Pulse of Engagement

Visual Analytics for Economic Health in Engagement, OH

VAST Challenge 2022 – Challenge 3

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Introduction

VAST Challenge 2022 – Challenge 3

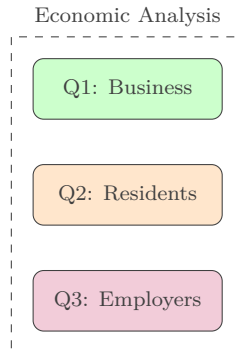
Introduction

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



Our Solution: Pulse of Engagement

Introduction

[**SCREENSHOT: Main Dashboard Overview**]
Show the tabbed interface with all three question areas

Interactive web application built with **React + D3.js** frontend and **Python Flask** backend

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Question 1: Business Prosperity

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Q1: Business Prosperity

Question 1: Business Prosperity

[PLACEHOLDER FOR THOMAS]

- Which businesses are thriving vs. struggling?
- Revenue trends over time
- Market share evolution

[**SCREENSHOT: Business Visualizations**]

Q1: Key Findings

Question 1: Business Prosperity

[PLACEHOLDER FOR THOMAS]

Prosperous Businesses

eammate

Struggling Businesses

To be filled by teammate

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Question 2: Resident Financial Health

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Q2: Analysis Approach

Question 2: Resident Financial Health

Three Complementary Lenses

Geographic

- Building heatmap
- Savings by location
- Identify red zones

Demographic

- Wage vs. cost
- K-Means clustering
- Education link

Trajectories

- Income vs. expenses
- Inequality trends
- Time evolution

Geographic Financial Health

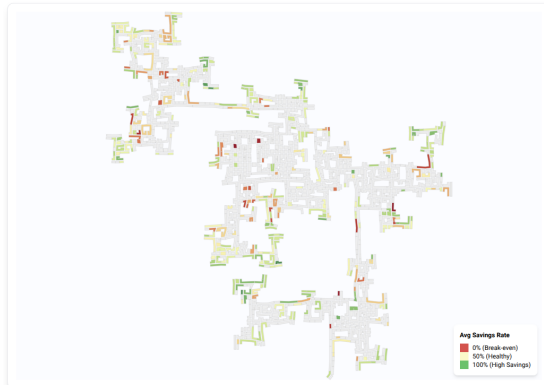
Question 2: Resident Financial Health

Building-Level Heatmap

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

Insights

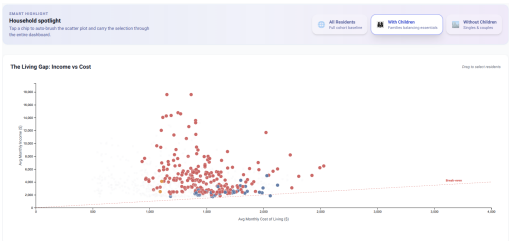
- “Red pockets” persist over time
- Chronic, not worsening, conditions
- Mini-clusters suggest local stressors



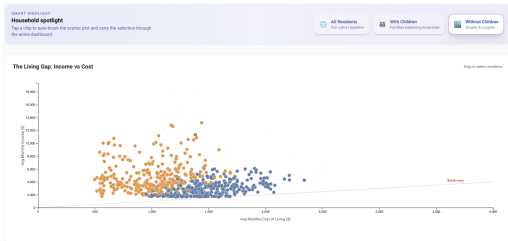
The “Living Gap” Analysis

Question 2: Resident Financial Health

With Children



Without Children



Diagonal = break-even • Families with children cluster near the line • Singles have more margin

Cluster Patterns: Three Resident Profiles

Question 2: Resident Financial Health

K-Means Clustering

Affluent Achievers

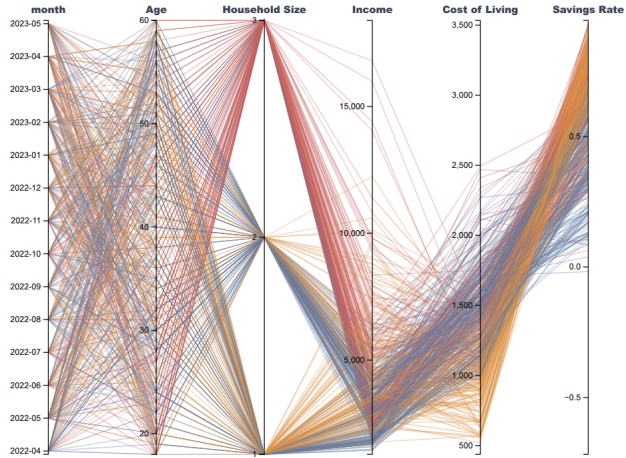
- High incomes, controlled costs

Stretched Households

- Lower income, little room to save

Lean Savers

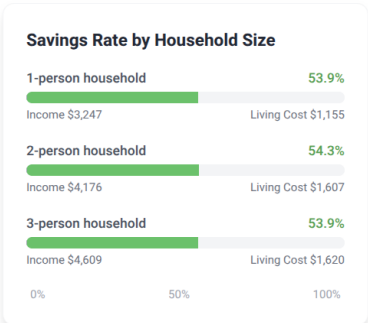
- Singles, average income, low costs



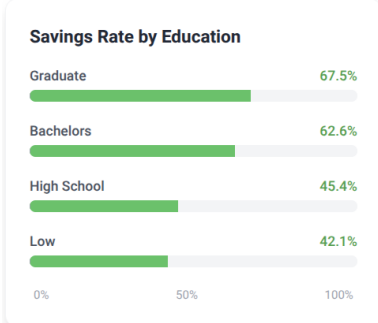
Savings Drivers: Household Size vs. Education

Question 2: Resident Financial Health

Household Size



Education Level



- Household size shows only minor differences in savings behavior.
- Education level shows a clearer pattern: higher education is associated with higher savings and greater financial resilience.

Inequalities Over Time

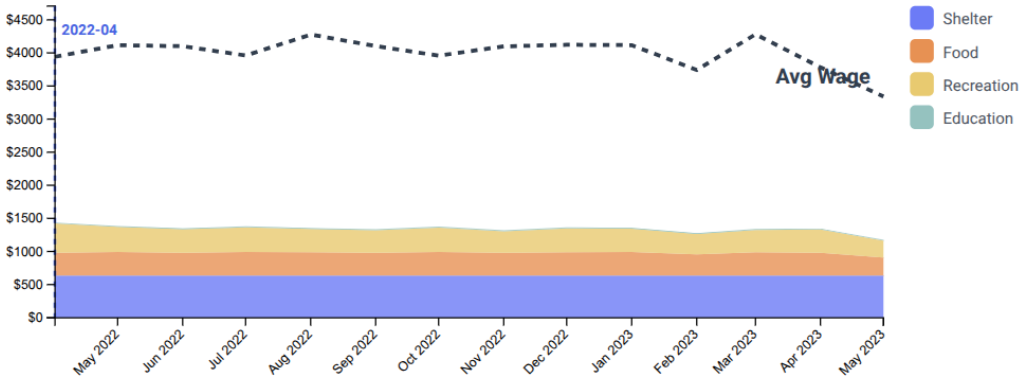
Question 2: Resident Financial Health

Inequality Trends

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

Expense Dynamics Over Time

Question 2: Resident Financial Health



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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

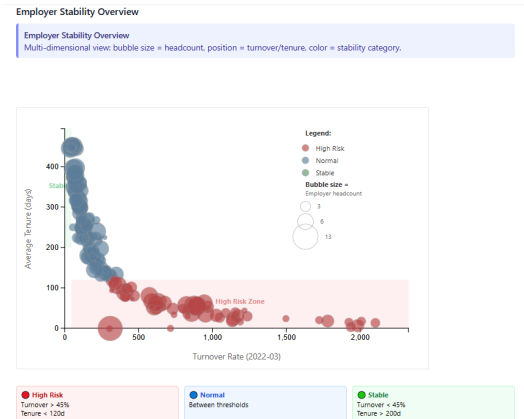
Question 3: Employer Health

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

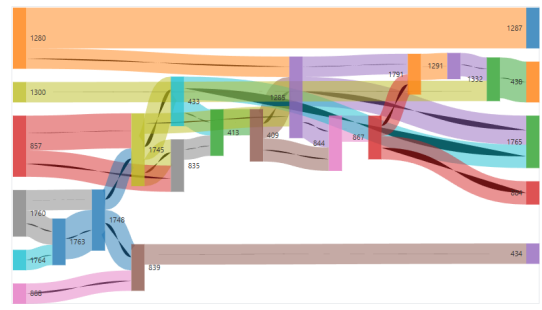
Question 3: Employer Health

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

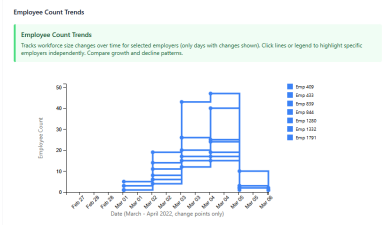


Short-Term Workforce Growth & Decline

Question 3: Employer Health

Non-highlighted View

Highlighted View



- Step-line chart: only days with changes
- Abrupt spikes and drops
- Reflects short-term, episodic workforce adjustments within the observed period

Geographic Concentration of Employer Instability

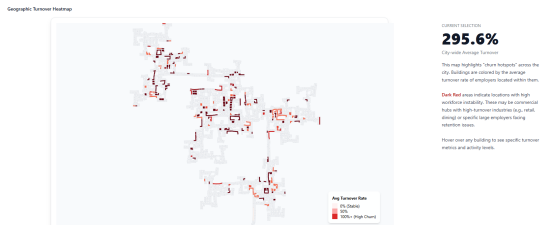
Question 3: Employer Health

Building-Level Aggregation

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

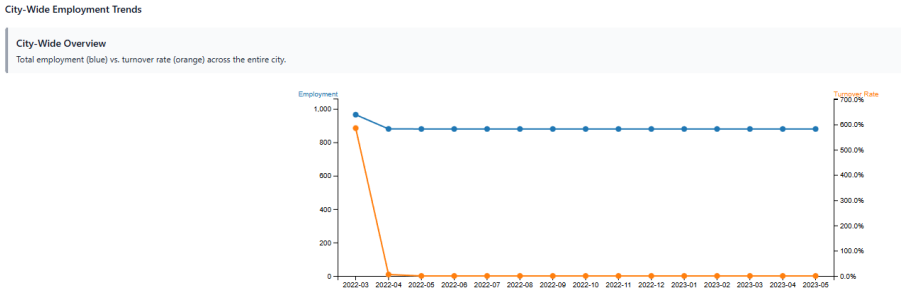
Implications

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



City-Wide Employment Context

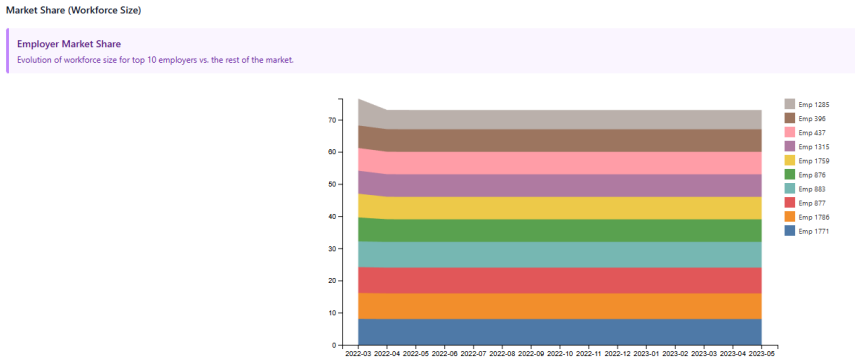
Question 3: Employer Health



Indicates workforce reallocation and churn rather than city-wide employment collapse.

Employer Market Share

Question 3: Employer Health



After the initial workforce shift, top employer concentration remains stable.

Estimated Monthly Payroll

Question 3: Employer Health

Adds economic scale to the analysis, highlighting the impact of large employers.

Design Decisions

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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

Key Design Decisions

Design Decisions

Visualization Choices

- **Tabbed interface**
  Separate concerns per question
- **Global time slider**
  Consistent temporal context
- **Linked views**
  Brushing propagates across charts
- **Color consistency**
  Same cluster colors everywhere
- **Color consistency**
  TODO: Add more points here

Data Processing

- **Monthly aggregation**
  Reduce 120M rows to manageable size
- **Caching**
  Pickle cache for expensive computations
- TODO: Add more points here

Interactive Features

Design Decisions

[**SCREENSHOT: Interactive Features Demo**]
Show hover tooltips, time slider, household filter chips

Hover tooltips

Time slider

Smart filters

Team Organization

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Work Organization

Team Organization

Division of Work

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

Thomas	Q1: Business Prosperity
Michal	Q3: Employer Health
Jan	Q2: Resident Financial Health

Shared Components

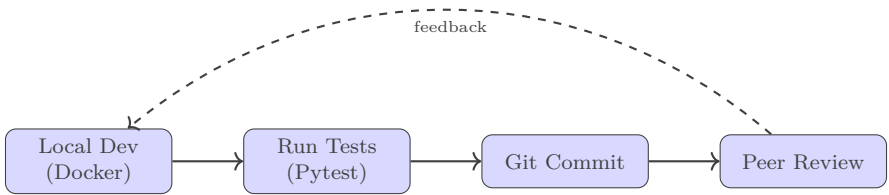
- Docker infrastructure
- API structure
- Test framework

Communication

- Regular syncs and feedback
- Clear API contracts

Development Workflow

Team Organization



Testing Strategy

- Backend: Pytest for each router (business, resident, employer)
- Docker Compose test configuration
- Tests run before each commit

Lessons Learned

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Lessons Learned

What Worked Well

- ✔ Docker for reproducibility
- ✔ Clear question separation
- ✔ Caching for large datasets
- ✔ React + D3 integration
- ✔ Test-driven development

Challenges

- ✖ TODO

Would Do Differently

- TODO

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Thank You!

Questions?

Thomas Gantz — Q1: Business

Michal Sterzel — Q3: Employers

Jan Marxen — Q2: Residents

github.com/janmarxen/VAST-challenge