Brane-World Economic Theory

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Motivation

- According to the **Brane-World** scenario, the universe we perceive corresponds to an infinitely, positive tendency **super-thin membrane**.
- This membrane is immersed in a **(4+n)-dimensional space-time** (Bulk), with gravity being able to propagate to additional dimensions and spread gravitational interactions throughout the space.
- Explaining how the geometric properties affect the orbits of other things in their gravitational fields, we can accurately locate all gravity interactions at any point in the **Brane-World membrane**.
- Based on this Brane-World theory it is studied the **interactions between the major stock markets**, as well as the **equilibrium relationship between them**.
- It is considered that the financial markets are bound to a super-thin membrane and their interdependencies can be determined precisely, by interpreting the **geometric properties of distorted space-time**, **estimating Shapley Values** and **calculating probability amplitude** for an event.

Financial Market Scenarios

- The global stock market crash was studied that began on 20 February 2020 and ended on 7 April and specifically the interaction between the stock markets of the **USA, China, and Germany.**

Figure 2: Depiction of stock market crash of the USA, China, and Germany

- In order to consolidate the World economy in a brane, we use the S-Brane function expanding in **4-dimensional space** and includes **3 sub-branes** (stock-markets).
- For the identifications of the interactions of the sub-branes, we use interpretability methodology by estimating **Shapley value** with **Monte-Carlo sampling**.
- The gravity interaction of each event is measured by calculating the **probability amplitude for an event** and adding its contribution to the sub-brane.

Mathematical Reasoning

- **Brane theory** by the use of a **delta density**:

$$S_{brane}[\bar{\varphi}] = \int d^4x d^\delta y \sqrt{|g_{(4)}|}\mathcal{L}(\bar{\varphi}(x))\delta^\delta(\vec{y}-\vec{y}_0)$$

- Estimating **Shapley Values** with **Monte-Carlo sampling**:

$$\hat{\phi}_j = \frac{1}{M}\sum_{m=1}^{M}\left(\hat{f}\left(x_{+j}^m\right) - \hat{f}\left(x_{-j}^m\right)\right)$$

- Calculating **probability amplitude** for an event:

$$\phi = \sum_i \phi_i; P = |\phi|^2 = \left|\sum_i \phi_i\right|^2$$

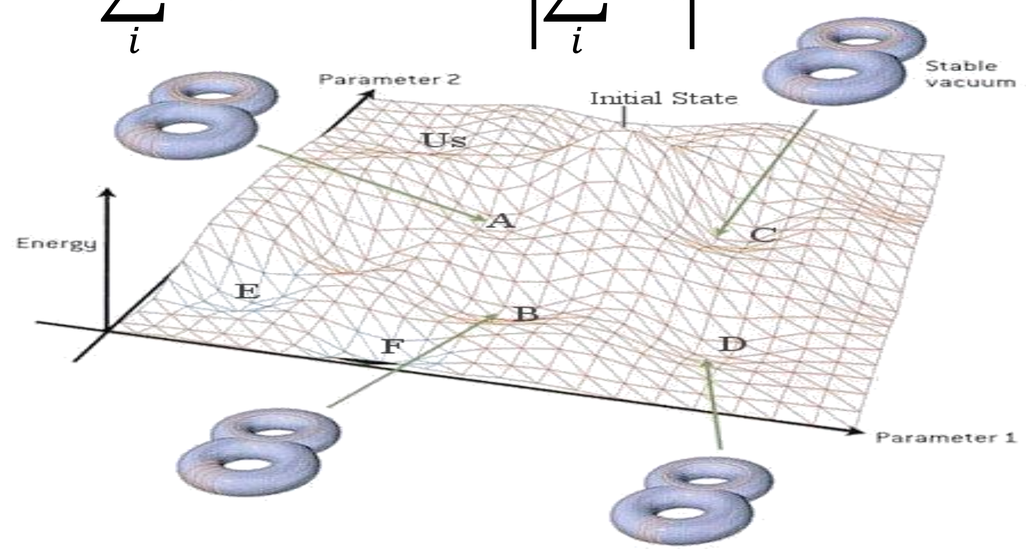

Figure 1: Gravity interactions in the Brane-World membrane

Results and Future Work

- It is a **multi-dimensional multivariate method** that has **multiple time-dependencies** as each variable depends on its **past values** and also has **strong relations** to other **attributes from others dimensions** (time series)[1].

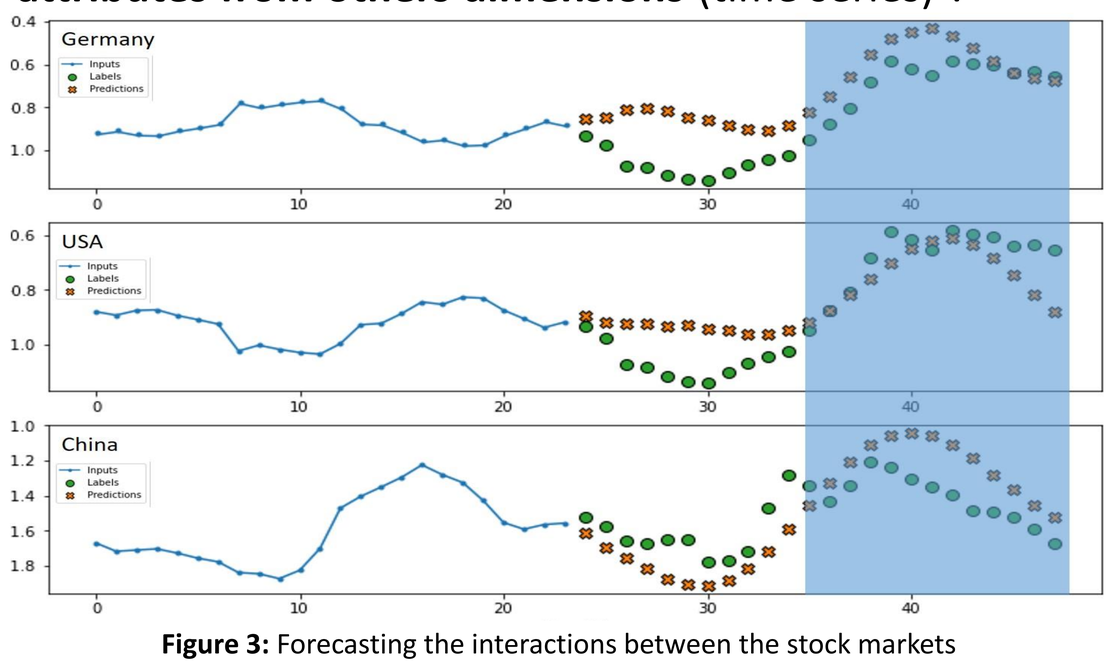

Figure 3: Forecasting the interactions between the stock markets

- Based on dependencies of variables, the method can **predict future economic events** and also can **explain thoroughly the future interactions between them**.
- **Future work** will include:
  - Effort to link this theory to the **post-pandemic**[2] situation and global divergence of economic prospects.
  - Modeling the equilibrium relationships between the **economic recovery of the developing countries**.
  - Analysis of the interactions between the **emerging financial cryptocurrencies markets** and traditional stock markets.

[1]Hanias, M., Magafas, L., & Stavrinides, S. (2019). "Reverse Engineering" in Econophysics. International Journal of Productivity Management and Assessment Technologies (IJPMAT), 7(1), 36-49. http://doi.org/10.4018/IJPMAT.2019010103

[2]Demertzis, K.; Tsiotas, D.; Magafas, L. Modeling and Forecasting the COVID-19 Temporal Spread in Greece: An Exploratory Approach Based on Complex Network Defined Splines. Int. J. Environ. Res. Public Health 2020, 17, 4693. https://doi.org/10.3390/ijerph17134693