Using logistics data for food safety and food security analysis

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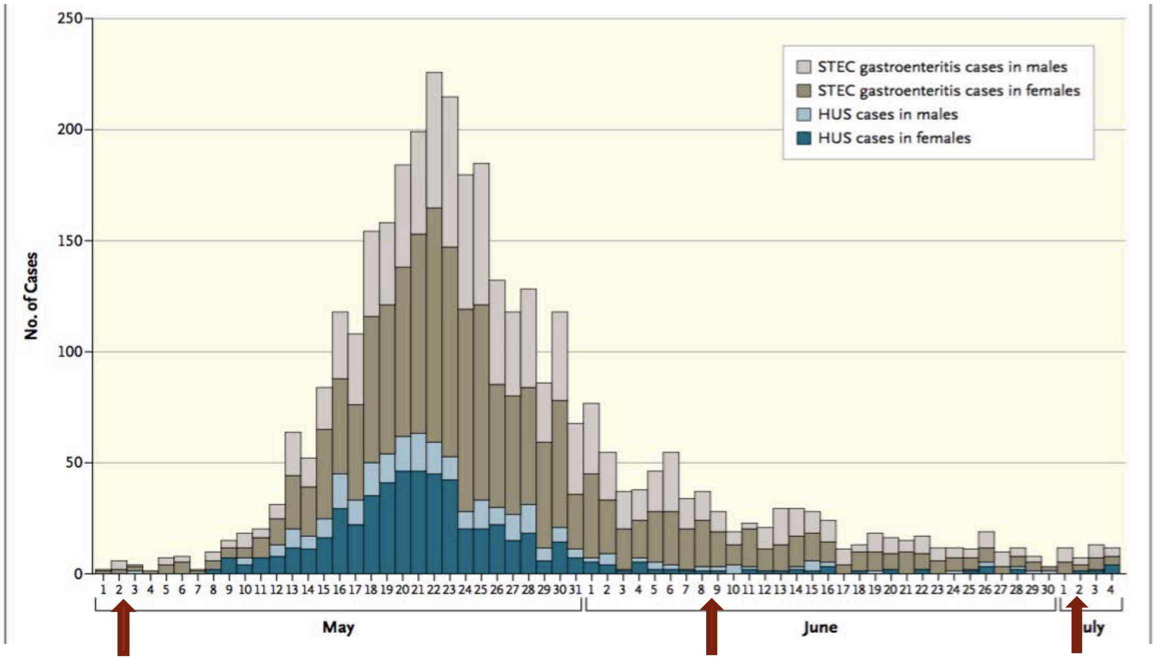
(based on work with Abigail Horn, Andreas Balster, Tim Schlaich, Ole Hansen, Linda-Ina Deuchert and Sandra Rudeloff)

MOTIVATION: TRACEBACK OF FOODBORNE DESEASES (THE EHEC OUTBREAK)

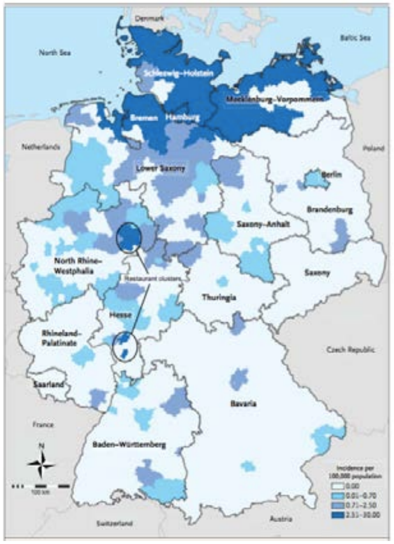


Outbreak identified

Food item identified

Soure identified

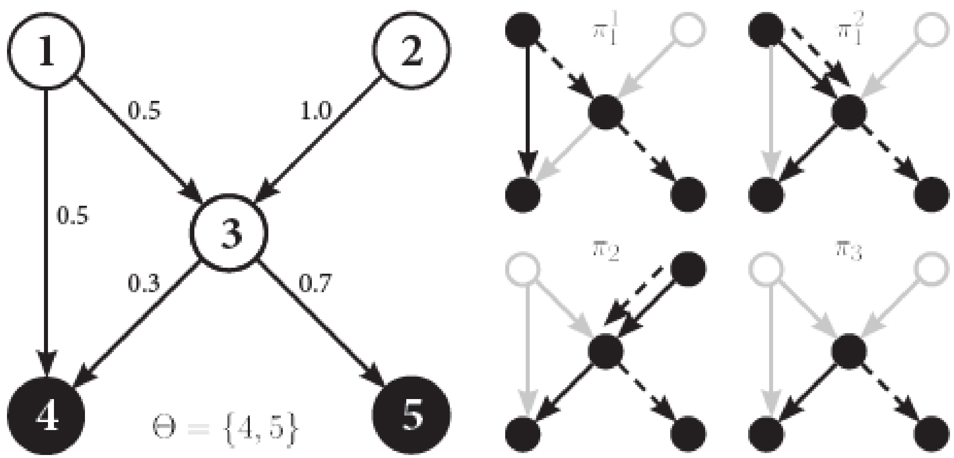
Key figures:
- 4075 illnesses
- 54 deaths
- 16 Countries with cases
- 9 weeks to identify the source

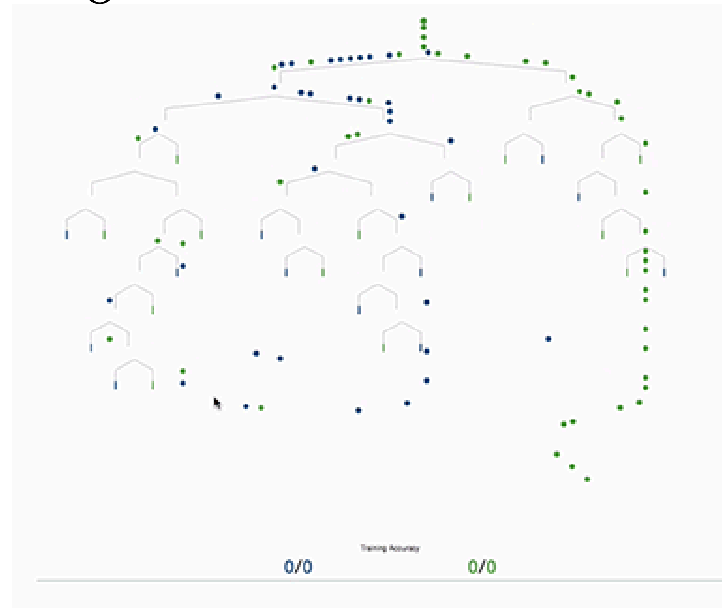


Source: Frank et al (2011), Welt.de, add. Visulaization: https://elenapolozova.github.io/food-outbreak-visualization/

WHICH WAS THE MOST "PROPABLE" SOURCE?

Step 1: What is the conditional probability of outbreaks Θ given a certain source s





$$P(\pi_1^1 | s^* = 1) = 0.5 \times 0.5 \times 0.7 \times 2 = 0.35$$
$$P(\pi_1^2 | s^* = 1) = 0.5 \times 0.3 \times 0.5 \times 0.7 \times 2 = 0.105$$

$$P(\Theta | s^* = 1) = 0.35 + 0.105 = 0.455$$

$$P(\pi_2 | s^* = 2) = 1.0 \times 0.3 \times 0.7 \times 2 = 0.42$$
$$P(\pi_3 | s^* = 3) = 0.3 \times 0.7 \times 2 = 0.42$$

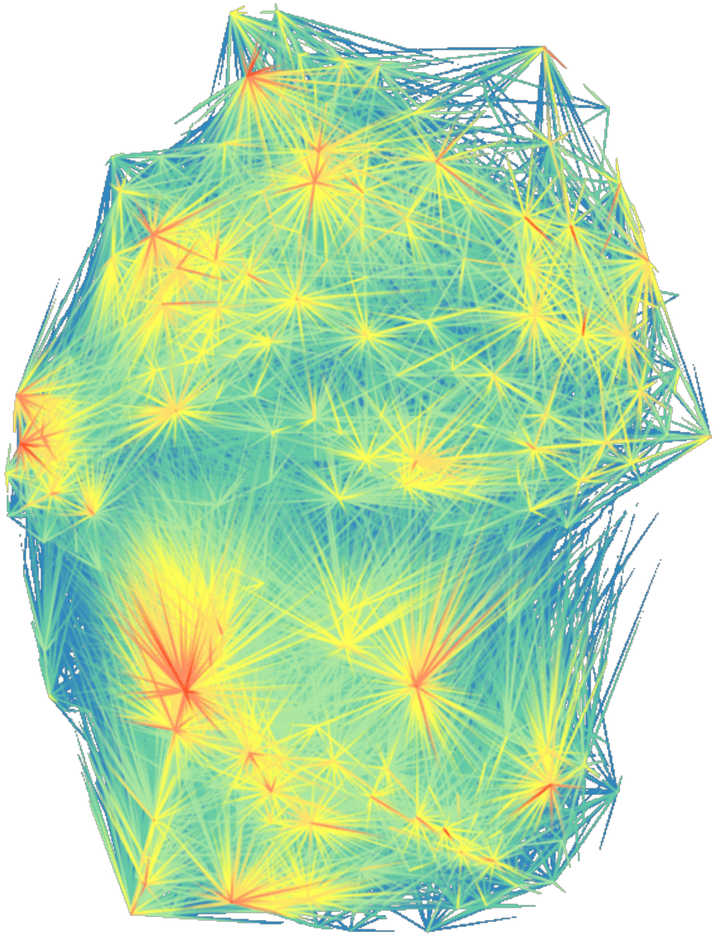
$$P(\Theta | s^* = 2) = 0.42$$
$$P(\Theta | s^* = 3) = 0.42$$

Step 2: Probability that s is the true source given the observed outbreaks Θ

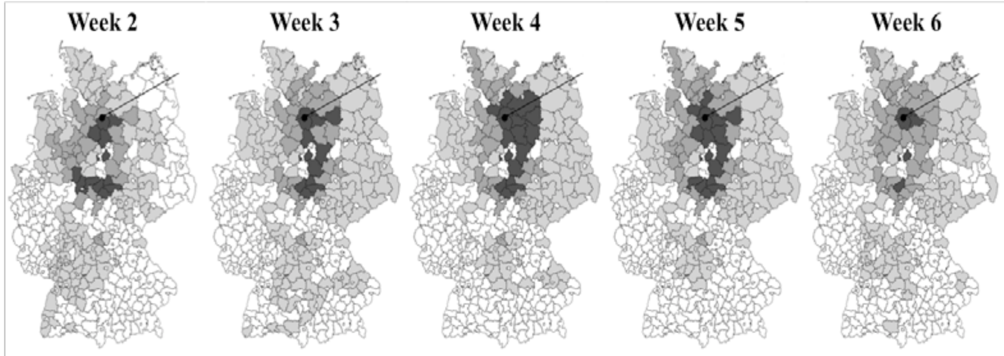
$$P(s^* = s | \Theta) = \frac{P(s^* = s) \times P(\Theta | s^* = s)}{P(\Theta)}$$

Source: Horn and Friedrich (2019), dynamic visualization decision tree: http://www.r2d3.us

RESULTS USING AN ESTIMATED GERMAN FOOD SUPPLY NETWORK MODEL

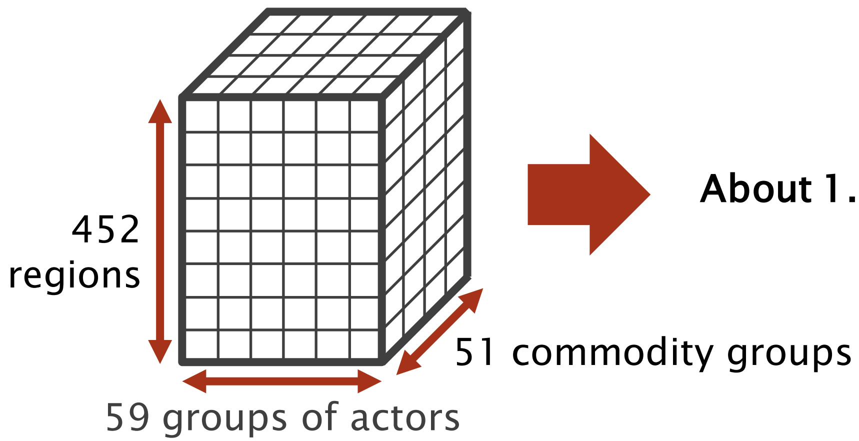


Outbreak Week	Rank of True Source Location		Top-3 Distance from True Source (in km)	
	This Work	Effective Distance [27]	This Work	Effective Distance [27]
1	38	–	180.0	–
2	3	–	148.8	–
3	2	1	83.7	71.3
4	2	>10	40.8	98.3
5	1	3	28.7	43.7
6	1	1	28.7	30.3
7	1	1	28.7	30.3
8	1	5	28.7	135.0
9	1	2	28.7	65.0

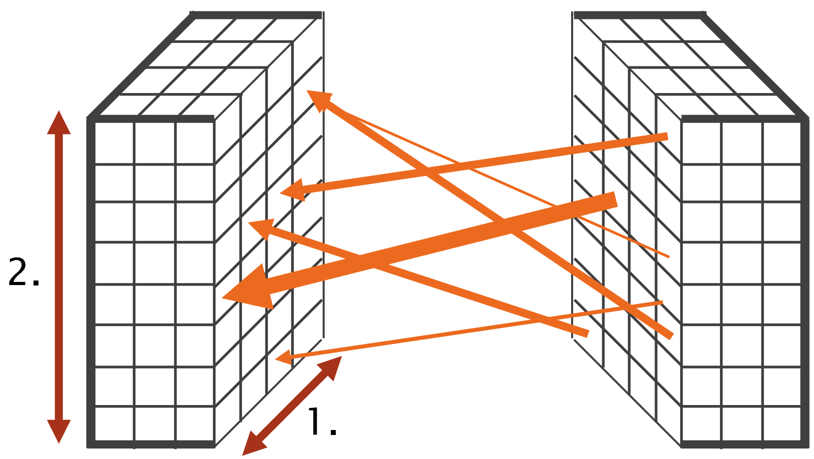


Source: Horn and Friedrich (2019), Animation Elena Polozova

THE UNDERLYING “MSMRIO” MODEL WAS ESTIMAED USING TRANSPORT DATA



About 1.4 million “inventory” values for every day



1. **Between categories of food**
- Industrial interactions
- E.g. production of confectionaries:
  Sugar, milk products, eggs, grain products

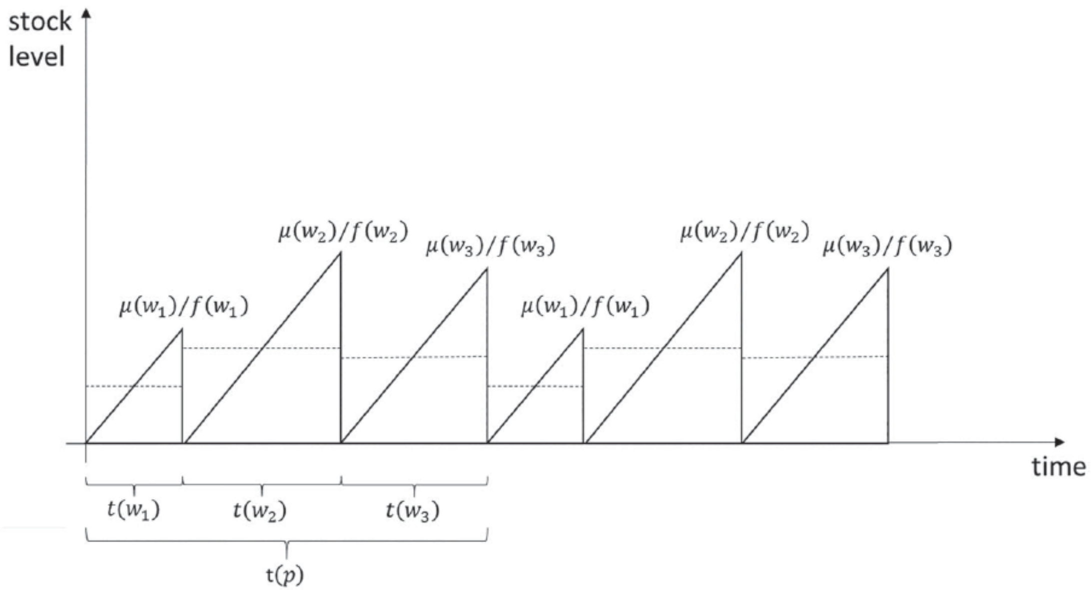
2. Between regions
- Gravity model $T_{ij} = A_i B_j O_i D_j \exp(-\beta \cdot d_{ij})$
- Calibrated using the transport matrix from the BMDV

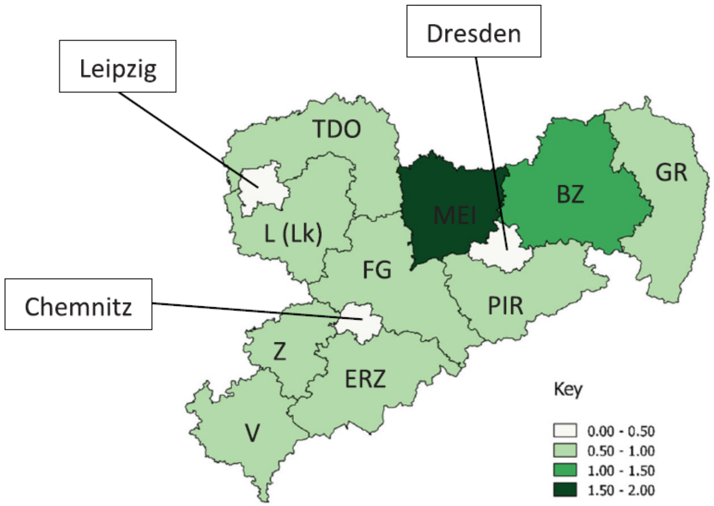
Source: Balster and Friedrich (2019)

DATA USED FOR THE MODEL

- Production data (statistics, reports of ministry and sector associations)
- Employment data
- Population Data
- Location data (POS and warehouses)
- Aggregate sales data of food retailers
- Trade data
- Transport data
- Not „yet“ used: tracing data

INVENTORY DATA IS AVAILABLE (ON COMPNY LEVEL) BUT CAN ALSO BE ESTIMATED



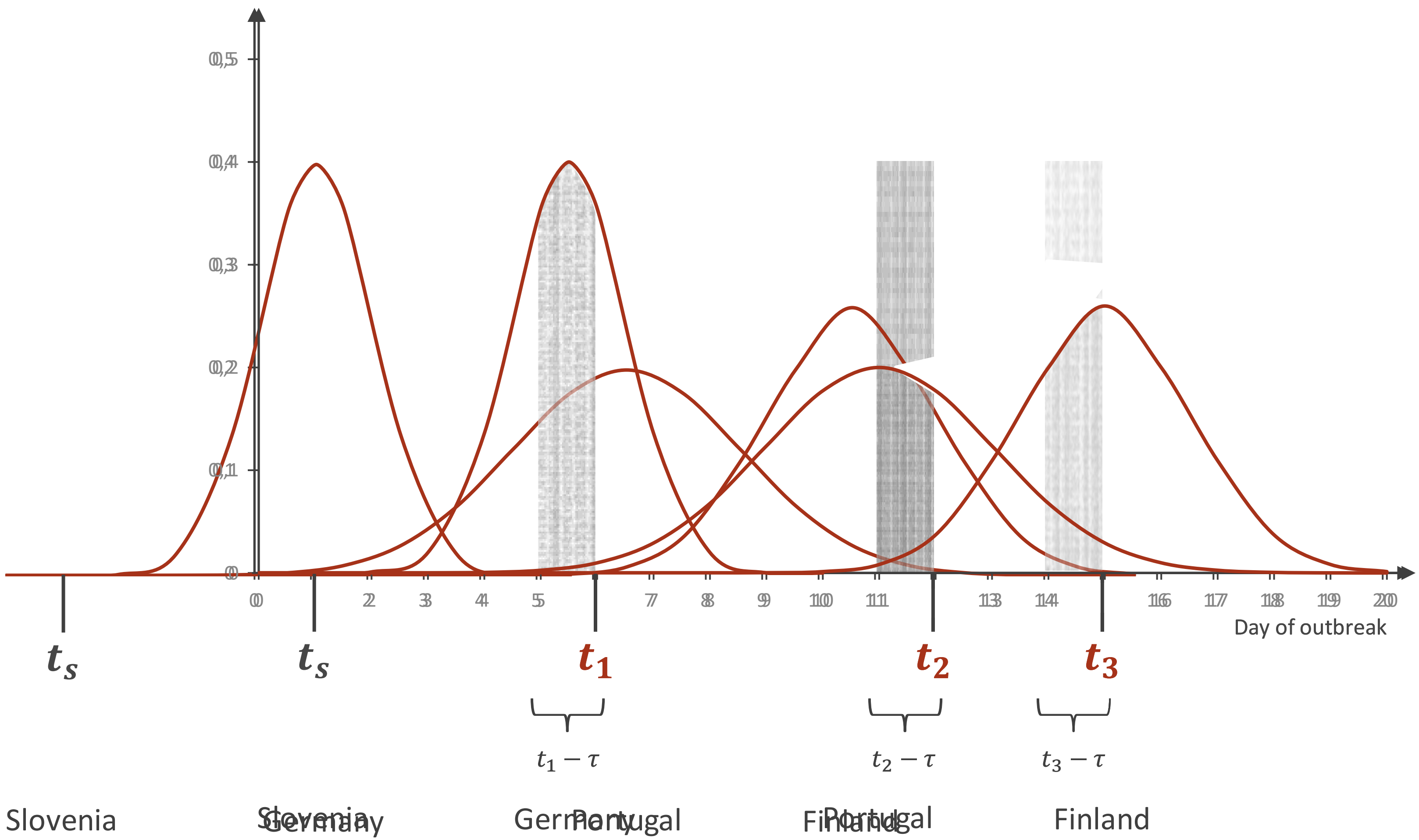


Source: Hansen et al. (2019)

EXAMPLE: LIDL WALNUT BREAD DISTRIBUTED FROM SLOVENIA THROUGHOUT EUROPE

Source: Interim Report Sandra Rudeloff (2021)

USING TRANSPORT AND INVENTORY DATA TO ANALYSE DIFFERENCES IN TIME OF OUTBREAKS

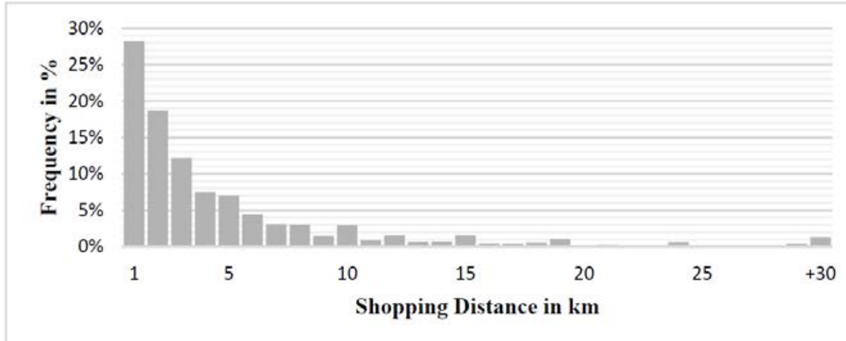


Source: Dissertation Abigail Horn (2017), Interim Präsentation Sandra Rudeloff (2021)

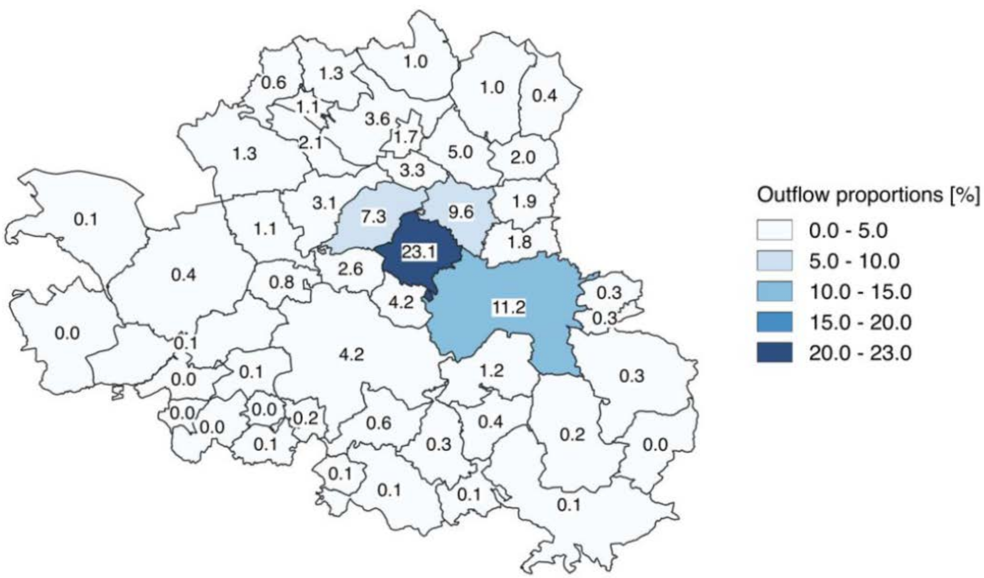
DETAILED DATA ON CONSUMER BEHAVIOUR IS AVAILABLE

- Cash out data (for example GFK)
- Loyalty programs
- Credit card data
- Expense Tracker Apps
- Social network data
- Mobility data (for example from navigation systems)
- …

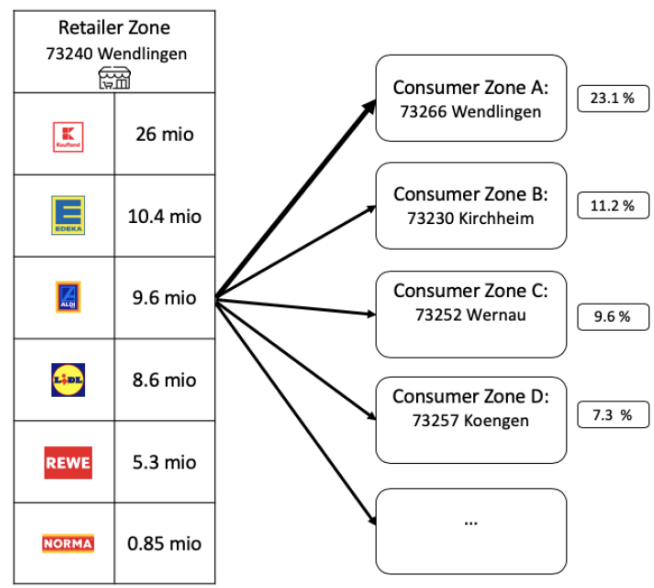
EXAMPLE USING MOBILITY DATA: MODELLING GROCERY SHOPPING IN WENDLINGEN



Modeled proportion of food sales in Wendlingen



Market shares of retailers in Wendlingen



Source: Schlaich, Horn and Friedrich (2020)

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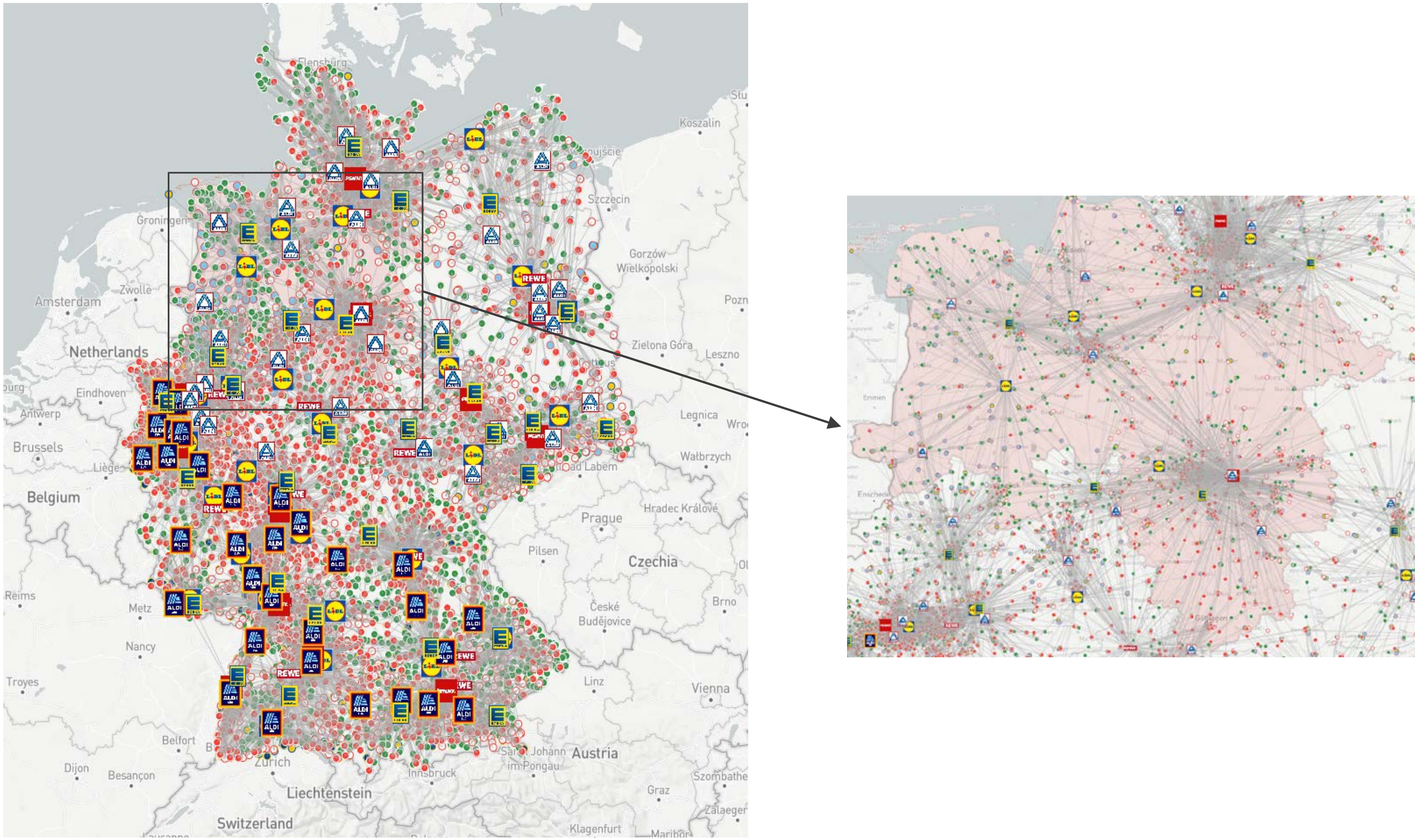
ALSO LOCATION DATA IS WIDELY AVAILABLE…

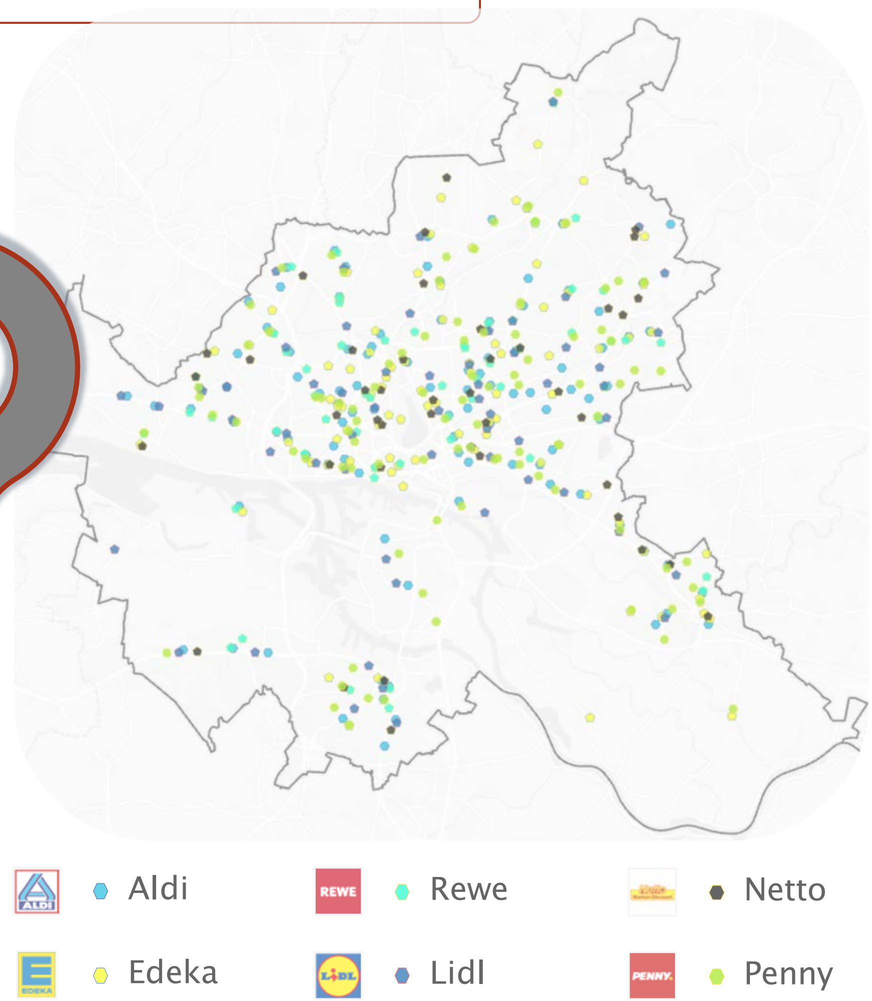


Source: KRITIS-ENV (2024)

… AND CAN BE USED TO COMPARE OUTBREAK AND LOCATION PATTERNS

Outbreak

Food outlet candidates



Source: Presentation Sandra Rudeloff (2024)

CONCLUSIONS / OUTLOOK

- Many opportunities to use logistics data (a lot to be done)
- More data becomes available through digitalization in supply chains
- Challenge: Need to integrate very different data sources
  (new standards and software ecosystems will be helpful here)
- Data gaps will remain and therefore a need to model data
  (especially since analysis in food safety/security often need comprehensive pictures/totals)