Introduction

Financial Markets Complexity

Many agents with different goals and limitations.

Adaptability.

Theory vs empirical facts.

Efficient Market Hypothesis (EMH)

It is a cornerstone for modern finance.

It assumes perfect rationality and full information.

It might not reflect real-world situations.

Adaptive Market Hypothesis (AMH)

Markets can be both in/efficient over time.

Agents can be influenced by emotions.

It can be used to develop new investment strategies.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

Motivation

EMH vs AMH

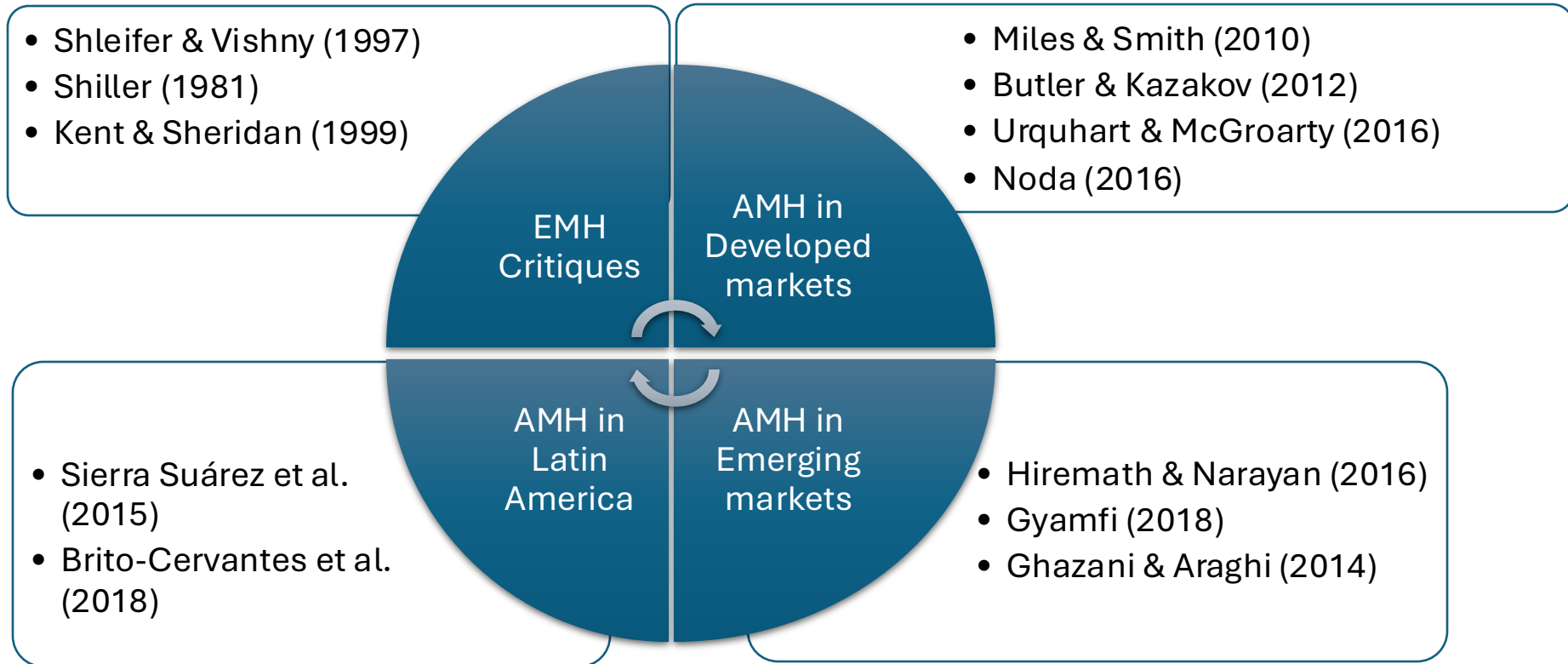| Eastern Europe	Latin America	Asia

Brazil	Colombia	Chile	Peru	Mexico
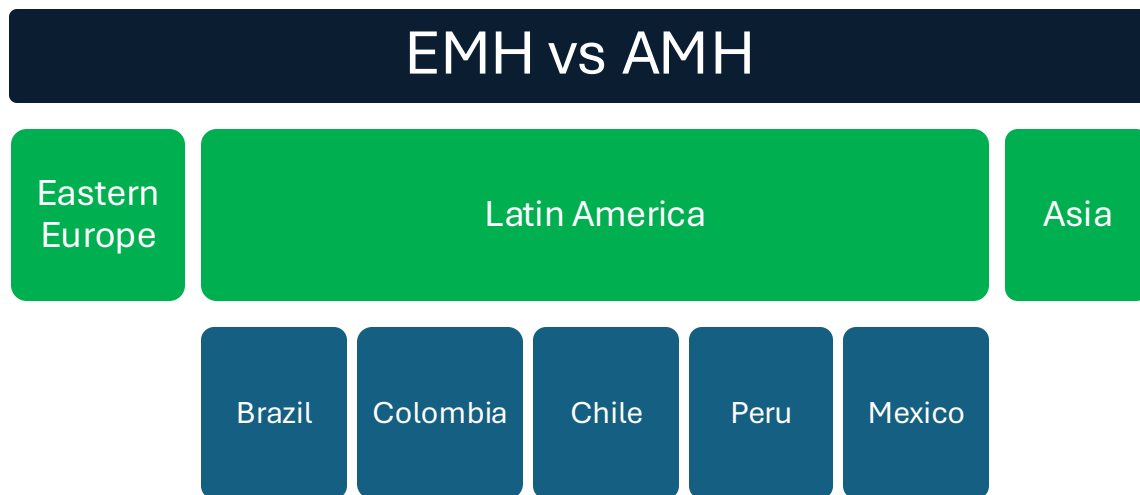
Changes in the efficiency due to:

- Regulation
- Technology
- Institutions

- Bubbles
- Crisis
- ...
- Market conditions

No/linearity

Switching behavior

Market in/efficiency

Predictability
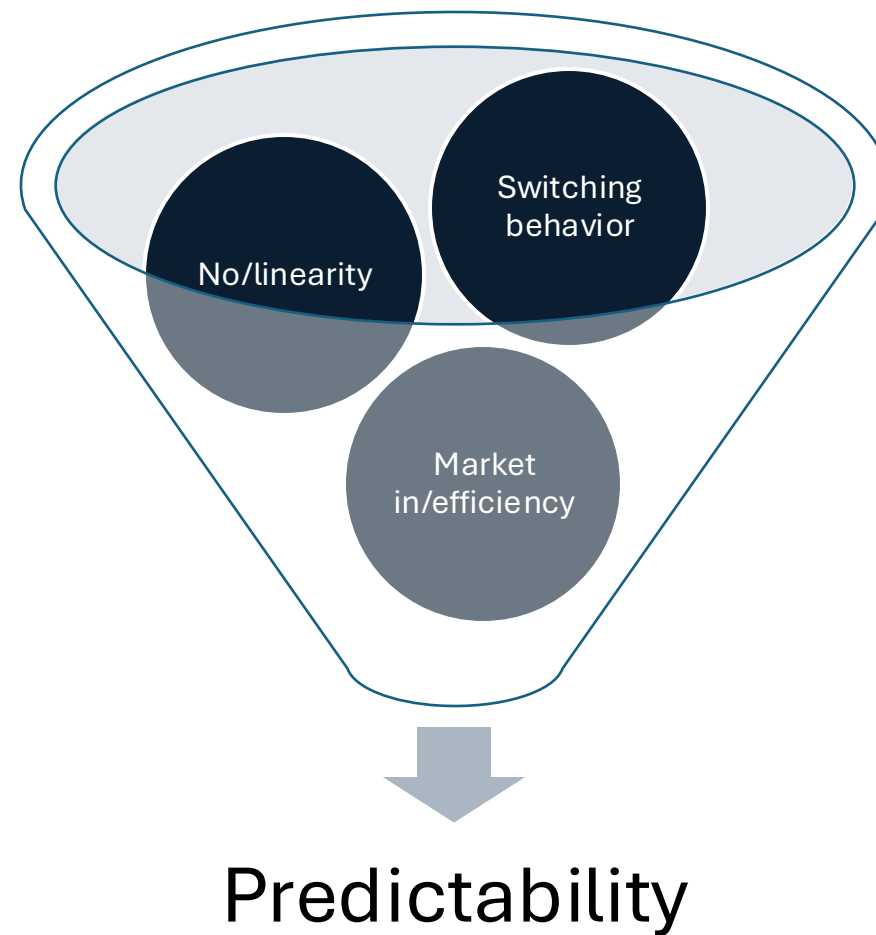
Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

Related literature

- Shleifer & Vishny (1997)
- Shiller (1981)
- Kent & Sheridan (1999)

- Miles & Smith (2010)
- Butler & Kazakov (2012)
- Urquhart & McGroarty (2016)
- Noda (2016)

EMH Critiques | **AMH in Developed markets**

AMH in Latin America | **AMH in Emerging markets**

- Sierra Suárez et al. (2015)
- Brito-Cervantes et al. (2018)

- Hiremath & Narayan (2016)
- Gyamfi (2018)
- Ghazani & Araghi (2014)

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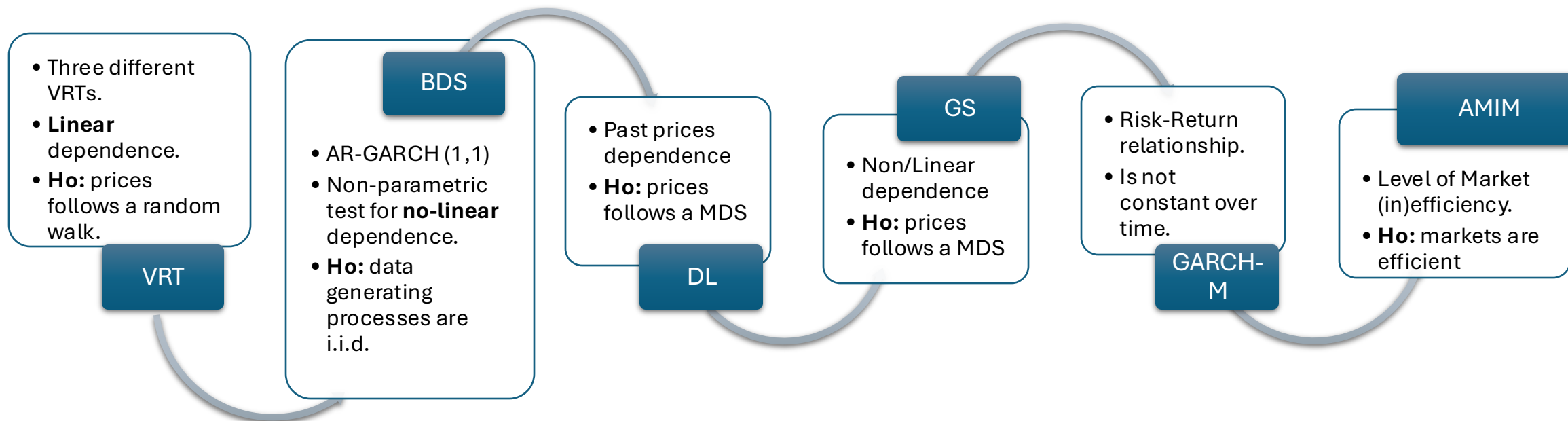
Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

Methodology

Daily data obtained from MSCI indices Emerging Markets (Eastern Europe, Asia, and Latin-America), Focus on Latin-America (Brazil, Colombia, Chile, Peru, and Mexico) and Carbon Pricing (EU ETS Spot, Futures, and S&P) - Bloomberg.

VRT
- Three different VRTs.
- **Linear** dependence.
- **Ho:** prices follows a random walk.

BDS
- AR-GARCH (1,1)
- Non-parametric test for **no-linear** dependence.
- **Ho:** data generating processes are i.i.d.

DL
- Past prices dependence
- **Ho:** prices follows a MDS

GS
- Non/Linear dependence
- **Ho:** prices follows a MDS

GARCH-M
- Risk-Return relationship.
- Is not constant over time.

AMIM
- Level of Market (in)efficiency.
- **Ho:** markets are efficient

VRT/BDS/GARCH-M.	Subsample rolling window of 500 observations.
DL/GS.	‖ 400 observations.
AMIM.	‖ 250 observations.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

# VRT - Results

Emerging Markets Asia
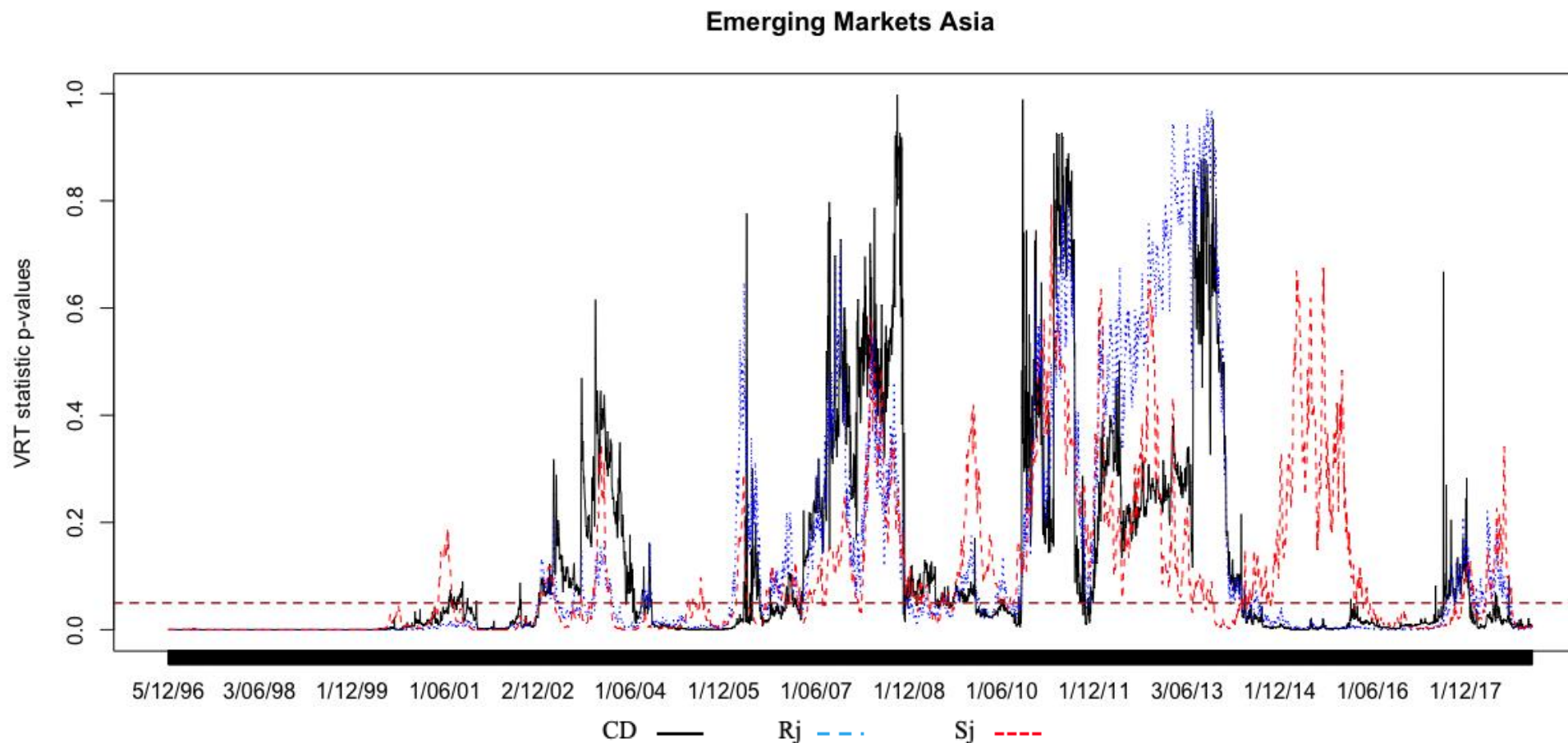
The three lines corresponds to the different Variance Ratio Tests statistic p-values over time for Asian index (daily, two-year window). The horizontal line corresponds to the 5% significance level. The null hypothesis is that returns are not serially correlated.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

BDS - Results

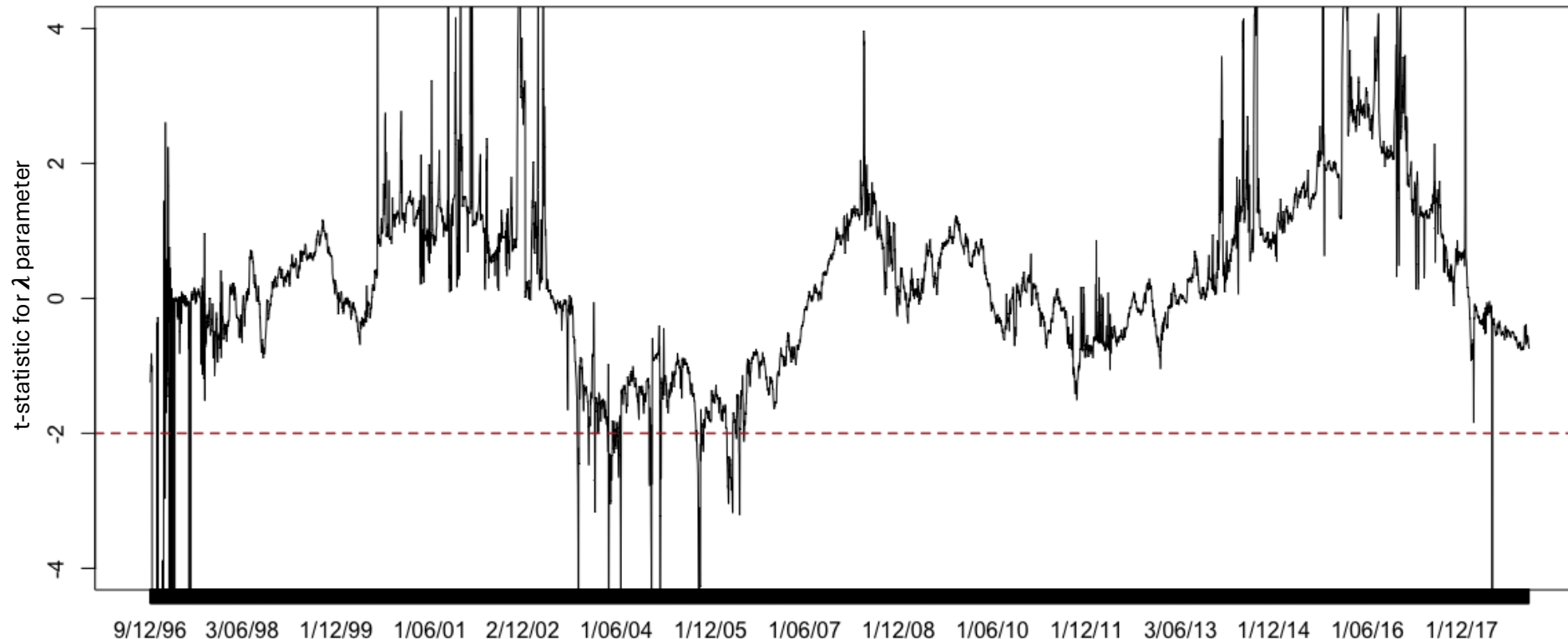**Emerging Markets Latin America**
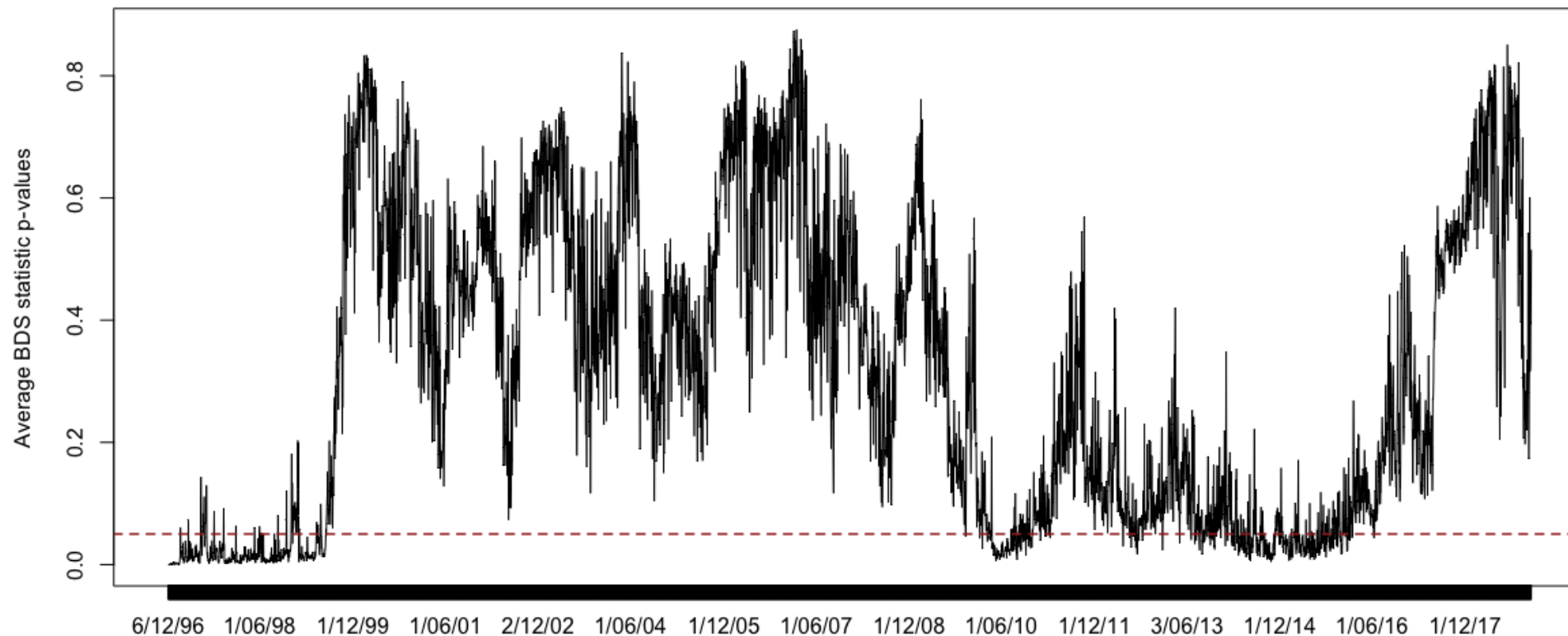
The average BDS statistic p-values over time for Latin America index (daily, two-year window). The horizontal line corresponds to the 5% significance level. The null hypothesis is that data is independent and identically distributed (i.i.d.).
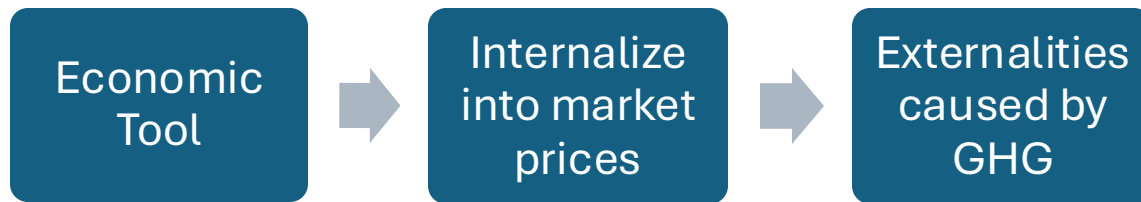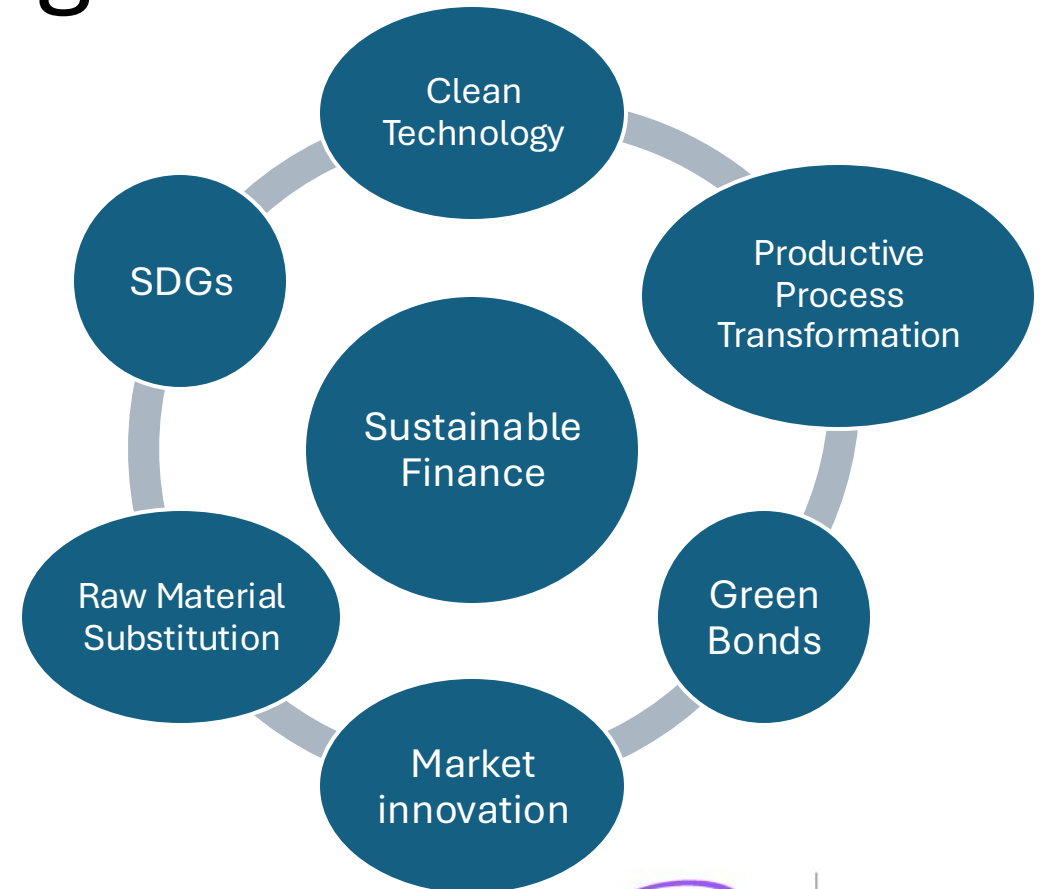
GARCH-M Results

Eastern Europe GARCH-M Model

"... the trade-off between risk and reward is not stable over time or circumstances but varies as a function of the population of market participants and the business environment in which they are immersed" (Lo, 2012).

Motivation – Carbon Pricing

Economic Tool → Internalize into market prices → Externalities caused by GHG

- Losses in crops
- Fires
- Droughts

- Flooding
- Health costs from heat or cold waves
- Damage of property

Clean Technology

Productive Process Transformation

SDGs

Sustainable Finance

Green Bonds

Raw Material Substitution

Market innovation

Related literature

| Information Efficiency in Emission Trading Scheme		
Variance Ratio Test (VRT) Montagnoli & De Vries (2010) Niblock & Harrison (2013) Daskalakis & Markellos (2008) Yang et al. (2018) Zhang et al. (2020) Zhou et al. (2019)	**Generalized Spectral (GS) Test** Null **Domínguez – Lobato (DL) Test** Null	**Adjusted Market Inefficiency Measure (AMIM) Test** Null

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

DL - Results

FUTURES DL Test
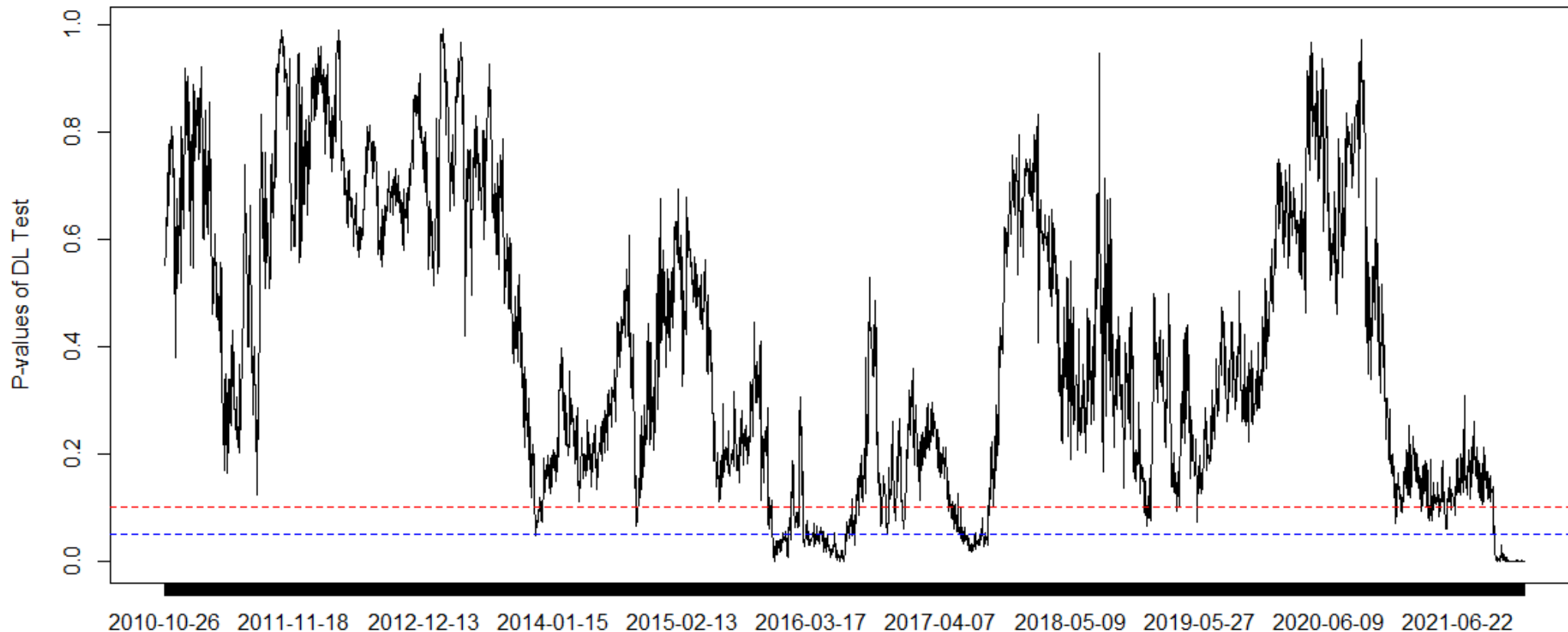
The DL test statistic p-values over time for the Spot ETS, Futures ETS, and S&P ETS indexes (daily, 400 observations window). The blue dotted line corresponds to the 5% significance level, while the red dotted line corresponds to the 10% significance level.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

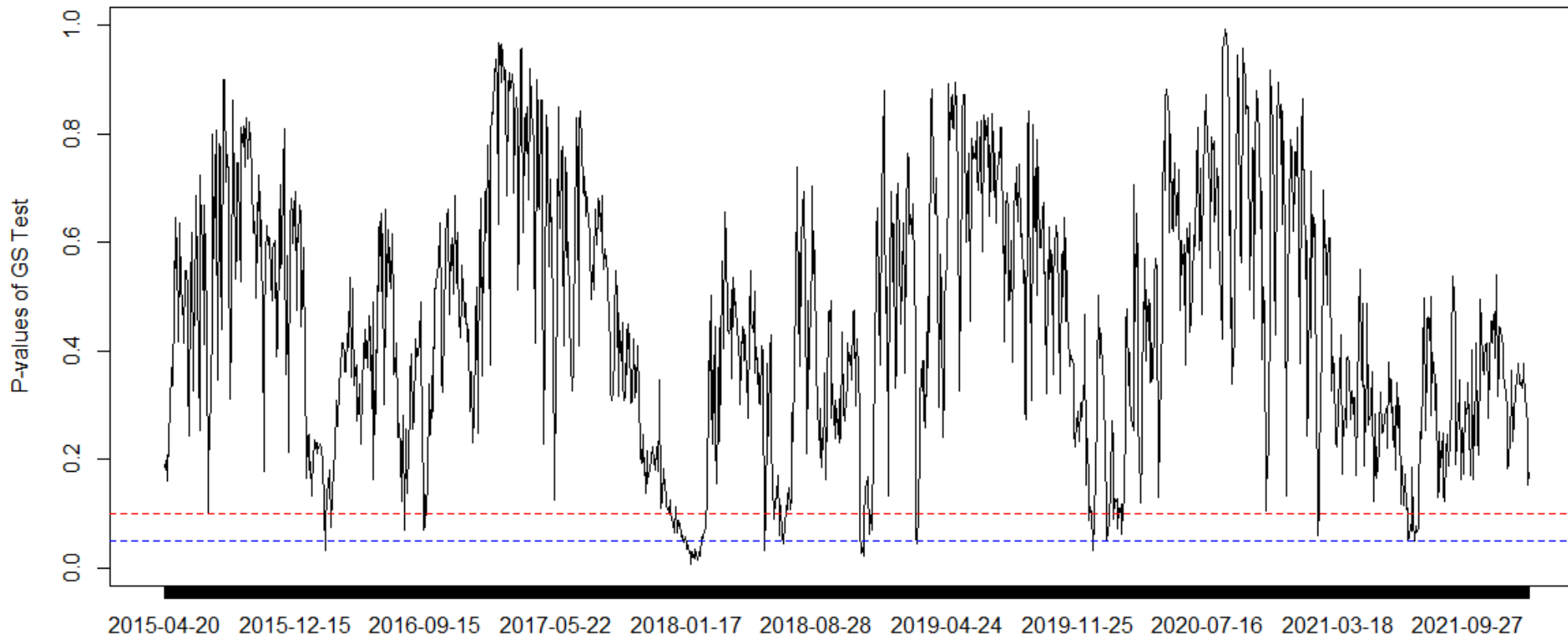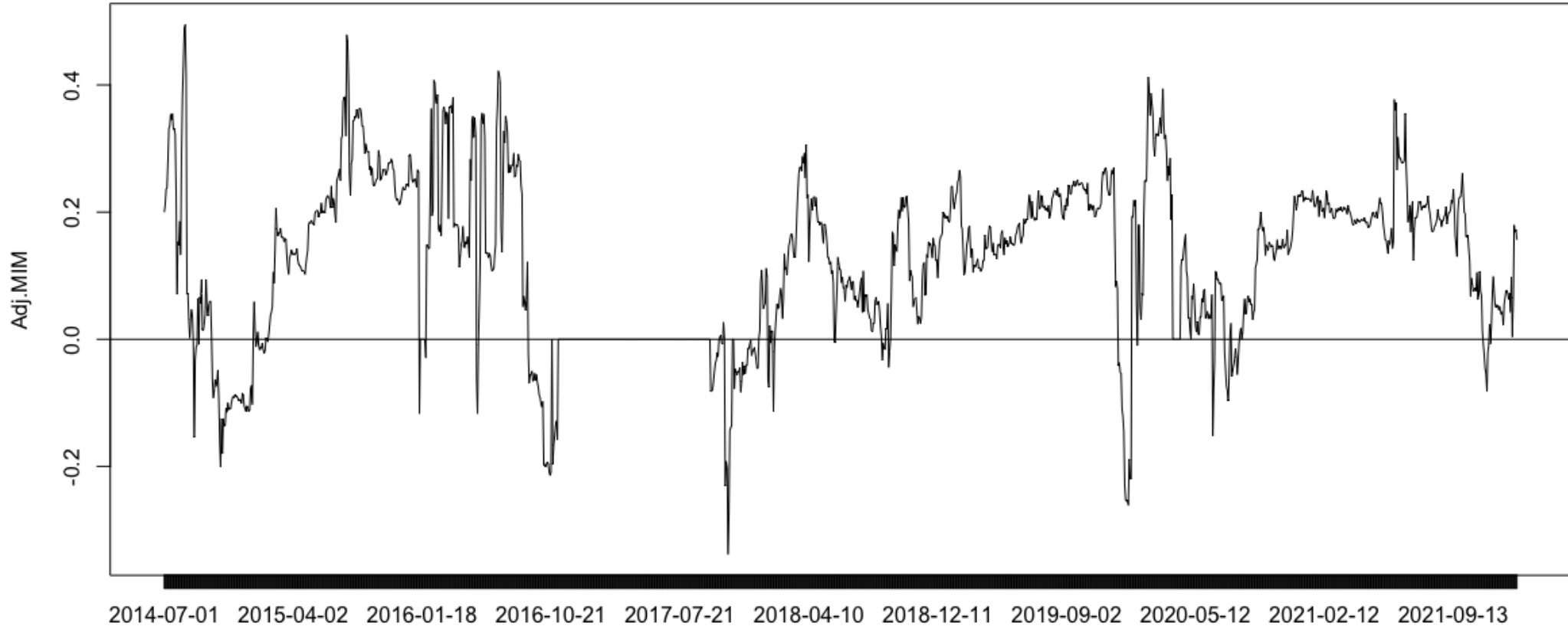# GS - Results

SPOT   GS Test

The GS test statistic p-values over time for the Spot ETS, Futures ETS, and S&P ETS indexes (daily, 400 observations window). The blue dotted line corresponds to the 5% significance level, while the red dotted line corresponds to the 10% significance level.

Contando historias con datos:
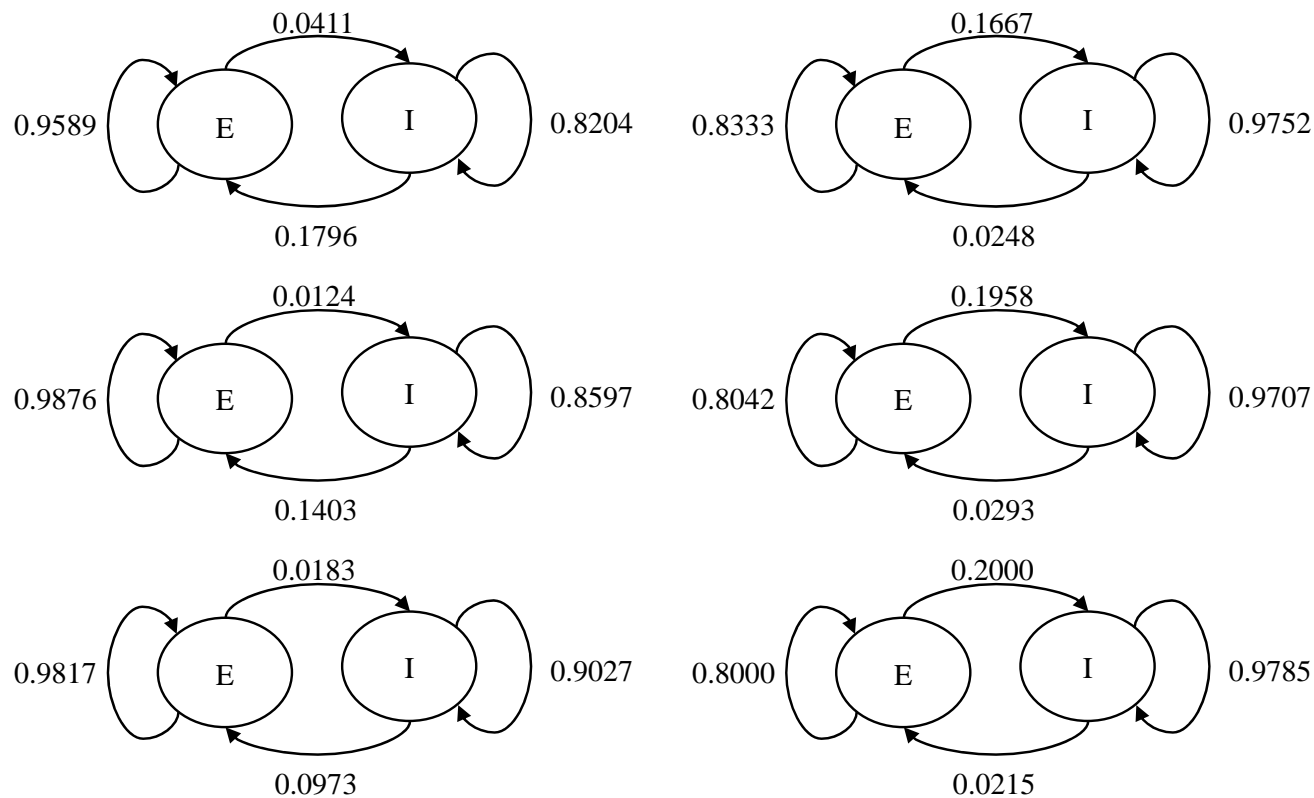## Herramientas y procedimientos estadísticos aplicados.

AMIM - Results

AMIM - Spot

The lower the AMIM, the more efficient the market it is.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.

Transition Probabilities - DL and AMIM results

Transition probabilities among states of efficiency and inefficiency given the DL (left column) and AMIM (right column) tests. The top row corresponds to Spot ETS, the middle row to Futures ETS, and the bottom row to S&P ETS.

Contando historias con datos:
Herramientas y procedimientos estadísticos aplicados.
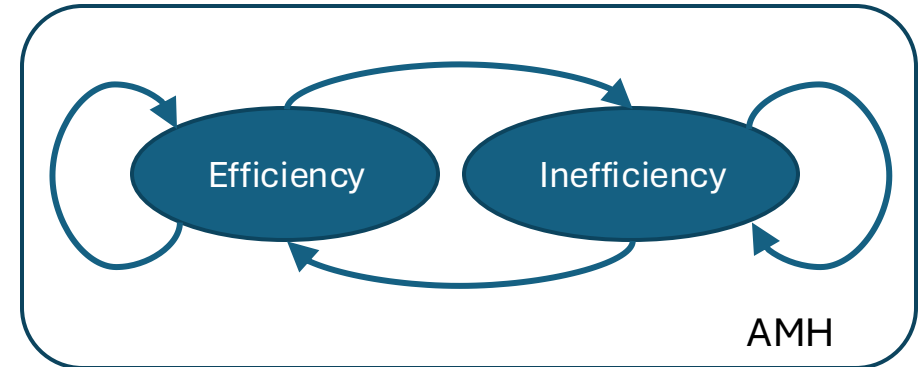
Conclusions

Battery of Tests
- Variance Ratio Test (3 versions)
- BDS Test
- Domínguez-Lobato
- Generalized Spectral
- Adjusted Market Inefficiency Measure

Switching Behavior
- Linear / non-linear relationship
- Risk – Return Relationship
- Transition probabilities
- Efficiency/Inefficiency
- AMH validation

Carbon Pricing
- To the best of our knowledge, this would be the first study to evaluate EU ETS with these tests and under AMH
- Different behavior on each index
- Evolves and behaves differently over time

Efficiency   Inefficiency

AMH

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Herramientas y procedimientos estadísticos aplicados.

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Herramientas y procedimientos estadísticos aplicados.

Thank you all