Search frictions in good markets and CPI inflation

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25 July 2024

Outline

Motivation

- In standard new Keynesian models, retailers are implicitly assumed to be homogeneous, aggregating and delivering goods with equal efficiency at all times.
- In reality, retailers solve search and matching problems. They match household demand and supply of varieties. For that value added, they impose a wedge between consumer and producer prices. Let's call it search wedge.
- There is evidence that search wedge plays a role in determining consumer prices, e.g., Nakamura (2008) and Hottman et al. (2016)

Motivation

- COVID-19 temporarily shifts customer preferences towards online retailers.

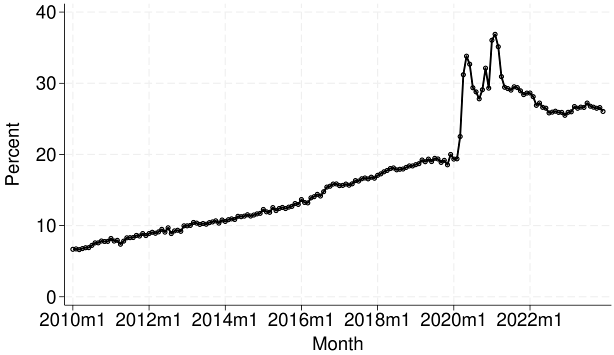


Figure 1: Share of online retail sales to total retail sales in the UK

Brief Empirical Exercise

- We assess CPI inflation response to an increase in the share of online retail sales, using the local projection method (LP) introduced by (Jordà, 2005),

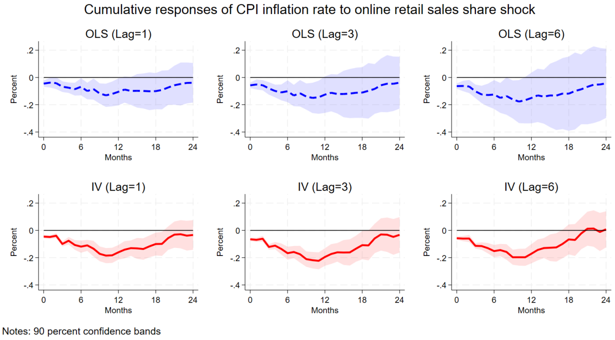


Figure 2: Response of CPI inflation to the share of online retail sales.

Research Question

- Why does CPI inflation respond negatively to an increase in the share of online retail sales?
- How should we capture this in a DSGE model?

Contribution and Findings

- This paper constructs and estimates a NK-DSGE model that incorporates frictional goods markets with search and matching between retailers and monopolistic producers.
- Our framework distinguishes between online and brick-and-mortar retailers, accounting for potential differences in search efficiency.
- Leveraging the demand shifts during the COVID-19 pandemic, we analyze how shocks to the share of online retail sales impact pricing dynamics and the relationship between inflation and economic activity (NKPC).

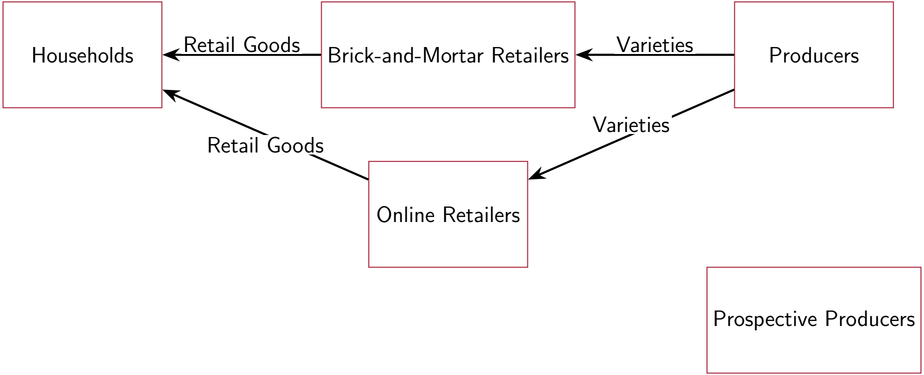
Related literature

- NK-DSGE model with firm entry
  - Bilbiie et al. (2008), Bilbiie et al. (2014), Hamano and Zanetti (2017), Hamano and Zanetti (2022)
- Good market search friction
  - Gourio and Rudanko (2014) , Petrosky-Nadeau and Wasmer (2015), Michaillat and Saez (2015), Petrosky-Nadeau et al. (2016)
- Close to
  - Dong et al. (2021).
  - Firm entry influences good market tightness; tightness influences the proportion of products undergoing price adjustments.
  - While sharing some similar mechanisms, we discuss temporal shifts in search efficiency.

How we model it?

- Extend the New Keynesian model with firm entry and exit as in Bilbiie et al. (2008)
  - Introduce a mass of representative retailers who aggregate differentiated producer goods
  - Introduce search friction between retailers and producers motivated by Michaillat and Saez (2015)

Flow of goods



Demand for retail goods

- Household purchases retail goods from online (O) and brick-and-mortar retailers (B). The basket of goods is

$$C_t = \left(\frac{C_{O,t}}{\alpha_t}\right)^{\alpha_t} \left(\frac{C_{B,t}}{1-\alpha_t}\right)^{1-\alpha_t},$$

where α_t is the expenditure share of retail goods from online retailers.

- $P_{j,t}$ denotes the price of the retail goods offered by a retailer of type $j \in \{O, B\}$ at time t. The consumption-based price index of the final goods is then

$$P_t = P_{O,t}^{\alpha_t} P_{B,t}^{1-\alpha_t}, \tag{1}$$

and the household's demand for retail goods from each retailer is

$$C_{O,t} = \alpha_t \frac{P_t C_t}{P_{O,t}} \text{ and } C_{B,t} = (1-\alpha_t)\frac{P_t C_t}{P_{B,t}}.$$

Demand for retail goods

- Express the consumer price index in real terms as

$$1 = \rho_{O,t}^{\alpha_t} \rho_{B,t}^{1-\alpha_t}, \tag{2}$$

  where $\rho_{O,t} = P_{O,t}/P_t$ and $\rho_{B,t} = P_{B,t}/P_t$, respectively.

- Rewrite demand in real terms

$$C_{O,t} = \frac{\alpha_t C_t}{\rho_{O,t}} \text{ and } C_{B,t} = \frac{(1-\alpha_t)\, C_t}{\rho_{B,t}}, \tag{3}$$

  respectively

Retailer's problem

- A retailer of type $j \in \{O, B\}$ purchases varieties indexed ω, $y_t(\omega)$, from a continuum of varieties, Ω, available in each period.
- They aggregate varieties into retail goods $Y_{j,t}$ using a CES aggregator that takes the form

$$Y_{j,t} = V_{j,t} \left(\int_{\omega_i} y_{j,t}(\omega)^{\frac{\sigma_t - 1}{\sigma_t}} \, d\omega \right)^{\frac{\sigma_t}{\sigma_t - 1}}, \tag{4}$$

  where $y_{j,t}$ is the demand of retailer of type j for variety ω.
- $V_{j,t} \equiv N_{j,t}^{\psi - \frac{1}{\sigma - 1}}$ in which $N_{j,t}$ stands for the number of varieties to which the retailer of type j has access.
- ψ stands for the marginal utility resulting from a unit increase in the number of varieties.
- $\sigma_t > 1$ is the stochastic elasticity of substitution between varieties.
- Assume that traditional and online retailers have access to the same set of varieties and buy all varieties. It implies that $N_{O,t} = N_{B,t} = N_t$

Matching in good markets

- Matching function determines the amount of variety purchased

$$Y_{j,t} = \left(\left(\zeta_j Y_{j,t}^{Search} \right)^{-\lambda} + N_t^{-\lambda} \right)^{-1/\lambda} \tag{5}$$

where $\zeta_j Y_{j,t}^{Search}$ is defined as efficiency-adjusted search efforts. $Y_{j,t}^{Search}$ is the retail goods that a retailer of type j pays for matching efforts, where

$$Y_{j,t}^{Search} = Y_{j,t} - Y_{j,t}^{Sales} \tag{6}$$

- $Y_{j,t}$ denotes the total output purchased from producers and
- $Y_{j,t}^{Sales}$ denotes the output sold to consumers and the new entrants.
- ζ_j is product-market search efficiency

Producer market tightness

- Good market tightness: $\mathcal{T}_{j,t} = \frac{\zeta_j Y_{j,t}^{Search}}{N_t}$
- Ratio of variety traded to total numbers of variety: $\mathcal{P}_{j,t} = \frac{Y_{j,t}}{N_t}$
- Ratio of variety traded to a unit of efficiency-adjusted matching effort: $\mathcal{Q}_{j,t} = \frac{Y_{j,t}}{\zeta_j Y_{j,t}^{Search}}$

Search wedge

- Retailer j maximises

$$d_{j,t} = \rho_{j,t} Y_{j,t}^{Sales} - \int_{\omega} \rho_t(\omega) \, y_{j,t}(\omega) \, d\omega \tag{7}$$

  subject to matching technology and allocation of final goods

- The first order condition with respect to $Y_{j,t}^{Sales}$ suggests that real retail prices set by the retailer of type j, are given by

$$\rho_{j,t} = \underbrace{\left(1 - \frac{1}{\mathcal{Q}_{j,t}\zeta_j}\right)^{-1}}_{\equiv \mathcal{M}_{j,t}} \rho_{P,t} \tag{8}$$

- where $\rho_{P,t}$ is the real aggregate producer price and $\mathcal{M}_{j,t}$ is interpreted as the markup that retailers j set to cover the cost of search activity,

CPI Decomposition

Starting from Eq. 2 and 8, decomposing $P_{P,t}$ into the individual producer price and variety effects yields

$$P_t = \mathcal{M}_{O,t}^{\alpha_t} \mathcal{M}_{B,t}^{1-\alpha_t} N_t^{-\psi} p_t. \tag{9}$$

We decompose p_t further by individual firm's pricing equation, and write it down in nominal terms:

$$P_t = \underbrace{\mathcal{M}_{O,t}^{\alpha_t} \mathcal{M}_{B,t}^{1-\alpha_t}}_{\text{Search wedge}} \underbrace{N_t^{-\psi}}_{\text{Variety effect}} \underbrace{\mu_t}_{\text{Monopolistic markup}} \underbrace{\frac{W_t}{Z_t}}_{\text{Marginal cost}}, \tag{10}$$

where

$$\mathcal{M}_{O,t} = \left(\frac{1}{1 - \zeta_{O,t} \mathcal{Q}_{O,t}} \right)^{-1} \text{ and } \mathcal{M}_{B,t} = \left(\frac{1}{1 - \zeta_{B,t} \mathcal{Q}_{B,t}} \right)^{-1} \tag{11}$$

Frictional good markets and NKPC

- We can write NKPC for CPI inflation as

$$\pi_t = \beta(1-\delta)\mathbb{E}_t\pi_{t+1} + \frac{\sigma-1}{\kappa}(\mathsf{w}_t - \mathsf{Z}_t) - \frac{\sigma-1}{\kappa}\psi \mathsf{N}_t$$
$$\underbrace{-\frac{\sigma-1}{\kappa}\left(\alpha\left(\ln\mathcal{M}_B - \ln\mathcal{M}_O\right)\tilde{\alpha}_t\right)}_{\text{Composition effects}} + \underbrace{\frac{\sigma-1}{\kappa}\left(\alpha\tilde{\mathcal{M}}_{O,t} + (1-\alpha)\tilde{\mathcal{M}}_{B,t}\right)}_{\text{Arbitrage effects}}$$

- **Composition Effects**: Consumers migrating to online retailers result in a compositional change between online and brick-and-mortar shopping in the aggregate basket.
- **Arbitrage Effects**: As consumers shift to online retailers, the increased competition in the online retail market may drive these retailers to exert more search effort and subsequently charge a higher wedge. Conversely, brick-and-mortar retailers charge a lower wedge.

Calibration strategy

- **Calibrate steady-states UK retail sector data and LP results.**
- Online retailer's search wedge ($\mathcal{M}_O$):
  - Estimated using Amazon's marketing costs relative to total net sales
  - Assumes ratio of marketing costs to online sales is the same as overall marketing costs to total net sales
  - Marketing costs for online sales represent 5.01% of online sales revenue from 2010 to 2022
  - Calculated to be 5.27% of the producer price index
- Brick-and-mortar retailer's search wedge ($\mathcal{M}_B$):
  - Aligned with value-added contribution of retailers to real gross value added (GVA)
  - Average weight of wholesale and retail sectors in real GVA between 2010-2022 was 12.76%
  - Calculated to be 14.23% of the producer price index

Impulse responses to online retail sales shock

- As search cost decreases, CPI inflation drops, driving higher demand for goods.

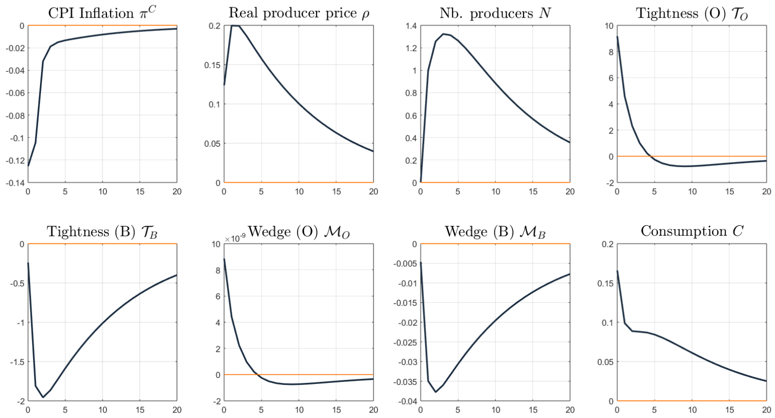


Figure 3: Response to positive shock on the share of online retail sales (%)

In response to online share increases, both compositional effects and arbitrage effects are negative

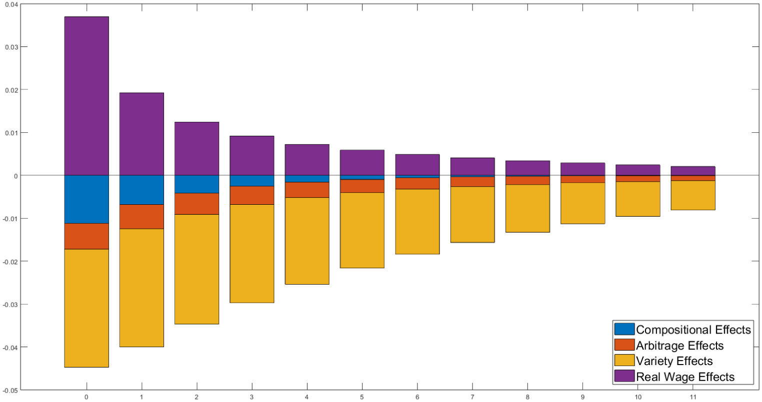


Figure 4: CPI inflation response to changing online shares by channels (%)

Calibrated NKPC

- We can write NKPC for CPI inflation as

$$\pi_t = \beta(1-\delta)\mathbb{E}_t\pi_{t+1} + \frac{\sigma-1}{\kappa}(\mathrm{w}_t - \mathrm{Z}_t) - \frac{\sigma-1}{\kappa}\psi \mathrm{N}_t$$
$$\underbrace{-\frac{\sigma-1}{\kappa}\left(\alpha\left(\ln\mathcal{M}_B - \ln\mathcal{M}_O\right)\tilde{\alpha}_t\right)}_{\text{Composition effects}} + \underbrace{\frac{\sigma-1}{\kappa}\left(\alpha\tilde{\mathcal{M}}_{O,t} + (1-\alpha)\tilde{\mathcal{M}}_{B,t}\right)}_{\text{Arbitrage effects}}$$

- **Composition Effects** (-)
- **Arbitrage Effects** (-)

Online share shocks contributed to disinflation during the pandemic

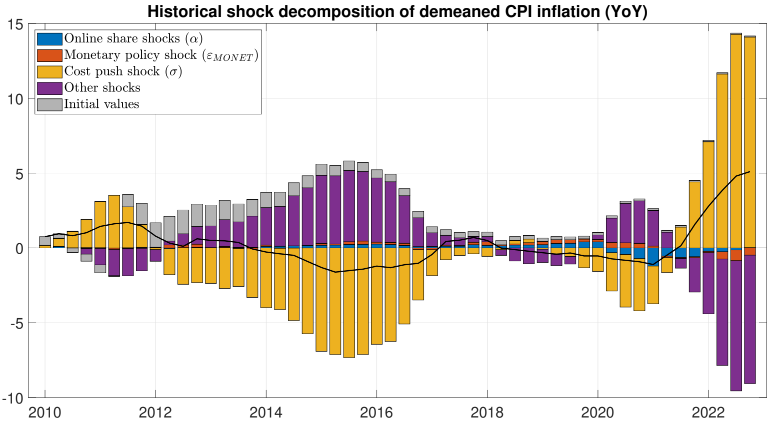


Figure 5: Shock decomposition (%)

Conclusion

- Developed a New Keynesian DSGE model incorporating frictional goods markets and endogenous product entry, distinguishing between online and brick-and-mortar retailers based on matching efficiencies.
- Analyzed the impact of online retail sales on CPI inflation dynamics, showing that a consumer shift towards online retailers leads to a decrease in CPI inflation due to lower search costs and enhanced search efficiency.

Next step: Implications to Monetary Policy

- Good market friction works against monetary policy

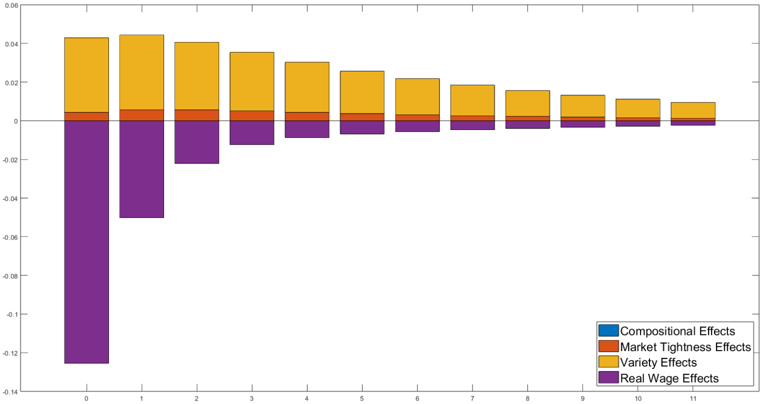


Figure 6: Response to contractionary monetary policy shock (%)

Next step: Implications to Monetary Policy

- What is the optimal monetary policy given that good market friction is present?

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