



## **Parallel Network Change:**

An Analysis of Migration-Trade-Terrorism

Co-Evolution with Temporal Graph Distances and  
Latent Space Modelling

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# Contents

1. Introduction
  - a. Background
  - b. Research Question
2. Methodology
  - a. Analytical framework
  - b. Predictive framework
3. Results
4. Future Work
5. Bibliography

## France slashes Olympics opening ceremony crowd size amid terror attack fears

French President Emmanuel Macron asked for capacity to be reduced to half of what was initially planned for showpiece event.

## Some 2,000 foreign troops to help with security for Paris Olympics

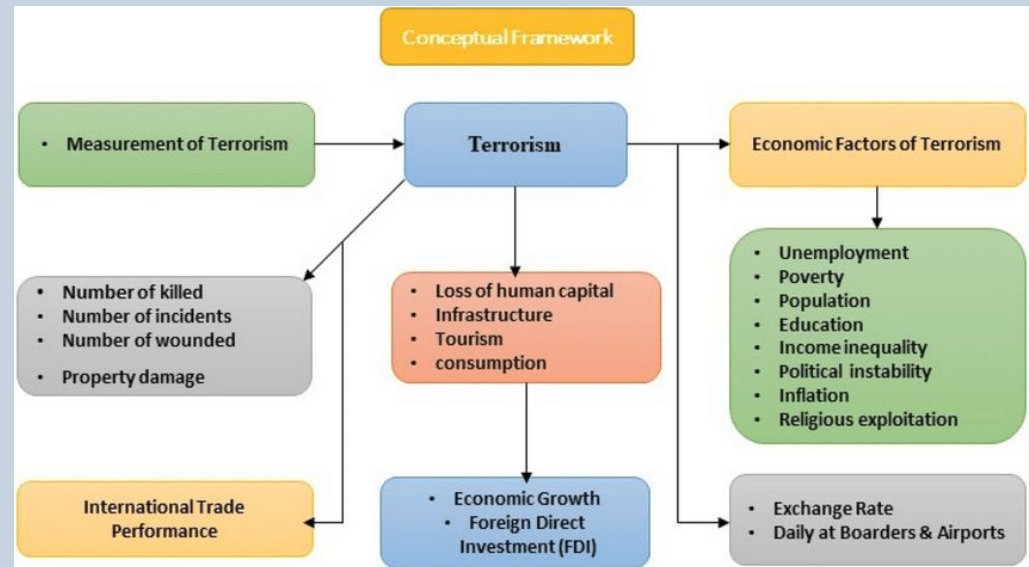
Some 2,000 foreign troops and police will be sent to Paris to bolster security for this summer's Olympic Games as France remains on high alert following attack threats, the French armed forces minister said Friday.

Issued on: 13/04/2024 - 10:26 Modified: 13/04/2024 - 10:27 1 min



## France assesses Paris Olympics terrorist threat in light of Moscow attack

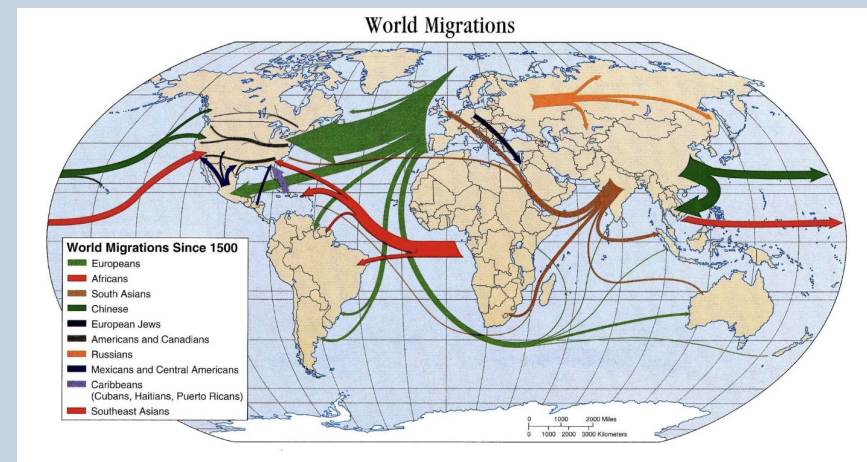
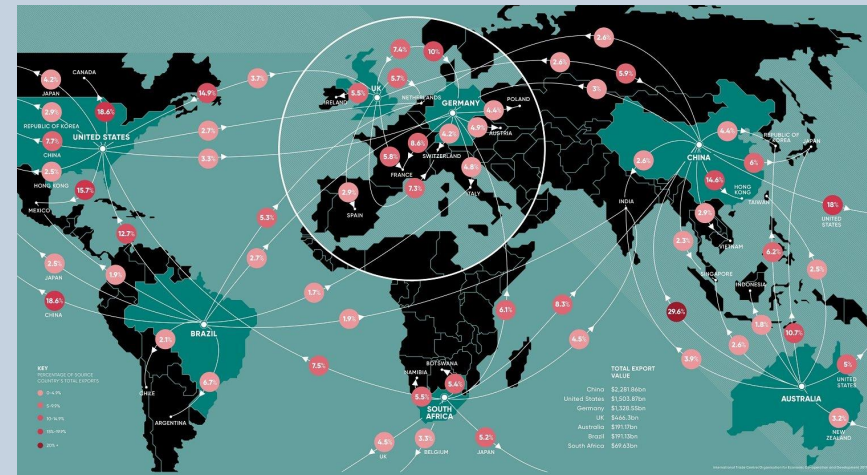
Minister and intelligence services meet to discuss security for Games that includes opening ceremony on the Seine



Khan et al. (2021)

# Predicting terrorism is complicated

- Two flows connect countries:
  - Flow of **people**
    - Terrorist activity mobilising migration linkages → *less costly* (Helbling and Meierrieks, 2020)
    - This is contingent on socio-economic / political factors
  - Flow of **money**
    - GDP per capita: significantly related to terrorism for target country, not source countries (Ghatak and Gold, 2017)
    - International economic integration does not cause more transnational terrorism (Li and Schaub, 2004).
  - Ambiguous → interesting!



# Research Question

**“Can we predict transnational terrorist activities from international trade and forced migration flows?”**

# Datasets

## Migration

### UNHCR Refugee Statistics dataset

- Aggregate headcounts of refugees / asylum seeker flows
- 184,353 unique country-dyad-years
  - 1978-2023
  - 8626 unique country pairs



## Trade

### Atlas of Economic Complexity dataset

- Export and import volumes
- 250 countries
- 20 product categories
- 1962-2021



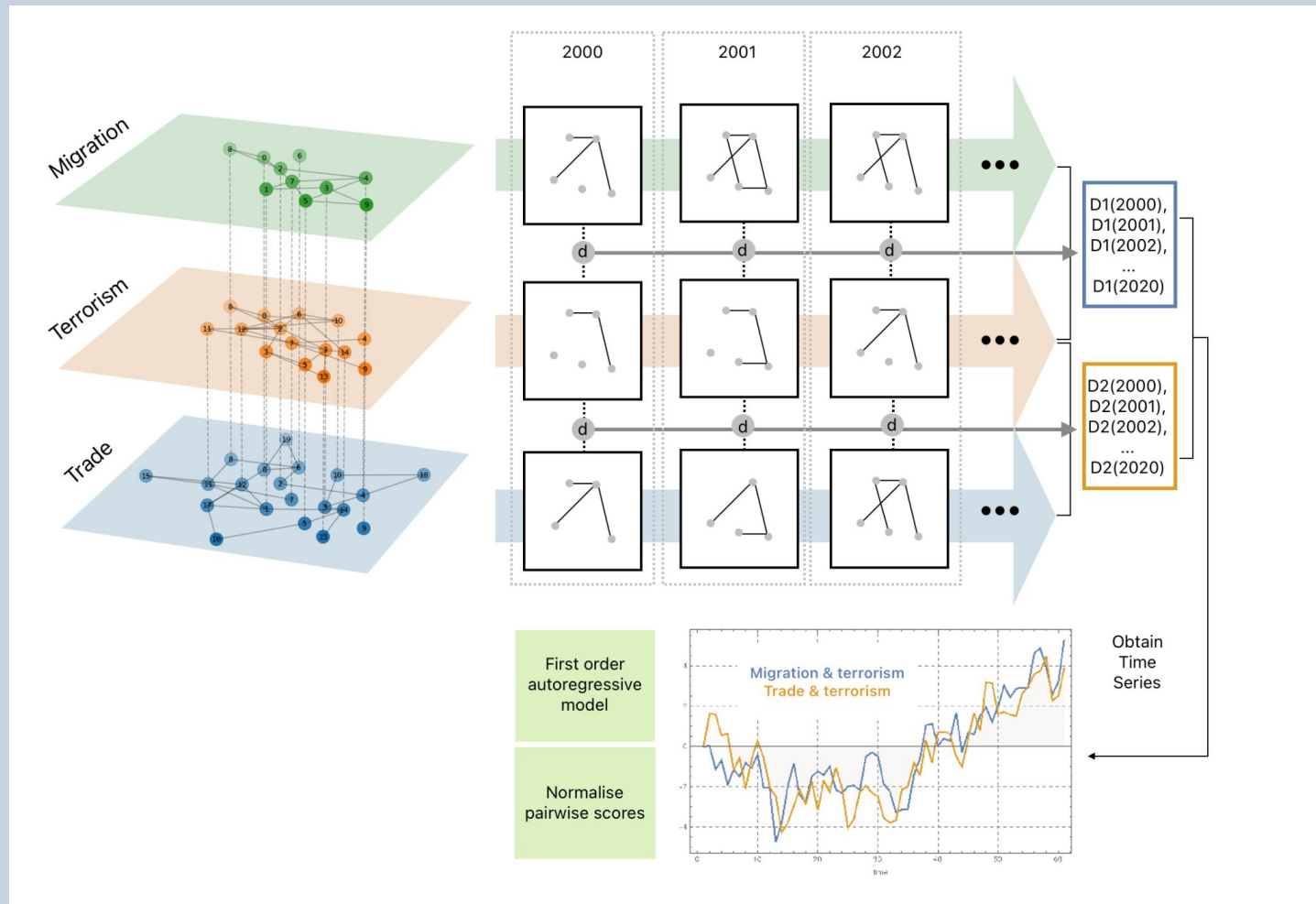
## Terrorism

### Global Terrorism Database

- Has data on *logistically international terrorism* (i.e., people have to cross international borders to conduct terrorism)
- $N > 200,000$  terrorist attacks around the globe



# Analytical framework





# Graph distances

- Spanning tree distance

$$d_{ST}(G, \tilde{G}) = \left| \log \left( 1 + \sum_{i=1}^{N-1} \frac{\epsilon_i}{\lambda_i} + \sum_{i,j=1}^{N-1} \frac{\epsilon_i \epsilon_j}{\lambda_i \lambda_j} + \dots \right) \right|$$

- Polynomial distance

$$d_{\text{poly}}(G_t, G_{t+1}) = \frac{1}{N^2} \|P(A_{i,j,t}) - P(A_{i,j,t+1})\|_{2,2}$$

- Jaccard distance

$$d_{\text{jaccard}}(G_t, G_{t+1}) = 1 - \frac{\sum_{i,j} \min(A_{i,j,t}, A_{i,j,t+1})}{\sum_{i,j} \max(A_{i,j,t}, A_{i,j,t+1})}$$

Scale

Macro

Meso

Micro



Donnat & Holmes (2018)



# Latent Space Model

$$\Pr[y_{i,i'} = 1 \mid \beta, \gamma_{i,i'}, \mathbf{x}_{i,i'}] = g^{-1}(\mathbf{x}_{i,i'}^\top \beta + \gamma_{i,i'}), \quad i < i',$$

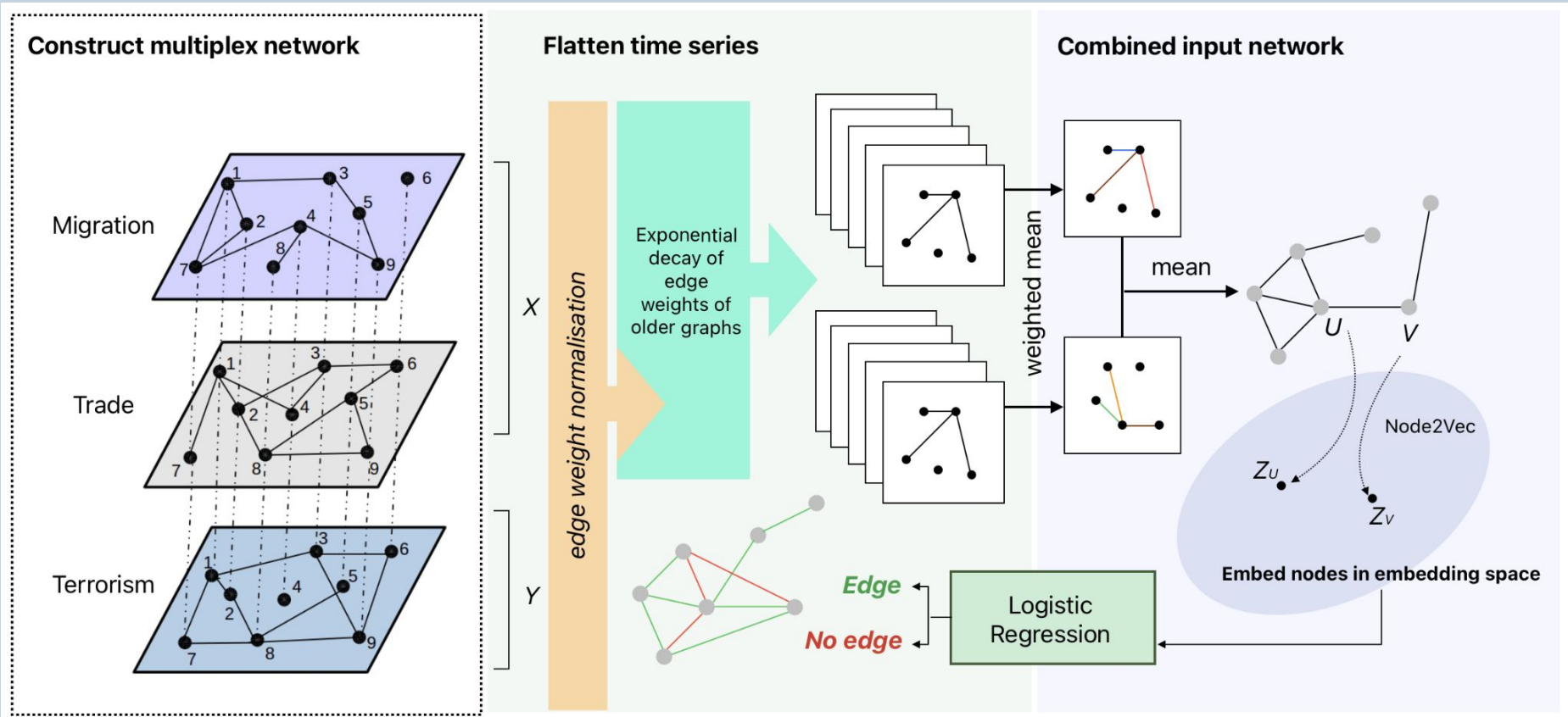
$$\gamma_{i,i'} = \alpha(\mathbf{u}_i, \mathbf{u}_{i'}),$$

Model	Latent effects	Latent space
Class	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = \theta_{\phi(\mathbf{u}_i, \mathbf{u}_{i'})}$	$\mathbf{u}_i \in \{1, \dots, K\}$
Distance	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = -\ \mathbf{u}_i - \mathbf{u}_{i'}\ $	$\mathbf{u}_i \in \mathbb{R}^K$
Projection	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = \mathbf{u}_i^\top \mathbf{u}_{i'} / \ \mathbf{u}_{i'}\ $	$\mathbf{u}_i \in \mathbb{R}^K$
Bilinear	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = \mathbf{u}_i^\top \mathbf{u}_{i'}$	$\mathbf{u}_i \in \mathbb{R}^K$
Spatial process	$\alpha(\mathbf{x}_i, \mathbf{x}_{i'}) = -\ z(\mathbf{x}_i) - z(\mathbf{x}_{i'})\ $	$\mathbf{x}_i \in \mathcal{X}^P$
Cluster	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = -\ \mathbf{u}_i - \mathbf{u}_{i'}\ $	$\mathbf{u}_i \in \mathbb{R}^K$
Eigen	$\alpha(\mathbf{u}_i, \mathbf{u}_{i'}) = \mathbf{u}_i^\top \Lambda \mathbf{u}_{i'}$	$\mathbf{u}_i \in \mathbb{R}^K$

TABLE 1: Summary of latent space models.

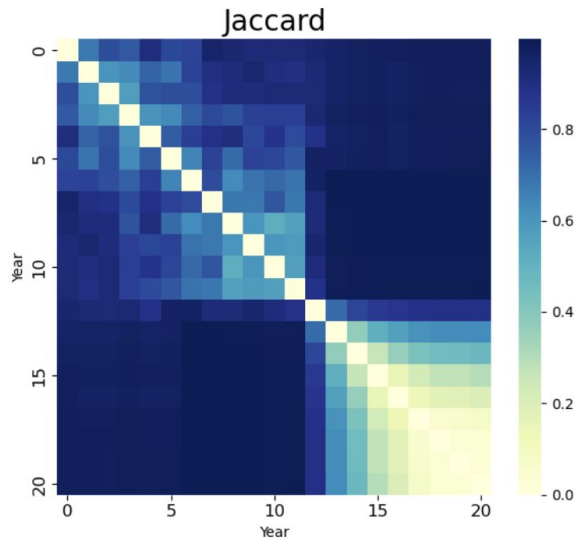
Sosa & Buitrago (2020, pp. 6-9)

# Predictive framework

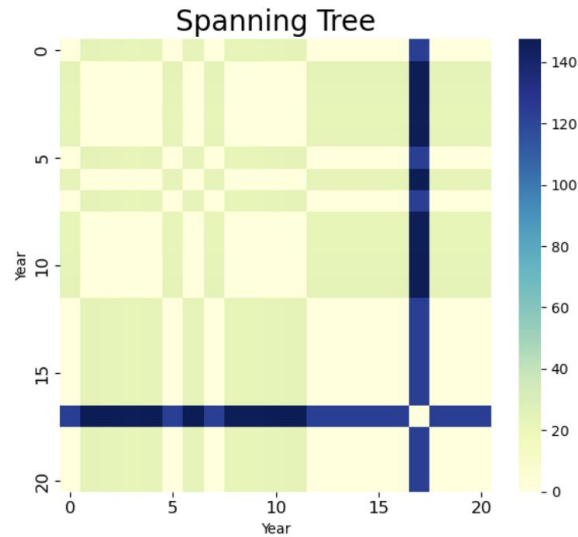


# Individual Network Distances

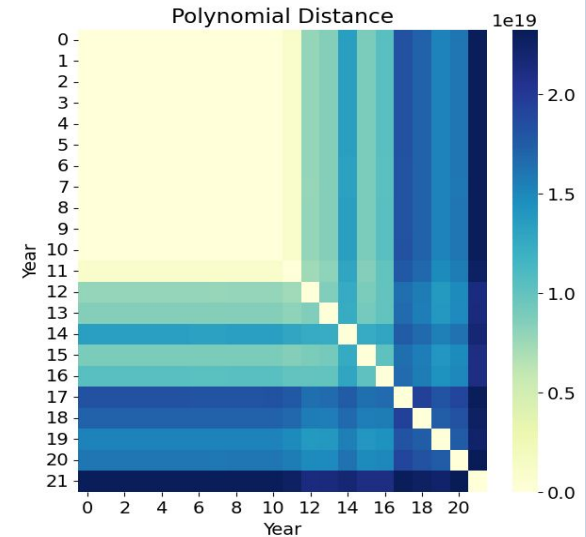
## Migration



## Terrorism



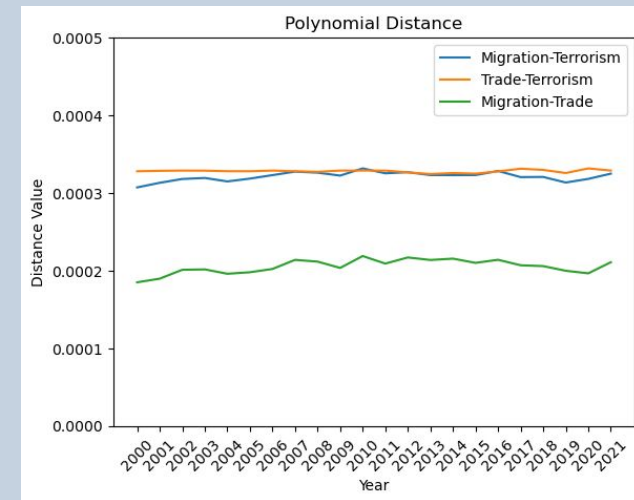
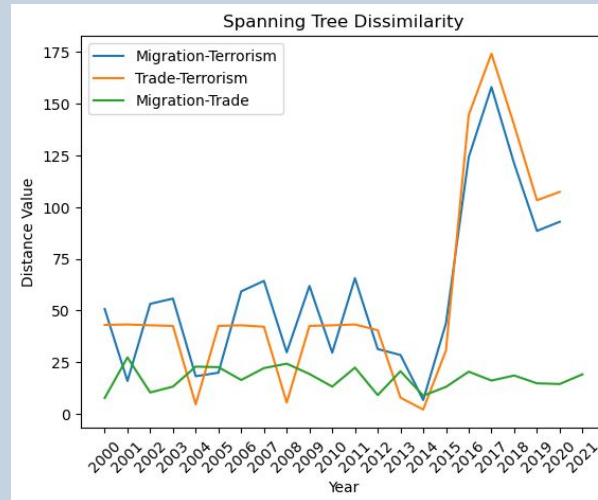
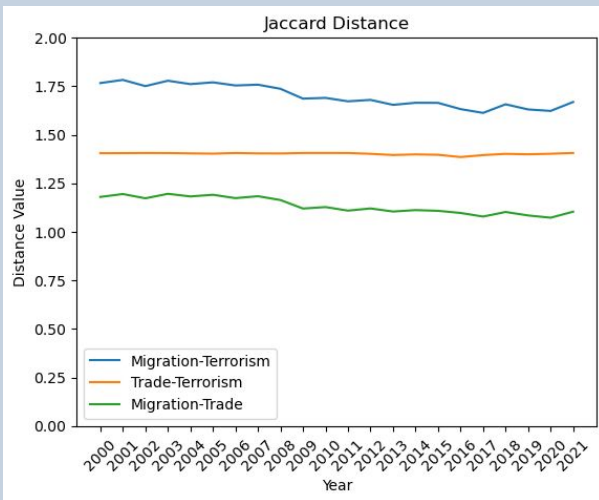
## Trade



# Combined Network Distances

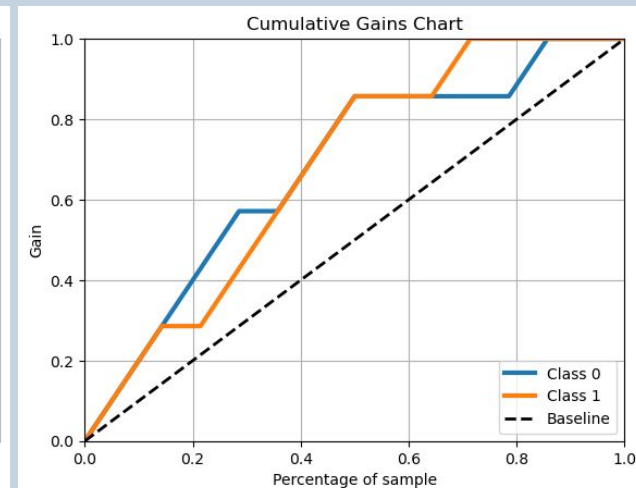
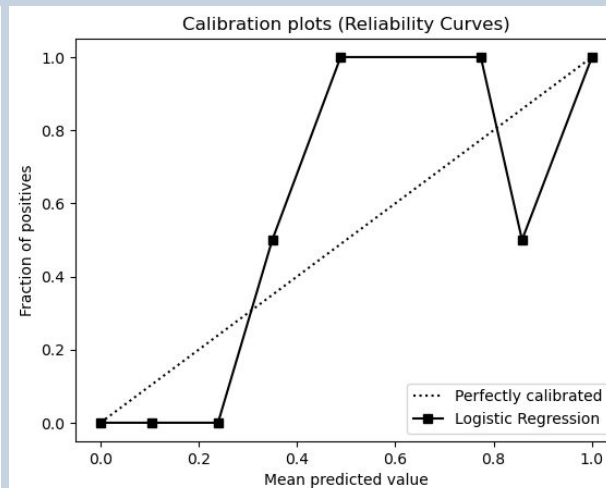
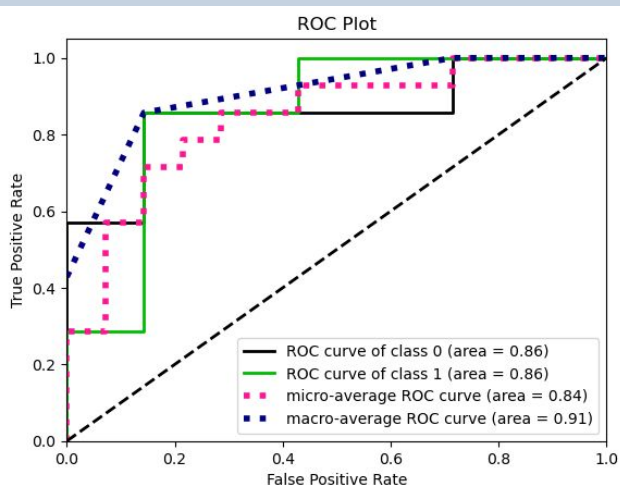
- Distances close to zero indicates similarity between two networks
- Migration and trade networks are very similar
- Polynomial shows greatest similarity between all network combinations

Series Name	Coefficient	P-value
● Migration-Terrorism (Jaccard)	0.827642	0.000000
● Migration-Terrorism (Polynomial)	0.729825	0.000000
● Migration-Terrorism (Spanning Tree)	0.388537	0.059000
● Trade-Terrorism (Jaccard)	0.427761	0.031000
● Trade-Terrorism (Polynomial)	0.685952	0.000000
● Trade-Terrorism (Spanning Tree)	0.489697	0.012000



# Predictive Framework Results

Class	Test set score		
	<i>Precision</i>	<i>Recall</i>	<i>F1</i>
<i>No Linkage</i>	0.75	0.86	0.80
<i>Linkage</i>	0.83	0.71	0.77
<i>Average</i>	0.79	0.79	0.78



# Predictive Framework Results

Input network	10-fold CV score		
	<i>AUC-ROC</i>	<i>Accuracy</i>	<i>F1</i>
<i>Combined (migration + trade)</i>	0.933	0.733	0.622
<i>Migration only</i>	0.775	0.658	0.743
<i>Trade only</i>	0.867	0.750	0.750

# Future Work

- Implement Latent Space Model - predicting terrorism (distance in latent dimension proportional to migration/trade volumes)
- Implement dynamic LSM (i.e. with dynetLSM) to improve on the time series flattening method.
- Implement better autoregressive models.
- Look into individual network importance.





**Thank you for your attention!**

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