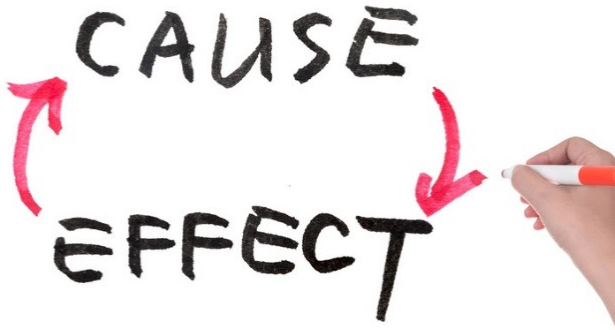

Transfer Entropy Test for Causality in Longitudinal Data.

Maximo Camacho[1] **Andres Romeu** [1] Manuel Ruíz Marín [2]

XXII AEM: June, 2019

[1]Universidad de Murcia [2]Universidad Politecnica de Cartagena

Motivation

Causality between GDP and # Tourists: mixed evidence?

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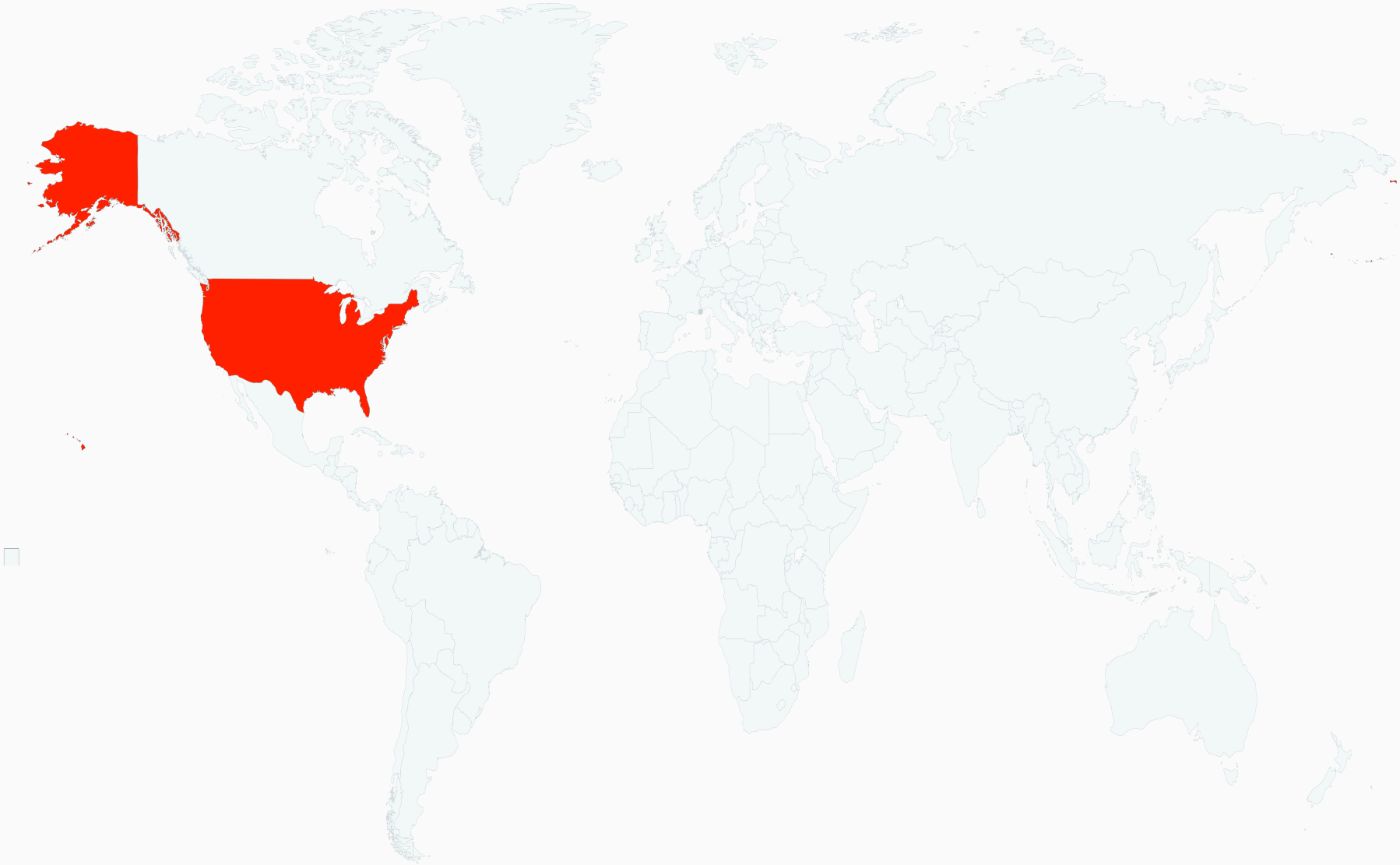

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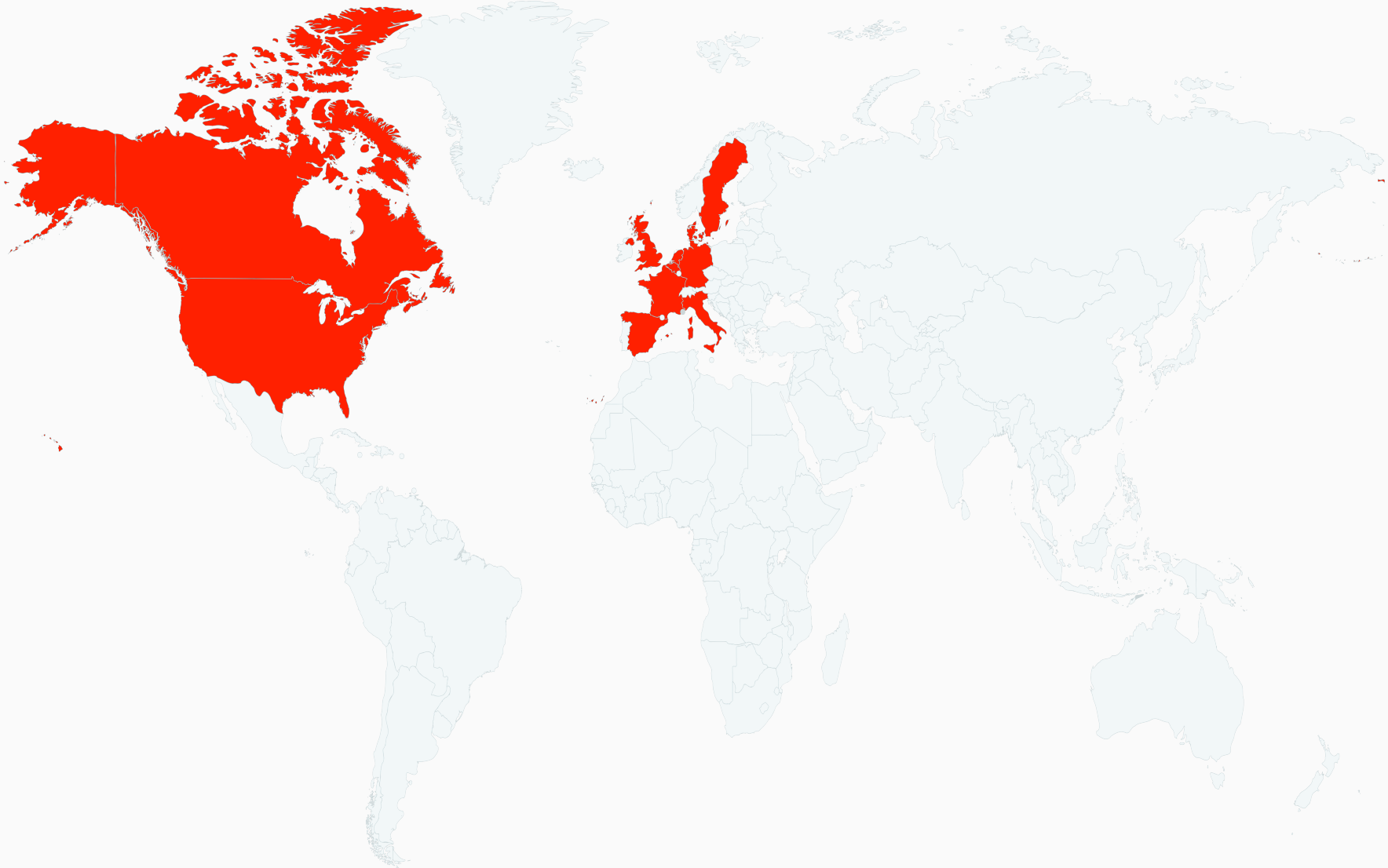

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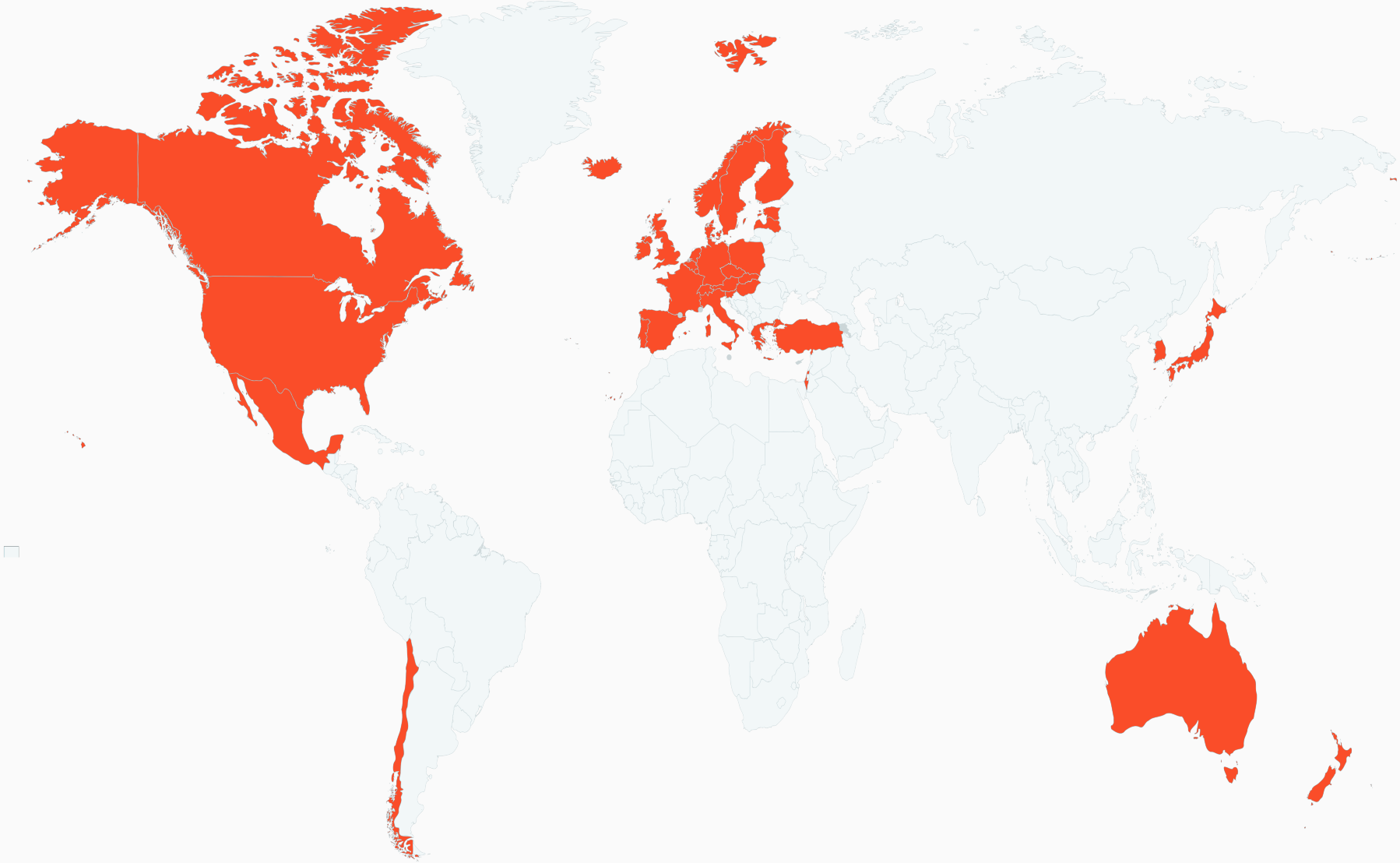

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Causality between GDP and # Tourists: mixed evidence?

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Causality between GDP and # Tourists: mixed evidence?

"There is no mixed evidence, only poorly synthesized evidence"

Answer causality **globally**. How?

Causality, parametric linear approach

(Granger, 1969, 1988) Assume that ...

1. the cause occurs before the effect and ...

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- Testing $X \Rightarrow Y$: test significance of lagged x_t on y_t in the presence of y_{t-r}.
- Commonly, use a linear, basically **autoregressive**, representation of the series.

Causality, parametric linear approach

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik} y_{i,t-k} + \sum_{k=1}^{K} \beta_{ik} x_{i,t-k} + \epsilon_{i,t},$$

1. **Homogeneous panel** ($\beta_{ik} = \beta_k \forall i$): significance test of lagged X. (*Tourism*: Sequeira & Nunes, 2008; *Debt*: Panizza & Presbitero, 2014)

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1. **Homogeneous panel** ($\beta_{ik} = \beta_k \forall i$): significance test of lagged *X*. (*Tourism*: Sequeira & Nunes, 2008; *Debt*: Panizza & Presbitero, 2014)
2. **Heterogeneous panel** ($\exists i, j, k \mid \beta_{ik} \neq \beta_{jk}$): use cross-section average of Wald statistics (Dumitrescu & Hurlin, 2012; López &Weber, 2017)

These tests display size & power problems under

- large cross-section heterogeneity,

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...but these are norm rather than exception!

Hiemstra and Jones (1994) propose a bivariate kernel-based approach. Bai et al. (2016) reformulate and extend.

Our Proposal

- A **non-parametric** casuality test for **panel data**
- based on **symbolic analysis** and

Our Proposal

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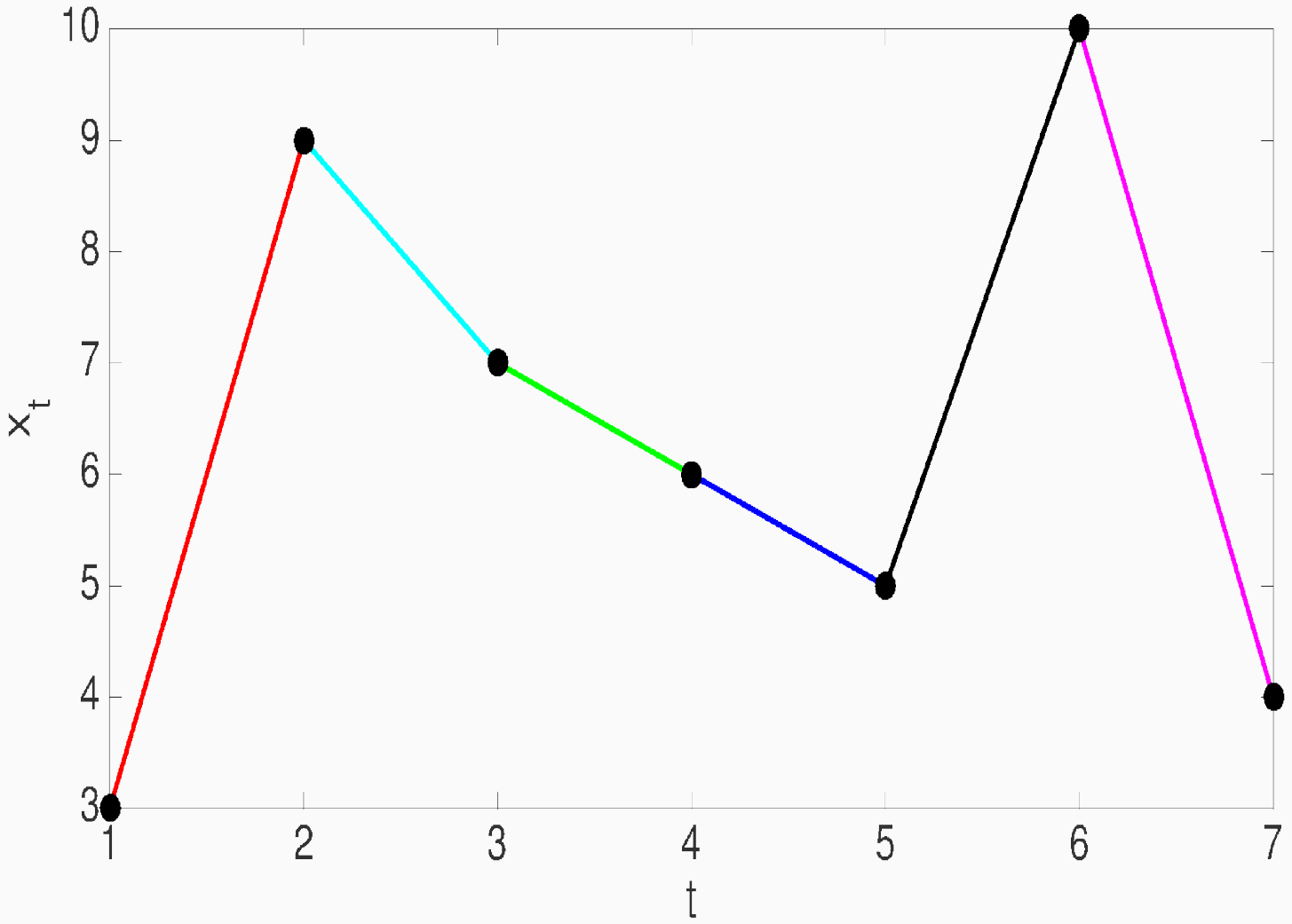
- **transfer entropy**.

Methodology

Symbolic Representation of Time Series

$$\{x_1 = 3, x_2 = 9, x_3 = 7, x_4 = 6, x_5 = 5, x_6 = 10, x_7 = 4\}$$



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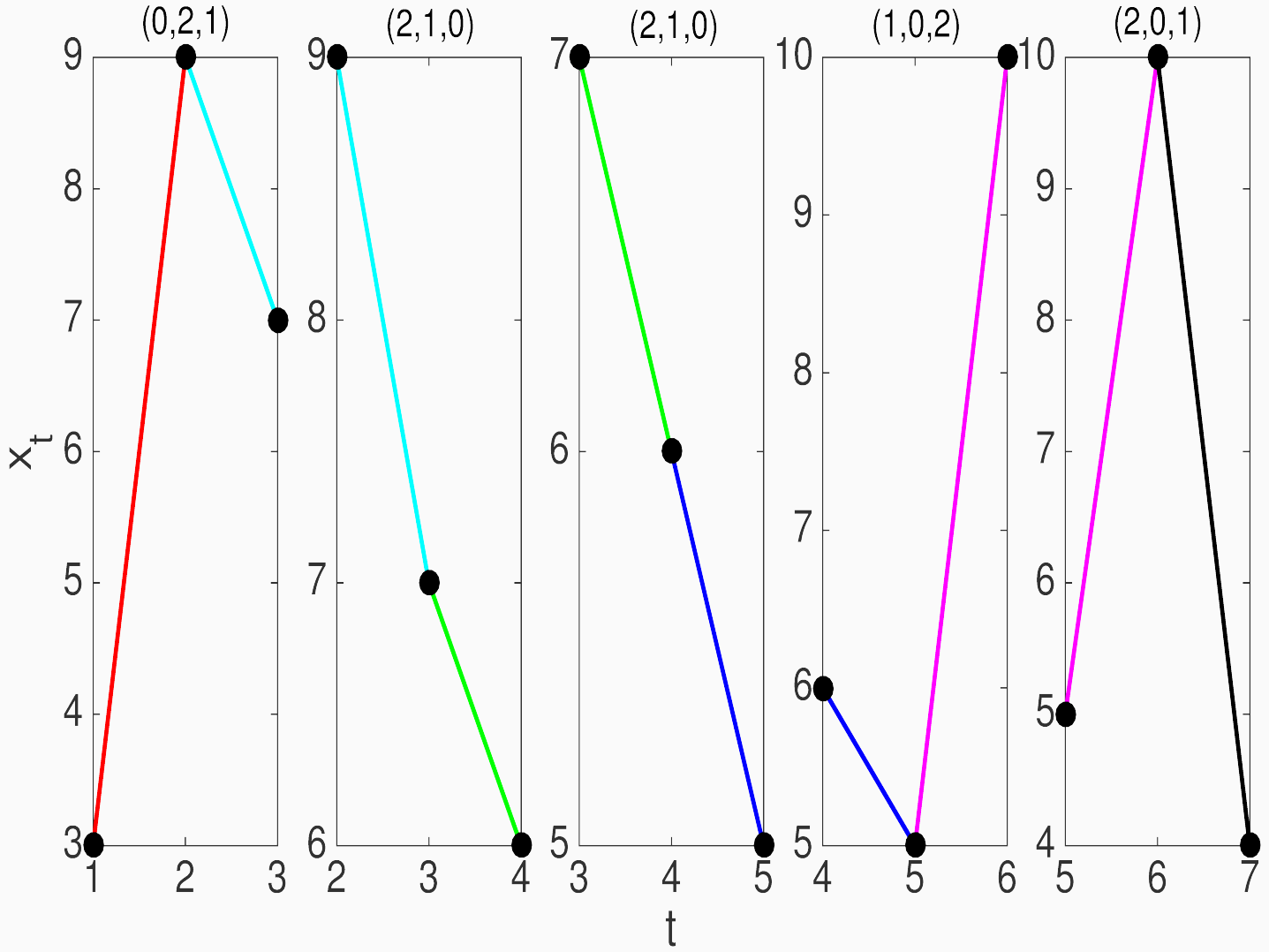
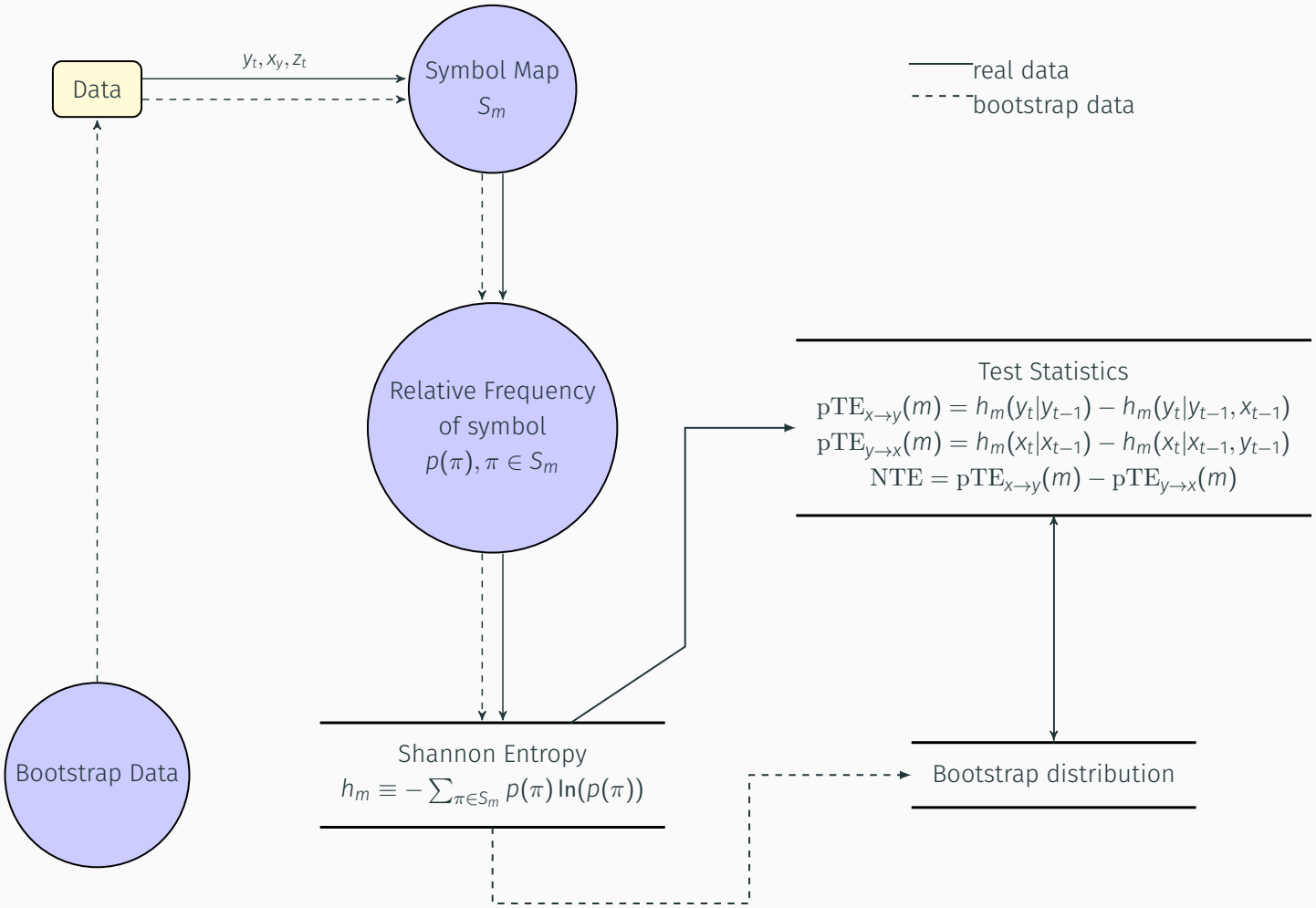


Testing procedure



Monte-Carlo experiment design

Monte-Carlo specifications

Simulate five DGP's covering problems of interest:

1. A homogeneous linear process (▸ HLM)

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3. A homogenoeus process with outliers (▸ HOUT)
4. A homogeneous process with non-linear mean (▸ HNLM)
5. A process with structural breaks (▸ SB)

Homogeneous Linear (HLM)

$$
\begin{aligned}
y_{it} &= \alpha y_{i(t-1)} + \beta x_{i(t-1)} + \varepsilon_{it} \\
x_{it} &\overset{\text{iid}}{} N(0,1) \\
\varepsilon_{it} &\overset{\text{iid}}{} N(0,1) \\
\alpha &= \{0, 0.3, 0.9\} \\
\beta &\sim U(0,2)
\end{aligned}
$$

Homogeneous Non-Linear Variance (HNLV)

$$
\begin{aligned}
y_{it} &= \alpha y_{i(t-1)} + \varepsilon_{it} \\
\varepsilon_{it} &\text{ iid } N(0, |x_{it}|) \\
x_{it} &\text{ iid } N(0, 1) \\
\alpha &= \{0, 0.3, 0.9\}
\end{aligned}
$$

Homogeneous with OUTliers (HOUT)

- The model is identical to Homogeneous Linear with $\beta = 0$, but we introduce outliers at begining and end of time-series sample).

$$\begin{aligned} y_{2,1} &= x_{1,1} = -10 \\ y_{T,N} &= x_{(T-1),N} = 10 \end{aligned}$$

Homogeneous Non-Linear Mean (HNLM)

$$
\begin{aligned}
y_{it} &= y_{i(t-1)} x_{i(t-1)} + \varepsilon_{it} \\
x_{it} &\overset{\text{iid}}{} N(0,1) \\
e_{it} &\overset{\text{iid}}{} N(0,1)
\end{aligned}
$$

Data Generating Process #5

Structural Break (SB)

$$
\begin{aligned}
y_{it} &= c_1 + \alpha y_{i(t-1)} + \beta_1 x_{i(t-1)} + \varepsilon_{it} \quad \forall t = 1, \ldots, T_1 \\
y_{it} &= c_2 + \alpha y_{i(t-1)} + \beta_2 x_{i(t-1)} + \varepsilon_{it} \quad \forall t = T_1, \ldots, T \\
x_{it} &\text{ iid } N(0, 1) \\
e_{it} &\text{ iid } N(0, 1) \\
\alpha &= \{0, 0.3, 0.9\} \\
c_1 &= -c_2 = 1 \\
\beta_1 &\sim U(0, 2) \\
\beta_2 &= -\beta_1
\end{aligned}
$$

Monte-Carlo specifications

For each of these processes,

- simmulate 1000 times

Monte-Carlo specifications

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- HLM, HLV, HNLM, SB under the alternative (causality) and HOUT under null (non-causality),

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Monte-Carlo specifications

For each of these processes,

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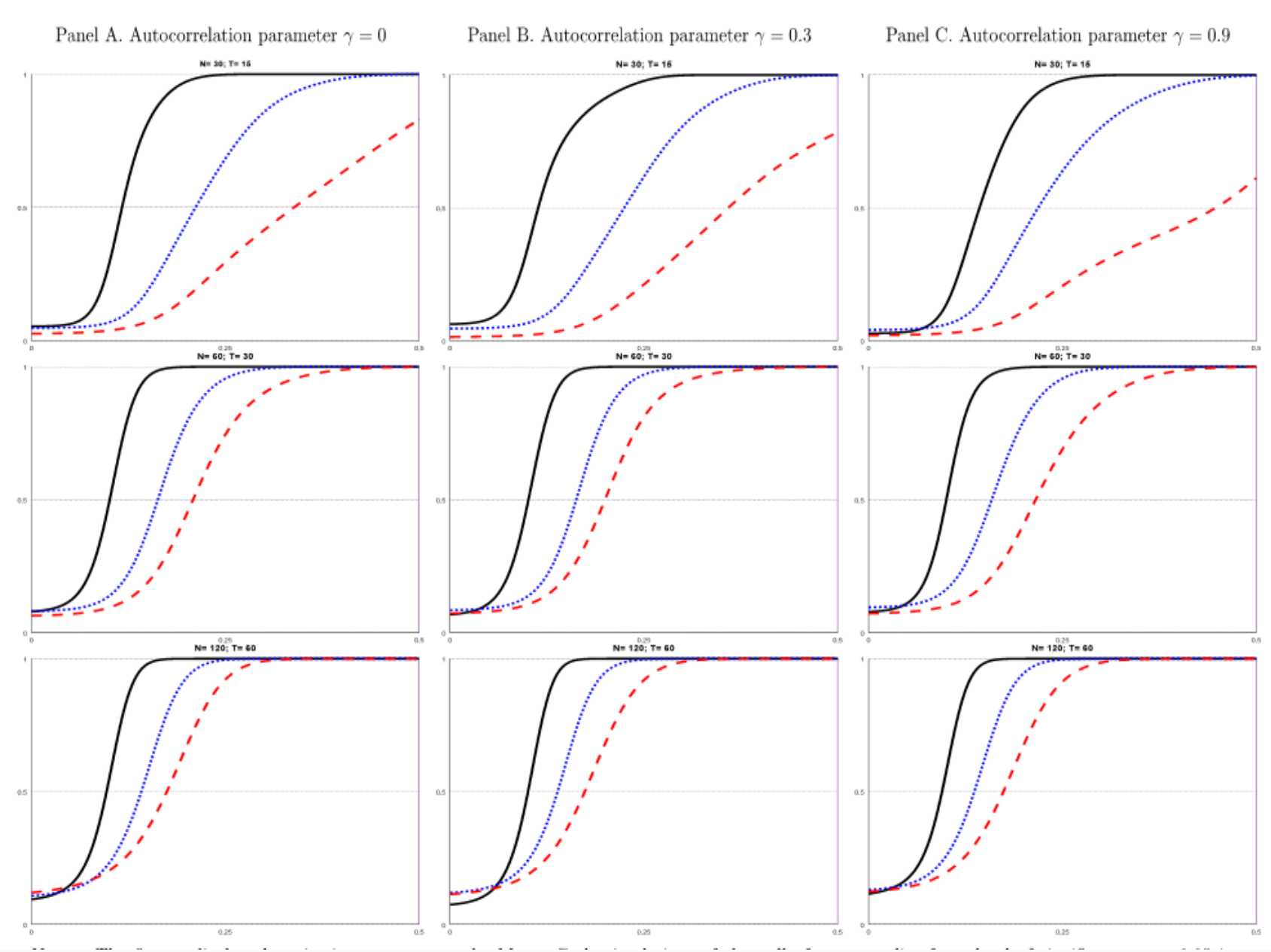
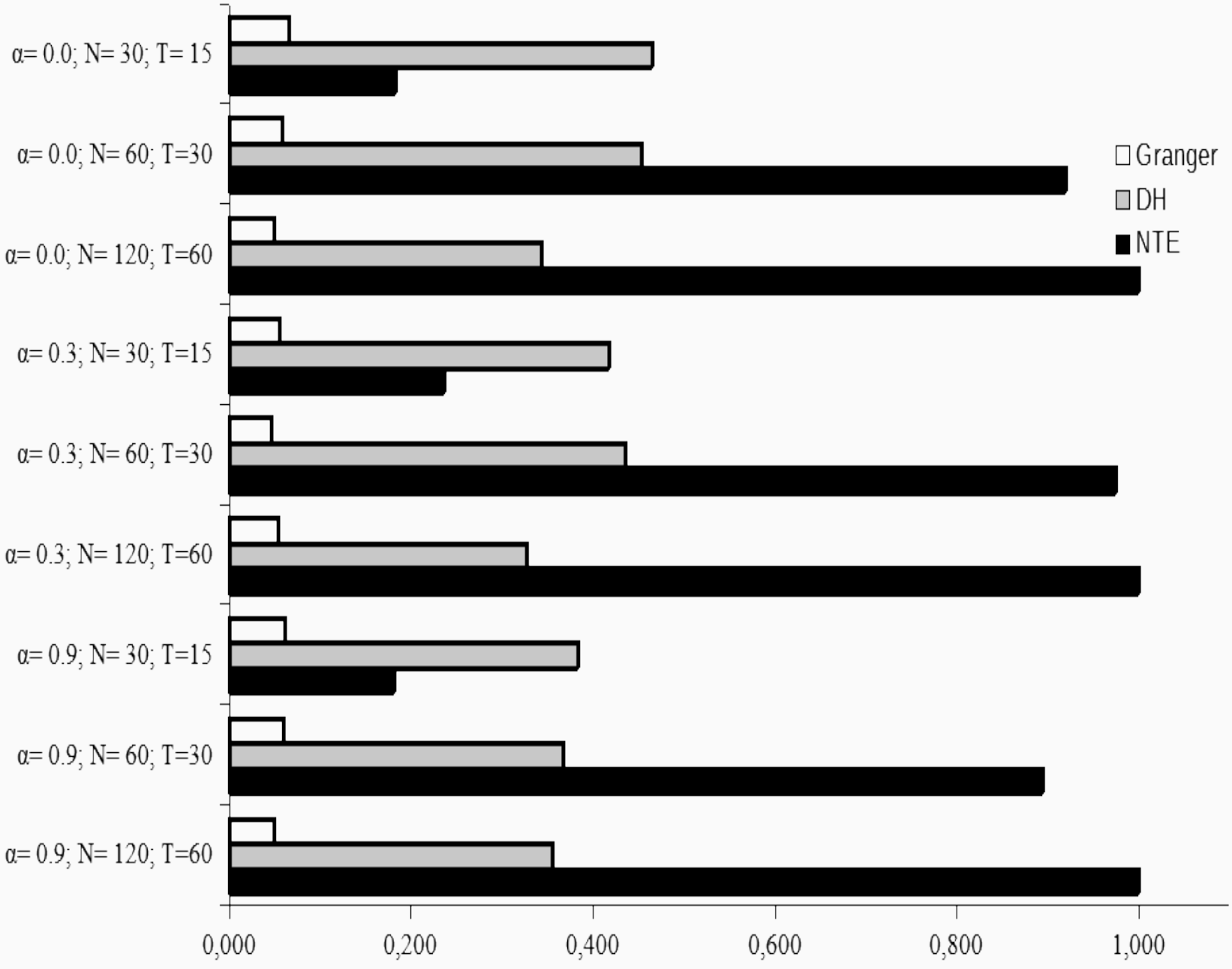
- compute Granger-OLS (*Granger*), Dumitrescu-Hurlin (*DH*) and permutation Transfer Entropy (NTE) tests and
- estimate Surface Response (SR) of test power for HLM, HLV, HNLM and SB and SR of test size for HOUT).

Monte-Carlo experiment results

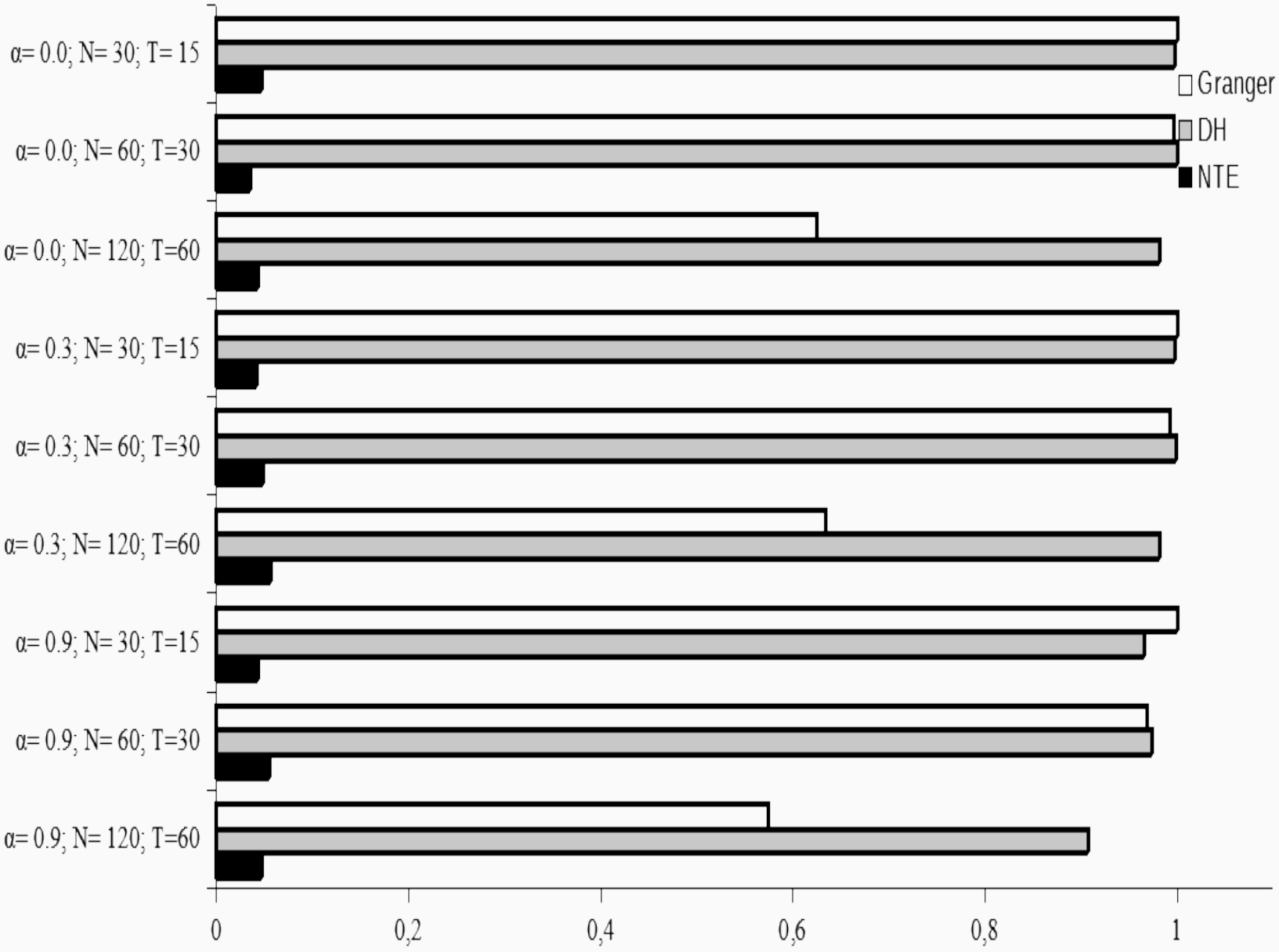
Homogenous Linear: Results



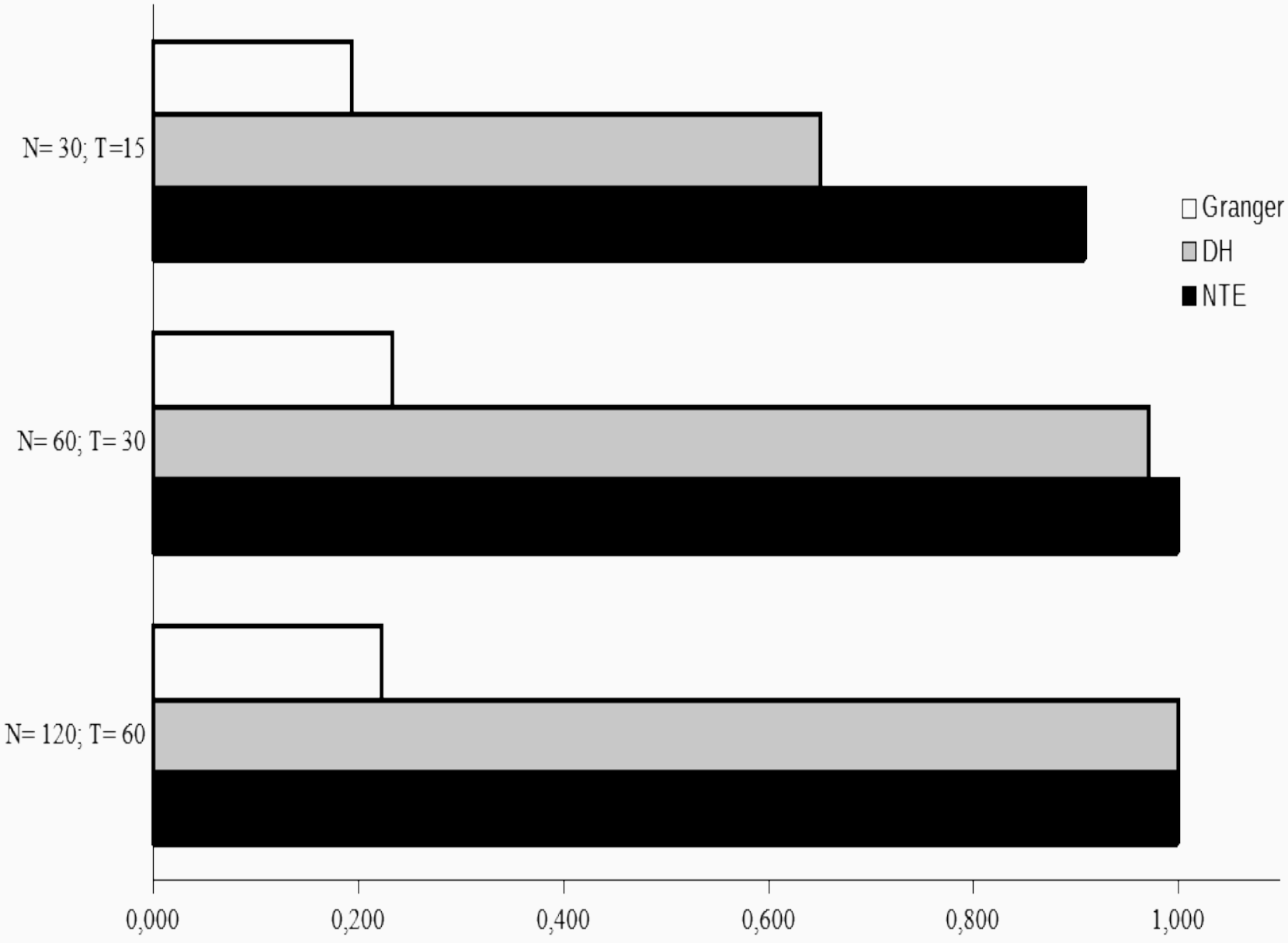
Homogeneous Non-Linear in Variance: Results



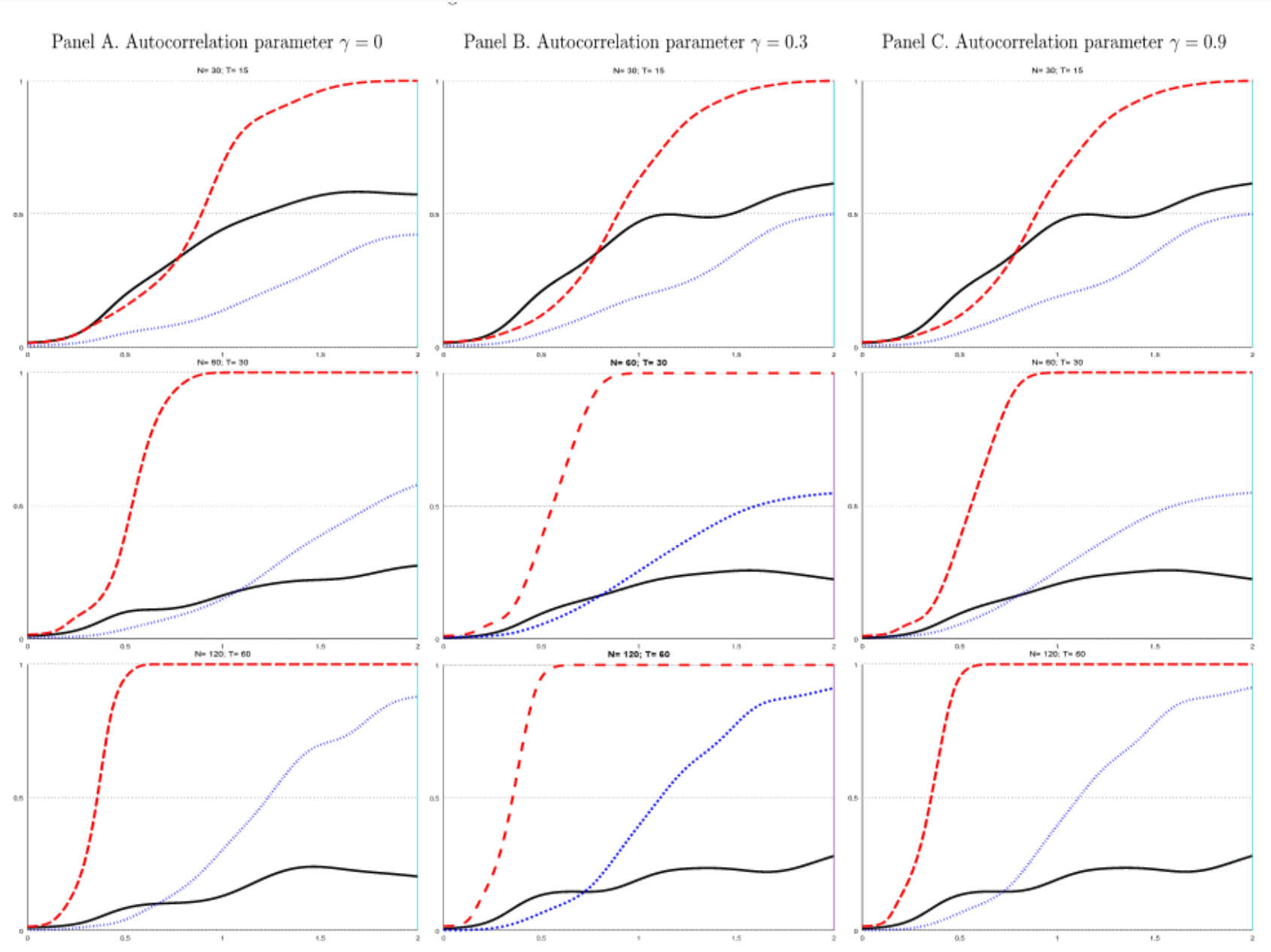
Homogeneous with Outliers: Results



Homogeneous Non-linear Mean: Results



Structural Break: Results



Some Application Examples

	HNR		DH		STE		
Direction	Stat	*p*-value	Stat	*p*-value	Stat	1-tail pval	2-tail pval
Panel A: $r = 1$							
Exp→GDP	-3.242	0.001	5.703	0.000	0.008	0.240	-
GDP→Exp	1.441	0.150	17.815	0.000	0.008	0.165	-
Net (Exp - GDP)	-	-	-	-	-0.001	0.455	0.820
Panel B: $r = 2$							
Exp→GDP	1.376	0.169	7.223	0.000	0.018	0.290	-
GDP→Exp	0.166	0.868	22.069	0.000	0.024	0.005	-
Net (Exp - GDP)	-	-	-	-	-0.005	0.050	0.110
Panel C: $r = 3$							
Exp→GDP	-2.397	0.017	6.065	0.000	0.017	0.520	-
GDP→Exp	-0.750	0.453	10.386	0.000	0.019	0.320	-
Net (Exp-GDP)	-	-	-	-	-0.001	0.345	0.700

Table 1 GDP vs. Gov.Expenditure: Summary of Results

	HNR		DH		STE		
Direction	Stat	*p*-value	Stat	*p*-value	Stat	1-tail pval	2-tail pval
				Panel A: r = 1			
Size→TFP	-6.850	0.000	6.189	0.000	0.025	0.005	-
TFP→Size	3.150	0.002	6.471	0.000	0.026	0.000	-
Net (Size - TFP)	-	-	-	-	-0.001	0.510	0.925
				Panel B: r = 2			
Size→TFP	1.126	0.260	1.469	0.315	0.057	0.000	-
TFP→Size	-1.430	0.153	-0.237	0.855	0.053	0.000	-
Net (Size - TFP)	-	-	-	-	-0.004	0.290	0.570
				Panel C: r = 3			
Size→TFP	0.358	0.720	0.704	0.580	0.049	0.010	-
TFP→Size	-0.122	0.903	0.073	0.945	0.049	0.010	-
Net (Size - TFP)	-	-	-	-	-0.001	0.450	0.905

Table 2 TFP vs. Firm Size: Summary of Results

GDP growth				Interest rate			
Direction	Stat	1 p-value	2 p-value	Direction	Stat	1 p-value	2 p-value
Panel A: r = 1							
Rating→GDP	0.017	0.060	-	Rating→I. Rate	0.026	0.650	-
GDP→Rating	0.025	0.115	-	I. Rate→Rating	0.033	0.895	-
Net effect	-0.008	0.610	0.610	Net effect	-0.007	0.735	0.740
Panel B: r = 2							
Rating→GDP	0.028	0.890	-	Rating→I. Rate	0.075	0.260	-
GDP→Rating	0.023	0.500	-	I. Rate→Rating	0.035	0.930	-
Net effect	0.005	0.825	0.830	Net effect	0.040	0.095	0.095
Panel C: r = 3							
Rating→GDP	0.035	0.675	-	Rating→I. Rate	0.064	0.925	-
GDP→Rating	0.024	0.465	-	I. Rate→Rating	0.033	0.995	-
Net effect	0.011	0.580	0.580	Net effect	0.031	0.435	0.435

Table 3 Fitch vs. GDP: Summary of Results

Thanks for your comments and suggestions !