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

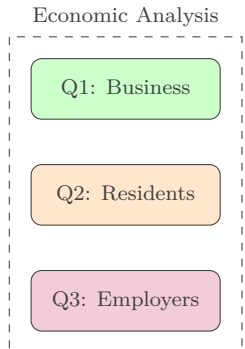
Introduction

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



Question 1: Business Prosperity

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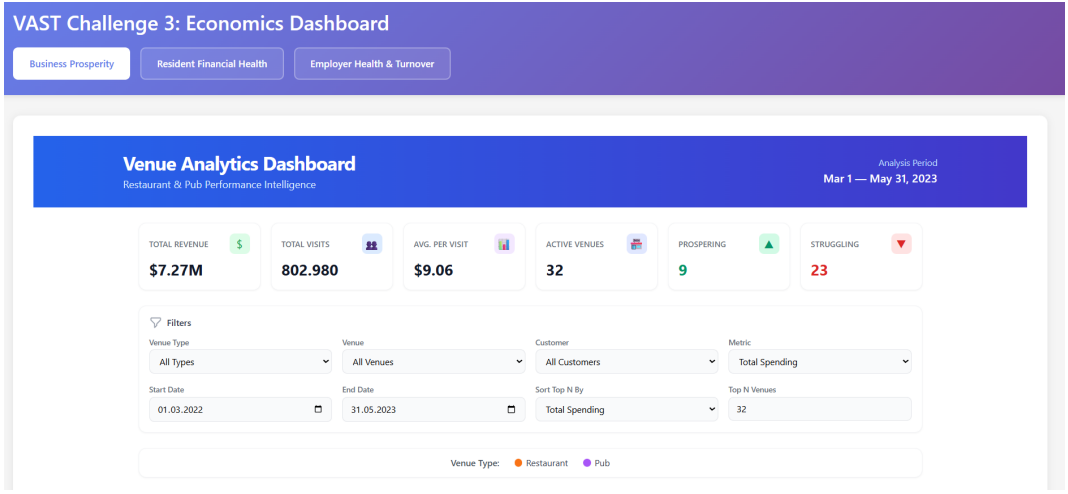
Dashboard Overview

Question 1: Business Prosperity



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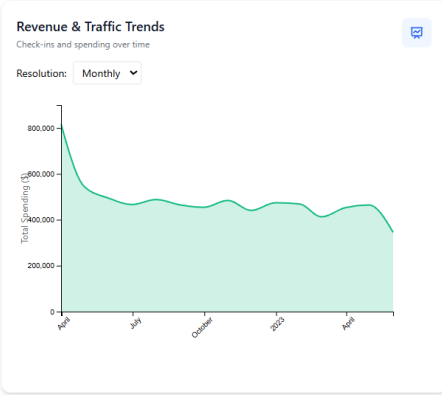
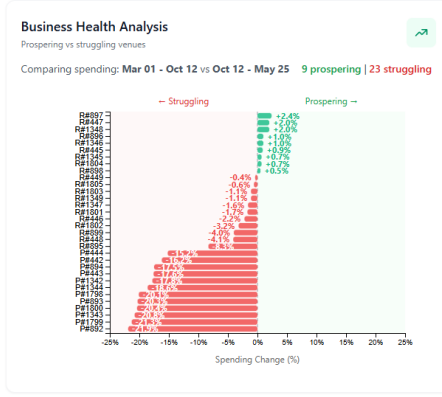
Growth Analysis

Question 1: Business Prosperity

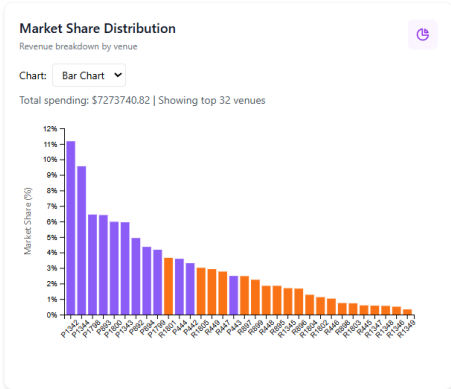




Key Insight: Revenue drops in April · Business health is heterogeneous:
~1/3 growth ↑ ~1/3 slight decline ↓ ~1/3 significant decline ↓

Market Concentration

Question 1: Business Prosperity



Key Insight: Two pubs capture 20% of total spending · Pubs dominate restaurants

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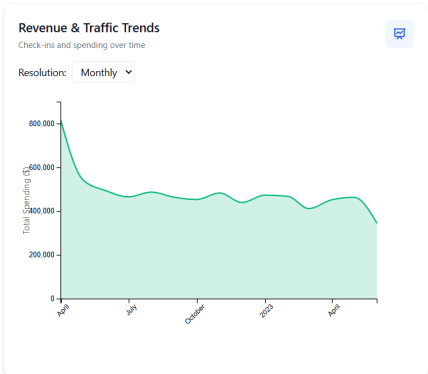
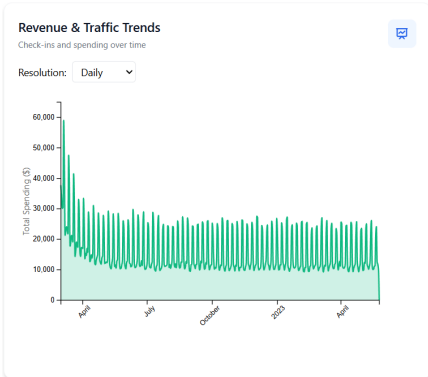
Temporal Trends

Question 1: Business Prosperity

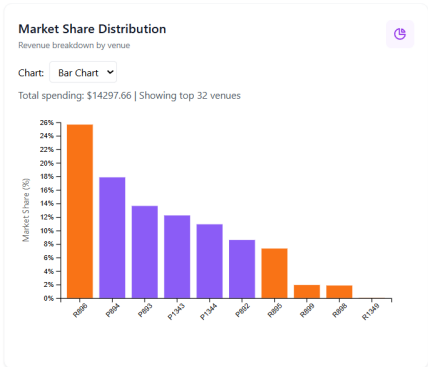


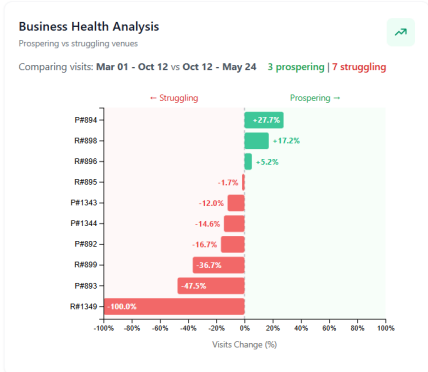


Key Insight: Weekend oscillation distinguishes cyclical from structural decline

Individual Customer Patterns

Question 1: Business Prosperity





Micro-level signals: ♥ R#896: 26% share · P#894: +27.7% growth · R#1349: abandoned

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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

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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

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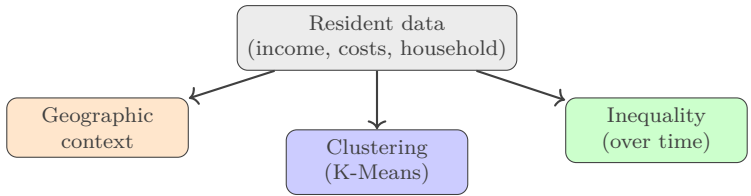
Question 2: Resident Financial Health

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

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Geographic Financial Health

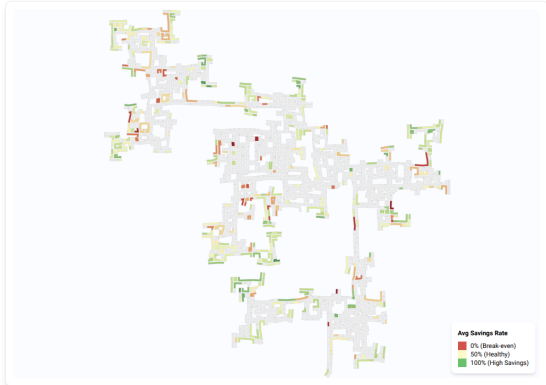
Question 2: Resident Financial Health

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

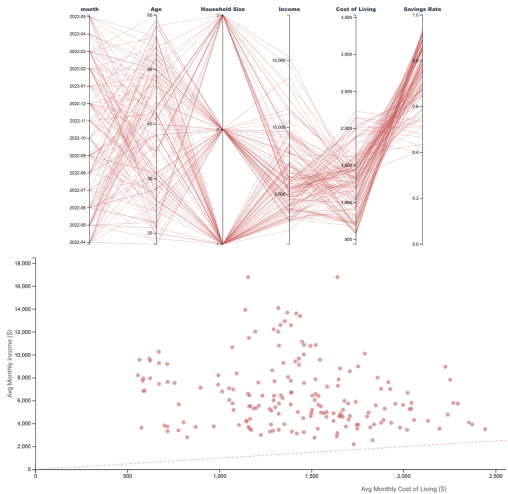
Affluent Achievers

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

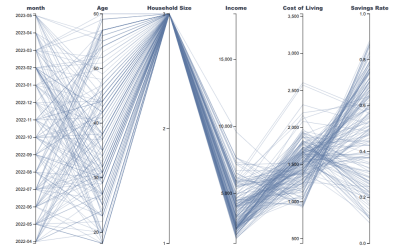
Stretched Households

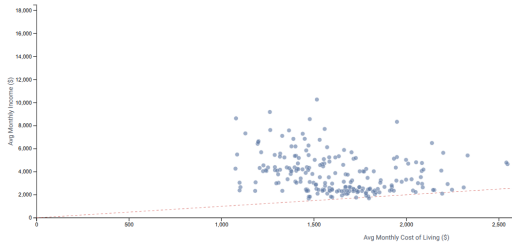
Main Characteristics

- 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

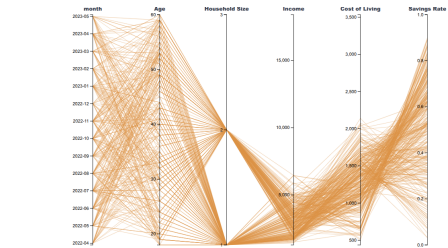
Lean Savers

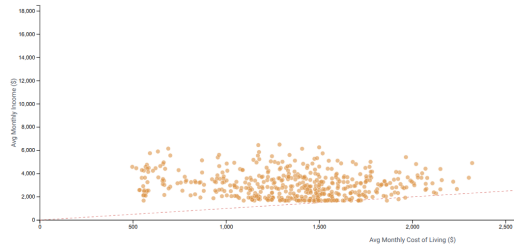
Main Characteristics

- 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

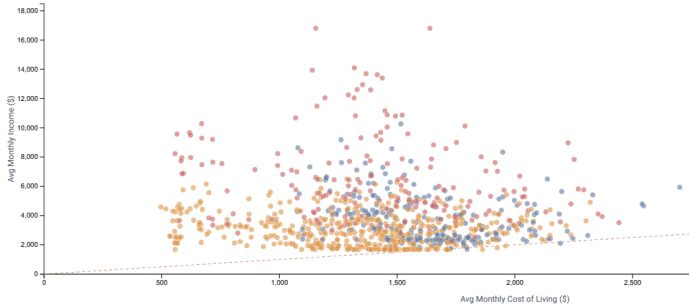
Demographic Drivers

Savings rate predictors (ΔR^2)

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

Cluster separators (η^2)

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



Inequalities Over Time

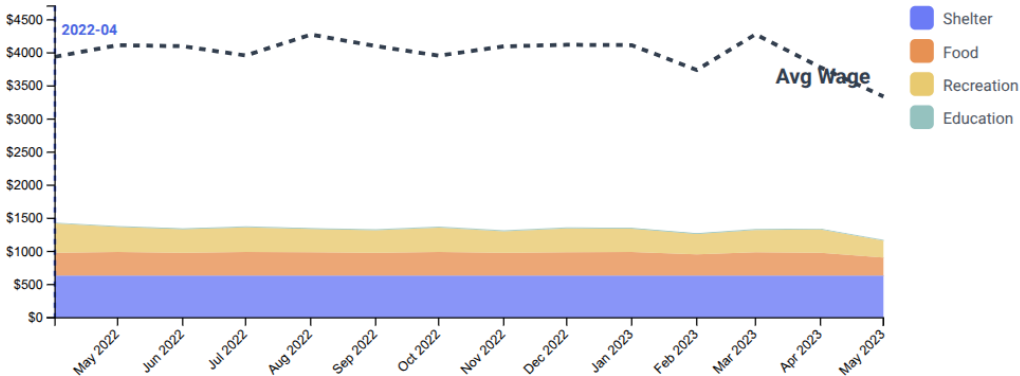
Question 2: Resident Financial Health

Inequality Trends

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

Expense Dynamics Over Time

Question 2: Resident Financial Health



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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

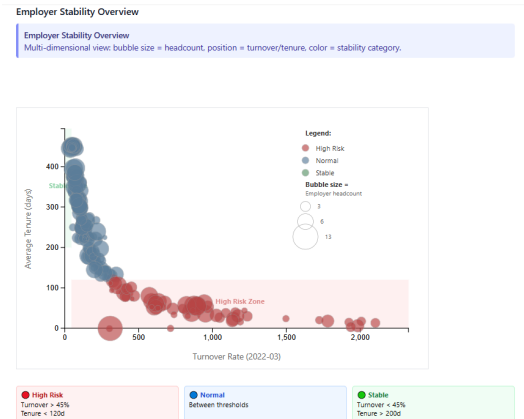
Question 3: Employer Health

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

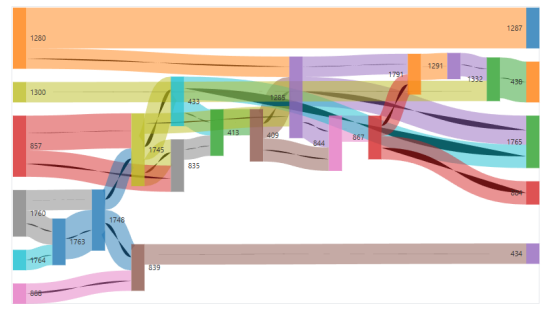
Question 3: Employer Health

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

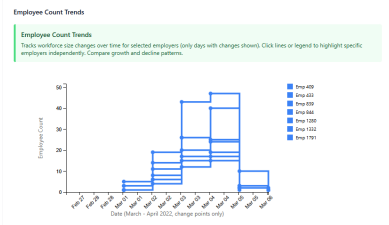


Short-Term Workforce Growth & Decline

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

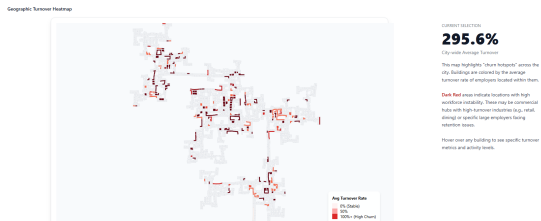
Question 3: Employer Health

Building-Level Aggregation

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

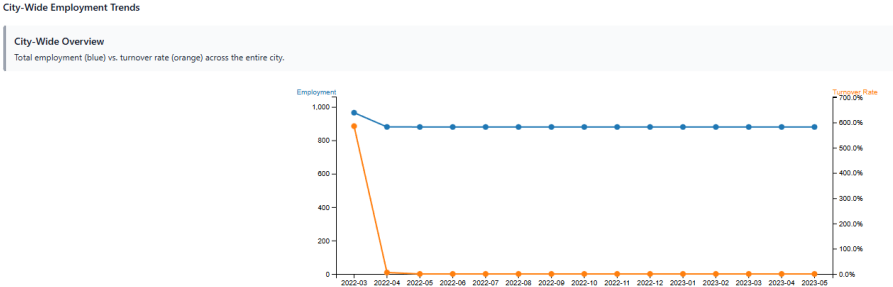
Implications

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



City-Wide Employment Context

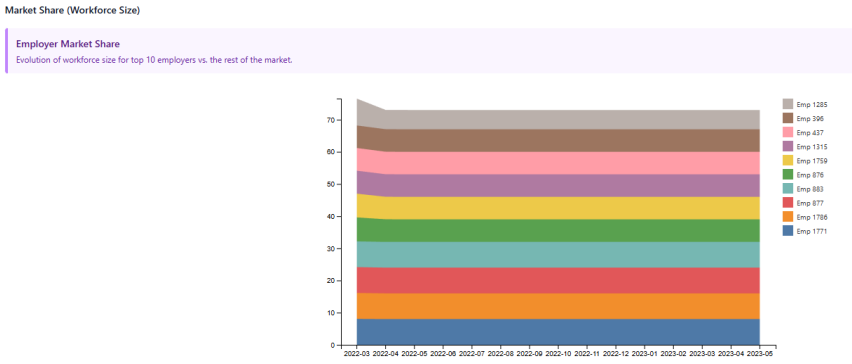
Question 3: Employer Health



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

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

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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
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

- ✖ TODO

Would Do Differently

- TODO

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Thank You!

Questions?

Thomas Gantz — Q1: Business

Jan Marxen — Q2: Residents

Michal Sterzel — Q3: Employers

github.com/janmarxen/VAST-challenge