{\int B(r)^6\, dr}}$$

where *B(r)* is the standard Brownian motion defined on $r \in [0,1]$

Critical values of the above distribution are for testing the null hypothesis of a unit root against an alternative of a nonlinear stationary exponential smooth transition autoregressive [ESTAR] process.

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General problems with standard tests of nonstationarity

- Recall the null hypothesis: A series is nonstationary or is a random walk
- Nelson and Plosser (1982): Dickey-Fuller tests are generally unable to reject the null hypothesis of nonstationarity.
- Pipenger and Goering (1993): when the alternative hypothesis is a threshold autoregressive model, the power of the Dickey-Fuller tests falls significantly.
- Diebold and Rudebusch (1990): found significant loss of power when the alternative hypothesis was a fractionally integrated process or a long memory process.
- Eklund (2003): standard nonstationarity tests tend to over-reject the null of unit root when there is a single structural break.

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Some direct quotes

- Maddala and Kim(1998)

  "Although often used, the ADF and PP tests are useless in practice and should not be used."

- Gourieroux and Jasiak(2001)

  "So called financial puzzles often result from a narrow interpretation of inference based on misspecified models."

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Example: Exponential smooth transition autoregressive model (ESTAR)

- The null hypothesis: $y_t = a_1 y_{t-1} + \varepsilon_t$
- The alternative hypothesis: $y_t = a_1 y_{t-1} + a_2 y_{t-1}[1 - \exp(-\gamma y^2_{t-d})] + \varepsilon_t$

$H_1 : \gamma > 0, a_2 \,\&\, a_1 < 0$

The null hypothesis cannot be tested directly due to the fact that γ and a_2 are not identified under the null hypothesis. This is called the Davies(1987) problem.

The modelling approach requires a truncated Taylor expansion approximation of the smooth transition function.

This leads to a simple auxiliary ordinary least squares (OLS) regression

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Nonlinear tests of nonstationarity

- Kapetanios, Shin and Snell (2003):
  - Nonlinear Augmented Dickey-Fuller-type test
- $\Delta y_t = \sum_{j=1}^{p} \varphi_j \Delta y_{t-j} + \delta y^3{}_{t-1} + error$
- Kapetanios and Shin (2002):
  - Nonlinear Wald-type test
- Smallwood (2005): Lagrange Multiplier-type statistic to jointly test for long memory and exponential STAR nonlinearity
- He and Sandberg(2005): Nonlinear Dickey-Fuller-type tests for logistic STAR models with time trend

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Other nonlinear tests

- Bec, Ben Salem and Carrasco (2004)
  - Wald-type test for 3-regime STAR models
- Park and Shintani (2005): Infinimum t-test

  "Our framework is truly general, permitting virtually all potentially interesting models with the threshold, discrete and smooth transition functions. It not only unifies into a single framework all the transitional models studied previously in the literature, but also provides a new class of more flexible and realistic models."
- Rothe and Sibbertsen(2006)
  - Non-linear Phillips-Perron test

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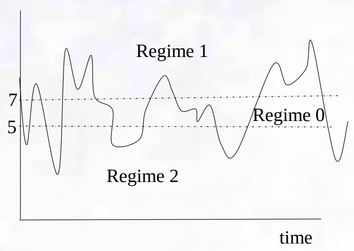
Suppose you want to analyse the behaviour of the rand/dollar exchange

- Rand/dollar



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Bec, Ben Salem and Carrasco (2004)

- The authors develop a supremum Wald-type test:

$$\Delta y_t = (\mu_1 + \alpha_1 y_{t-1}) I_{[y_{t-1} \le \lambda_1]} + (\mu_0 + \alpha_0 y_{t-1}) I_{[\lambda_1 < y_{t-1} \le \lambda_2]}$$
$$+ (\mu_2 + \alpha_2 y_{t-1}) I_{[y_{t-1} > \lambda_2]} + \varepsilon_t$$

Hypothesis testing:

$$H_o = \alpha_1 = \alpha_0 = \alpha_2 = 0$$

$$H_a \alpha_1 < 0; \alpha_0 \le 0; \alpha_2 < 0$$

The test statistic is:

$$\sup W = \sup_{\lambda \in [\lambda_{\min}, \lambda_{\max}]} W_T(\lambda)$$

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Seminal and most referenced contributions in respect of nonlinear PPP analysis

- Enders and Granger (1998),
- Gonzalez and Gonzalo (1998),
- Berben and van Dijk (1998),
- Shin and Lee (2001),
- Kapetanios and Shin (2002),
- Bec, Ben Salem and Carrasco (2004),
- Kapetanios, Shin and Snell (2003)

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Alternative method: Bayesian hypothesis testing

- Bayesian unit root testing was introduced by Zellner and Siow (1980) but was popularised by Koop (1992) and Ahking (1997, 2004), among others. Under the null hypothesis, a times series is an autoregressive model of order p with a linear time trend.
- In the paper we compare four hypotheses, based on both prior and sample information, by calculating the posterior odds ratios.
- The basic assumption is that all three alternative hypotheses have equal prior probability.

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PPP Puzzle 2: half-lives

- Speed of mean reversion is too slow, given the high volatility of real exchange rates
- Consider $y_t = \varphi y_{t-1} + \varepsilon_t$
- Traditional half-life is $h = \log(0.5)/\log(\hat{\varphi})$
  - Half-lives are generally found to be between 3 and 5 years.
    - This is not consistent with the sticky price theories.
    - Half-lives of less than 3 years are considered acceptable.

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PPP Puzzle 2: half-lives (continued)

- Seminal works in trying to solve the half-life puzzle:
  - Kim, Silvapulle and Hyndman (2007) propose a bias-corrected bootstrap procedure for the estimation of half-life deviations from PPP by adopting Hyndman (1996) highest density region (HDR) approach to point and interval estimation.
  - The authors' approach necessitates the use of the Kilian (1998) bias-corrected bootstrap to approximate the sampling distribution of the half-life statistic.

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Half-lives seminal works (continued)

- Seminal works in trying to solve the half-life puzzle:
  - Rossi (2005) introduces a half-life measure for an R(p) process that produces improved asymptotic approximations in the presence of a root close to unity.
  - Thus the analysis is based on the local-to-unity asymptotic theory. In this context, a half-life can diverge to infinity at the rate of the sample size.

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Half-lives seminal works (continued)

- Seminal works in trying to solve the half-life puzzle:
  - Half-lives for ESTAR processes: Norman (2007)
  - Fractional integration tests: Smallwood (2005)

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Issues for future research

- When the time series manifest structural changes, shifts in mean, and growth in the levels of the variables, a new comprehensive methodology is really necessary:
- We need to be fairly accurate about whether the time series are:
  - linear and covariance stationary,
  - nonlinear and/or covariance stationary,
  - nonstationary fractionally integrated,
  - stationary fractionally integrated,
  - nonlinear and fractionally integrated.

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The exchange rate disconnect puzzle

- There are currently two strands of research trying to explain the exchange rate disconnect puzzle.
- The first strand of research is theoretical in that it attempts to explain the conditions under which "the disconnect" between the economic fundamentals and exchange rate movements is expected to exist. This strand relies on DSGE models.
- Such studies include Devereux and Engel (2002), Xu (2005), Duarte and Stockman (2005), Evans and Lyons (2005), and Bacchetta and van Wincoop (2006).

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Devereux and Engel (2002)

- The authors explain that a combination of local currency pricing, heterogeneity in international price setting and goods distribution, as well as biases in expectations in international financial markets may produce very high exchange rate volatility without significant repercussions for the volatility of other macroeconomic variables.
- The authors stress that "there ought to be a greater disconnect when the degree of local-currency pricing is high and the wealth effects of exchange rate changes are small."

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Duarte and Stockman (2005)

- The authors focus on the effects of rational speculation in the foreign exchange markets. They argue that as new information comes becomes public, the risk premia associated with exchange rates adjust in such a way that the changes take place in asset markets but not in the goods market.
- The premise is that international market segmentation coupled with incomplete risk sharing can invalidate the fundamental equilibrating condition, namely, the equality between relative prices and the marginal rate of substitution.
- The break-down of the link between product markets and foreign exchange market allows the asset markets to determine the changes such that expectations and premia change the exchange rates without changing the fundamental variables such as GDP growth rates.

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Exchange rate determination puzzle

- Market micro structure approach
  - *Order flow:* In this model, order flow depends upon the portfolio allocation decisions of domestic and foreign households, the level and international distribution of household wealth and the outstanding stock of foreign bonds held by dealers from last period.
  - These elements suggest that order flow contains both backward-looking and forward-looking components.
  - In particular, there will be positive order flow for foreign bonds if households are more optimistic about the future value of the exchange rate than home dealers.

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Evans and Lyons (2005)

- In the Evans and Lyons (2005) model spot rates are determined by dealer expectations regarding fundamentals, while order flow reflects the differences between household and dealer expectations regarding future spot rates.

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Conclusions

- We conclude that the exchange rate puzzles are likely to be less puzzling, if researchers decide to move to non-linear econometric frameworks and microfounded general equilibrium models.
- Future research may even cover dynamic factor models

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