Hotelling Meets Keynes: Aggregate Adjustment with Spatial Competition and Nominal Rigidity

by

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Motivation

Cost-push shocks in general and markup shocks in particular have shown to be elusive objects.

Estimates of DSGE models attribute a large fraction of the variance of key macro indicators, especially inflation, to markup shocks.

But what drives those movements?

This Paper

Provides microfoundations for a cost-push shock arising from changes in the cost consumers incur to access goods markets. We refer to this cost as transportation costs, broadly defined to include various frictions beyond physical transport.

It merges a circular model of spatial competition à la Hotelling with a new-Keynesian model.

An increase in transportation costs:

– reduces the price elasticity of demand and therefore induces an endogenous increase in markups.
– reduces the supply of labor for the production of goods.

Intuition

Demand faced by firm selling good i

$$c_i = c \cdot (P_i + TC)^{-\eta} \times \text{ MktSize} \left(\frac{P_i - P_i^{sc}}{TC} \right)$$

Supply of labor for production

$$h^p = h - h^s(TC)$$

Notation: c_i = demand for good i; c = total consumption; P_i = price of good i; TC = transportation cost; P_i^{sc} = price of good i charged by a spatial competitor (located in a neighboring market).

The model

- There is a continuum of households evenly distributed around a circle with circumference 1.

- Households belong to an extended family that centrally assigns the same level of consumption of a composite good to every household.

- The composite good is made of a continuum of varieties indexed by $i \in [0, 1]$.

- A household living at distance δ from a shopping center faces transportation costs proportional to δ. It chooses how much to consume of each variety i.

- There are N shopping centers evenly spaced around the circle.

- In each shopping center there is a continuum of producers/sellers of varieties $i \in [0, 1]$.

- Prices are sticky à la Calvo.

An Extended Family

Utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t e^{\xi_t} \left[\frac{c_t^{1-\sigma} - 1}{1-\sigma} - \chi \frac{h_t^{1+\gamma}}{1+\gamma} \right]$$

Budget constraint

$$P_t^c c_t + \frac{B_{t+1}}{1+i_t} + T_t = W_t h_t + \Phi_t + B_t$$

Notation:
$h_t =$ hours dedicated to work or shop
$P_t^c =$ consumer price level
$W_t =$ nominal wage
$B_t =$ nominal bond
$i_t =$ nominal interest rate
$T_t =$ lump-sum taxes
$\Phi_t =$ profits from firms
$\xi_t =$preference shock

Household Living at Distance δ from the Market

Choose consumption of variety i, $c_{\delta it}$ to minimize total expenditure,

$$\int_0^1 (P_{it} + \tau_t \delta W_t) c_{\delta it} di,$$

subject to the aggregation technology

$$c_t = \left[\int_0^1 c_{\delta it}^{1-1/\eta} di \right]^{\frac{1}{1-1/\eta}},$$

Notation:
$\tau_t \cdot \delta =$ time required to travel distance δ.
$c_{\delta it} =$ consumption of variety i by a household located at distance δ from the market.

The Demand for Variety i in Location δ

$$c_{\delta it} = c_t \left(\frac{P_{it} + \tau_t \delta W_t}{P_{\delta t}} \right)^{-\eta}$$

where $P_{\delta t}$ is given by

$$P_{\delta t} \equiv \left[\int_0^1 (P_{it} + \tau_t \delta W_t)^{1-\eta} di \right]^{\frac{1}{1-\eta}}$$

Firms

Demand faced by producer of variety i in period t

$$\mathcal{D}(P_{it}, b_{it}; \tau_t) = 2c_t \int_0^{b_{it}} \left(\frac{P_{it} + \tau_t \delta W_t}{P_{\delta t}} \right)^{-\eta} d\delta$$

No–arbitrage condition with spatial competitor

$$P_{it} + \tau_t b_{it} W_t = P_{it}^{sc} + \tau_t \left(\frac{1}{N} - b_{it} \right) W_t$$

Notation:
b_{it} = border of the market with spatial competitors
P_{it}^{sc} = price of spatial competitor
N = number of firms producing variety i located evenly around the circle

Problem of Firm i Reoptimizing Price in t

$$\max_{\{P_{it},\{b_{it+s},h_{it+s}\}_{s\geq 0}\}} E_t \sum_{s=0}^{\infty} (\beta\theta)^s \frac{\lambda_{t+s}}{P^c_{t+s}} \left[P_{it}\mathcal{D}(P_{it}, b_{it+s}; \tau_{t+s}) - W_{t+s}h_{it+s}\right]$$

subject to

$$e^{z_{t+s}} h_{it+s} \geq \mathcal{D}(P_{it}, b_{it+s}; \tau_{t+s})$$

and

$$P_{it} + \tau_{t+s} b_{it+s} W_{t+s} = P^{sc}_{it} + \tau_{t+s}\left(\frac{1}{N} - b_{it+s}\right) W_{t+s}.$$

Notation
h_{it} = hours employed by firm i
z_t = aggregate technology shock
θ = probability of not being able to reoptimize the price
λ_t = household's marginal utility of consumption.

First-Order Condition

$$E_t \sum_{s=0}^{\infty} (\beta\theta)^s \lambda_{t+s} \tilde{\eta}_{it+s} \mathcal{D}(P_{it}, b_{it+s}; \tau_{t+s}) \left[\frac{P_{it}}{P^c_{t+s}} \left(1 - \frac{1}{\tilde{\eta}_{it+s}} \right) - mc_{t+s} \right] = 0$$

where $\tilde{\eta}_{it+s}$ is the **price elasticity of demand**:

$$\tilde{\eta}_{it+s} \equiv -\frac{\mathcal{D}_1(P_{it}, b_{it+s}; \tau_{t+s}) P_{it}}{\mathcal{D}(P_{it}, b_{it+s}; \tau_{t+s})} - \frac{\mathcal{D}_2(P_{it}, b_{it+s}; \tau_{t+s}) \frac{\partial b_{it+s}}{\partial P_{it}} P_{it}}{\mathcal{D}(P_{it}, b_{it+s}; \tau_{t+s})}$$

Symmetric Equilibrium

Fixed market borders

$$b_t = \frac{1}{2N}$$

Labor resource constraint

$$h_t^p = h_t - h^s(\tau_t)$$

Notation:
N = number of shopping centers
h_t = labor supply
h_t^p = labor used in production
$h^s(\tau_t)$ = time spent shopping

Two Useful Propositions

1. The equilibrium value of all endogenous variables depends on

$$\frac{\tau_t}{4N}$$

but not on τ_t or N separately. Useful for calibration: 1 new parameter (not 2) vis-à-vis the NK model.

2. If the production function is linear in labor, then

$$\frac{\tau}{4N} = \frac{\text{time spent shopping}}{\text{time spent working}}$$

This is of use, because there is data on the RHS. According to the American Time Use Survey (ATUS), in 2023

$$\frac{\text{time spent shopping}}{\text{time spent working}} = 0.14$$

not a negligible number.

The Markup

In the steady state, the markup, denoted μ is given by

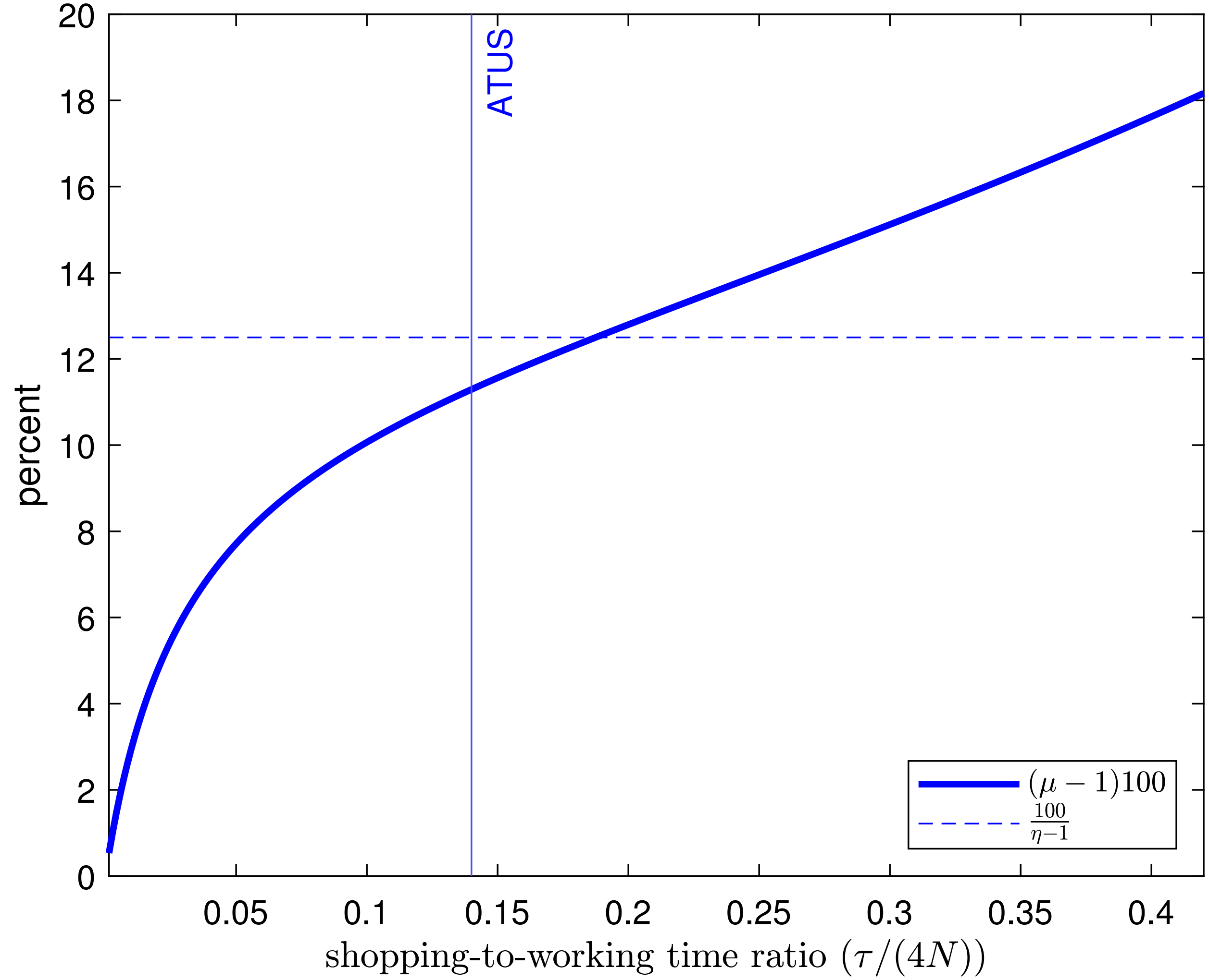
$$\mu = \frac{\tilde{\eta}(\tau)}{\tilde{\eta}(\tau) - 1}$$

So we have that

$$\tau \uparrow \Rightarrow \tilde{\eta}(\tau) \downarrow \Rightarrow \mu \uparrow$$

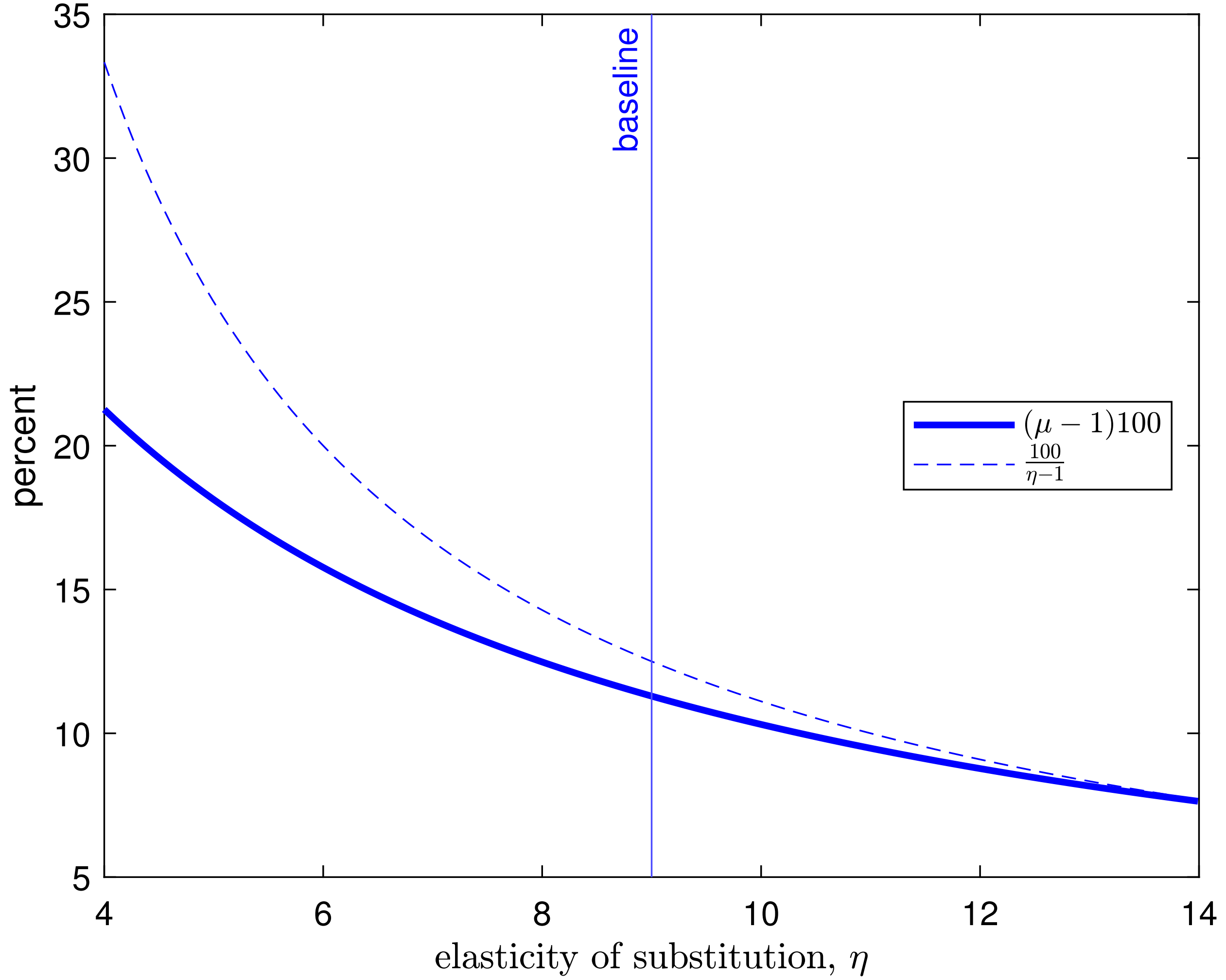
An increase in transportation costs raises the markup.

Transportation Costs and the Markup



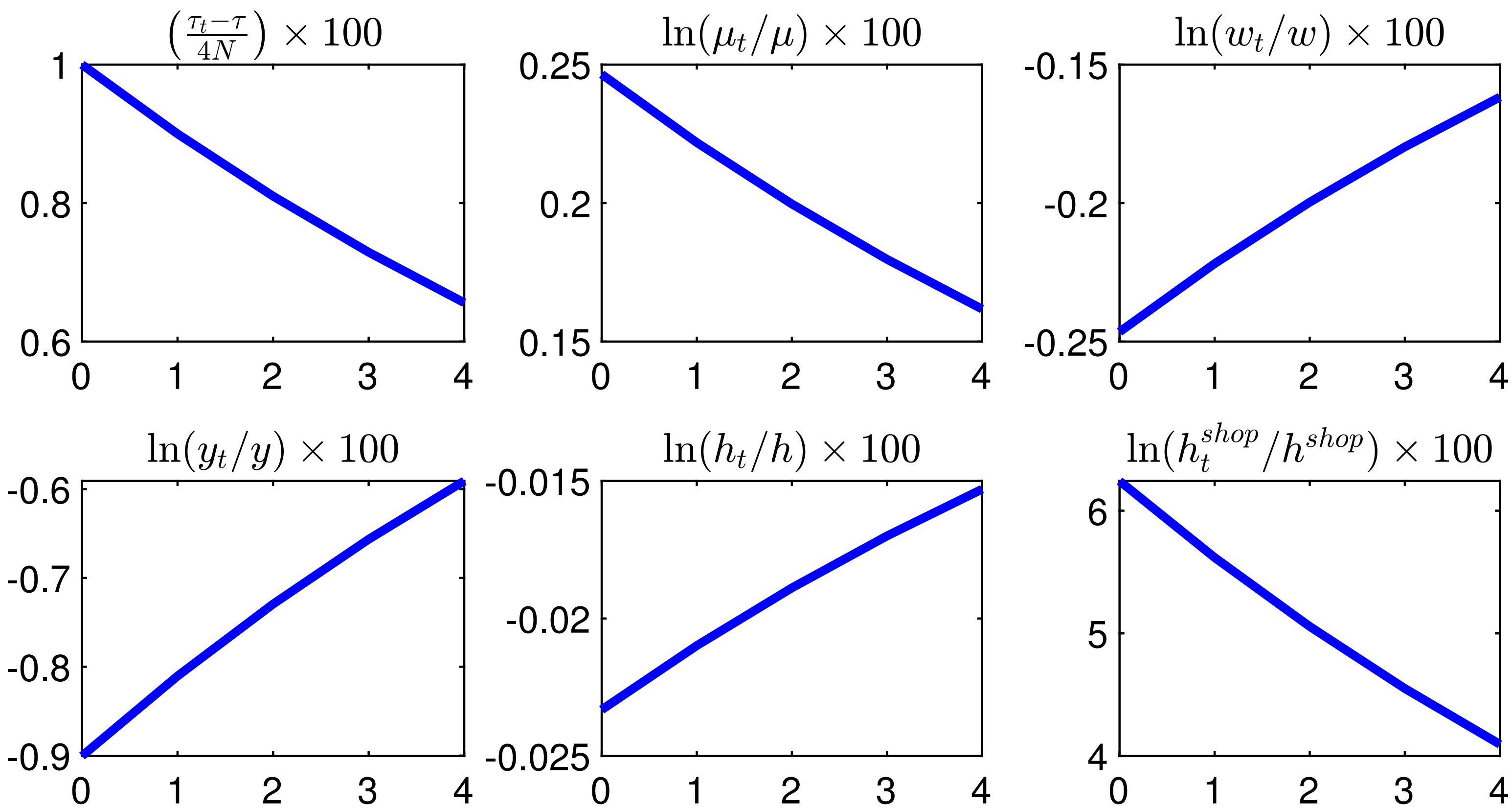
Calibration:
$\tau/(4N) = 0.14$ (ATUS, 2023); $\eta = 9$ (Galí, 2015).

The Elasticity of Substitution and the Markup



Calibration:
$\tau/(4N) = 0.14$ (ATUS, 2023); $\eta = 9$ (Galí, 2015).

Impulse Response to a Transportation Cost Shock: HOT Model



Notes. The HOT model features spatial frictions and flexible prices. The shock is a one percentage point increase in the shopping-to-working time ratio, $\tau_t/(4N)$, from 0.14 to 0.15. The logarithm of τ_t is assumed to follow an AR(1) process with persistence 0.9. The horizontal axis measures quarters after the shock. Variables without a time subscript represent steady-state values. The variable h_t^{shop} denotes time allocated to shopping.

Monetary Policy

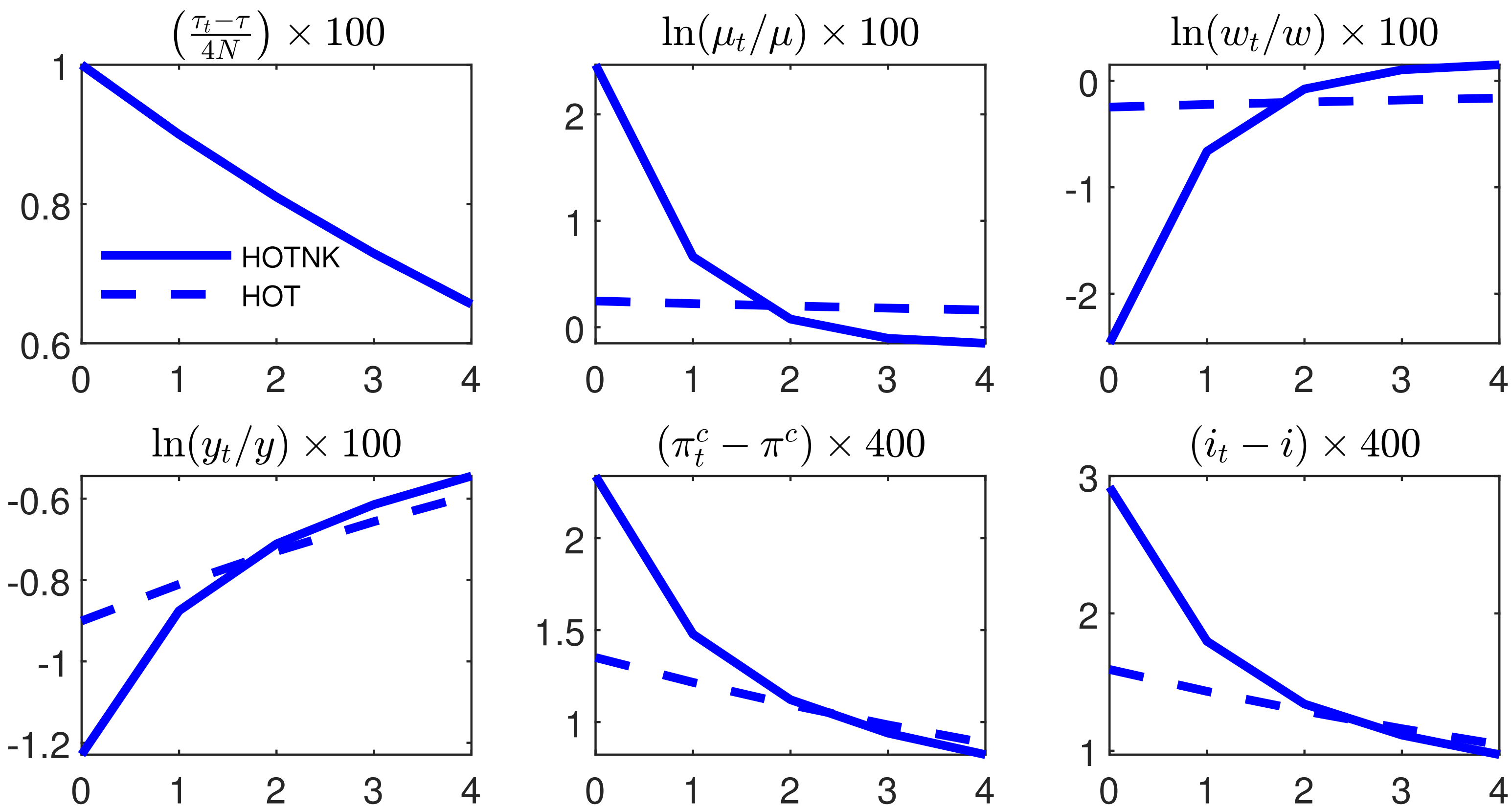
$$\frac{1+i_t}{1+i} = \left(\frac{1+\pi_t^c}{1+\pi^c}\right)^{\alpha_\pi} \left(\frac{y_t}{y}\right)^{\alpha_y} e^{\nu_t},$$

$$\alpha_\pi = 1.5 \quad \text{and} \quad \alpha_y = 0.125$$

Notation:
π_t^c = consumer price inflation
y_t = output
ν_t = monetary policy shock

Transportation Cost Shocks As Cost-Push Shocks

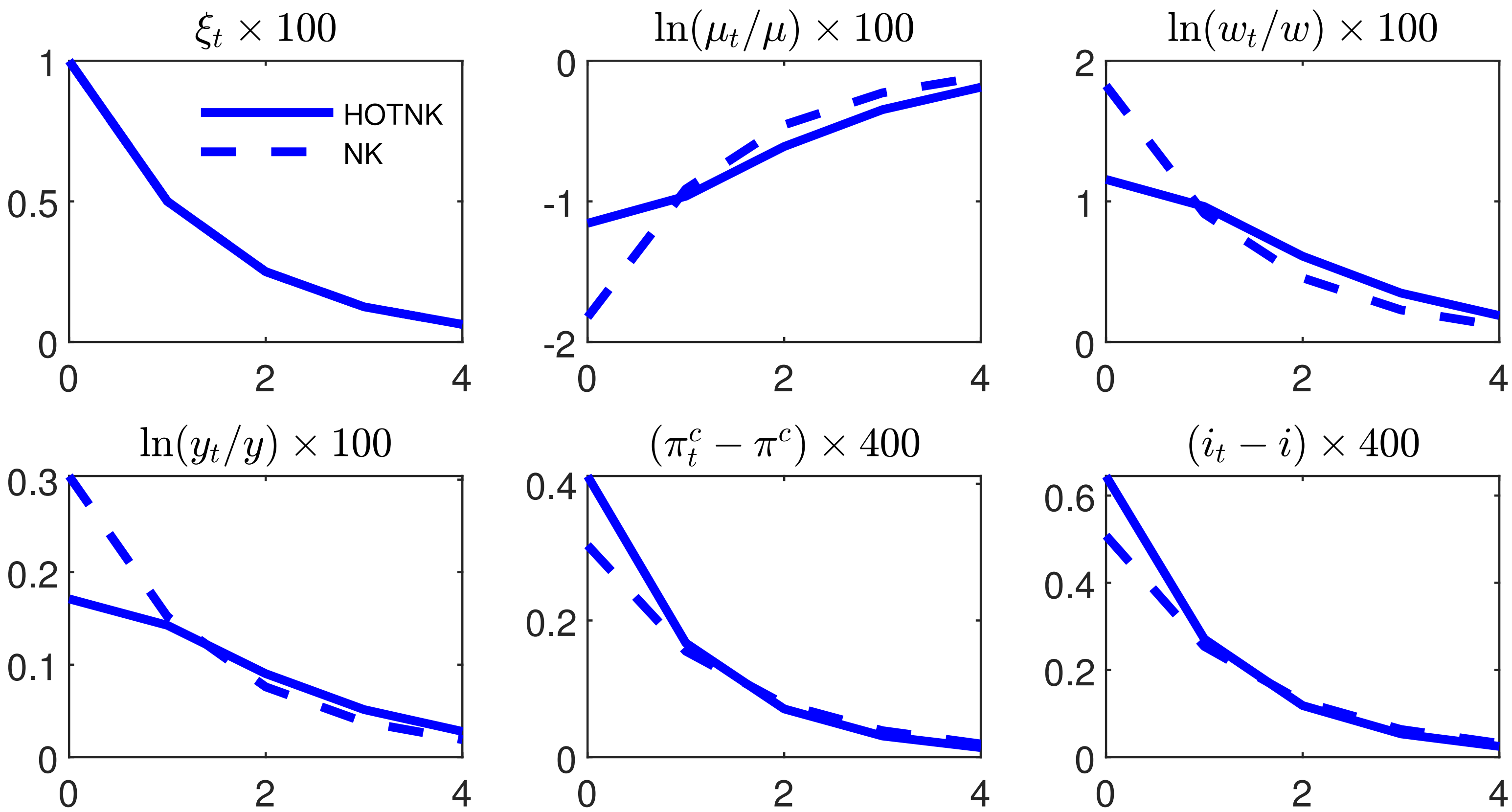
Impulse Response to a Transportation Cost Shock in the HOTNK and HOT Models



Notes. The HOTNK model features spatial frictions and sticky prices. The shock is a one percentage point increase in the shopping-to-working time ratio, $\tau_t/(4N)$, from 0.14 to 0.15. The logarithm of τ_t is assumed to follow an AR(1) process with persistence 0.9. The horizontal axis measures quarters after the shock. Variables without a time subscript represent steady-state values.

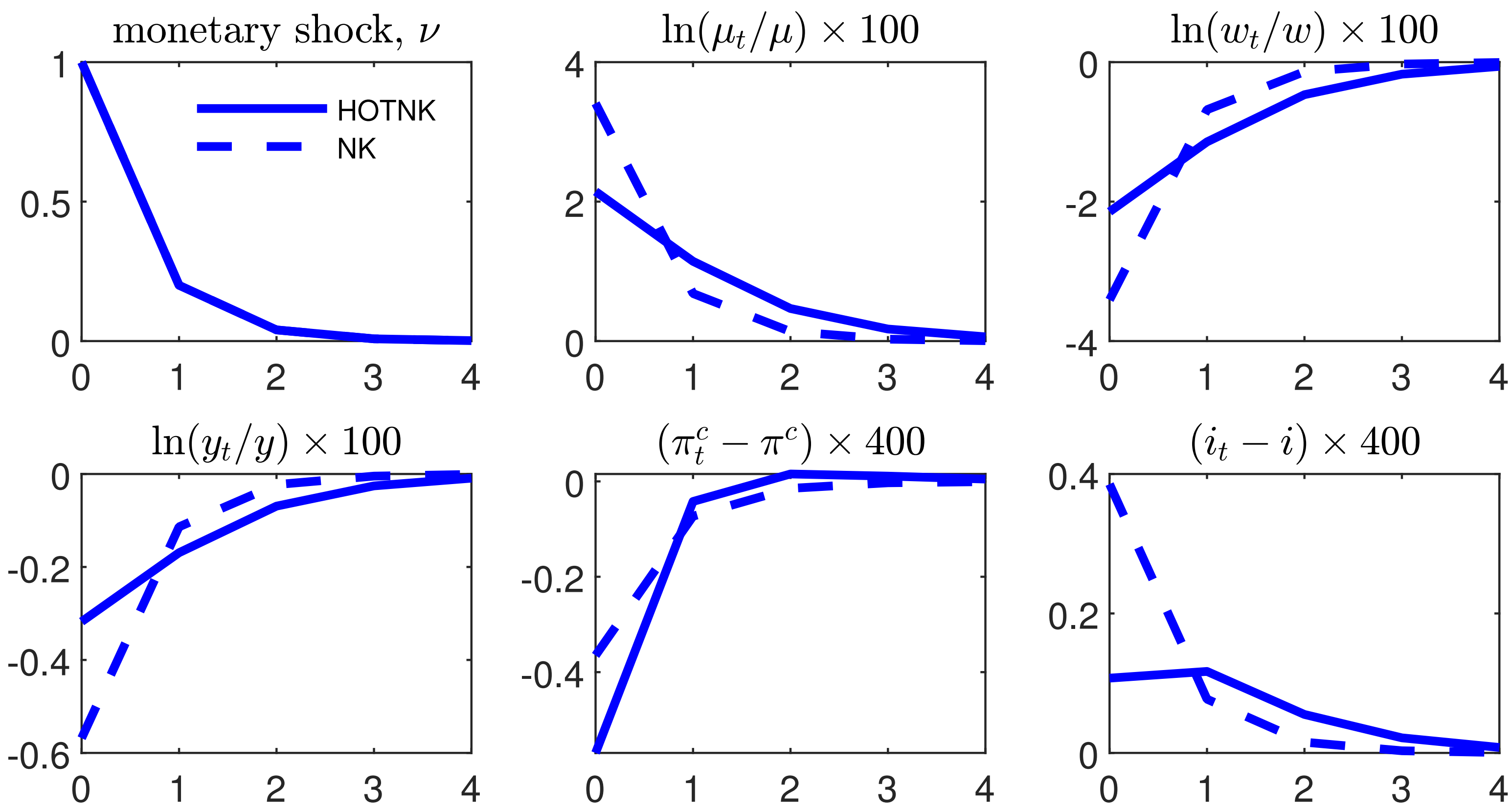
Spatial Frictions as Dampeners of Demand Shocks

Impulse Response to a Preference Shock in the HOTNK and NK Models



Notes. Solid lines correspond to the HOTNK model and dashed lines to the NK model. The shock is a 1 percentage point increase in e^{ξ_t}.

Impulse Response to a Monetary Shock in the HOTNK and NK Models



Notes. Solid lines correspond to the HOTNK model and dashed lines to the NK model. The shock is a 1 percentage point increase in the exogenous component of the Taylor rule, e^{ν_t}.

Conclusion

• This paper aims to provide microfoundation to cost-push shocks.

• To this end, it embeds a circular model of spatial competition into a new-Keynesian model.

• An increase in transportation costs causes:
(a) an endogenous increase in markups. And
(b) a contraction in the supply of labor allocated to production.
Both effects are contractionary.

• These effects are stagflationary.

• Nominal rigidity amplifies the effects of transportation costs.

• Spatial frictions dampen the output effect of monetary and preference shocks but amplify their inflationary effects.

• Spatial frictions are found to be quantitatively significant.