Price Discrimination, Backhaul Problems, and Trade Costs: Theory and Evidence from E-commerce Delivery

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Highlight

We used a novel dataset from the largest logistics platform Cainiao.
We found asymmetric pricing in both marginal price and fixed price.
We developed a model to analyse optimal two-part pricing by logistics firms.

Background of E-commerce Delivery in China

Transportation cost is one of the most important components of trade cost, particularly for e-commerce trade. China has the world's largest market for e-commerce and e-commerce delivery.

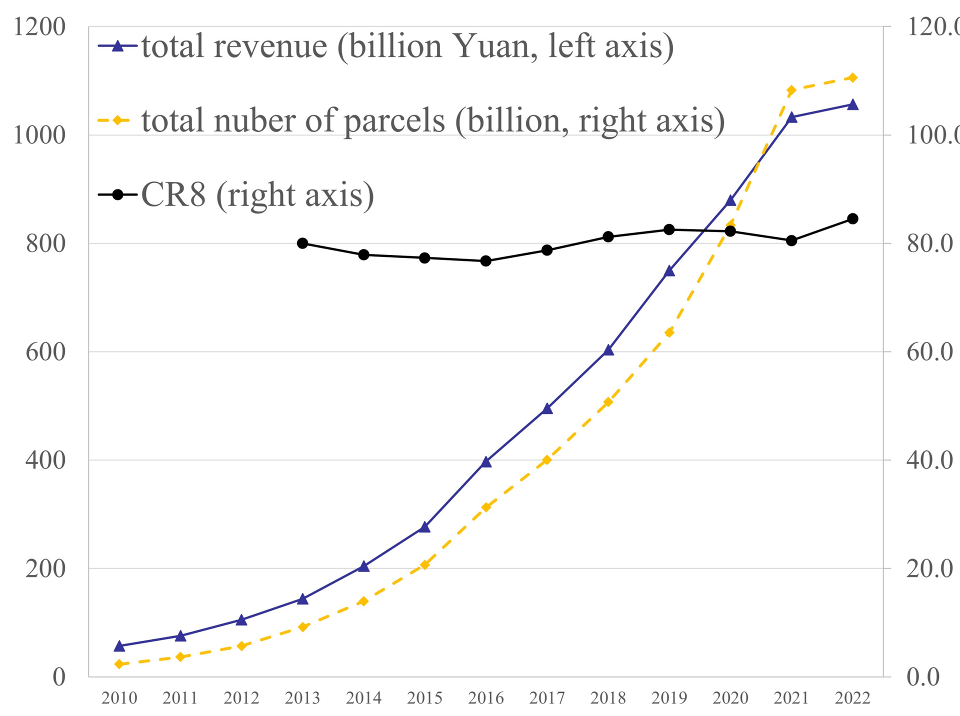

Fig. 1: Market Size and Concentration

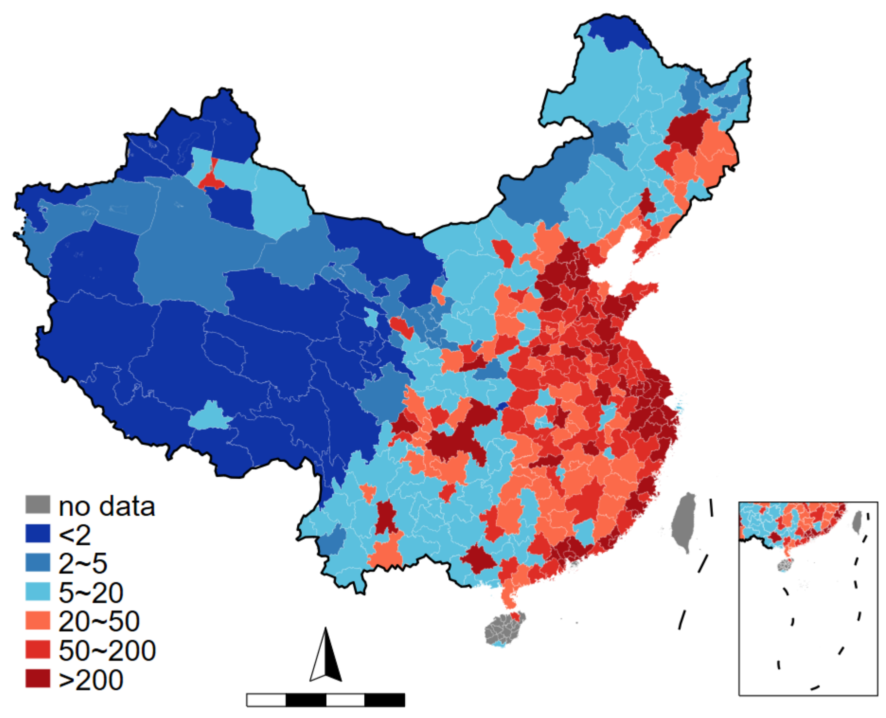

Fig. 2: Parcel Throughput per City

High market concentration in the e-commerce delivery
⇒ **price discrimination**

Extremely uneven spatial distribution of e-commerce activity
⇒ **backhaul problem**

Three Stylized Facts

1. Substantial imbalances in e-commerce deliveries between Chinese cities.
2. Significant asymmetries in the fixed and variable parts of delivery prices.
3. Price asymmetries vary with differences in city size and number of delivery firms.

Model the Transportation

Delivery firms face heterogeneous demands (Pareto distribution with α_i and $\underline{\theta}_i$).
Due to the backhaul problem, the delivery firm's total cost function is

$$c_{ij} \cdot \frac{1}{n_{ij}} \cdot \max(q_{ij}, q_{ji}) + f_{ij},$$

where c_{ij} is symmetric marginal cost and f_{ij} is fixed cost, and n_{ij} is number of delivery firms between city pairs.
The firm charges marginal price p_{ij} and fixed price F_{ij} to elicit seller types.

$$T_{ij}(q) = p_{ij}q + \mathbb{1}_{\{q>0\}}F_{ij}.$$

Proposition and Collary

For any city pair (i, j), in equilibrium, $q_{ij} \neq q_{ji}$, the marginal price is

$$p_{ij} = \begin{cases} \frac{\underline{\theta}_i}{\alpha_i - 1} + c_{ij}, & \text{if } q_{ij} > q_{ji}, \\ \frac{\underline{\theta}_i}{\alpha_i - 1}, & \text{if } q_{ij} < q_{ji}, \end{cases} \tag{1}$$

and the fixed fee is

$$F_{ij} = \frac{(\underline{\theta}_i - p_{ij})^2}{2}. \tag{2}$$

Price asymmetries can be decomposed to two parts:

$$p_{ij} - p_{ji} = \underbrace{\frac{1}{\alpha_i - 1}\underline{\theta}_i - \frac{1}{\alpha_j - 1}\underline{\theta}_j}_{\textbf{price discrimination}} + \underbrace{(\mathbb{1}_{\{q_{ij}>q_{ji}\}} - \mathbb{1}_{\{q_{ij}<q_{ji}\}})c_{ij}}_{\textbf{backhaul problem}}$$

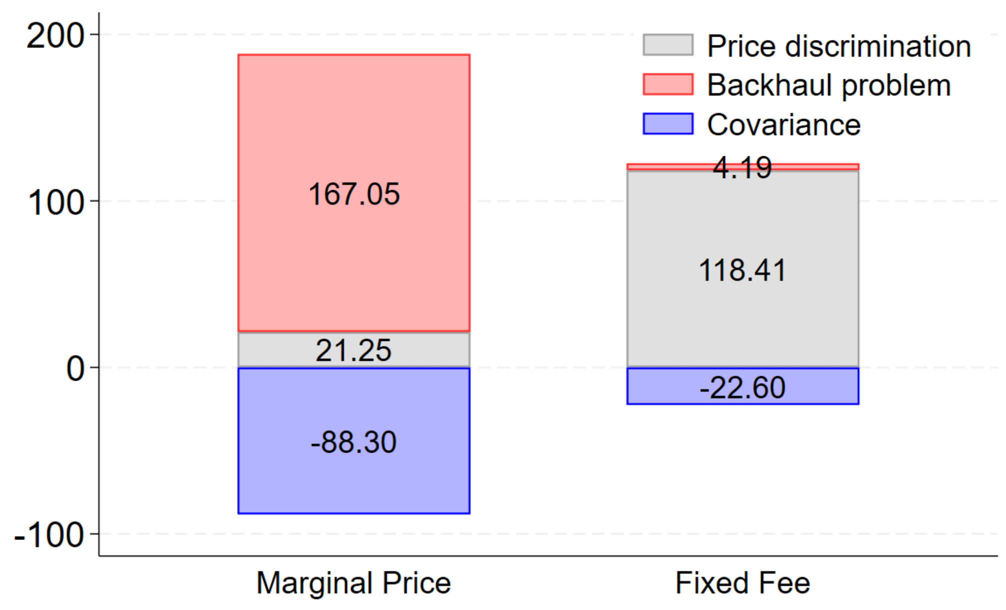

Fig. 3: Decomposition of Price Variation

Quantitatively, the backhaul problem primarily drives asymmetry in marginal prices across city pairs, while price discrimination mostly explains asymmetry in fixed fees.

Counterfactual: 10% Reduction in Marginal Shipping Cost

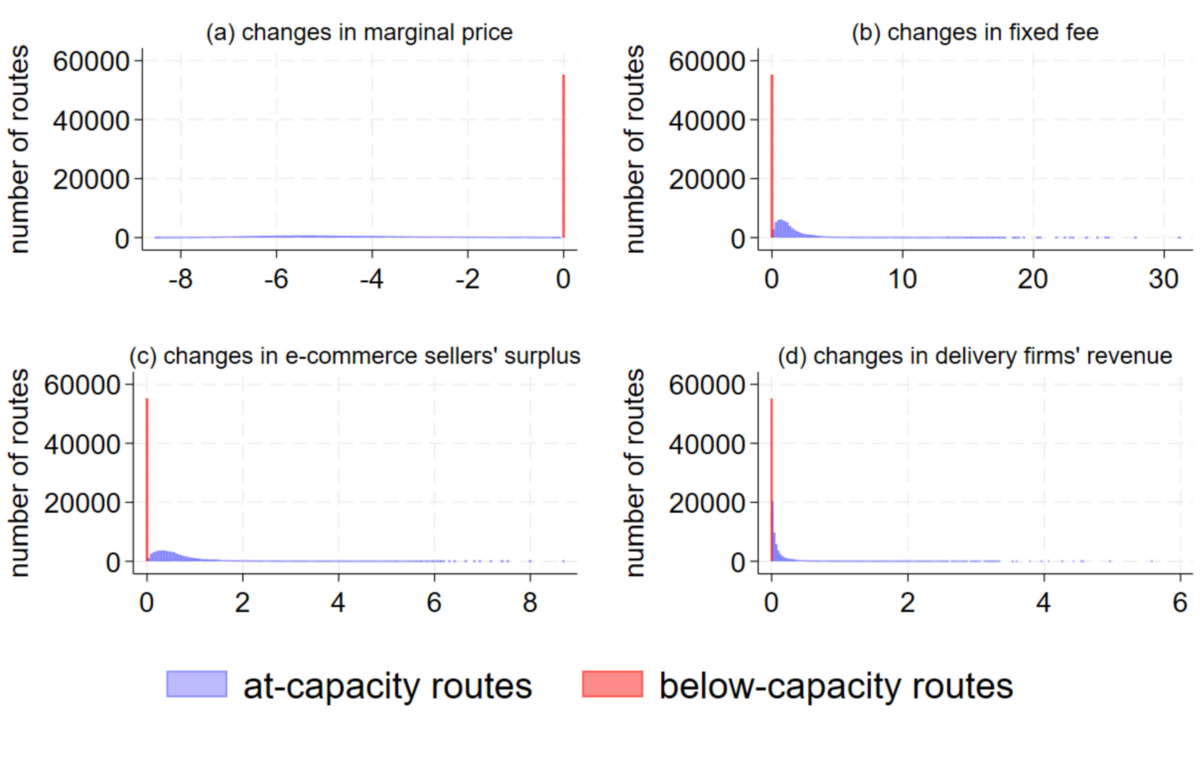

Fig. 4: Counterfactual Effects across Routes

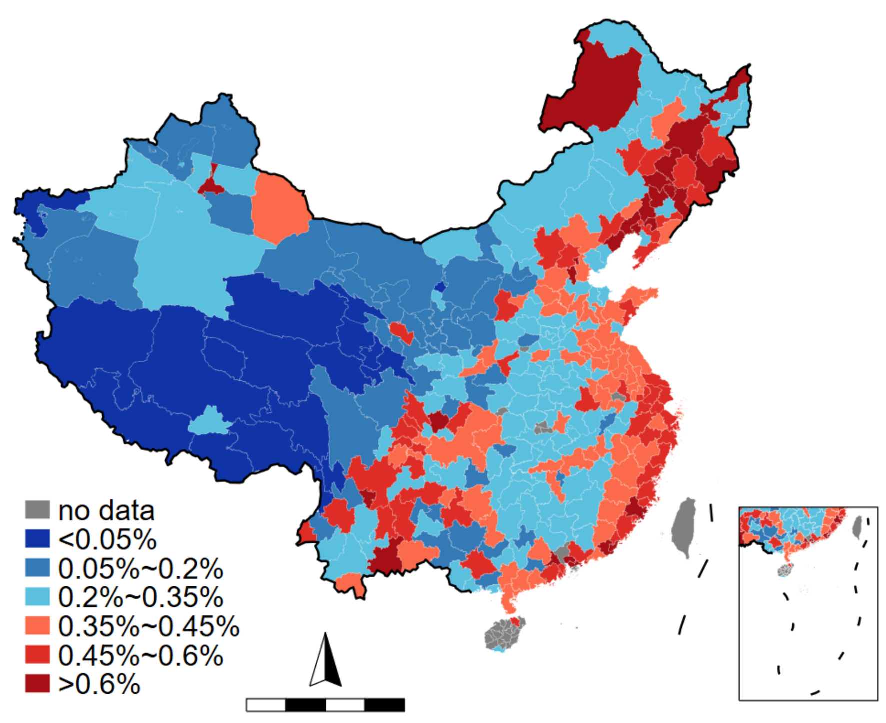

Fig. 5: Change in E-commerce Seller Surplus

No changes in below-capacity routes; significant variations in at-capacity routes.

Coastal and eastern cities gain more than western and hinterland cities.

Extension

To estimate the backhaul problem's severity, we extend the baseline model with a parameter δ_{ij} to quantify it between city pairs.
The delivery firm's total cost function is revised to:

$$c_{ij} \cdot \frac{1}{n_{ij}} \cdot (\delta_{ij} \cdot 2\max(q_{ij}, q_{ji}) + (1 - \delta_{ij})(q_{ij} + q_{ji})).$$

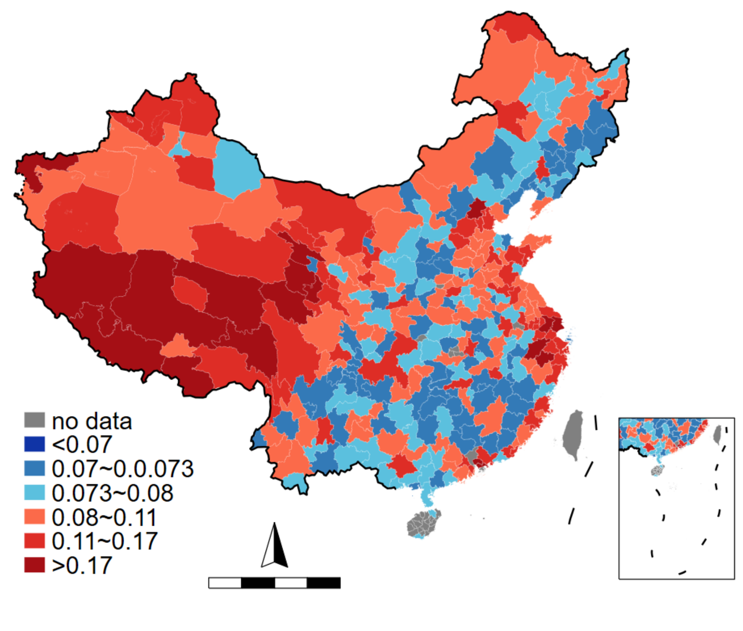

Fig. 6: Estimated Average δ