Review and Replication of Lengnick (2013)'s Macroeconomic Agent-Based Model

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Introduction

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- Reproduced endogenous business cycles without growth or aggregate shocks
- Reproduced various aggregate phenomena (Phillips curve, Beveridge curve)
- Some deviations in frequency and severity of downturns, and firm-level decisions

Motivations for Agent-Based Macroeconomic Models

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- No assumptions of perfect foresight or equilibrium conditions unlike HANK models

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- Added (skeletal) dashboard capabilities with Mesa's Solara-based modules

Model Overview

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- Each step represents one day; 21 days = one month

Model Parameters

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- $n = 7$ firms in household's seller network
- Dozens other parameters governing price/wage adjustments, inventories, job search

Parameters table

Parameter	Description	Value
γ	Months of labor market slack until wage cut.	24
δ	Upper-bound of wage adjustment.	0.019
$\underline{\phi}$	Minimum desirable inventory (multiplier on units of goods demanded).	0.25
$\overline{\phi}$	Maximum desirable inventory (multiplier on units of goods demanded).	1
$\underline{\rho}$	Minimum desirable price (multiplier on "marginal cost").	1.025
$\overline{\rho}$	Maximum desirable price (multiplier on "marginal cost").	1.15
θ	Probability firm considers changing price.	0.75
η	Upper-bound of price adjustment.	0.02
ψ_p	Probability household tries to switch seller for price.	0.25
ψ_y	Probability household tries to switch seller for inventory.	0.25
ξ	Minimum price decrease required to switch	0.01

Monthly Actions: Firms

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3. Adjust prices, only if headcount was adjusted, and if it's not within some target multiple of marginal costs

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At the start of each month, households:

1. Update seller networks based on prices and inventory
2. Seek new jobs if unemployed
3. Possibly seek better jobs if employed but underpaid
4. Plan consumption based on money and average price within network

Daily Actions

- Households buy and consume goods from their network

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- Firms produce according to production function: $y_{fs} = \lambda l_{ft}$

End of Month Actions

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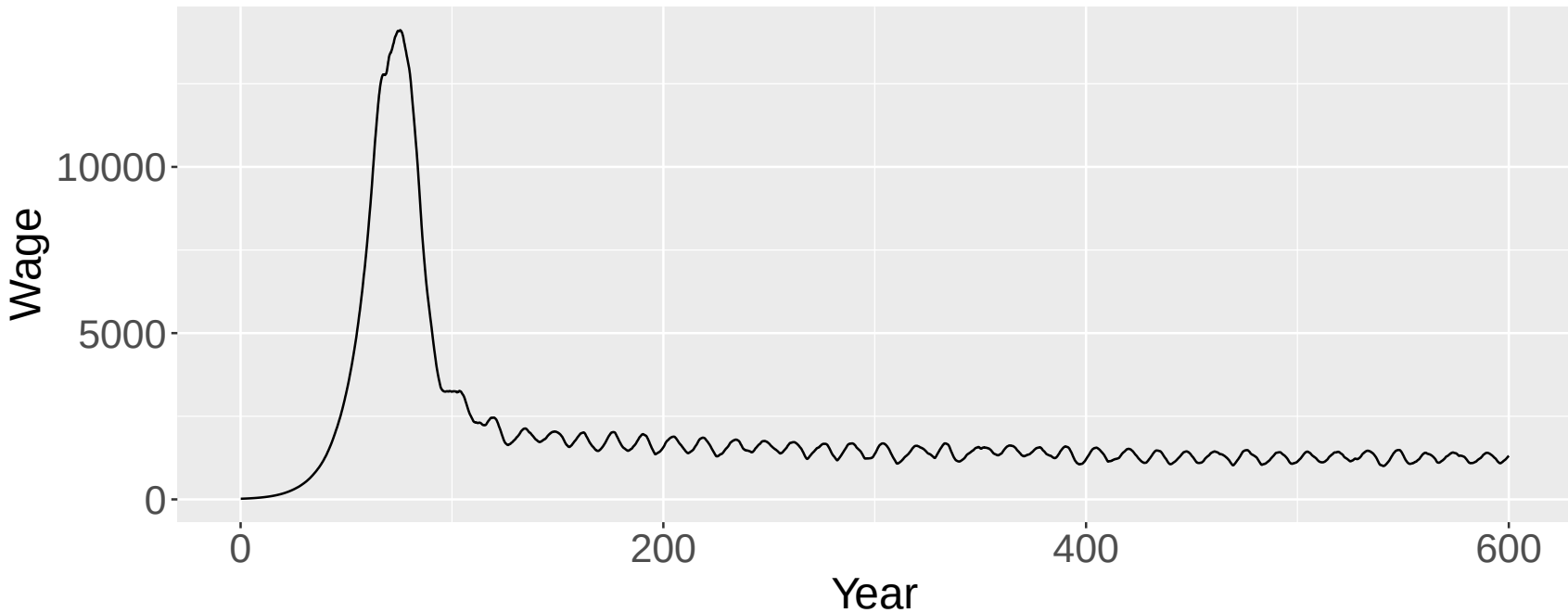
- Firms retain buffer for future wages
- Firms pay dividends to shareholders (all households)
- Households adjust reservation wages

Implementation Challenges

- Omissions in original paper made replication difficult:
  - Initial step not specified
  - Unknown initial parameters (initial money, wages, prices)
    - Thankfully starting values don't matter too much.
  - Unclear definitions (demand, marginal cost)

Example

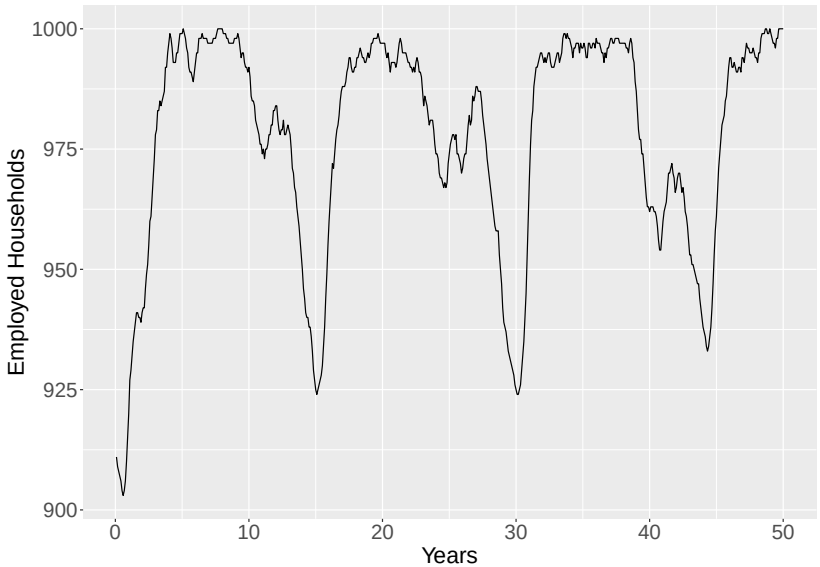
What price-adjustment looks like over the very long-term:



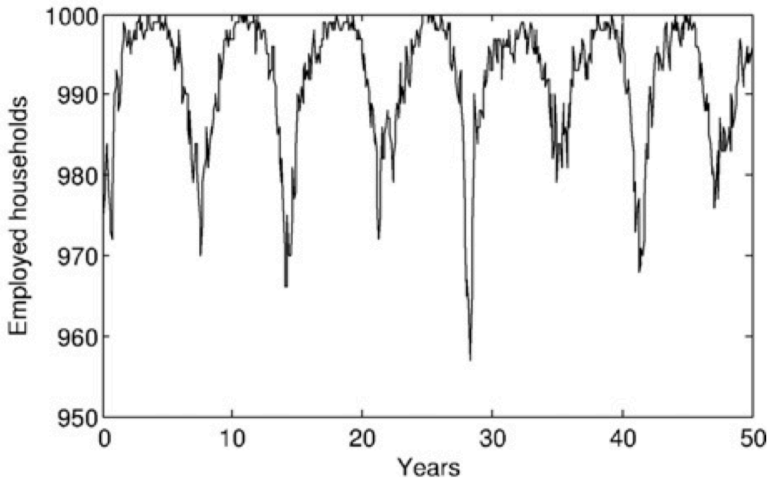
We therefore remove the first 100 years of observations.

Results: Business Cycles Comparison

My Replication

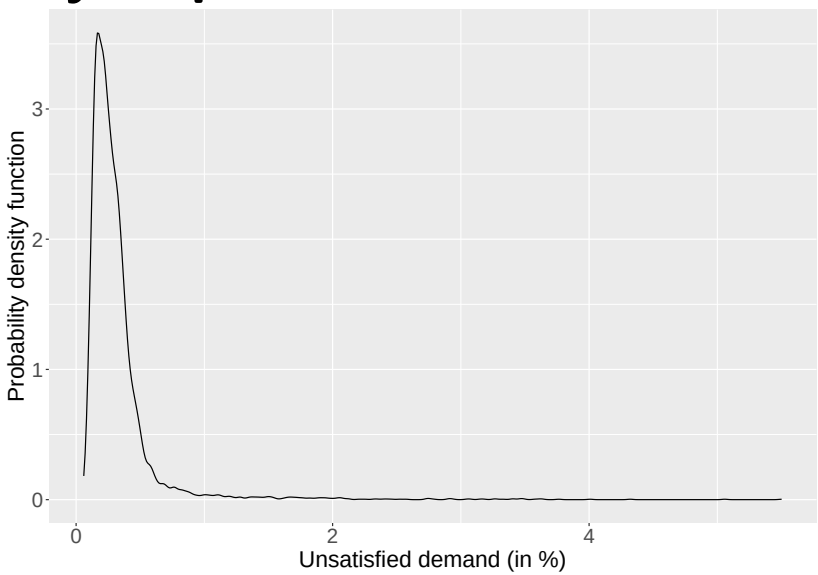


Lengnick (2013)

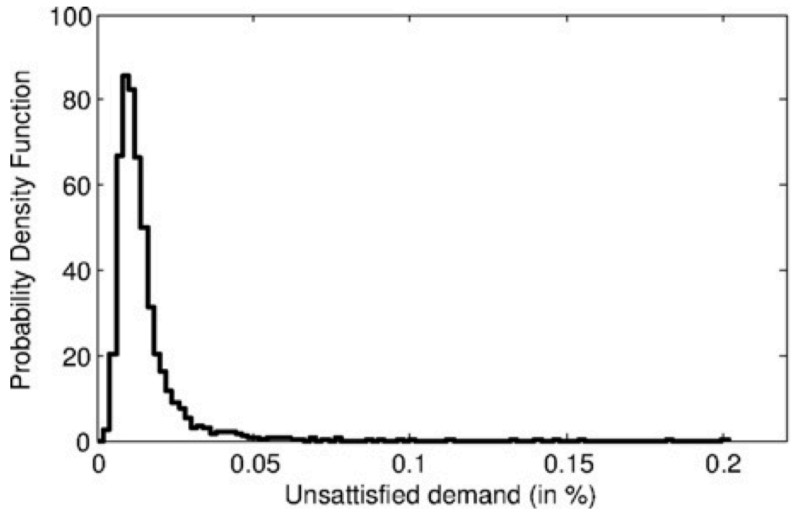


Results: Unsatisfied Demand Comparison

My Replication

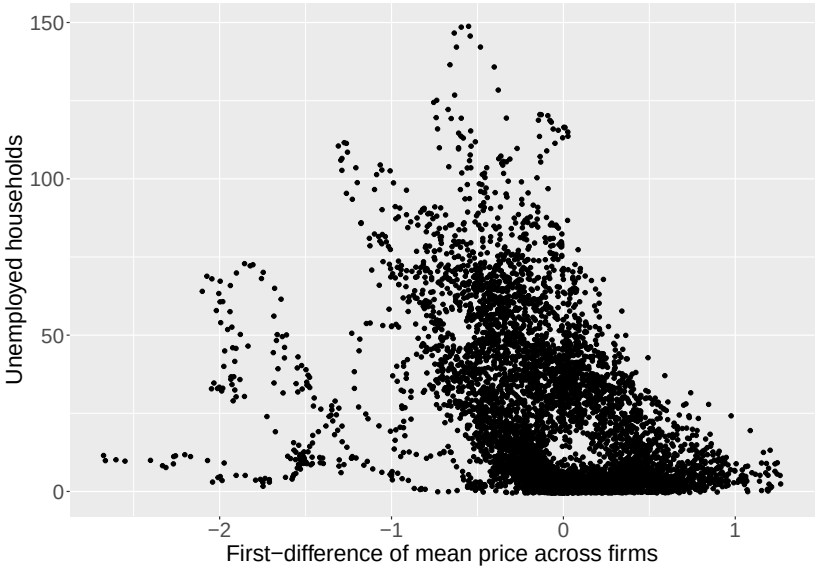


Lengnick (2013)

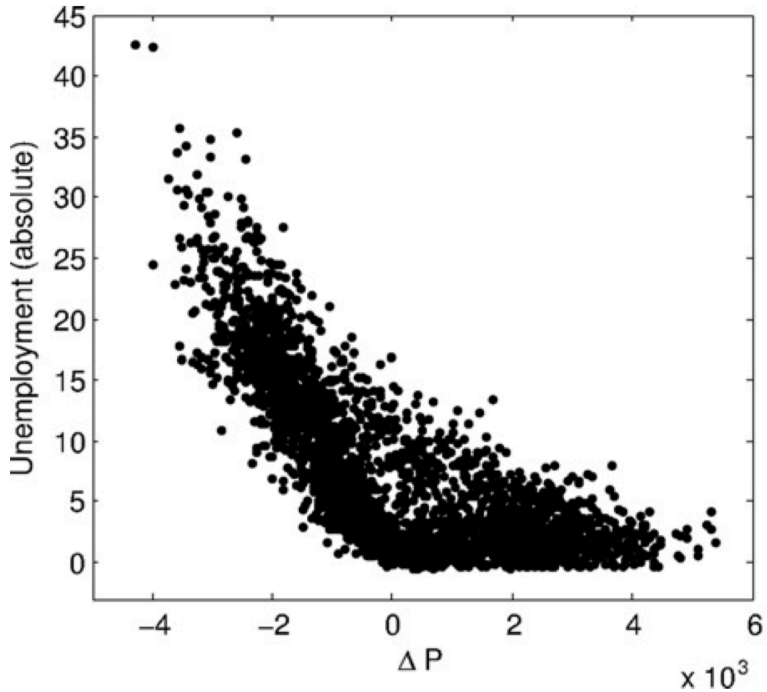


Results: Phillips Curve Comparison

My Replication

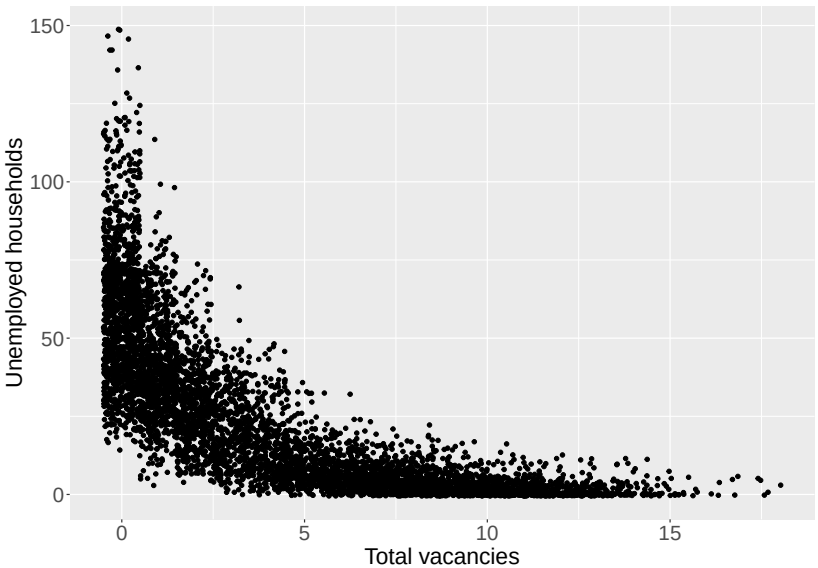


Lengnick (2013)

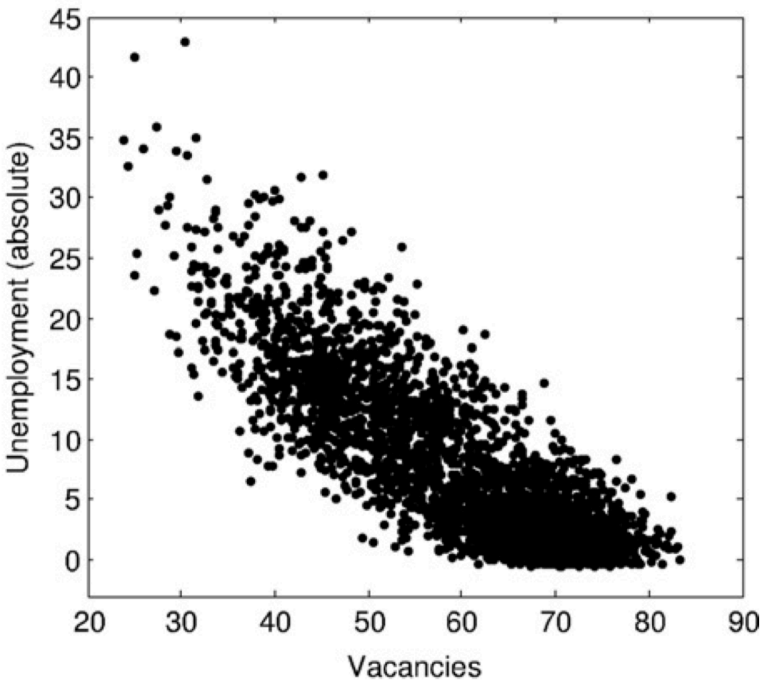


Results: Beveridge Curve Comparison

My Replication



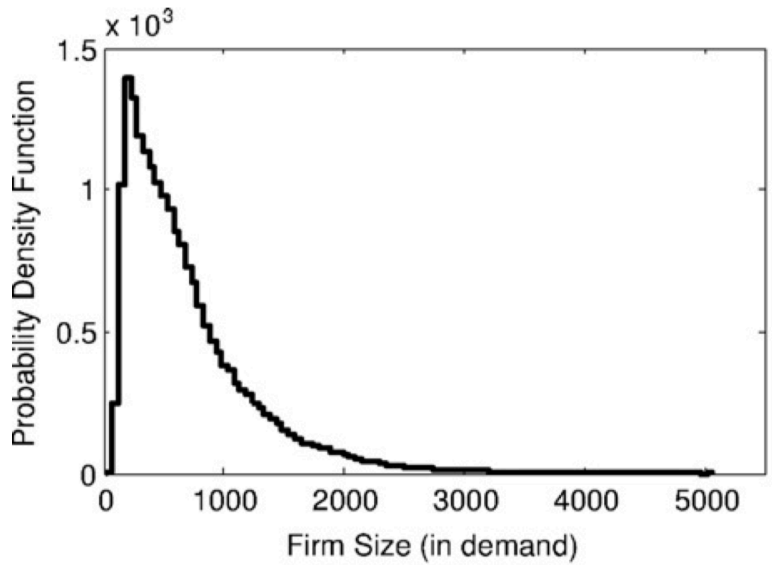
Lengnick (2013)



Results: Firm Size Distribution Comparison

My Replication

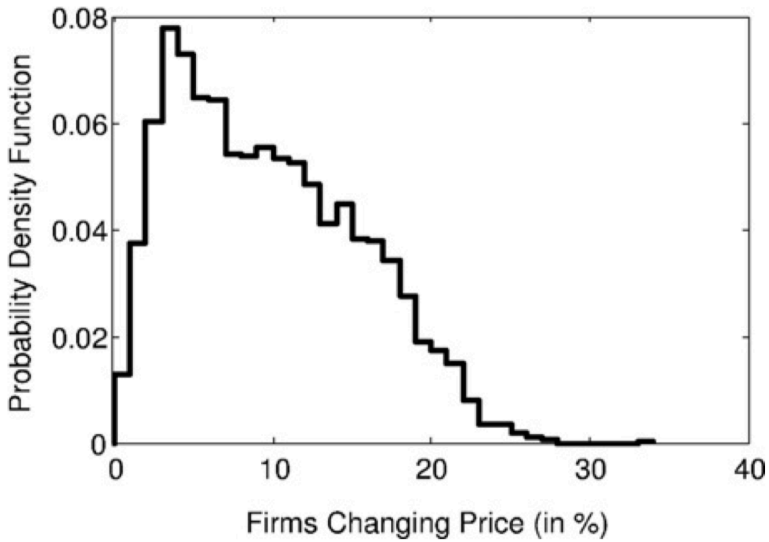
Lengnick (2013)



Results: Price Change Distribution Comparison

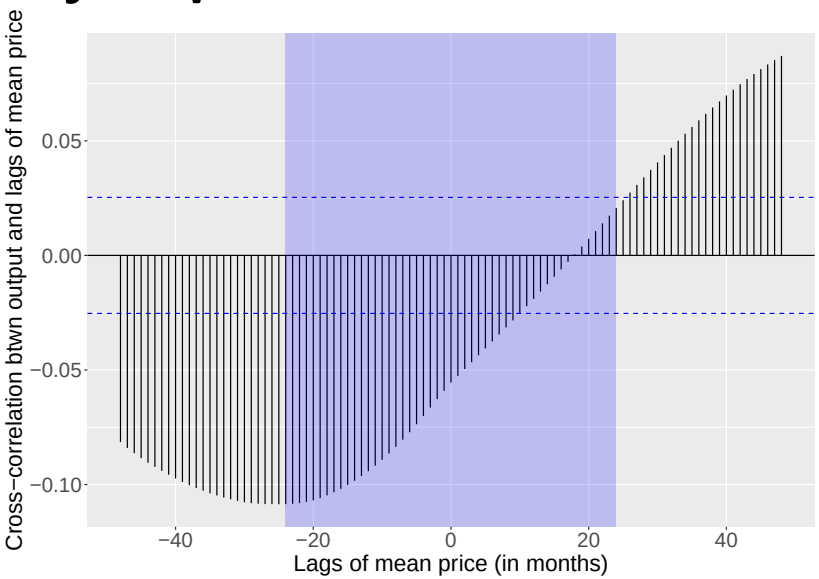
My Replication

Lengnick (2013)

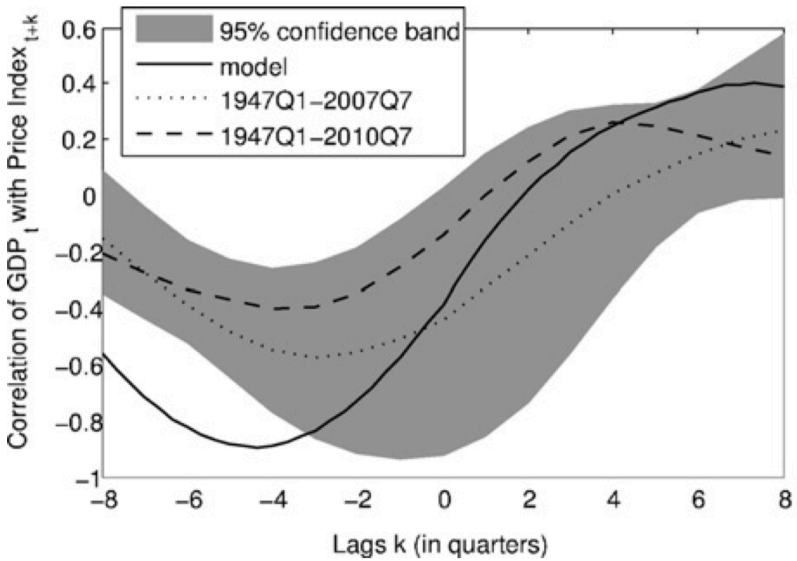


Results: Cross Correlations Comparison

My Replication



Lengnick (2013)



Key Differences in Results

- **Business cycles**: Less frequent but more severe in my replication
  - 10% unemployment vs. 4.5% in original
- **Unsatisfied demand**: Similar mode but fatter tails in replication
- **Phillips and Beveridge curves**: Similar patterns but different scales
  - Price changes mostly within ± 1 vs. ± 4 in original
  - Fewer vacancies in replication (max 20 vs. 80)
- **Price changes**: My distribution is multimodal with second peak at ~75%
- **Cross-correlations**: Negative correlation with price lags persists longer (18 months vs. 6 months)

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  - Many parameters difficult to estimate from real data
- Disequilibrium makes some extensions difficult
- What I want to add next: modify search behaviors to incorporate tax policies and integrate model with tax calculators for policy forecasting

References

Lengnick, Matthias. 2013. "Agent-Based Macroeconomics: A Baseline Model." *Journal of Economic Behavior & Organization* 86 (February): 102–20. https://doi.org/10.1016/j.jebo.2012.12.021.