

# Pulse of Engagement

Visual Analytics for Economic Health in Engagement, OH

VAST Challenge 2022 – Challenge 3

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December 2025



# Introduction

# VAST Challenge 2022 – Challenge 3

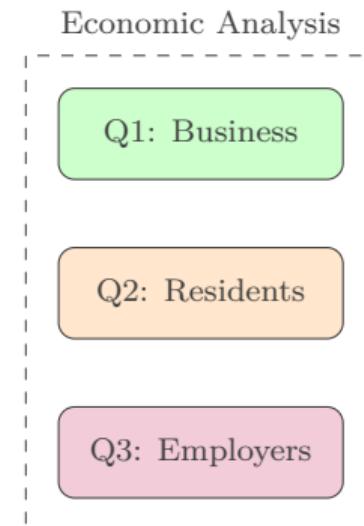
## Introduction

### The Challenge

- Analyze economic health of a fictional city
- Dataset: ~120 million data points
- 15 months of 5-minute granularity data

### Three Questions

1. Business Prosperity
2. Resident Financial Health
3. Employer Health & Turnover



# Question 1: Business Prosperity

# Dashboard Overview

## Question 1: Business Prosperity

### VAST Challenge 3: Economics Dashboard

Business Prosperity

Resident Financial Health

Employer Health & Turnover

### Venue Analytics Dashboard

Restaurant & Pub Performance Intelligence

Analysis Period

Mar 1 — May 31, 2023

TOTAL REVENUE



\$7.27M

TOTAL VISITS



802.980

AVG. PER VISIT



\$9.06

ACTIVE VENUES



32

PROSPERING



9

STRUGGLING



23

Filters

Venue Type

All Types

Venue

All Venues

Customer

All Customers

Metric

Total Spending

Start Date

01.03.2022

End Date

31.05.2023

Sort Top N By

Total Spending

Top N Venues

32

Venue Type: ● Restaurant ● Pub

# ↗ Growth Analysis

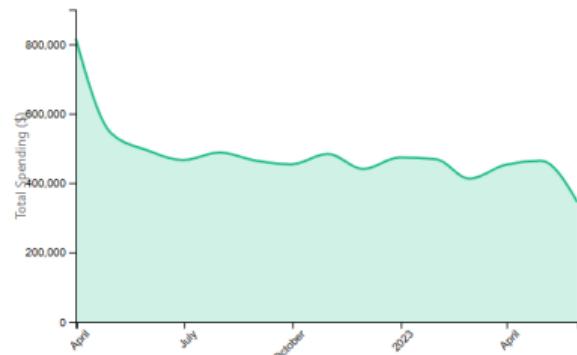
## Question 1: Business Prosperity

### Revenue & Traffic Trends

Check-ins and spending over time



Resolution: Monthly

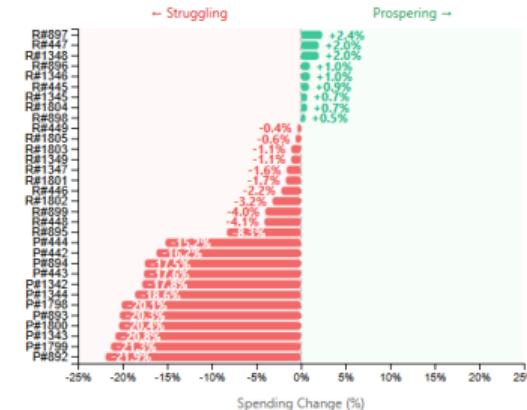


### Business Health Analysis

Prospering vs struggling venues



Comparing spending: Mar 01 - Oct 12 vs Oct 12 - May 25 9 prospering | 23 struggling



**Key Insight:** Revenue drops in April · Business health is heterogeneous:  
 ~1/3 growth ↑    ~1/3 slight decline ↓    ~1/3 significant decline ↓

# Market Concentration

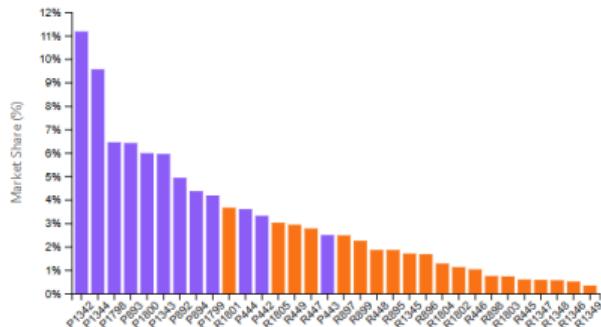
## Question 1: Business Prosperity

### Market Share Distribution

Revenue breakdown by venue

Chart: Bar Chart ▾

Total spending: \$7273740.82 | Showing top 32 venues



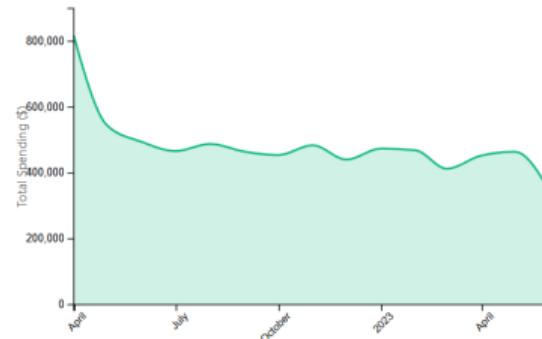
# ⌚ Temporal Trends

## Question 1: Business Prosperity

Revenue & Traffic Trends

Check-ins and spending over time

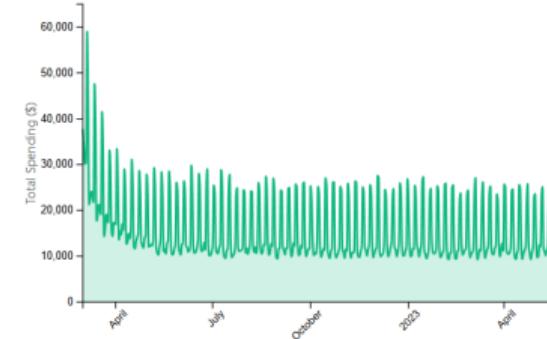
Resolution: Monthly ▾



Revenue & Traffic Trends

Check-ins and spending over time

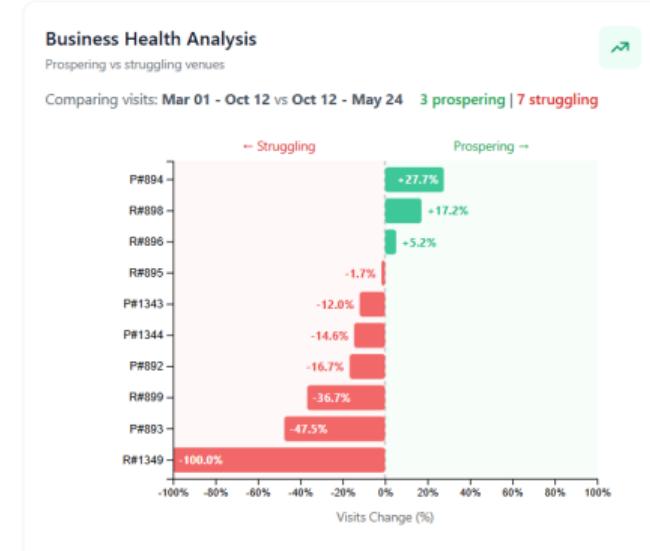
Resolution: Daily ▾



**Key Insight:** Weekend oscillation distinguishes cyclical from structural decline

# Individual Customer Patterns

## Question 1: Business Prosperity



**💡 Micro-level signals:** ❤️ R#896: 26% share · 💼 P#894: +27.7% growth  
 · 🚫 R#1349: abandoned

## 📋 Key Findings

### Question 1: Business Prosperity

#### 👍 Prosperous

- ✓ Pubs outperform restaurants
- ✓ P#1342, P#1344 dominate market

#### 👎 Struggling

- ✗ Top performers decline in H2
- ✗ ~1/3 show substantial drops



**Overall:** Aggregate spending declining over 15 months

# ❖ Design Rationale

Question 1: Business Prosperity

## ☰ Visualization Progression

- ⌚ Overview → establish baseline context
- ⌚ Temporal filtering → identify patterns over time
- ⌚ Individual detail → surface micro-level signals

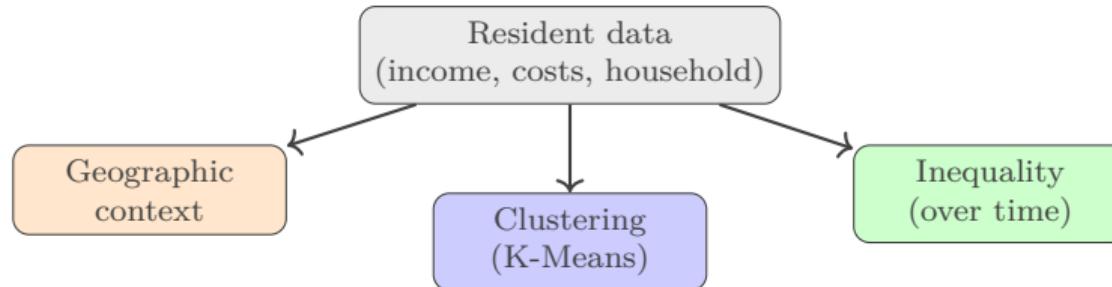
## ⚙️ Key Design Decisions

- ⌚ Coordinated views: hover-linking for cross-chart exploration
- ⌚ Split-period comparison: quantifies growth directly
- ⌚ Global filters: all-to-all, one-to-all, one-to-one analysis
- ⌚ Dual metrics: visits and spending reveal correlation

# Question 2: Resident Financial Health

## Q2: Analysis Approach

### Question 2: Resident Financial Health



- Building heatmap
- Savings by location
- Identify red zones
- Wage vs. cost features
- K-Means segmentation
- Personas & drivers
- Expense dynamics over time
- Inequality trends (Gini)
- Income vs. expenses

# Geographic Financial Health

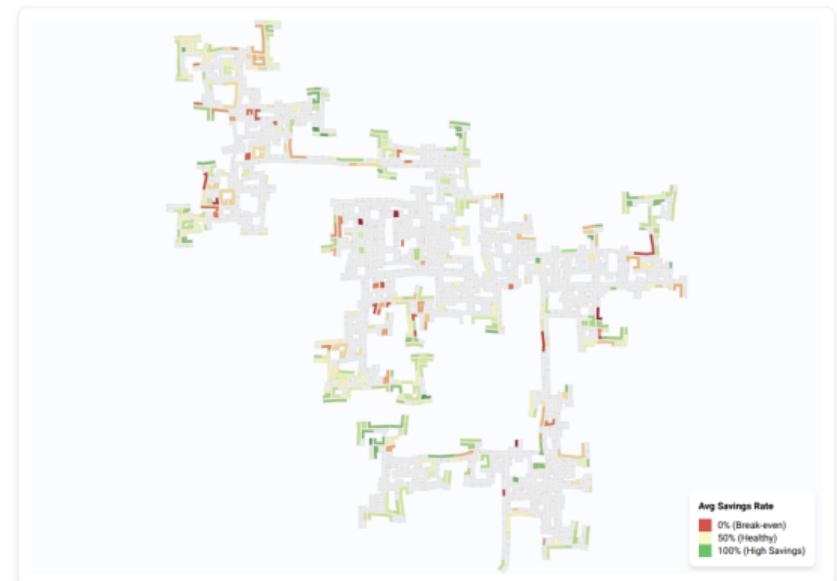
Question 2: Resident Financial Health

## Building-Level Heatmap

- Colors by average savings rate
- Red: break-even or negative
- Yellow: moderate savings
- Green: high savings

## Insights

- “Red pockets” persist over time
- Chronic, not worsening, conditions
- Mini-clusters suggest local stressors



# Resident Profile: Affluent Achievers

## Question 2: Resident Financial Health

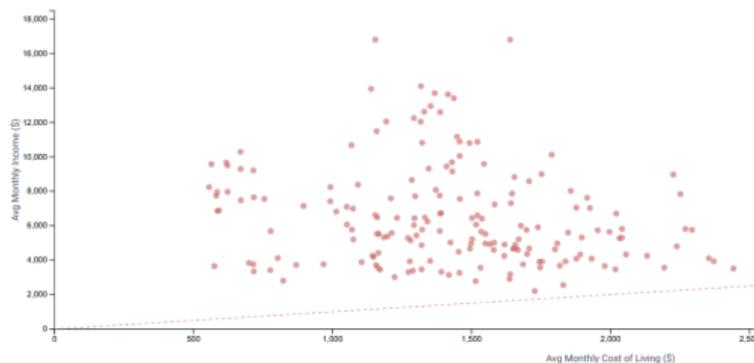
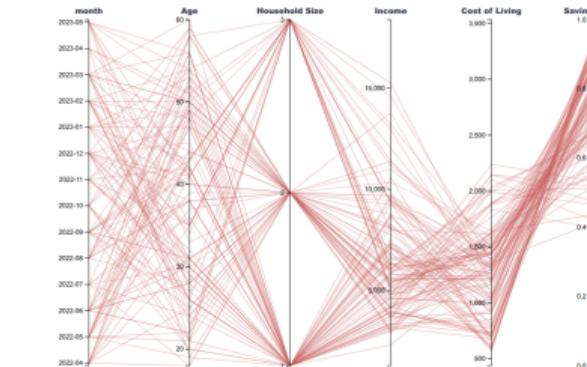
### Affluent Achievers

#### Main Characteristics

- High income levels
- Predominantly graduate education
- Significant financial buffer

#### Median Statistics (Apr 2022)

- Income: \$5,756
- Cost: \$1,419
- Savings: 76.6%



# Resident Profile: Stretched Households

## Question 2: Resident Financial Health

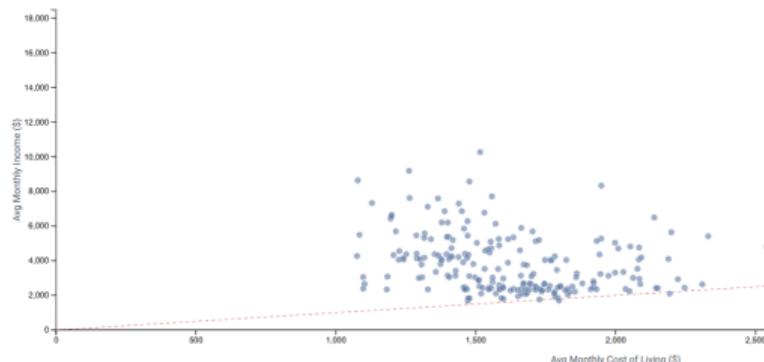
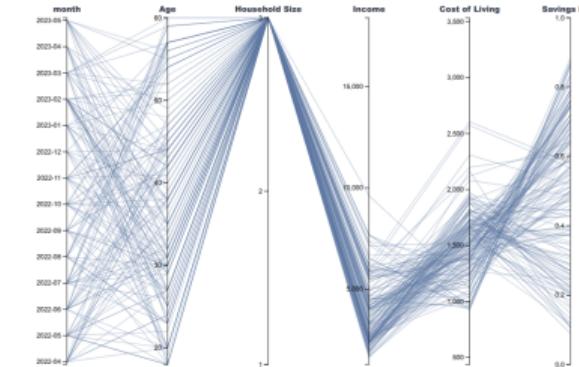
### Stretched Households

#### Main Characteristics

- Larger households, often with children
- Tightest budget constraints
- "Living Gap" pressure is highest here

#### Median Statistics (Apr 2022)

- **Income:** \$2,869
- **Cost:** \$1,405
- **Savings:** 51.0%



# Resident Profile: Lean Savers

## Question 2: Resident Financial Health

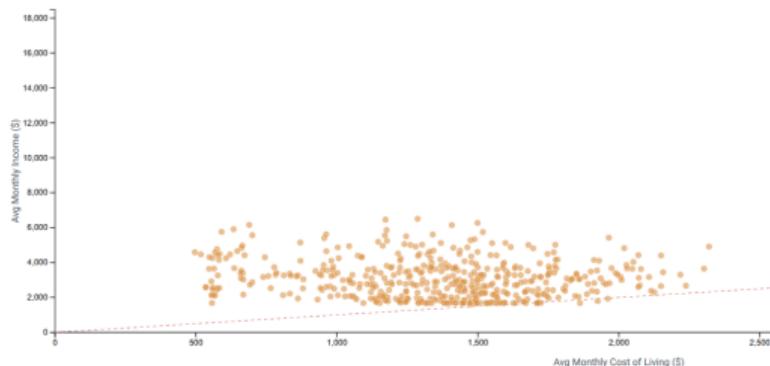
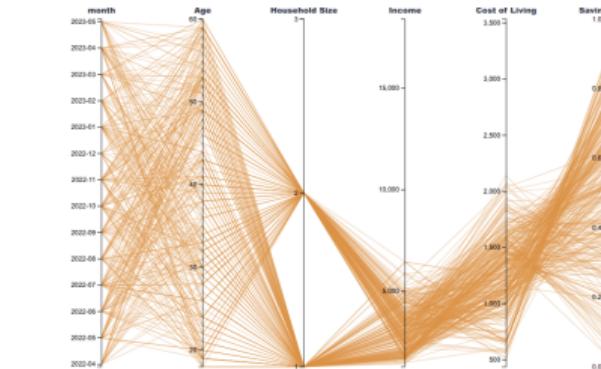
### Lean Savers

#### Main Characteristics

- Smaller households
- Typically without children
- Moderate income, but lower costs than families

#### Median Statistics (Apr 2022)

- **Income:** \$3,352
- **Cost:** \$1,586
- **Savings:** 54.5%



# What Drives Savings?

## Question 2: Resident Financial Health

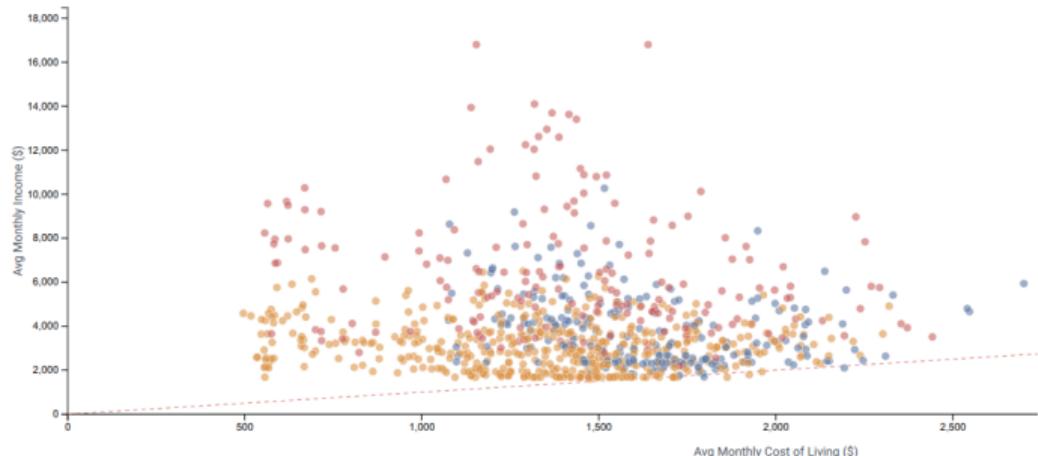
### Demographic Drivers

#### Savings rate predictors ( $\Delta R^2$ )

- Cost of living (0.828)
- Income (0.408)
- Household size (0.376)
- Has kids (0.127)

#### Cluster separators ( $\eta^2$ )

- Has kids (83.1%)
- Graduate education (72.0%)
- Household size (61.9%)
- Income (38.0%)



# Inequalities Over Time

## Question 2: Resident Financial Health

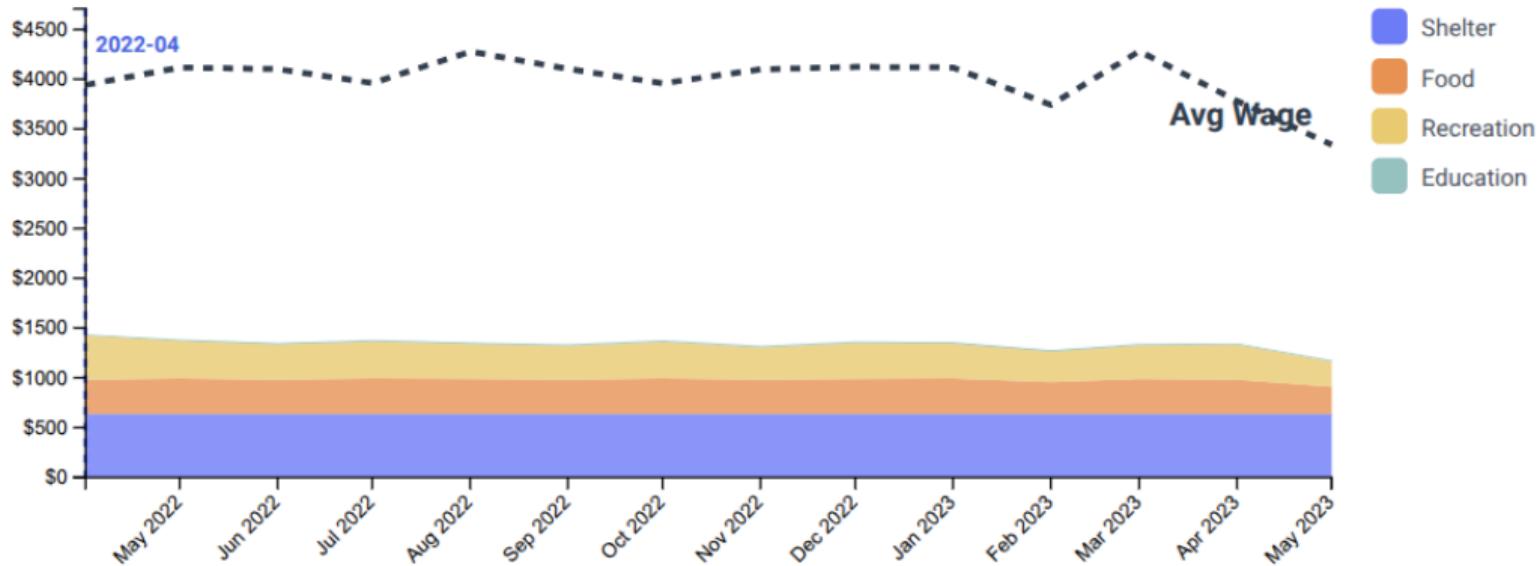


## Inequality Trends

- Gini coefficient tracks disparity
- Income inequality stable over time
- Savings inequality slightly higher

# Expense Dynamics Over Time

Question 2: Resident Financial Health



# Question 3: Employer Health

# Employer Health: Methodology & Approach

## Question 3: Employer Health

### Workforce Dynamics

- Turnover, hires, quits, net change
- Identifies extreme churn and instability
- Focus on employer-level change intensity

### Stability & Retention

- Turnover vs. average tenure
- Headcount as contextual factor
- Distinguishes stable vs. high-risk employers

### Mobility & Context

- Job-to-job flows between employers
- Geographic concentration of churn
- City-level employment and economic scale

# Employer Turnover Ranking

## Question 3: Employer Health

### Ranking Methodology

- Ranks employers by turnover, hires, quits, or net change
- Focuses on upper tail of workforce churn
- Highlights extreme instability cases

### Key Observation

- Some employers exceed 100% turnover
- Driven by small average headcounts
- Indicates intense, concentrated churn



# Turnover vs. Workforce Tenure

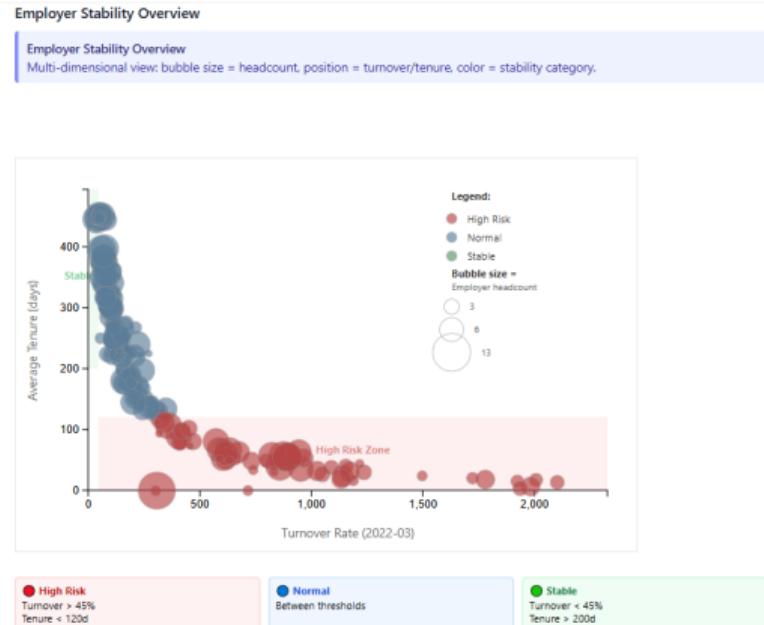
## Question 3: Employer Health

### Inverse Relationship

- Clear separation into two regimes
- **Stability Zone:** low turnover, high tenure
- **Instability Zone:** high turnover, low tenure

### Bubble Size

- Encodes employer headcount
- Size alone does not guarantee stability
- High-risk large employers amplify impact



# Worker Mobility Between Employers

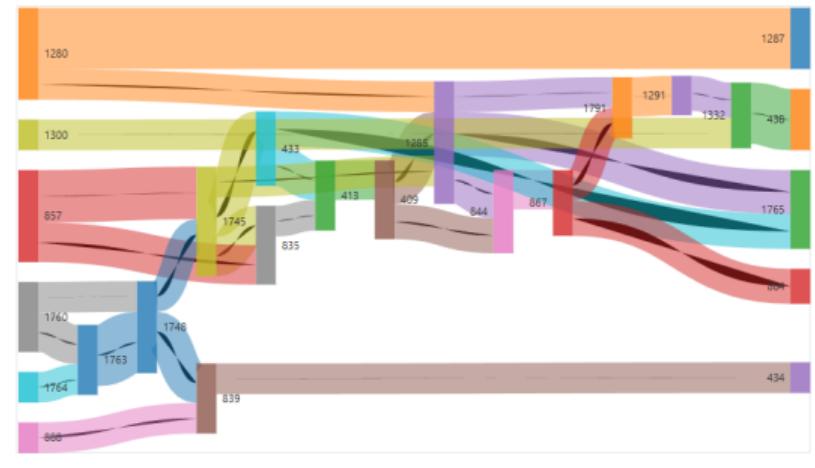
## Question 3: Employer Health

### Job-to-Job Flows

- Directional worker movement
- Some employers act as labor sources
- Others function as recipients

### Network Effects

- Worker movement links employers
- Instability propagates through network
- Asymmetry reveals labor market structure



# Short-Term Workforce Growth & Decline

## Question 3: Employer Health

### Non-highlighted View



# Geographic Concentration of Employer Instability

Question 3: Employer Health

## Building-Level Aggregation

- Turnover aggregated to building level
- Clear spatial hotspots visible
- Identifies localized instability clusters



## Implications

- Workforce instability concentrates spatially
- Not uniformly distributed across city
- Suggests local economic stressors

# Design Decisions

# Tech Stack

Design Decisions

## Frontend

- **React 18:** Component architecture
- **D3.js v7:** Visualization rendering
- **TailwindCSS:** Styling
- **Axios:** API communication

## Infrastructure

- **Docker Compose:** Orchestration
- **Nginx:** Reverse proxy

## Backend

- **Python 3.11:** Core language
- **Flask:** REST API
- **Pandas/NumPy:** Data processing
- **Scikit-learn:** K-Means clustering
- **Pytest:** Testing



# Team Organization

# Work Organization

## Team Organization

### Division of Work

- One question per team member
- Shared infrastructure setup
- Code reviews via Git

**Thomas** Q1: Business Prosperity

**Jan** Q2: Resident Financial Health

**Michal** Q3: Employer Health

### Shared Components

- Docker infrastructure
- API structure
- Test framework

### Communication

- Regular syncs and feedback
- Clear API contracts

# Lessons Learned

# Lessons Learned

## Lessons Learned

### 👍 What Worked Well

- ✓ Docker for reproducibility
- ✓ Clear question separation
- ✓ Caching for large datasets
- ✓ Test-driven development

### ⚠ Challenges

- 🟡 Large dataset with uneven distributions
- 🟡 Balancing detail vs. overview
- 🟡 Pre-processing for real-time usage

### ⌚ Would Do Differently

- 🔴 More upfront data profiling

# Thank You!

Questions?

Thomas Gantz

Q1: Business

Jan Marxen

Q2: Residents

Michal Sterzel

Q3: Employers

 [github.com/janmarxen/VAST-challenge](https://github.com/janmarxen/VAST-challenge)

Data Visualization – EUMaster4HPC – December 2025