The Complex Food Network and Associated Risks

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About Me

- **From Nashik, India**
- **B.E. in Computer Engineering**
  MET's Institute of Engineering
  (2020–2024)
- **MSc in Data Science & Statistical Learning**
  University of Limerick
  (2024–2025)

Motivation

Globalised trade → wider food supply, higher risk

Unsafe food → 600M illnesses, 420k deaths/year (WHO)

EU imports widely → increased exposure

RASFF is reactive → need proactive early warning

Trade networks can provide features for prediction

Aim of the project

1. Trade network exploration (2010–2024, 5-year blocks)

- Calculate exporter risk per trade volume (tonnes)
- Visualise positions of the top 5 risk scorers in each 5-year period.
- Highlight Ireland’s place within the trade network

2. Forecasting RASFF alerts

- Apply Prophet and TBATS models
- Test the effect of trade-based predictors on forecasts.

Data Sources

European Commission | RASFF Window

WAGENINGEN UNIVERSITY & RESEARCH

- Alerts on non-compliant products detected in the EU
- Data used: date, product category, origin country, notifying country
- Data (2000–2024) obtained from the Wageningen University dashboard
- Includes historical backup (2000–2019) and recent alerts (2020–2024)

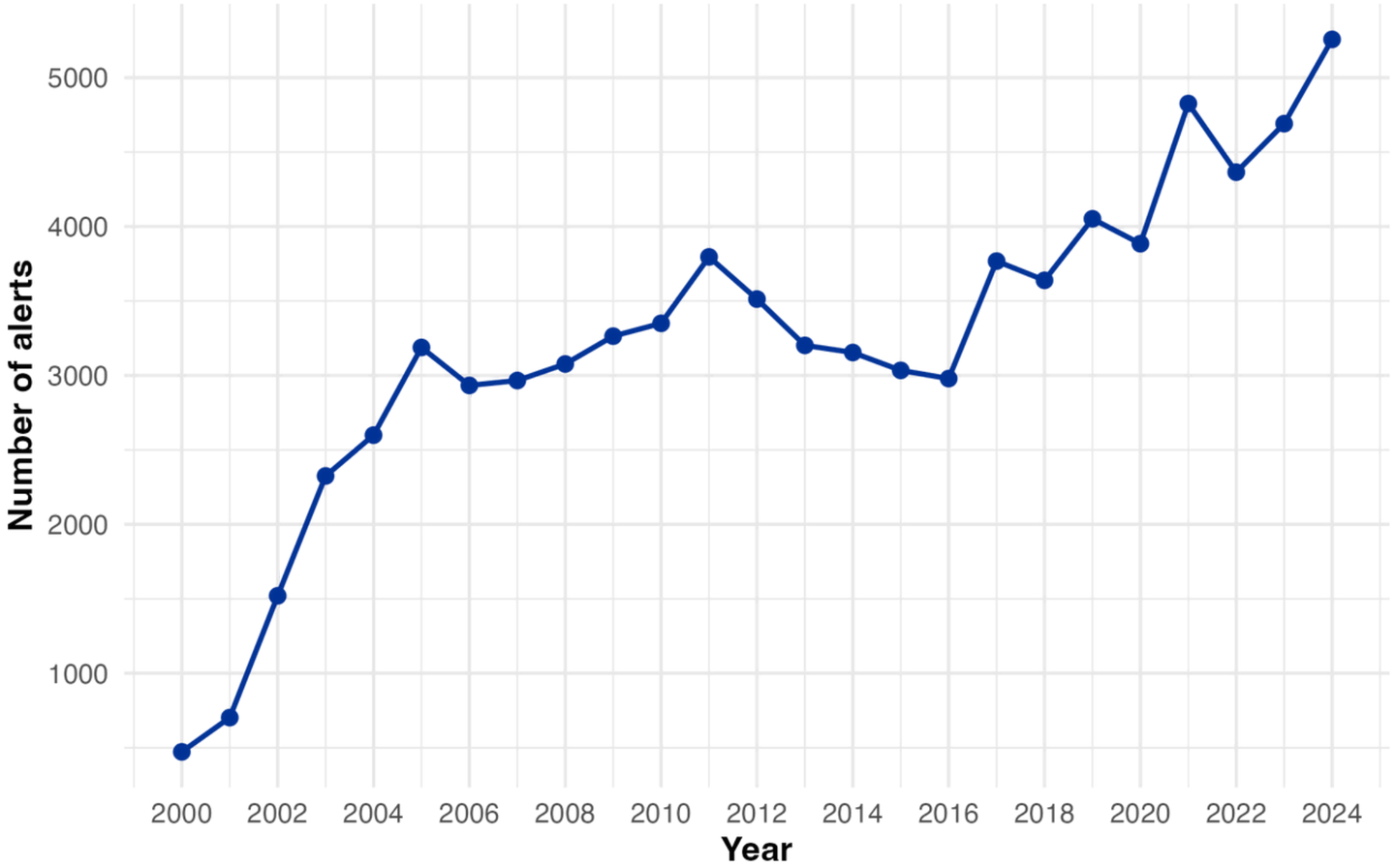
Data Sources

- Manual mapping of RASFF categories to CN codes (Combined Nomenclature)
- Based on CN 2025 reference
- Example:
  0701 – Potatoes
  0702 – Tomatoes
  …
  0714 – Manioc, arrowroot, taro

eurostat

- Monthly EU import volumes (reported in 100 kg units)
- Classified by CN codes (EU's Combined Nomenclature)
- CN codes mapped to RASFF product categories

Annual RASFF Alerts (2000–2024)



- Alerts have increased over time
- 2024 shows the highest number of alerts in the 25-year dataset
- Indicates growing importance of monitoring food safety risks

Top Alert-Generating Countries vs Ireland’s Key Suppliers

- Across all categories (2000–2024): Türkiye, China, India, Spain, and the US generated the most RASFF alerts.
- For Ireland’s fruit & vegetable imports (2020–2024): top suppliers were the UK (22%), Netherlands (19%), and Spain (12%).
- These suppliers also appear among the top 15 alert-generating countries, showing overlap between major trade partners and higher-risk origins.

Top RASFF Alerts by Country–Product Pairs (2020–2024)

Rank	Country of Origin	Product Category	Alert Count
1	Türkiye	Fruits and vegetables	4,319
2	Iran	Nuts, nut products and seeds	2,702
3	China	Food contact materials	2,263
4	Türkiye	Nuts, nut products and seeds	1,631
5	Poland	Poultry meat and poultry meat products	1,611
6	China	Nuts, nut products and seeds	1,410
7	United States	Nuts, nut products and seeds	1,329
8	India	Nuts, nut products and seeds	1,154
9	Spain	Fish and fish products	1,141
10	United States	Dietetic foods, food supplements and fortified foods	1,110

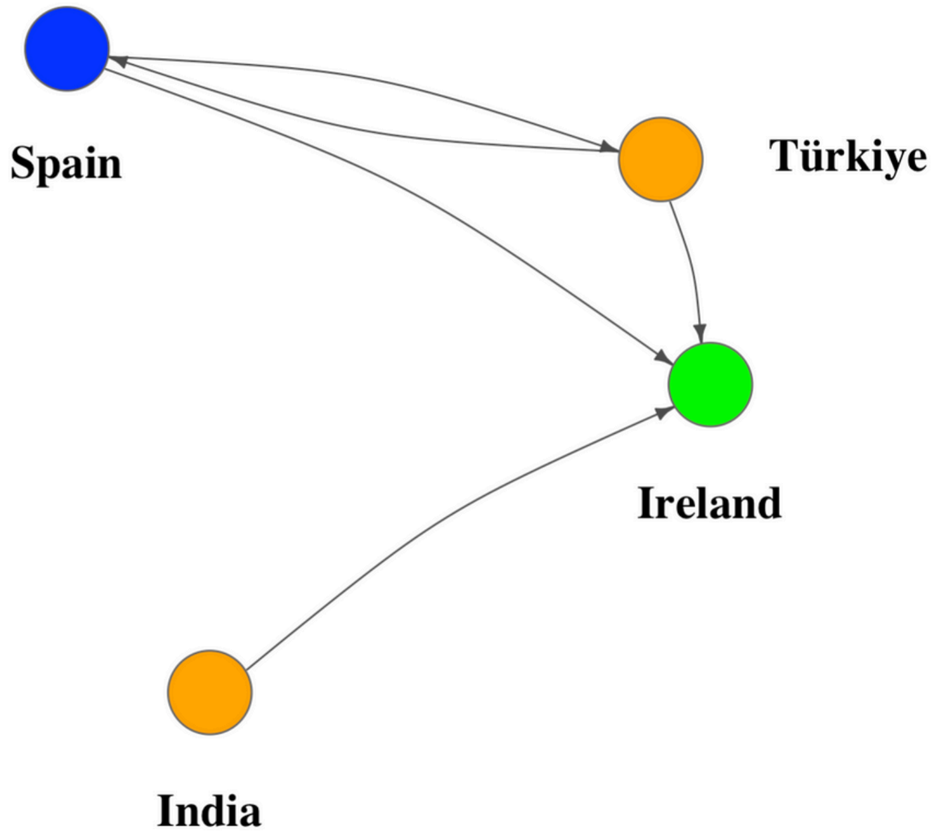
Results: Trade Network Exploration

- Nodes = countries
- Edges = trade flows

- Layout (weighted by trade) → stronger trade = closer; weaker trade = farther.

- Analysis split into 2010–14, 2015–19, 2020–24.

- Fruits & vegetables category.



Example of a Simple Trade Network

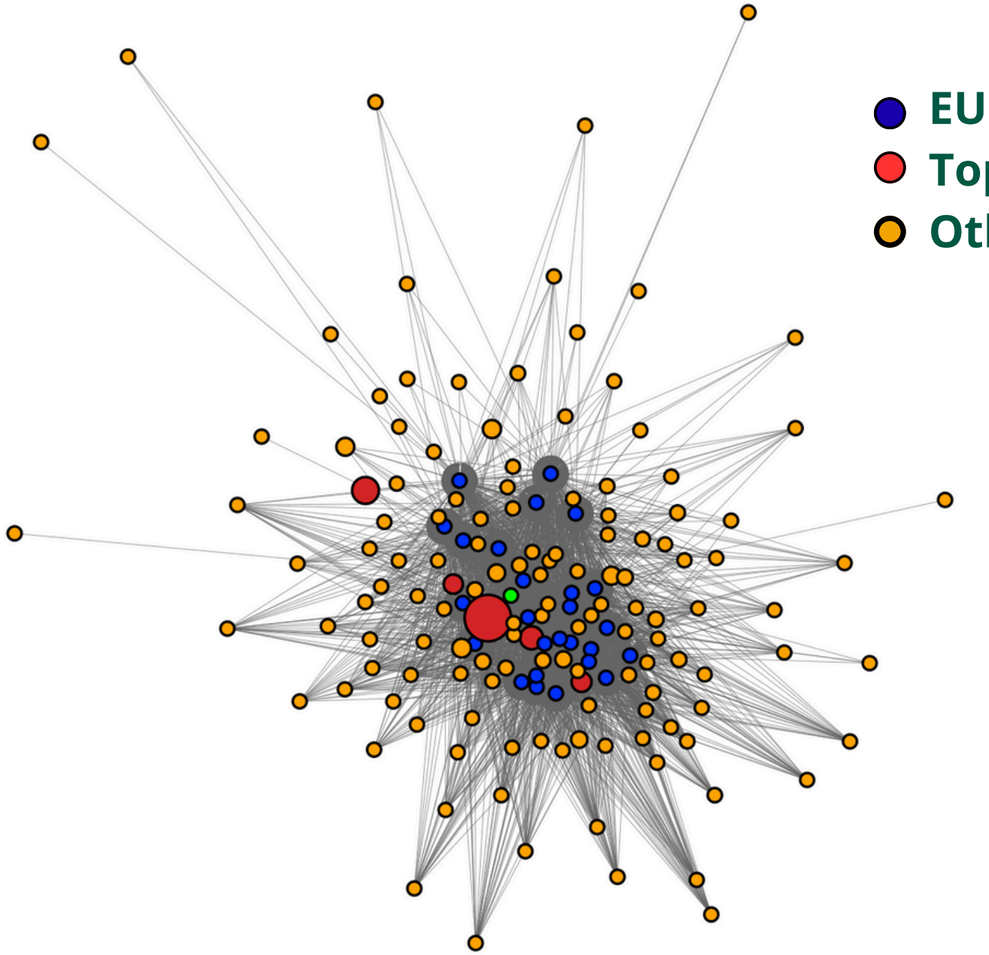
Results: Trade Network Exploration

Period	Exporter	Total Trade (tonnes)	Alert Count	Risk Score
2020–2024	Burundi	317.40	3	0.00945
	Philippines	1,089.89	8	0.00734
	Cambodia	4,993.49	23	0.00461
	Bangladesh	7,480.94	25	0.00334
	Sri Lanka	14,449.87	41	0.00284

Table: Top 5 Exporters by Risk Score (2020–2024, Fruits & Vegetables)

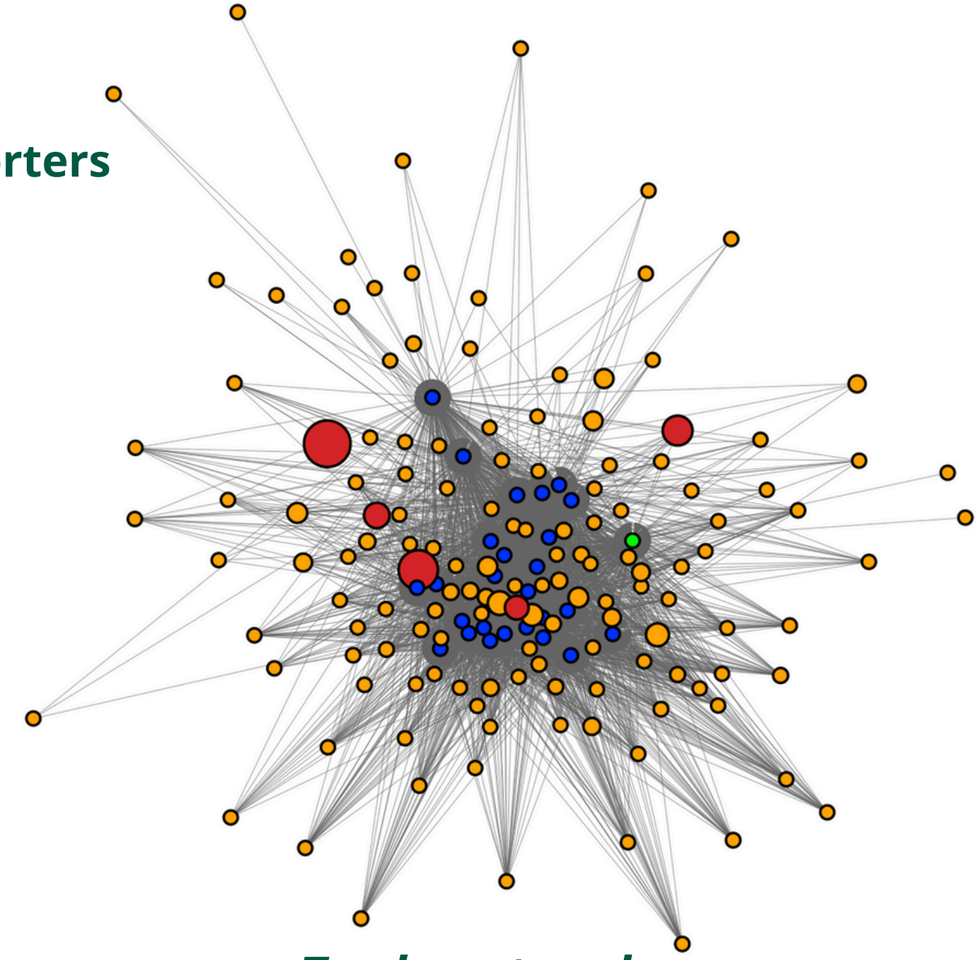
- **Exporter risk score = alerts ÷ trade volume (tonnes)**
- **Normalises risk by trade size → exporters of different scales can be compared**
- **Identifies exporters with unusually high alerts relative to their volume**

Results: Trade Network Exploration



EU Countries
Top 5 Risky Exporters
Other Countries

Trade network
(Fruits & Vegetables, 2015–2019)



Trade network
(Fruits & Vegetables, 2020–2024)

Results: Trade Network Exploration

- Network density increased → EU trade became more interconnected
- In-flow grew → importers sourced from more countries
- Out-flow grew → exporters accessed more markets
- High-risk exporters → smaller trade volumes but still raising alerts; positioned outward in the network

Ireland's Position in the Network

- Ireland's in-flow increased (more exporters).
- While that reduces dependency on one exporter, it also increases exposure → more sources means more possible entry points for contaminated products.

What is Time Series Forecasting?

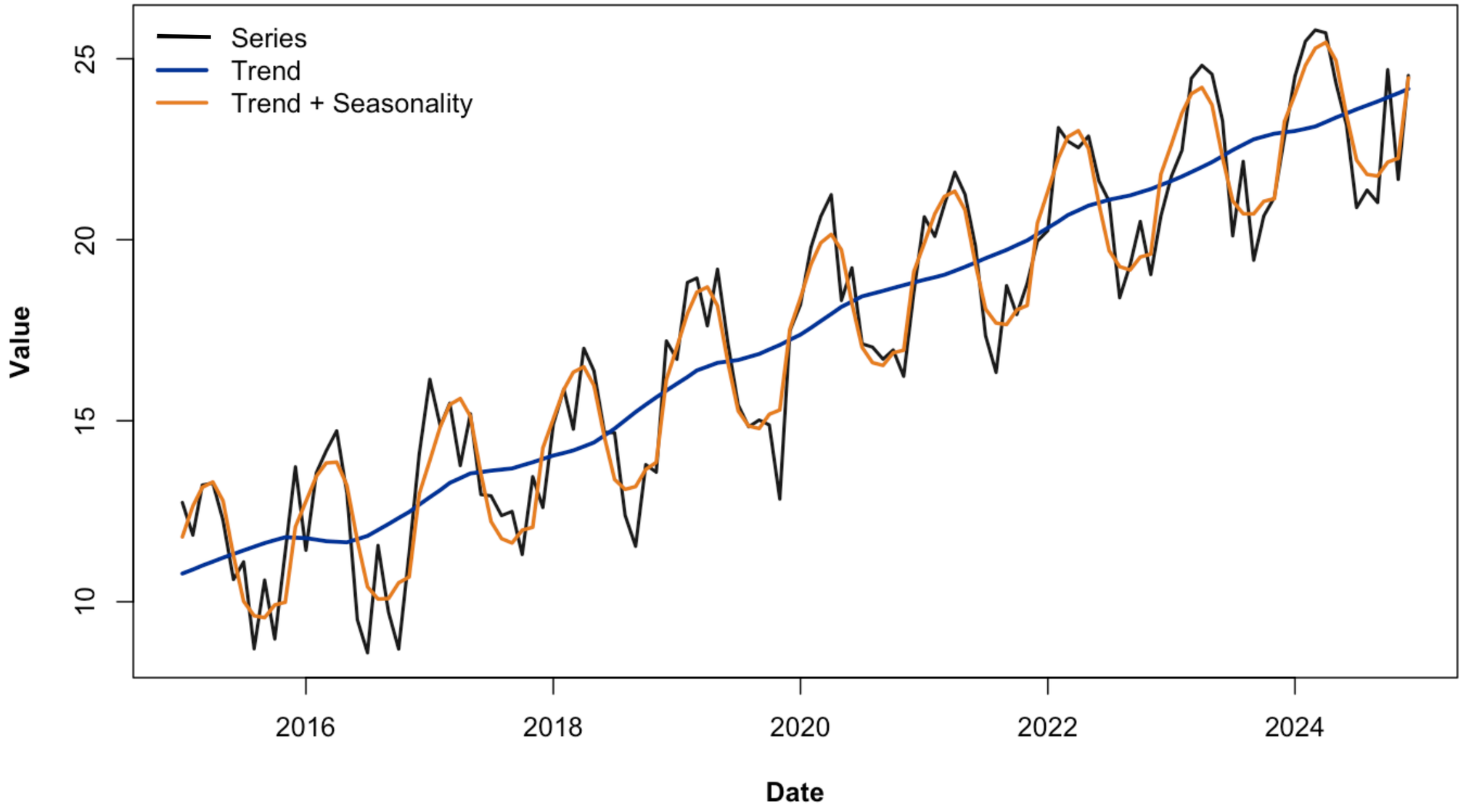
- **Data collected over time (e.g., monthly alerts, trade volumes)**

- **Patterns may include:**

1. **Trend → long-term increase or decrease**
2. **Seasonality → repeating cycles (e.g., yearly)**
3. **Noise → random ups and downs**

- **Forecasting = using past patterns to predict future values**

Example Time Series with Trend and Seasonaility

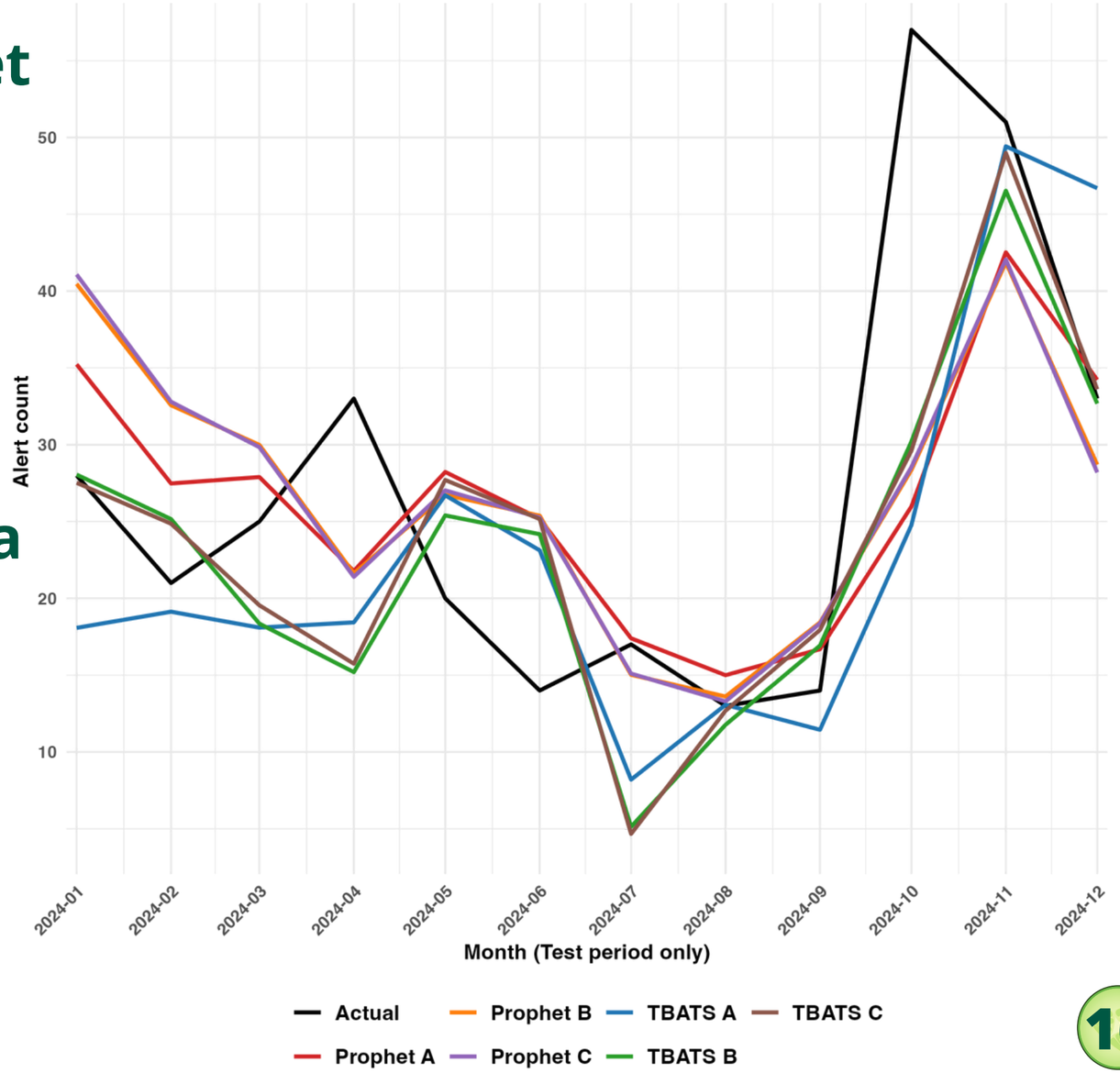


Methods, Models and Setups Used

- Prophet (developed by Facebook)
- TBATS (developed by Rob Hyndman’s team)
- Applied to forecast RASFF alerts
- Compared three setups:
- Alerts only (**Model A**)
- Alerts + trade volumes (**Model B**)
- Alerts + trade volumes + out-flow (**Model C**)
- Goal: test whether adding trade and network features improves predictions

Forecasting Results (Prophet vs TBATS)

- Compared two methods: Prophet and TBATS
- Prophet: best with alerts-only (adding trade or out-flow increased error)
- TBATS: improved with trade data (Model B performed best)
- Adding out-degree (Model C) made little difference for TBATS
- Both methods missed some sharp peaks in late 2024



Model Performance (Türkiye – Fruits & Vegetables, Test MAE)

Models	MAE
Prophet A	7.753
Prophet B	8.969
Prophet C	8.796
TBATS A	9.002
TBATS B	7.653
TBATS C	7.709

- MAE = average difference between predicted and actual alerts
- Best model: TBATS with trade (Model B) → MAE = 7.65
- Predictions were typically 7–9 alerts off per month, with largest errors from the 2024 peak (~57 actual vs. ~25 predicted)
- Test period mean = 27.17 alerts/month

Practical Insights from Forecasting

- Forecasts can guide when to allocate inspection resources.
- Monitoring could be increased during higher-risk months and reduced in quieter periods.
- Helps authorities focus on exporters repeatedly linked to alerts.
- Forecasts give an early warning signal, even if not perfect, supporting proactive decisions.

Conclusion and Future Directions

- Trade and alert data can be combined to monitor food safety risks.
- Network exploration highlighted shifts in risky exporters and Ireland’s position.
- Forecasting methods can provide useful early warning signals.
- Results show potential for more targeted and efficient monitoring.
- Future work: extend to more products, pairwise specific timeframes, and improved features.