Local Market Effects with Heterogeneous Expectations

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Motivation

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- Macroeconomics models (DSGE, VAR) assume FIRE agents with instant price adjustment and perfect competition[2]
    - Shown to have little policy power and limited applications in practice
- Local information creates unique opportunities[1]
    - Knowledge of "time and place" driven by supply-demand dynamics
    - For example, arbitrage from local differences in prices
- ABMs can help bridge this gap, acting as a complement to analytical models
    - Spatial models can account for search costs & market frictions
    - Adaptation enables a more truthful representation of an economy

ODD - Entities, Variables, & Scales

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- *Consumer logic*
  - Consume a portion of wealth
  - Price is the main determinant of decision
  - Receive wage every 24 hours
  - Choose target market based on prices
- *Producer logic*
  - Supply based on past demand
  - Choose target market based on demand
- *Market properties*
  - Receive supply and offer it at a unit-price
  - Price set based on supply-demand dynamics

Agent Type	Variable	Initialization
Consumers	wealth	$\sim$ Normal$(500, 50)$
	wage	$\sim$ Normal$(300, 15)$
	price-expectations	$\sim$ Uniform$\{$"up","stay","down"$\}$
	debt	~ 0
	demand	~ 0
	unmet-demand	~ 0
	last-price-paid	~ 0
	origin-x	Set based on household patch[1]
	origin-y	Set based on household patch[1]
	target-market	$\sim$ *Nobody*
	steps-to-market	~ 0
	state	"moving-to-market" initially
	ticks-at-market	~ 0
Producers	output	~ 0
	costs	Cost of supplying output[2]
	capacity	~ 150
	demand-expectations	$\sim$ Uniform$\{$"up","stay","down"$\}$
	last-demand-supplied	~ 0
	origin-x	Set based on factory patch
	origin-y	Set based on factory patch
	target-market	$\sim$ *Nobody*
	steps-to-market	~ 0
	state	"moving-to-market" initially
	ticks-at-market	~ 0
Market Patches	quantity-available	Minimal stock level[3]
	unit-price	Base price[4]
	market-capacity	Geographical and economic factors[5]

Table 1

ODD - Submodules

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- *Search Problem*
  - Find closest market, switch if no longer affordable
- *Consumer Problem*
  - Decide how much to demand based on 1) price expectations and 2) debt level
- *Producer Problem*
  - Decide how much to supply based on 1) demand expectation, and 2) market capacity
- *Price adjustment*
  - Each market adjusts unit price based on local demand/supply

Category	Submodule	Purpose
Creating	create-households	Initializes consumer agents in household patches.
	create-markets	Initializes market patches.
	create-factories	Initializes producer agents in factory patches.
Movement	determine-target-market	Determines the target market for each agent based on proximity and other factors.
	move-towards-market	Moves agents towards their chosen market.
	return-to-origin	Sends agents back to their starting points after completing their market activities.
	return-to-market	Determines when agents should head back to the market from their origin.
Market Interactions	consumer-decision	Manages the purchasing decisions of consumers based on current market conditions and personal circumstances.
	producer-decision	Manages the production and pricing decisions of producers based on market demand and other factors.
Adjustments	new-price	Adjusts the price in market patches based on supply and demand dynamics.
	adjust-expectations	Updates the expectations of agents based on market outcomes and experiences.

Demo + Design Concepts

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- 25x25 grid – origin at center – 8 patch size
- Prices **emerge**
- **Stochastic** adaptation
- Agents **learn**:
  - Last price paid
  - Last demand supplied
- Agent **adapt** to:
  - Local information
  - Average statistics
- Consumers and Producers **interact** at markets
 - Through supply-demand
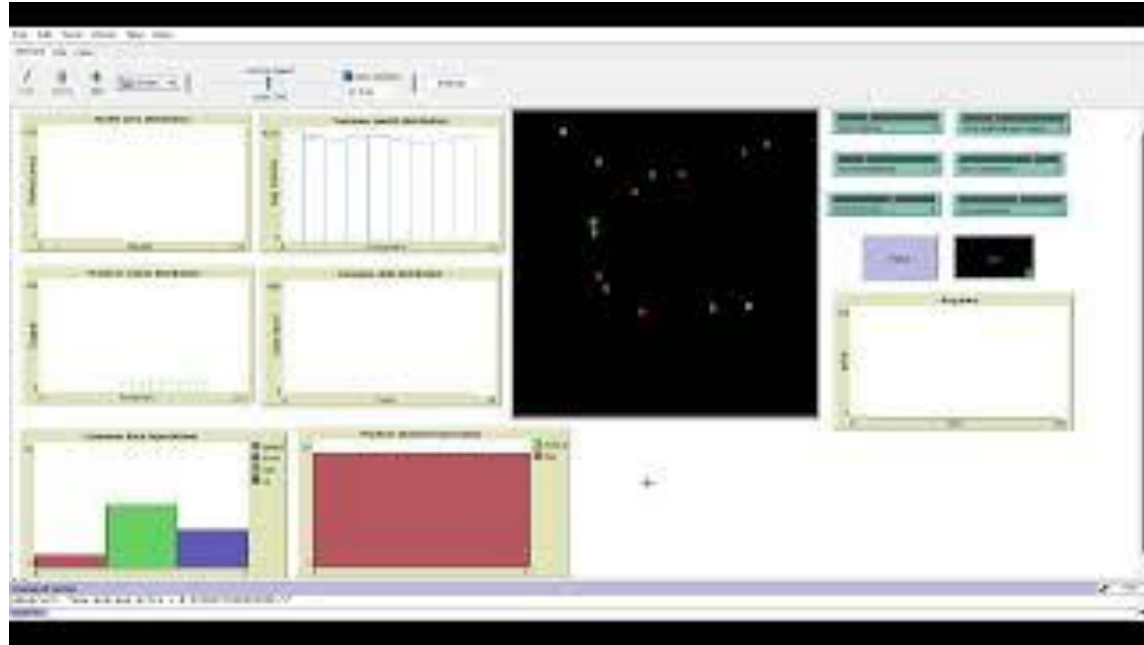
Experiments & Analysis

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- Experiment 1: Changes in consumer expectations from varying number of households and consumers
  - ["num-consumers" [1 2 6]]
  - ["num-households" [1 1 4]]
  - *Report* frequency of "up", "stay", and "down" price expectations aggregated over all consumers each tick

- Hypothesis:
  - Competition grows with the number of consumers in the local economy, which drives prices down, and thus a higher count of consumers expecting prices to go down.

Results (Consumer Expectations)

Results (Consumer Expectations)

Correlation Matrix of Total Consumers and Expectations
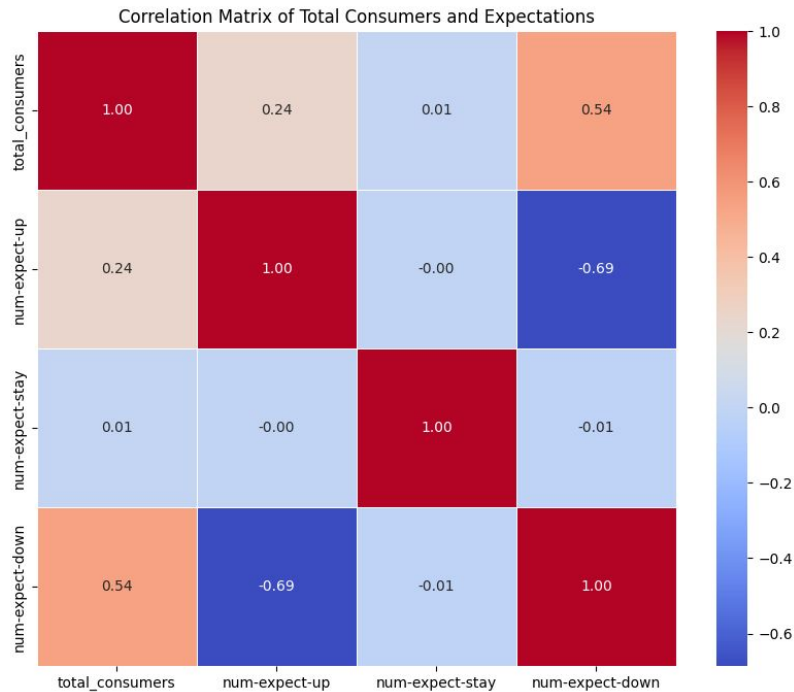
Average Expectation Distribution Over Runs
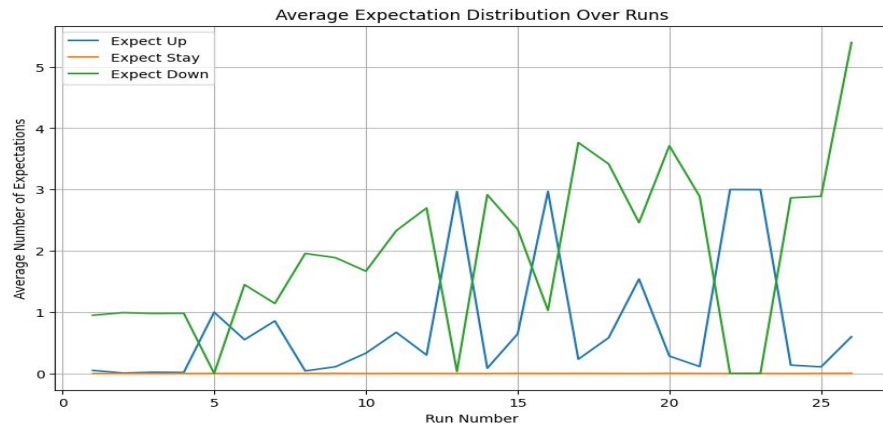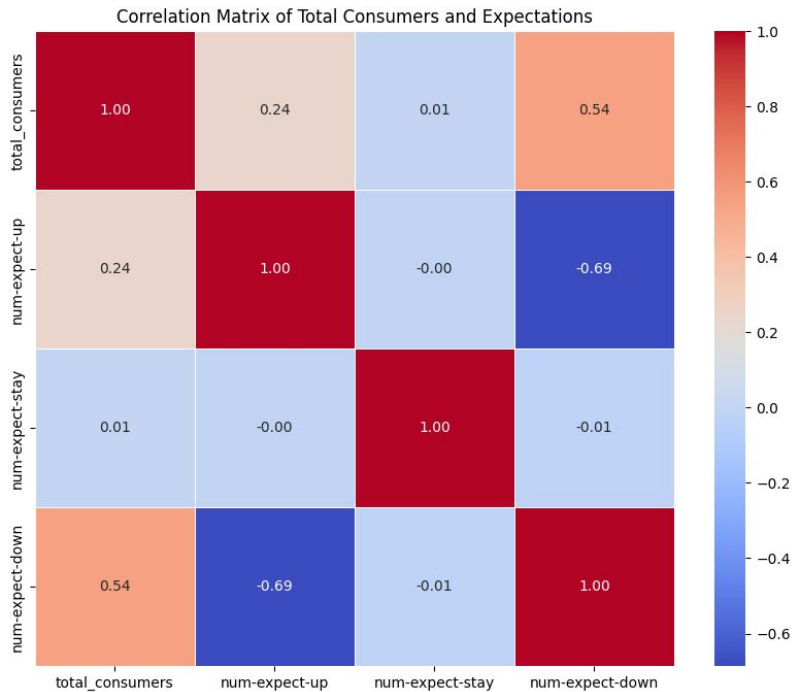
```
            ZeroInflatedPoisson Regression Results
==============================================================================
Dep. Variable:          num-expect-down   No. Observations:              29237
Model:               ZeroInflatedPoisson   Df Residuals:                  29235
Method:                             MLE    Df Model:                          1
Date:                  Wed, 24 Apr 2024    Pseudo R-squ.:                0.1019
Time:                        22:46:26      Log-Likelihood:              -44498.
converged:                         True    LL-Null:                     -49548.
Covariance Type:              nonrobust    LLR p-value:                   0.000
==============================================================================
                          coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
inflate_const           -2.0774      0.050    -41.818      0.000      -2.175      -1.980
inflate_total_consumers  0.1875      0.015     12.578      0.000       0.158       0.217
const                   -0.3109      0.012    -25.448      0.000      -0.335      -0.287
total_consumers          0.3541      0.003    105.206      0.000       0.347       0.361
==============================================================================
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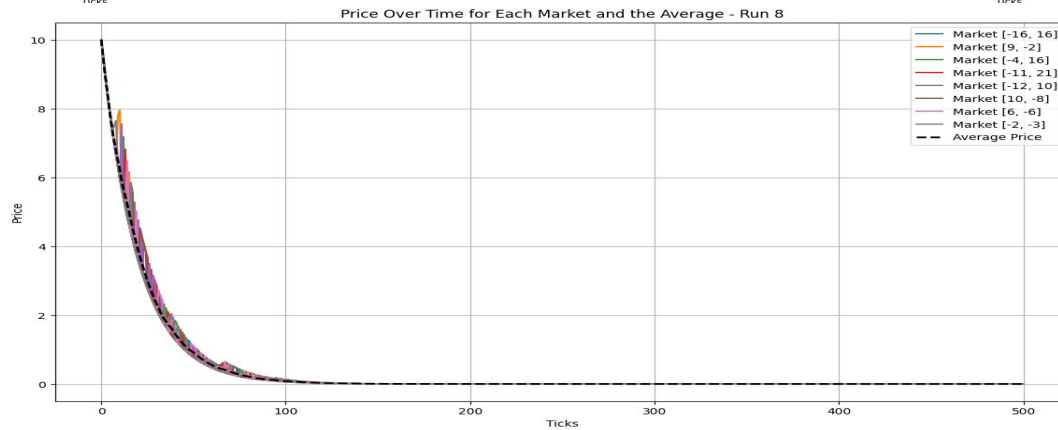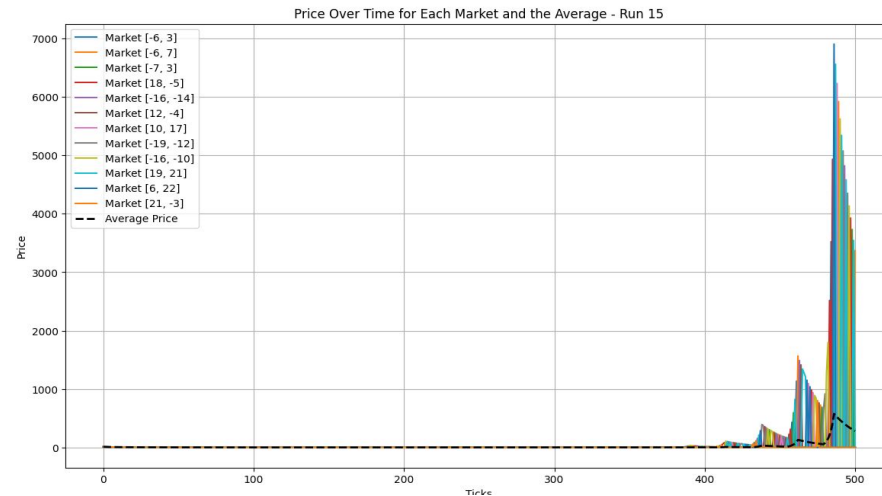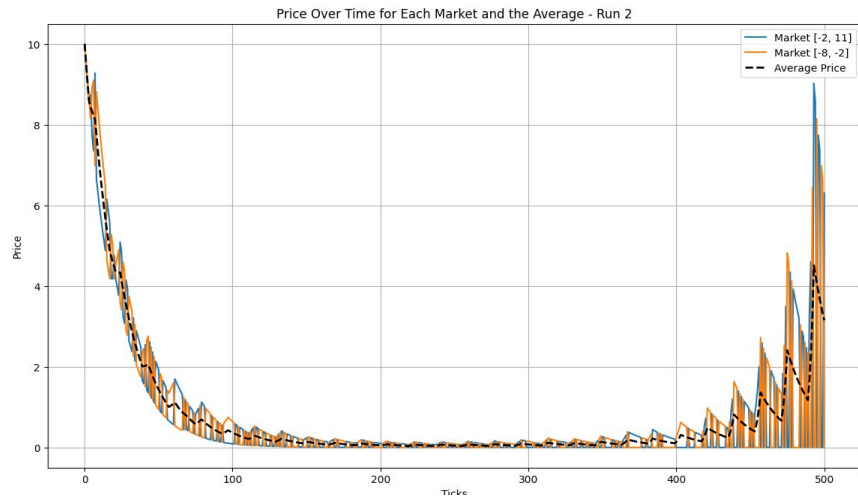
Experiments & Analysis

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- Experiment 2: Changes in market prices from varying number of regions and markets per region
  - ["num-markets-per-region" [1 1 4]]
  - ["num-regions" [1 1 5]]
  - *Report* individual market prices and average price over all markets in local economy

- Hypothesis:
  - "Diamond Paradox"[3]
  - Search costs and product differentiation exists will drive prices down due to competition but opens up the opportunity to arbitrage. If one of the markets increases its unit price, others will follow, leading to market failure (hyperinflation).

Results (Market Prices)

Price Over Time for Each Market and the Average - Run 2

Price Over Time for Each Market and the Average - Run 15

Price Over Time for Each Market and the Average - Run 8

Conclusion & Further Thoughts

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- Local information and heterogeneous expectations matter, a lot.

  - As consumers and producers converge on expectations, the price level is highly driven by that consensus.

- Adapting to information of "time and place" creates unexpected market interactions

  - As the number of markets grow, adaptive behavior creates arbitrage opportunities.

- Heuristics led to expected economic phenomena

  - No analytical consumption nor production functions employed

Thank you for listening!

References

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1. Hayek F. A. (1945). The use of knowledge in society. The American Economic Review, September 1945. Volume XXXV
2. Poledna, Sebastian & Miess, Michael & Hommes, Cars & Rabitsch, Katrin. (2022). Economic forecasting with an agent-based model. European Economic Review. 151. 104306. 10.1016/j.euroecorev.2022.104306.
3. Anderson, S. P., & Renault, R. (1999). Pricing, Product Diversity, and Search Costs: A Bertrand-Chamberlin-Diamond Model. The RAND Journal of Economics, 30(4), 719-735. https://doi.org/10.2307/2556072