

ECONOMIES OF SCOPE IN TRANSPORTATION AND DOMESTIC TRADE

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Any opinions and conclusions expressed herein are those of the authors and do not represent the views of the U.S. Census Bureau or the World Bank.

MOTIVATION

- Freight transportation of goods: Economic foundation of a modern economy
- Road freight: Key in developing countries
 - ▶ India: 67% of transport sector + 3.1% of GDP
- How transporters leverage geography to gain efficiency?
 - ⇒ Group deliveries into a single shipment
 - ⇒ i.e. Trip chaining, **economies of scope**

THIS PAPER

Research questions

- Are there “economies of scope” from exploiting grouped shipments in transportation markets?
- How do economies of scope in transportation affect intensive and extensive margins of domestic trade?

Setting: Freight trucking within India

- Universe of firm-to-firm transactions for one large state
- Can trace path trucks take to deliver shipments

Stylized Facts

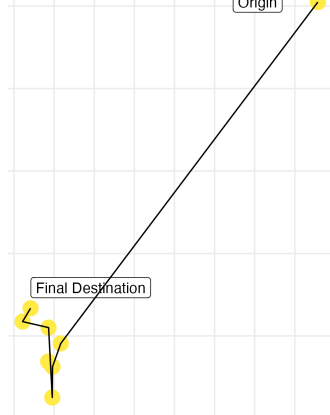
- Grouped shipments common and characterize a large portion of domestic
- Evidence for economies of scope in transportation
 - ▶ Around 40% of trade by value

Quantitative Trade Model

- Trade costs *endogenous* to trucker route choices

Counterfactuals

- Role of economies of scope on trade flows
 - ▶ Bilateral trade 30% lower due to loss of opportunities to group shipments (partial equilibrium)



LITERATURE AND CONTRIBUTIONS

- **Trade Costs and Economic Geography:** Samuelson (1954), Anderson and van Wincoop (2003), Eaton and Kortum (2002), Allen and Arkolakis (2014), Ahlfeldt et al. (2015)
 - ▶ **Contribution:** Focus on role of economies of scope and grouped shipments shaping trade costs.
- **Transportation Sector in Economic Geography and International Trade:** Hummels et al. (2009), Asturias (2020), Brancaccio et al. (2020), Yang (2021), Miyauchi et al. (2022), Wong (2022), Allen and Arkolakis (2022), Allen et al. (2023)
 - ▶ **Contribution:** Study effect of grouping shipments (ex ante trip chaining) (Allen et al., 2023).
- **Production Location Decisions:** Melitz (2003), Tintelnot (2016), Antras et al. (2017), Antras et al. (2022), Alfaro-Urena et al. (2023)
 - ▶ **Contribution:** Study role of domestic transportation sector in shaping market entry.

DATA AND CONTEXT

Transaction Data:

- Establishment-to-establishment transactions at the HS-8 level for a large Indian state for 2019.
- Censoring: All transactions that begin or end in the state.
- Key: Data generated when transporter picks up shipment.

TABLE 1: Example Data

Date	ID	Seller	Seller Pincode	Buyer	Buyer Pincode	Product	Value	Vehicle
2019-01-01-13:01:32	12345	Brian	48104	Gaurav	90210	Shoes	X	GO B!U3
2019-01-01-13:01:32	12346	Brian	48104	Brock	90212	Socks	Y	GO B!U3
2019-01-01-15:00:01	12347	J.J.	48127	Blake	90210	Shirts	Z	GO B!U3

Defining Shipments:

- All uninterrupted transactions fulfilled by a vehicle that originate close together, in both space and time.
- Grouped shipments VS Direct shipments.

FACTS 1 + 2: GROUPED SHIPMENTS ARE COMMON AND IMPORTANT

Fact 1: Grouped shipments are common and important

TABLE 2: Prevalence of Grouped Shipments within the Sample

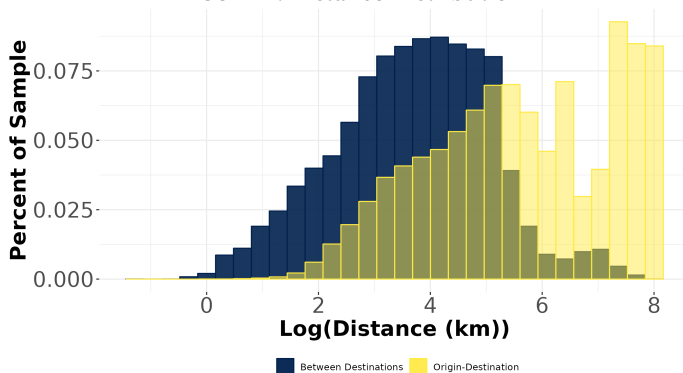
	Transactions	Shipments	Fraction of Trade	Vehicles	Sellers
Direct Shipments	0.4	0.79	0.6	0.96	0.90
Grouped Shipments	0.6	0.21	0.4	0.46	0.63

Fact 2: Sellers of grouped shipments are well-connected

- Firms ever apart of a grouped shipment: Average 13 customers, 12 destination locations.
 - ▶ Median: 3 customers, 3 destinations.
- Firms never apart of a grouped shipment: Average 2 customers, 2 destination locations.
 - ▶ Median: 1 customer, 1 destination.

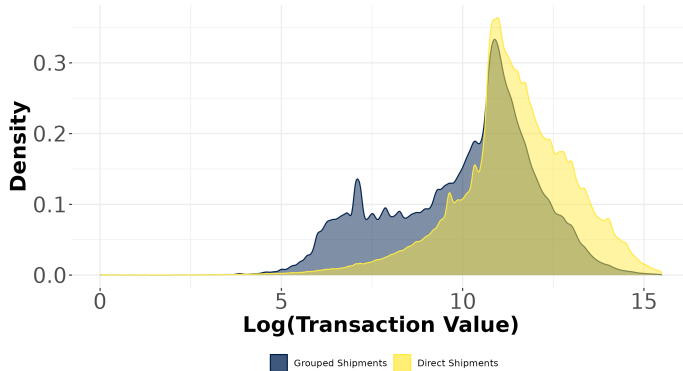
FACT 3: GROUP SHIPMENTS' STOPS ARE CLOSE TOGETHER

FIGURE 2: Distance Distribution



FACT 4: VALUE OF TRANSACTIONS IN GROUPED SHIPMENTS ARE LOWER

FIGURE 3: Transaction Value Distribution



MODEL

Setup: Allen and Arkolakis (2022) + Antras et al. (2022)

- J locations: L_j consumers in j immobile, supply labor inelastically.
- Production: Perfectly competitive final goods firms produce varieties, $\omega \in [0, 1]$.
- Preferences: CES with elasticity of substitution σ across *truckers* (φ) and varieties (ω).

Trade and Transportation Sector:

- Trade between locations requires use of monopolistically competitive truckers, φ .
- Final goods producer sell output to truckers at marginal cost.
- Truckers deliver j 's output via a route: $r \equiv \{j, d_1, d_2, \dots\} \in 2^J$.
- Truckers incur variable trade costs (Allen and Arkolakis, 2022):

$$r^*(\varphi, \omega) = \arg \min_{r \in \mathcal{R}_{ji}(\varphi)} \left\{ c_{ji,r}(\varphi, \omega) \right\} = \arg \min_{r \in \mathcal{R}_{ji}(\varphi)} \left\{ \frac{1}{\epsilon_r(\varphi, \omega)} \tau(r) \right\}, \quad \epsilon_r(\varphi, \omega) \sim \text{Frechet}(\theta)$$

- And fixed route-entry costs, f_r .
- Set of routes entered between j and i : $\mathcal{R}_{ji}(\varphi)$.

TRANSPORTATION SECTOR

Transportation Sector's Problems:

- (1) Enter into routes ($\mathcal{R}_{ji}(\varphi)$), (2) Route assignment ($r^*(\varphi, \omega) \in \mathcal{R}_{ji}(\varphi)$), (3) Pricing ($p_{ji}(\varphi, \omega)$).

Pricing Problem:

- $\pi_{ji,r^*}(\varphi, \omega) = (1 + \tau_{ji}(\varphi, \omega)) p_j(\varphi, \omega) q_{ji}(\varphi, \omega) - (1 + c_{ji,r^*}(\varphi, \omega)) p_j(\varphi, \omega) q_{ji}(\varphi, \omega)$
- $p_{ji}(\varphi) = \mu p_j \left[\Xi(\mathcal{R}_{ji}(\varphi)) \right]^{\frac{1}{1-\sigma}}, \Xi(\mathcal{R}_{ji}(\varphi)) \in [0, 1].$
- $\Xi \equiv$ “Efficiency of φ ’s delivery capabilities.”
 - When $\tau \downarrow$ or $\mathcal{R}_{ji}(\varphi) \uparrow \Rightarrow \Xi \rightarrow 1$, good for transportation firm given it is now the seller.

Entry Problem:

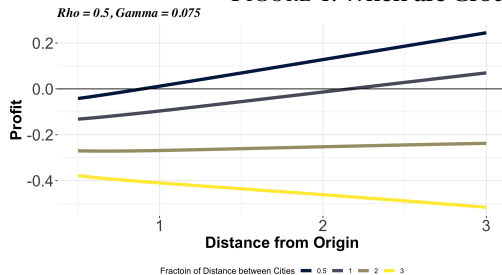
$$\pi_j \left(\varphi, \{\mathcal{R}_{ji}(\varphi)\}_{j=1}^J \right) \equiv \kappa \sum_{i \in \mathcal{I}} p_j^{1-\sigma} E_i P_i^{\sigma-1} \Xi(\mathcal{R}_{ji}(\varphi)) - \sum_{r \in \cup_i \mathcal{R}_{ji}(\varphi)} w_j f_r$$

ECONOMIES OF SCOPE?

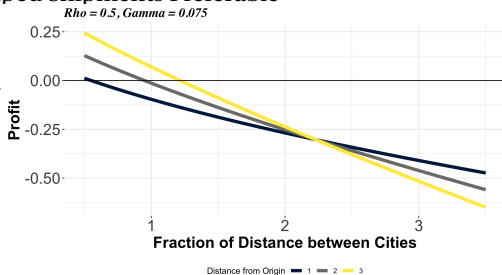
Exercise: Consider shipment from O to d_1 and d_2 .

- $\text{dist}(\{d_1\}) = \text{dist}(\{d_2\}) = z$, where z is distance from origin
- $\text{dist}(\{d_1, d_2\}) = z + yz$, where y is fraction of distance between cities
- **When is grouped shipment profitable?**

FIGURE 4: When are Grouped Shipments Preferable



(A) Distance from Origin



(B) Distance between Cities

- Change in profit: $\pi(\{d_1, d_2\}) - \pi(\{d_i\}_{i=1}^2)$

QUANTIFICATION

Key parameters: Trade elasticity $\tau(r)$ + route choice heterogeneity (θ) + fixed costs of route entry (f_r).

$\tau(r) + \theta$: [Details](#)

- $\tau(r) = \zeta_0(\text{distance}(r))^{\zeta_1}$.
- Leverage our data, an instrumental variables strategy, and model implied gravity equation.
- $\zeta_1 \approx 0.023$.
- $\theta \approx 1.197$.

Fixed costs:

- $f_r = \gamma \times \text{distance}(r)$.
- Leverage equilibrium conditions:
 - ▶ All truckers ex ante identical, $\Omega_{ji} = \Omega_i$.
 - ▶ $L_i = \Omega_i \sigma \sum_j \sum_{r \in \mathcal{R}_{ij}} f_r$.

COUNTERFACTUALS AND CONCLUSION

Counterfactual: Details

- Effect of grouped shipments on domestic trade (intensive margin).
- Estimate how Ξ would change if no grouped shipments were allowed holding entry into markets constant.
- Find domestic bilateral would fall by about 30% in absence of ability to group shipments (in partial equilibrium).

Conclusion:

- Document presence and prevalence of grouped shipments in domestic trade.
- Develop quantitative model that can rationalize grouped shipments via economies of scope.
- Estimate a substantial degree of heterogeneity in route choices.
- Trade cost benefit from grouping shipments contributes to domestic trade via lower trade costs.

COMPARATIVE STATIC ASSUMPTIONS

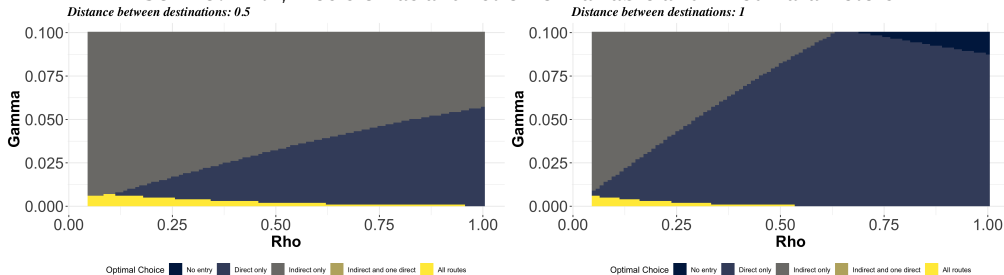
Exercise: Consider shipment from O to d_1 and d_2 . When is grouped shipment profitable?

- $\mathcal{J} = \{O, d_1, d_2\}$.
- We consider the route entry decisions for a transporter, φ , located in O .
- The sets of possible routes for each destination are: $\mathcal{R}_{Od_1} \equiv \left\{ \{d_1\}, \{d_1, d_2\} \right\}$,
 $\mathcal{R}_{Od_2} \equiv \left\{ \{d_2\}, \{d_1, d_2\} \right\}$.
- The distance of the routes are:
 $\text{distance}(\{d_1\}) = \text{dist}(\{d_2\}) = z$, $\text{distance}(\{d_1, d_2\}) = z + yz$
- $\tau(r) = \text{distance}(r)^\rho$.
- Normalize the following: $E_d P_d^{\sigma-1} = p_O^{1-\sigma} = \kappa \varphi^{\sigma-1} = w_O = 1$, for each $d \in \{d_1, d_2\}$.
- Fixed costs are linear functions of distance: $f_r = \gamma \times (\text{distance}(r))$.
- Finally, $\sigma - 1 < \theta$. More specifically: $\theta = 8, \sigma = 2$.

COMPARATIVE STATICS CONTINUED (2)

Exercise: Consider shipment from O to d_1 and d_2 . When is grouped shipment profitable?

FIGURE 5: Entry Decision as a function of Variable and Fixed Parameters



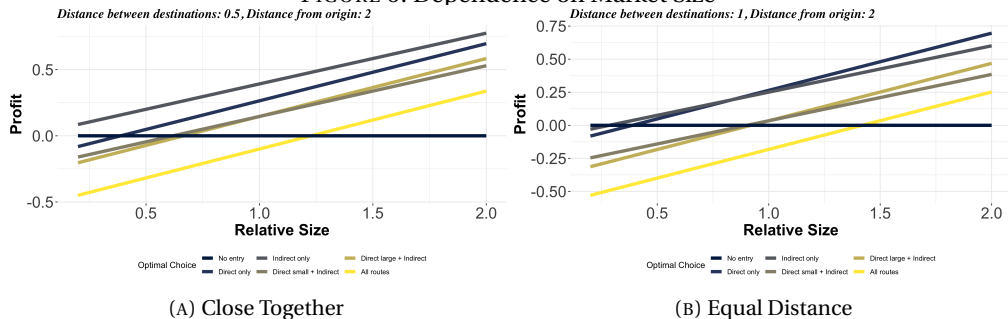
(A) Close Together

(B) Equal Distance

COMPARATIVE STATICS CONTINUED (3)

Exercise: Consider shipment from O to d_1 and d_2 . When is grouped shipment profitable?

FIGURE 6: Dependence on Market Size



ESTIMATING θ

Estimation Equation (ζ_1):

$$\underbrace{\log(p_{sobd\text{tvhi}})}_{\log(p_{od,r}(\varphi,\omega))} = \underbrace{\kappa_1 \times \log(\text{distance}(r))}_{\tau(r)} + \underbrace{f_{s,o,h,t}}_{\log(p_o(\omega))} + \underbrace{f_{\varphi,o,d,h}}_{-\log(\epsilon_{ji,r}(\varphi,\omega))} \\ + f_{b,d,t} + f_{\text{unit}(hi)} + \beta \log(q_{sobd\text{tvhi}}) + \nu_{sobd\text{tvhi}}$$

- Note, omitted variable bias due to $\epsilon_{ji,r}(\varphi,\omega)$.
 - ▶ Instrument $\log(\text{distance}(r))$ with bilateral distance between seller pincode and origin pincode.
 - ▶ Need that productivity not correlated with the bilateral distance.

Gravity Equation:

$$\log(\lambda_{ji,r}) = -\theta \times \kappa_1 \log(\text{distance}(r)) + \log(\Omega_{ij,r}) + f_{ji} + \nu_{ji,r}$$

Back $\lambda_{ji,r} \equiv X_{ji,r}/X_{ji}$, $\Omega_{ji,r}$ entrants into r .

ESTIMATING ζ_1

TABLE 3: Estimation of ζ_1

Dependent Variable:				Log(Unit Value)				
Model:	(1)	(2)	(3)	OLS (4)	(5)	(6)	(7)	IV (8)
<i>Variables</i>								
I(Shipment includes more than one destination) = 1		-0.0131*** (0.0043)	-0.0176*** (0.0038)		-0.0117*** (0.0039)		-0.0135*** (0.0050)	-0.0440*** (0.0115)
Log(Bilateral Distance)	0.0072** (0.0031)		0.0071** (0.0031)					
Log(Route Distance)				-0.0070** (0.0033)	-0.0039 (0.0029)			0.0223** (0.0099)
Log(Added Distance)						-0.0012*** (0.0004)	0.0001 (0.0005)	
<i>Fixed-effects</i>								
Unit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HSN-Seller-Origin Pin-Year-Month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vehicle-Origin Pin-Destination Pin-HSN		Yes		Yes	Yes	Yes	Yes	
Buyer-Destination Pin-Year-Month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vehicle-HSN	Yes		Yes					Yes
<i>Controls</i>								
Log(Quantity)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>								
R ²	0.91719	0.92794	0.91719	0.92794	0.92794	0.92794	0.92794	0.91719
Observations	11,797,553	11,797,553	11,797,553	11,797,553	11,797,553	11,797,553	11,797,553	11,797,553
Kleibergen-Paap								210

ESTIMATING θ

TABLE 4: Estimation of θ

Dependent Variable: Model:	Log(λ) (1)
<i>Variables</i>	
Log(Route Distance)	-0.0267** (0.0105)
Log(Number of Vehicles)	1.414*** (0.0076)
<i>Fixed-effects</i>	
Origin Pin-Destination Pin	Yes
<i>Fit statistics</i>	
R ²	0.84099
Observations	3,285,833

COUNTERFACTUAL

Goal: Identify how presence of grouped shipments affect bilateral trade flows.

Approach:

- Remove grouped shipments from \mathcal{R}_{od} .
- New route-entry sets: \mathcal{R}_{od}^D .
- Given estimates* of θ, ζ , construct counterfactual $\Xi(\mathcal{R}_{od}^D)$.
 - ▶ Effect on $\Xi(\mathcal{R}_{od}^D)$ ambiguous. Improves (approaches 1) or worsen (approaches 0), depending on:
 - ▶ (1) number of routes (route choice heterogeneity),
 - ▶ (2) presence of grouped routes (longer variable trade costs).

- Estimate model's aggregate gravity equation:

$$\log(X_{od}) = f_o + f_d + \log(\Omega_{od}) + \log(\Xi_{od}(\mathcal{R}_{od})) + \epsilon_{od}$$

- Save f_o, f_d and construct counterfactual $\widehat{\log(X_{od})}$ using $\Xi(\mathcal{R}_{od}^D)$.

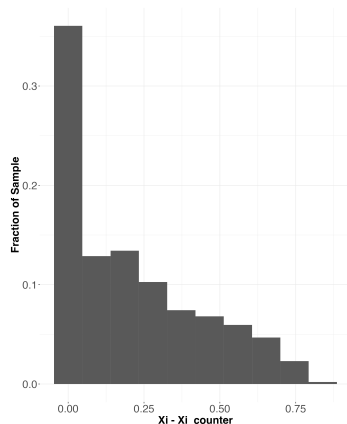
Results: (more details on next slide)

- Bilateral trade declines by about 30% across all od pairs.

Back

COUNTERFACTUAL CONTINUED

FIGURE 7: Difference in Ξ



[Back](#)

~~TABLE 5: Aggregate Gravity Regression~~
Dependent Variable: $\log(X_{od})$
Model: (1)

Variables

$\log(\Xi(\mathcal{R}))$	0.6342*** (0.0351)
$\log(\Omega_{od})$	1.069*** (0.0184)

Fixed-effects

Origin Pin	Yes
Destination Pin	Yes

Fit statistics

R^2	0.70837
Observations	66,098
