WAIAF 2019

Avaliação de Métodos para Tomada de Decisão Multicritério aplicados a um Sistema Operacional de Negociação

Michel C. R. Leles

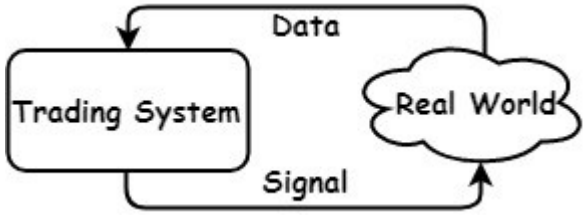
16 de Maio

Roteiro

- Introduction
- Methodology
  - Trading System:
    - Technical Trading Rules
    - Performance Metrics
    - Decision-Making Process
  - MultiCriteria Decision Aid:
    - Ensemble
    - Interactive Multi-criteria Decision Making (TODIM)
- Results & Discussion
- Final Remarks & Future Works

Introduction

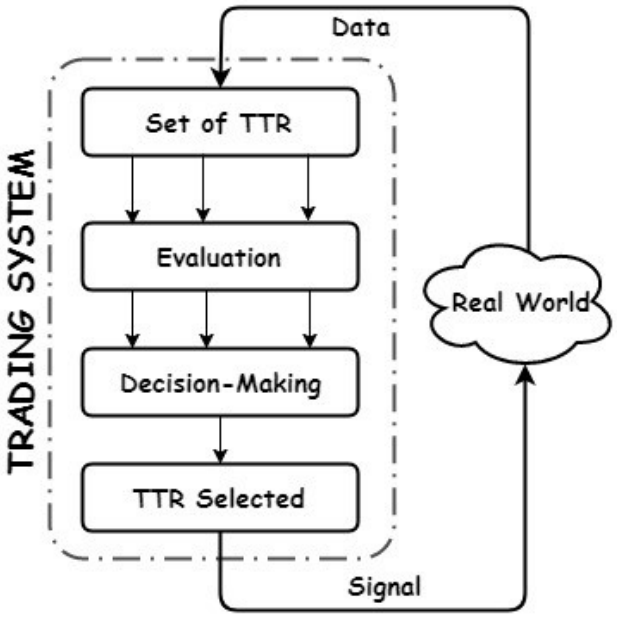
- Financial Markets
  - **Challenges:** complex, non-linear, subject to different factors
- Market Practitioner tools:
  - Discretionary trading **vs** Fundamental Analysis **vs Technical Analysis**
- Performance Evaluation:
  - Artificial Stock Markets based on Multi-Agent Systems
  - ***Backtesting***
- Trading System:



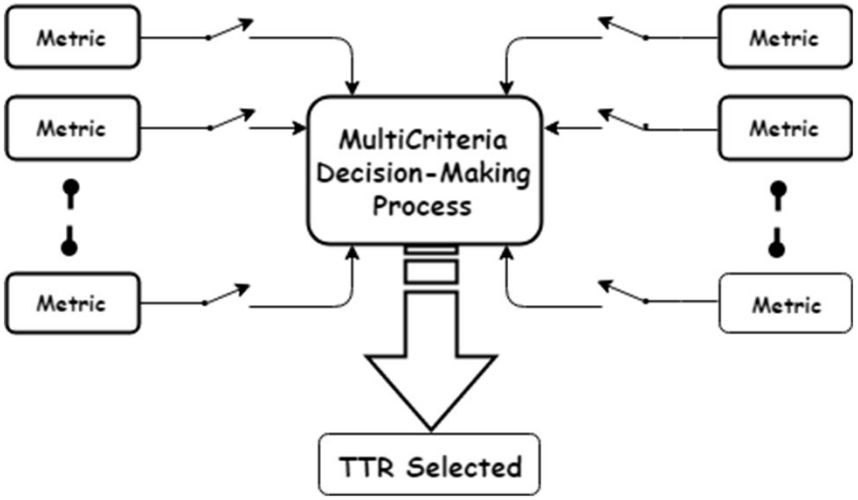
- **Main Purpose:**
  - Evaluation of two MultiCriteria Decision-Making Approaches

Methodology

Trading System Details:



MultiCriteria Decision-Making:



Methodology

Performance Metrics:

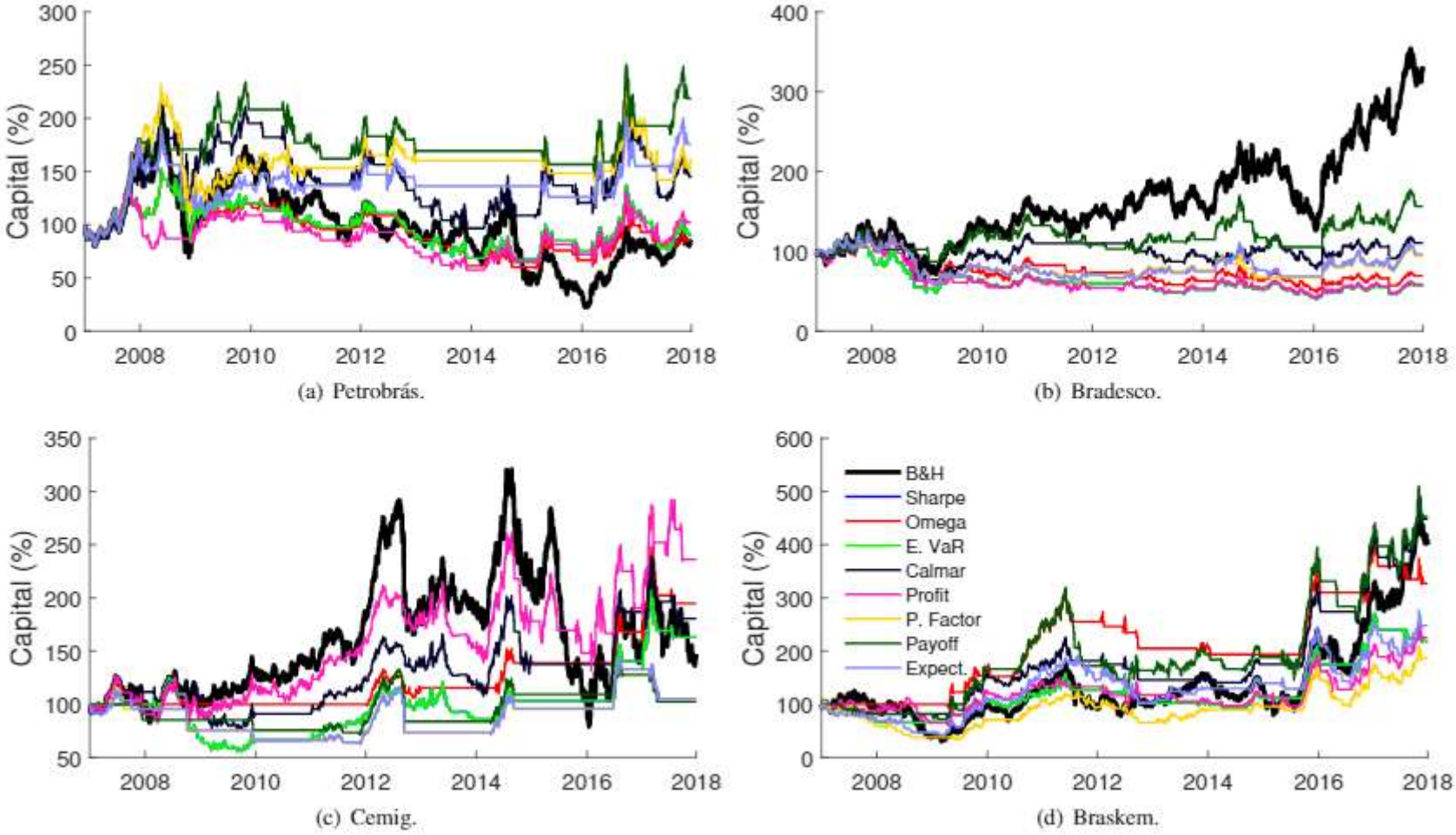
Measure	Formulation
Profit Factor	$F = \sum_{p=1}^{P} S_p^+ \Big/ \sum_{q=1}^{Q} S_q^-$
Payoff Ratio	$\mathcal{P} = \overline{P^+} \big/ \overline{P^-}$
Expected Value	$\mathrm{E} = \left[\left(1 + \overline{P^+}/\overline{P^-}\right) P_r^+\right] - 1$
Sharpe	$\mathbb{S} = (\overline{R} - \gamma)/\sigma_R$
Omega	$\Omega = (\overline{R} - \gamma)/\Upsilon_1(\zeta) + 1$
Calmar	$\mathcal{C} = (\overline{R} - \gamma)/-MD_1$
Excess Var	$\varphi = (\overline{R} - \gamma)/\nu$

Technical Trading Rules:

Indicators	Parameters
Moving Averages	$L = \begin{cases} 5, 6, \cdots, 12, \\ 13, 15, 17, \cdots, 25, \\ 27, 30, 33, 36, \cdots, 57, \\ 60, 65, 70, \cdots, 95, \\ 100, 110, 120, \cdots, 200. \end{cases}$
Bollinger Bands	$L = 18, 19, \cdots, 22;$ $\eta = 1.8, 1.85, \cdots, 2.2.$
MACD	$P = 11, 12, 13;$ $Q = 24, 25, \cdots, 28;$ $K = 8, 9, 10.$
Momentum	$K = 3, 4, 5, \cdots, 52.$
RSI	$L = 12, 13, \cdots, 16;$ $\mathrm{RSI}^- = 25, 30, 35;$ $\mathrm{RSI}^+ = 65, 70, 75.$
Stochastic	$M = 8, 11, 14, 17;$ $L = 5, 8, 11, 14;$ $D^- = 25, 30;\ D^+ = 80, 85.$

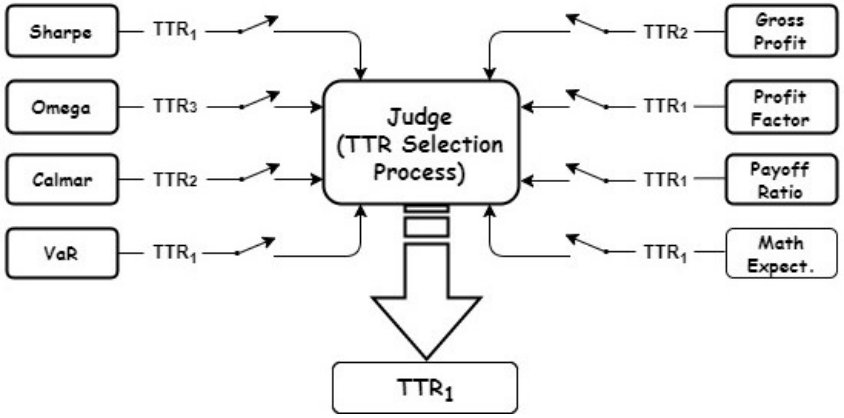
Methodology

- **Individual Metrics:**

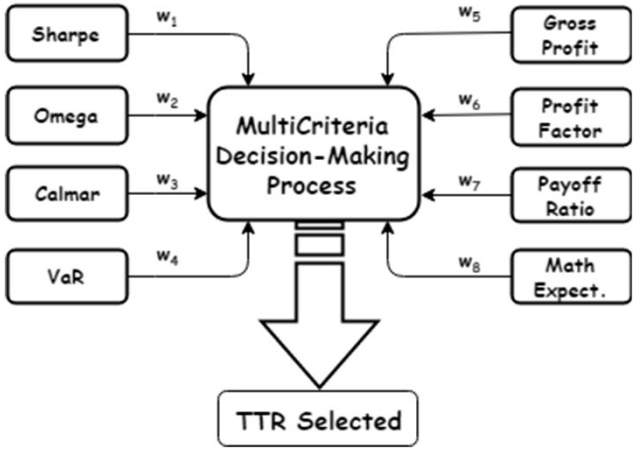


Methodology

Ensemble:



TODIM:



Alternatives	Criteria					
	C_1	C_2	...	C_j	...	C_m
A_1	P_{11}	P_{12}	...	P_{1j}	...	$P_{1\,m}$
A_2	P_{21}	P_{22}	...	P_{2j}	...	$P_{2\,m}$
...	...	...	...	...	...	
A_i	P_{i1}	P_{i2}	...	P_{ij}	...	P_{im}
...	...	...	...		...	...
A_n	P_{n1}	P_{n2}	...	P_{nj}	...	P_{nm}

Methodology

- TODIM: Similarities with MCDA, but difference in the **premise**:

Traditional economic theory: each agent is similar and rational

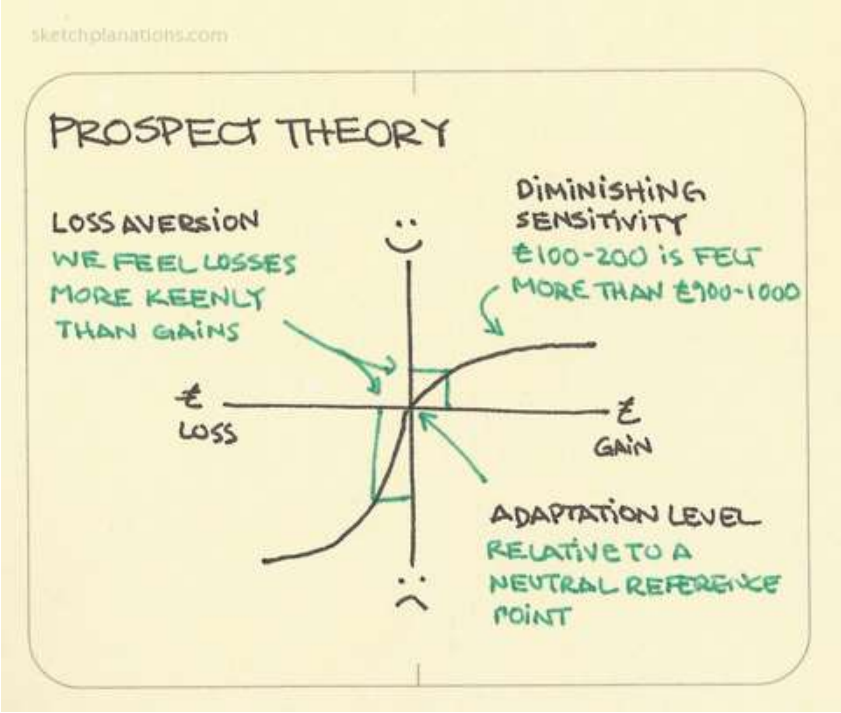
MCDA - the decision maker always looks for some maximum value

VS

TODIM: based on **Prospect Theory**

How people effectively make decisions in the **face of risk**

Asymmetry: gains and losses



Methodology

- TODIM:
  - Consider a set of **n alternatives** to be ordered in the presence of **m criteria** (quantitative or qualitative)
  - For each one of the qualitative **criteria c**, the contribution of each **alternative i** (also known as **Decision Matrix**) is:

Sharpe	Omega	Ex. Var	Calmar	Profit (%)	Pr. Factor	Payoff	Expect.
0.0731	1.2958	0.0424	0.0043	300.6529	0.5798	0.4910	-0.2023
0.0803	1.3264	0.0463	0.0052	354.4406	0.5105	0.3928	-0.2239
0.0771	1.3151	0.0446	0.0052	330.1258	0.5323	0.3267	-0.1886
0.0646	1.2562	0.0376	0.0040	245.9310	0.6004	0.3374	-0.1541
0.0639	1.2505	0.0372	0.0041	244.3992	0.6041	0.3679	-0.1612
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
0.0338	1.1696	0.0200	0.0020	60.7919	0.4053	0.3839	-0.3081

  - Define a weighting satisfying $w_i \in [0,1]$ e $\sum_{i=1}^{m} w_i = 1$.
  - w_{rc} is the weight of **criterion c** divided by the the **reference criterion**.

Methodology

- TODIM Algorithm:
  - **Step 1:** Normalize the Decision Matrix
  - **Step 2:** Calculate the dominance of each alternative A_i over each alternative A_j (incorporated to Prospect Theory):

$$\delta(A_i, A_j) = \sum_{c=1}^{m} \Phi_c(A_i, A_j) \quad \forall (i,j). \tag{1}$$

$$\Phi_c(A_i, A_j) = \begin{cases} \sqrt{\frac{w_{rc}(P_{ic} - P_{jc})}{\sum_{c=1}^{m} w_{rc}}} & \text{if } (P_{ic} - P_{jc}) > 0, \quad (2) \\ 0 & \text{if } (P_{ic} - P_{jc}) = 0, \quad (3) \\ \frac{-1}{\theta} \sqrt{\frac{\left(\sum_{c=1}^{m} w_{rc}\right)(P_{jc} - P_{ic})}{w_{rc}}} & \text{if } (P_{ic} - P_{jc}) < 0, \quad (4) \end{cases}$$

Partial contributions in the calculation of the dominance matrix.

Loss mitigation Factor

  - **Step 3:** Compute the overall value of ξ_i according to:

$$\xi_i = \frac{\sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)}{\max \sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)} \tag{5}$$

  - **Step 4:** Choose the best alternative by rank the values of ξ_i.

Methodology

1) Normalize the Decision Matrix:

Sharpe	Omega	Ex. Var	Calmar	Profit (%)	Pr. Factor	Payoff	Expect.
0.0731	1.2958	0.0424	0.0043	300.6529	0.5798	0.4910	-0.2023
0.0803	1.3264	0.0463	0.0052	354.4406	0.5105	0.3928	-0.2239
0.0771	1.3151	0.0446	0.0052	330.1258	0.5323	0.3267	-0.1886
0.0646	1.2562	0.0376	0.0040	245.9310	0.6004	0.3374	-0.1541
0.0639	1.2505	0.0372	0.0041	244.3992	0.6041	0.3679	-0.1612
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
0.0338	1.1696	0.0200	0.0020	60.7919	0.4053	0.3839	-0.3081

2) Dominance of A_i over A_j

$$\delta(A_i, A_j) = \sum_{c=1}^{m} \Phi_c(A_i, A_j) \quad \forall (i,j). \tag{1}$$

$$\Phi_c(A_i, A_j) = \begin{cases} \sqrt{\frac{w_{rc}(P_{ic} - P_{jc})}{\sum_{c=1}^{m} w_{rc}}} & \text{if } (P_{ic} - P_{jc}) > 0, \quad (2) \\ 0 & \text{if } (P_{ic} - P_{jc}) = 0, \quad (3) \\ \frac{-1}{\theta} \sqrt{\frac{\left(\sum_{c=1}^{m} w_{rc}\right)(P_{jc} - P_{ic})}{w_{rc}}} & \text{if } (P_{ic} - P_{jc}) < 0, \quad (4) \end{cases}$$

Loss Mitigation Factor

3) Compute ξ:

$$\xi_i = \frac{\sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)}{\max \sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)}$$

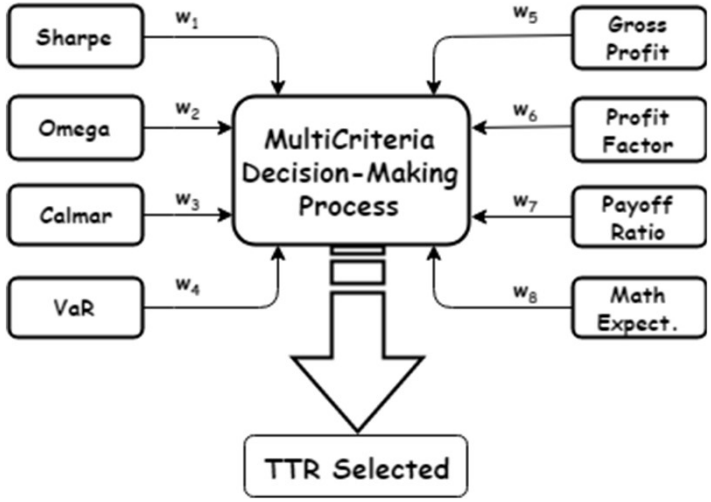
4) Choose the best alternative by **rank** ξ

✓ **Remarks:**

- ✓ The global multiattribute value function of TODIM then **aggregates all measures** of gains and losses over all criteria.
- ✓ Ranks from TODIM are **linear**, or **strong**, in a sense that it has **no ties** between the alternative solutions.

Results & Discussion

- **Experimental Setup:**
  - TODIM vs Ensemble:

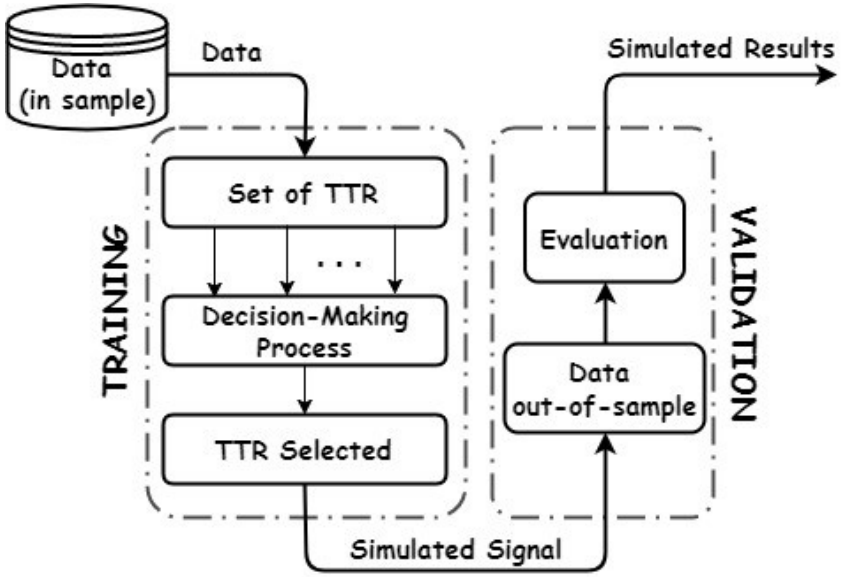


  - TODIM: θ effect

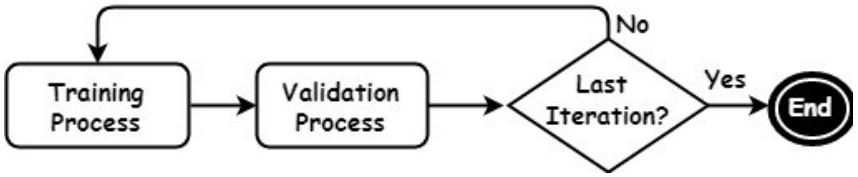
  - Time-Series from the Brazilian Stock Market:
    - Different economic sectors:2002 to 2017;
    - 2002 to 2006 → first training window.

Results & Discussion

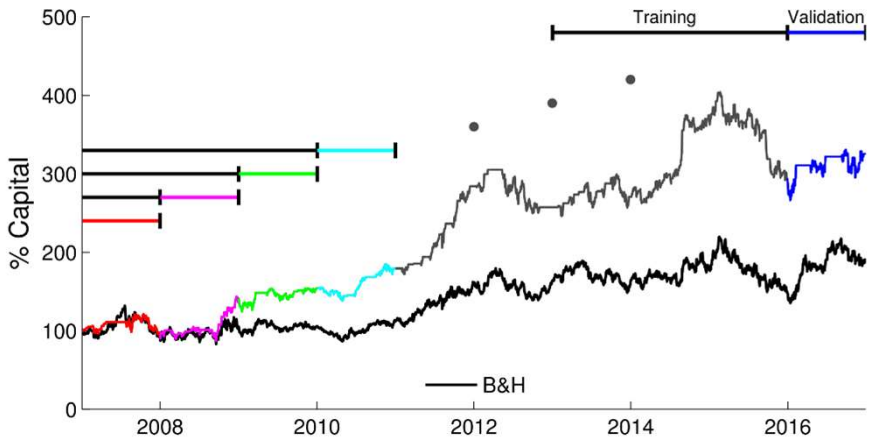
Trading System Simulation:



Walk Forward:



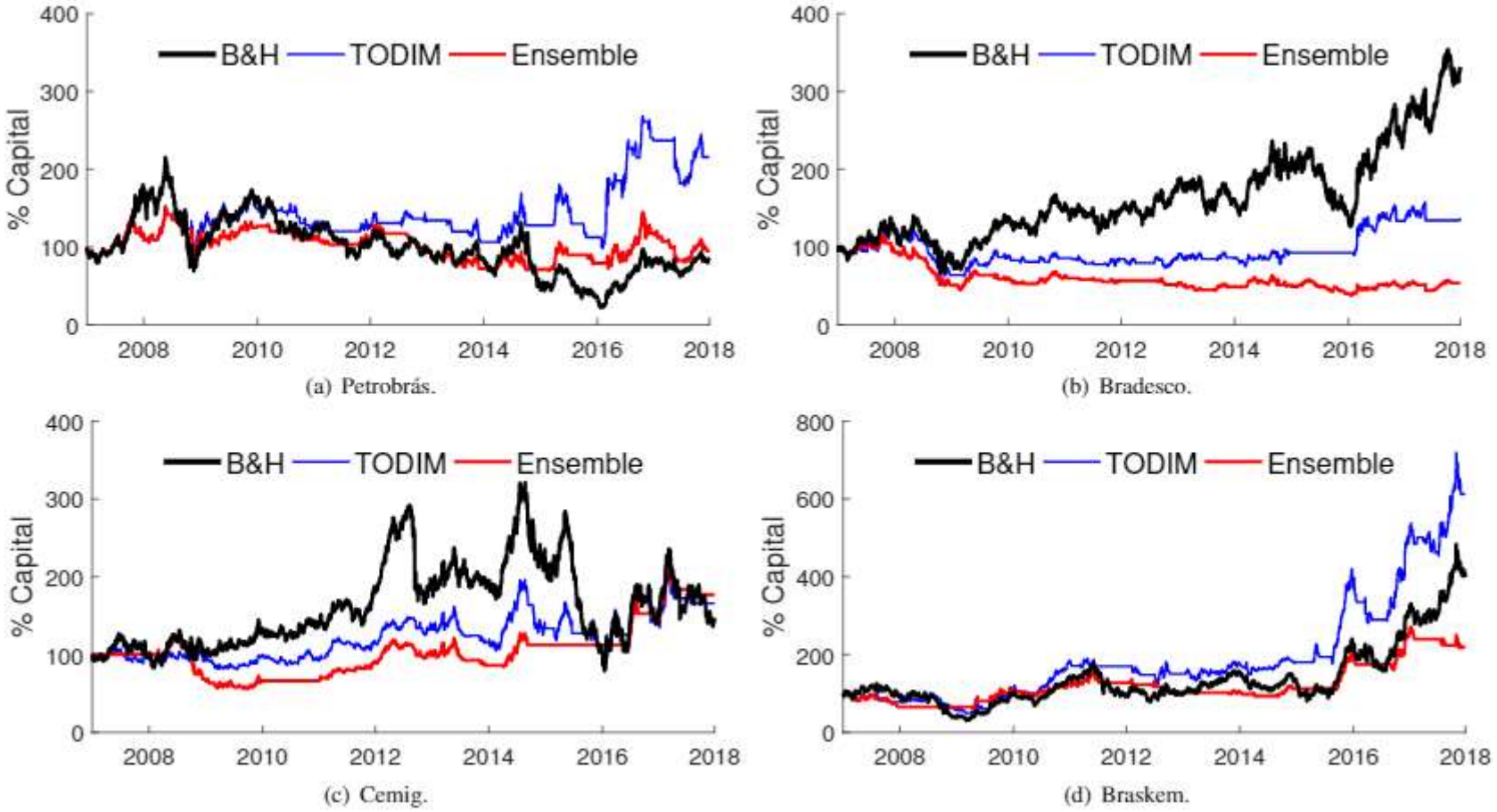
Iterative Process



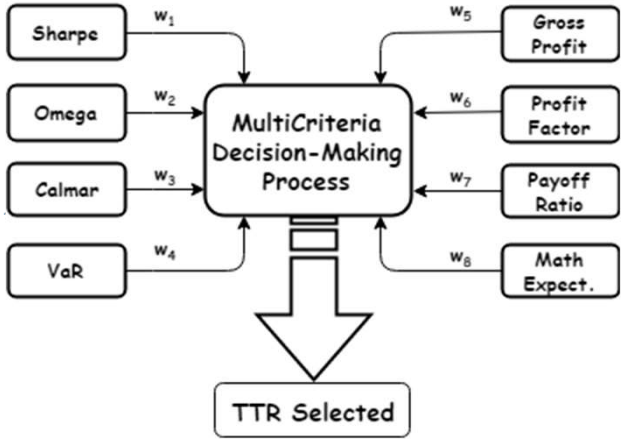
Time-Series Evolution

Results & Discussion

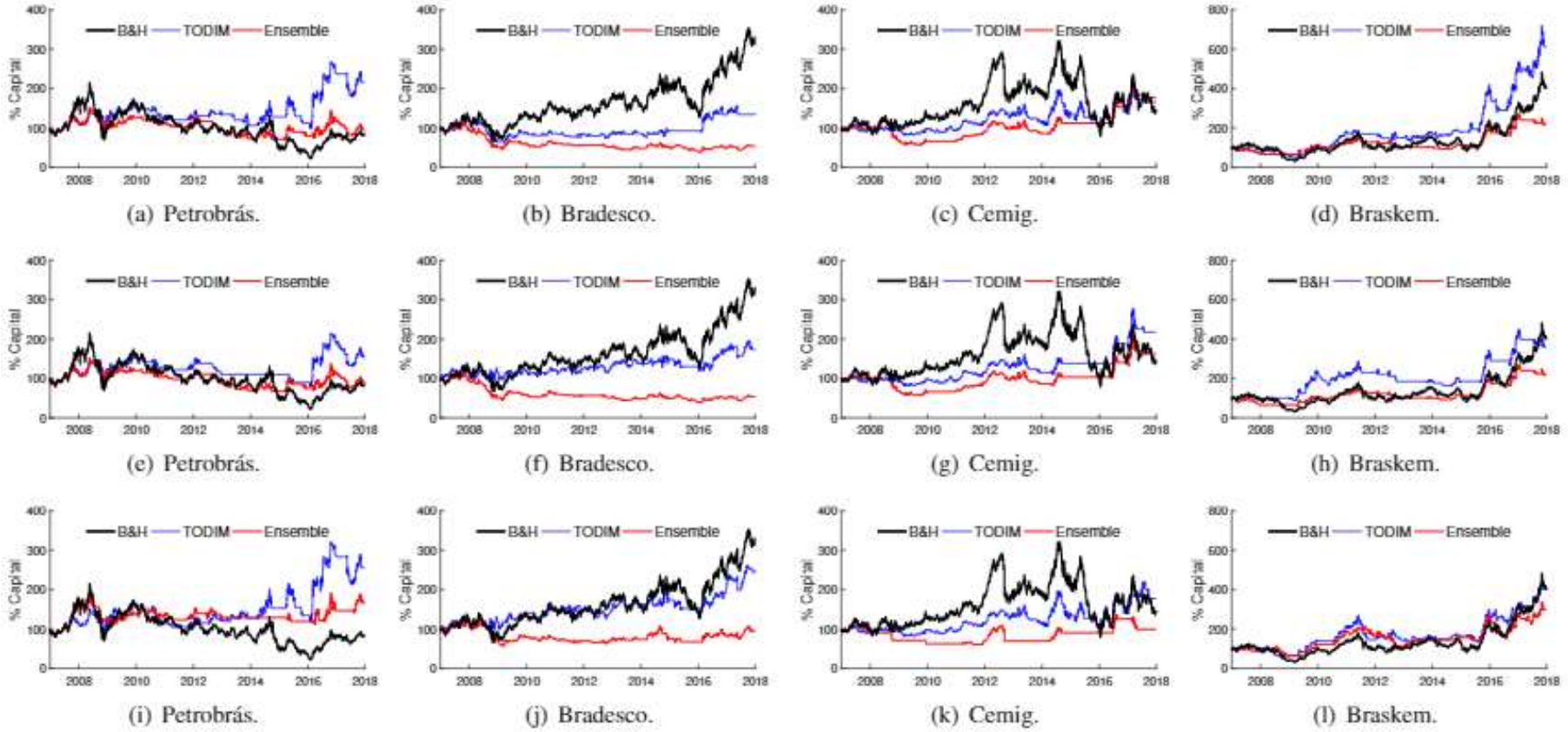
- Comparison: TODIM vs Ensemble:



Results & Discussion

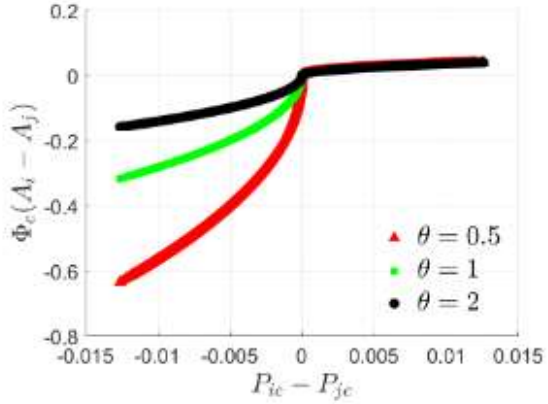


- Comparison: TODIM vs Ensemble:
  - All Metrics **vs** Risk-Adjusted **vs** Profit-Based

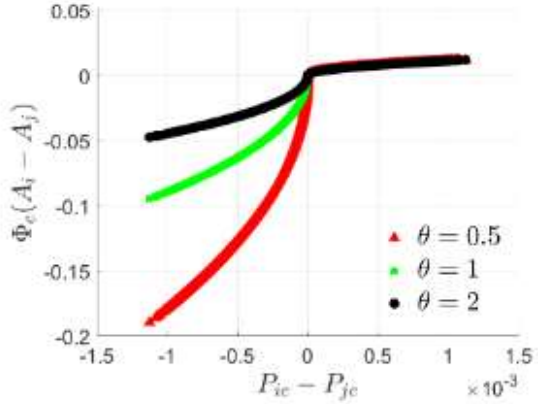


Results & Discussion

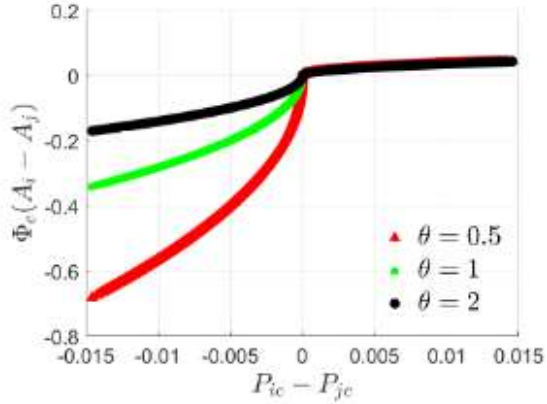
- Parameter $\boldsymbol{\theta}$: **Sensitiviness Analysis**



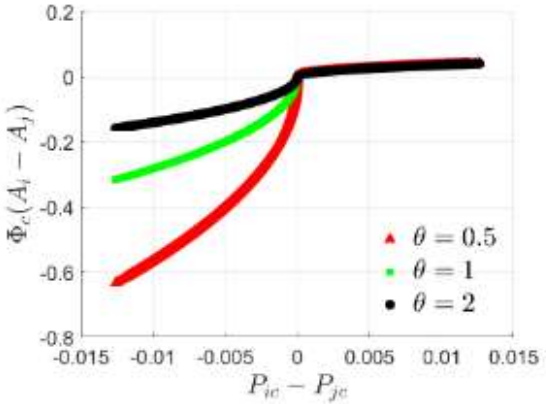
(a) Sharpe.



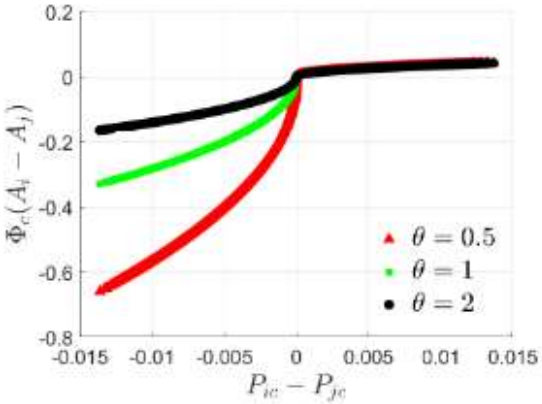
(b) Omega.



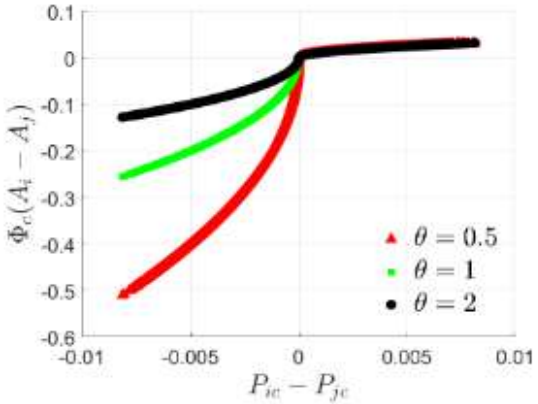
(c) Calmar.



(d) Excesso Var.



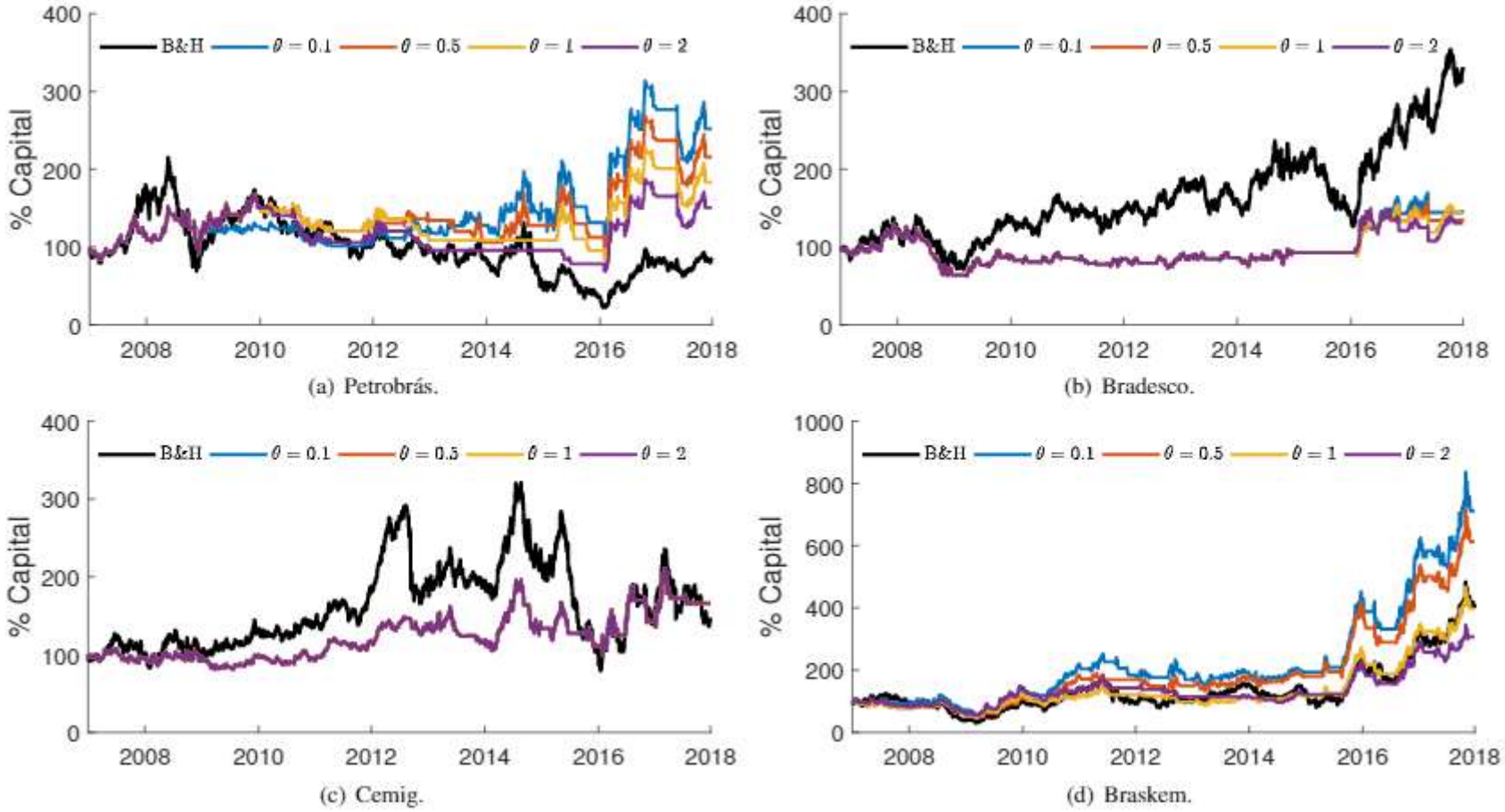
(e) Profit.



(f) Profit Factor.

Results & Discussion

- Parameter θ: **Sensitiviness** **Analysis**



Final Remarks

- Trading System → Decision-Making Process
  - Evaluation of two MultiCriteria Decision-Making Approaches
  - TODIM vs Ensemble

- In the presented simulations TODIM outperforms the Ensemble

- Effect of TODIM parameters:
  - Wheights: w_i
  - Loss Mitigation Factor: θ

- Promising preliminary results...

Future Works

- Use of different:
  - Technical Trading Rules and/or Performance Metrics
- **Artificial Intelligence** for parameter setting:
  - Adaptive parameters (in each iteration)
- Window data size changing in training/validation datasets
  - Structural Break Detection in Time Series
- Inclusion and Discussion of:
  - Transactions Cost; Fundamentalist Data; **...**

Encerramento

WAIAF 2019

Obrigado!

Contato: mleles@ufsj.edu.br