

Global Production and Trade in the Knowledge Economy

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Very Preliminary!

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Introduction

Multinational Enterprises (MNE) are at the center of attention of knowledge creation and international knowledge dissemination.

- Key assumptions of theory of the multinational firm
 - MNE create knowledge and this knowledge gives them an advantage in foreign environments (OLI framework)
- Key assumption in empirics
 - Extensive “knowledge spillovers literature”

There is reason to believe that it is costly for multinationals to transfer their technology abroad.

- The market share of the foreign affiliates of individual MNE is much smaller than the market share of their parent firm in their home country.
- Case studies suggest that the productivity of the affiliate is lower than the productivity of the parent.
- Multinational activity in general decreases in distance between source and host country.

This paper makes the following contributions.

- 1) Propose a simple mechanism that features an *interaction* between *physical shipping costs* and *technology transfer costs* that determines affiliate's marginal costs.
- 2) Embed this mechanism in a simple general equilibrium model to generate predictions over the behavior of individual multinationals.
- 3) Estimate the implied geography of the marginal costs of U.S. multinationals using firm-level data.

The Model

Consider a three country world with a single factor L

- Two identical (northern, N) countries (E,W), where wage is w_N
- One country is the south (S) where wage is w_S

Preferences in the north are given by

$$U = \sum_{i=1}^I \frac{\chi_i}{\alpha} \ln \left[\int_{\omega \in \Omega^i} x_i(\omega)^\alpha d\omega \right] + (1 - \sum_{i=1}^I \chi_i) \ln Y,$$

where $\alpha = 1 - 1/\sigma$ and $\sigma > 1$.

The south consumes only Y .

Differences in productivity in Y give rise to the wage differences.

Firm ω in the differentiated good industry i can assemble its variety from a continuum of variety-specific intermediates using the following technology:

$$x_i(\omega) = \psi_i \exp\left(\int_0^\infty \beta_i(z) \ln(m(z)) dz\right),$$

$m(z)$ is the quantity of an intermediate of “technical complexity” z , and

$$\beta_i(z) = \phi_i \exp(-\phi_i z)$$

is the cost share of intermediate z . (low ϕ_i are the technically complex).

There exists a continuum of potential entrants in the north

Each endowed with the property rights to a particular variety.

An entrant incurs fixed cost Φ_i to enter and draws its type φ from known distribution G .

A firm's type is related to its productivity producing each of the continuum of intermediates necessary to produce the final good.

Technology Transfer Costs

Consider a firm that has entered in E. This firm can produce any given intermediate in E, W, or S.

Because of technology transfer costs, a firm's productivity for a given intermediate depends on

- its type,
- the technical complexity of the intermediate,
- and the location in which the intermediate is produced.

If intermediate z specific to a firm of type φ is produced by

- the **parent** in E, then productivity = φ ,
- an **affiliate** in S, then productivity = $\varphi \exp(-\lambda_S z)$,
- the **affiliate** in W, then productivity = $\varphi \exp(-\lambda_N z)$.

where $\lambda_S > \lambda_N > 0$ reflects technology transfer costs that are higher in the south.

In the paper we rationalize this functional form assumption using a simple framework inspired by Arrow (1969).

Shipping Costs

Goods shipped from S to N incur iceberg transport cost τ_S .

Goods shipped from E to W incur iceberg transport cost τ_N .

Fixed Entry Cost

To sell its product in any country, a firm must incur a fixed cost f in order to set up a distribution network and to market its variety.

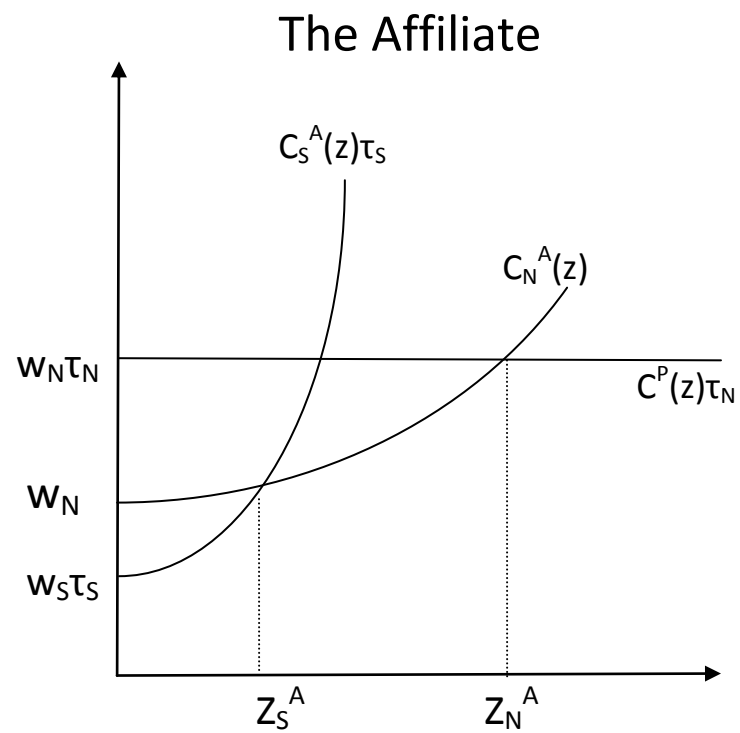
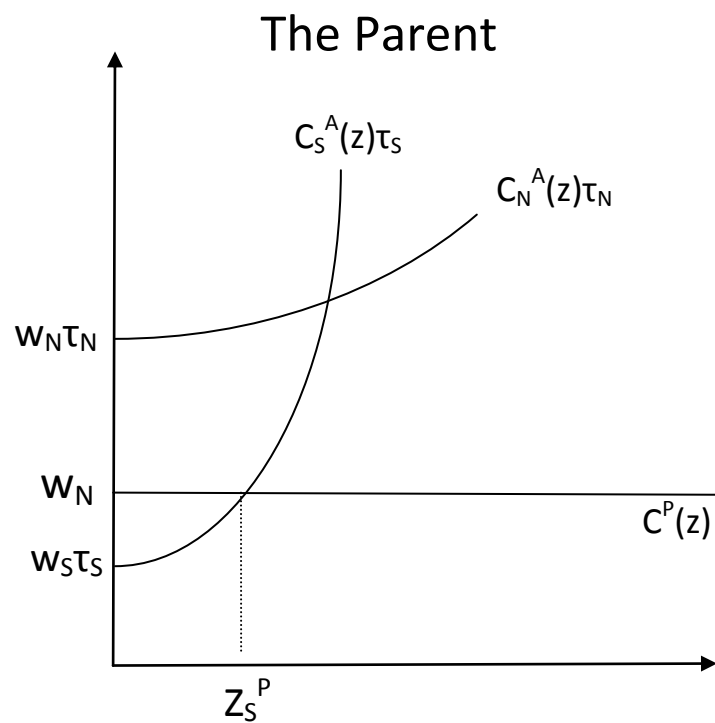
Analysis of the Model

1. Consider the optimal sourcing decisions for each intermediate of a parent firm and its affiliate in the other northern country.
2. Derive the marginal costs associated with these sourcing decisions
3. Derive the optimal sales revenue of parent and affiliate as a function of marginal cost
4. Analyze the entry decision
5. Comparative Statics

Along the way, we emphasize a number of empirical implications.

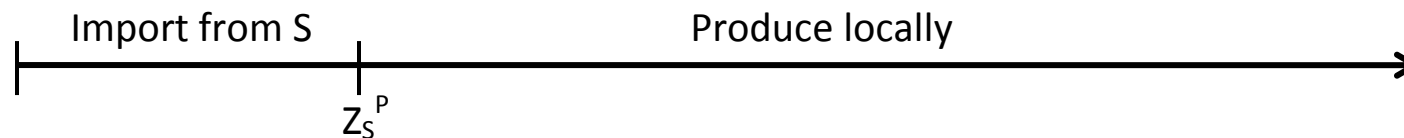
The Structure of Intermediate Sourcing

Firms simply buy from the lowest cost location for a given z

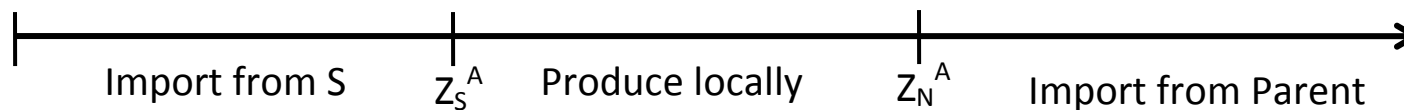


The Pattern of Sourcing summarized

Parent



Affiliate



Empirical Implications

1. Affiliates in N source more intermediates from S than do parents.
2. An increase in τ_N decreases the range of intermediates imported from the parent firm.

The Geography of Marginal Costs

The marginal costs of parents of type φ in industry i

$$C_i^P(\varphi) = \frac{(\Gamma_i^S(0, z_S^P) w_S \tau_S)^{\theta_i(z_S^P)} (w_N)^{1-\theta_i(z_S^P)}}{\varphi}$$

where

$$\Gamma_i^S(0, z_S^P) = \exp \left[\lambda_S \int_0^{z_S^P} z \frac{\beta_i(z)}{\int_0^{z_S^P} \beta_i(z) dz} dz \right]$$

measures technology transfer costs, and

$$\theta_i(z_S^P) = \int_0^{z_S^P} \beta_i(z) dz$$

is the cost share of imported intermediates

The marginal cost of the affiliate is

$$C_i^A(\varphi) = \frac{(\Gamma_i^S(0, z_S^A) w_S \tau_S)^{\theta_i(z_S^A)} (\Gamma_i^N(z_S^A, z_N^A) w_N)^{\theta_i(z_N^A) - \theta_i(z_S^A)} (w_N \tau_N)^{1 - \theta_i(z_N^A)}}{\varphi}.$$

Integrating using the cost share function, we obtain

$$C_i^A(\varphi) = \frac{1}{\varphi} \exp(g_i^A), \text{ where}$$

$$g_i^A = \ln(w_S \tau_S) + \frac{\lambda_S}{\phi_i} - \frac{\lambda_S - \lambda_N}{\phi_i} \left(\frac{w_N}{w_S \tau_S} \right)^{\frac{-\phi_i}{\lambda_S - \lambda_N}} - \frac{\lambda_N}{\phi_i} (\tau_N)^{\frac{-\phi_i}{\lambda_N}}$$

The cost share of intermediates imported $(1 - \theta_i(z_N^A))$ by the affiliate from the parent is then

$$\ln(1 - \theta_i(z_N^A)) = -\frac{\phi_i}{\lambda_N} \ln \tau_N$$

Key Empirical Implications

- The cost share of intermediates imported from the parent is decreasing in τ_N , and the rate of increase is *slower* in high-tech industries (i.e. low ϕ_i).
- The marginal cost of the affiliate is increasing in τ_N , and the rate of increase is *faster* in high-tech industries (i.e. low ϕ_i).

The Structure of Multinational Activity across Firms and Countries

Consider firm of type φ in industry i and country k

The preferences imply iso-elastic demand.

Conditional on serving country k , the **Local Sales** are

$$R_i^k(\varphi) = A_i (C_i^k(\varphi))^{1-\sigma}, \quad k \in \{A, P\}$$

where A_i is the endogenous mark-up adjusted demand level.

The profit in country k is

$$\pi_i^k(\varphi) = \frac{R_i^k(\varphi)}{\sigma} - w_N f, \quad k \in \{A, P\}$$

A firm will serve country k if it has sufficiently low marginal cost.

The **Cutoff Productivity Level** for country k , $\hat{\varphi}_i^k$, is implied by

$$C_i^k(\hat{\varphi}_i^k) = \left(\frac{A_i}{w_N f} \right)^{\frac{1}{\sigma-1}}, \quad k \in \{A, P\}$$

Only firms with productivity $\varphi > \hat{\varphi}_i^k$ open an affiliate.

Empirical Implications

Holding fixed the mark-up adjusted demand level A_i

- The probability that a firm opens an affiliate is decreasing in τ_N and the rate of decrease is *faster* in high-tech industries.
- Conditional on entry, the value of an affiliate's sales to local customers is decreasing in τ_N and the rate of decrease is *faster* in high-tech industries.

These implications both follow from the effect of τ_N on affiliate marginal cost.

Closing the model with the free entry condition allows General Equilibrium Comparative Statics

Proposition: A decrease in either τ_S or τ_N results in a decrease in $\hat{\varphi}_i^A$ and an increase in $\hat{\varphi}_i^P$.

Trade liberalization in general leads to an increase in the range of firms engaged in FDI.

Affiliates use a wider range of intermediate inputs imported from the south.

Empirical Strategy

Exploit variation in two distinct datasets to assess the predictions and to estimate structural relationships.

1. Use **firm-level data** from the BEA Benchmark survey for 1994, which allow us to observe
 - location of U.S. Affiliates and their sales to local customers
 - aggregate intra-firm trade between U.S. parent and each of its affiliates
 - observe parent firm sales in U.S., R&D spending, and industry
2. Use Census data on the **commodity composition** of intra-firm trade aggregated by type of good to analyze the range of goods sold to affiliates.

The structure of U.S. multinational activity

Theory implies that the cost share of intermediates imported from the parent firm j to affiliate in country k satisfies

$$\ln(1 - \theta_j(z_k^A)) = -\frac{\phi_j}{\lambda_N} \ln \tau_k.$$

- Let τ_k varies by country, let FC_k be a measure of freight and shipping costs between the U.S. and country k .
- Let $\phi_j = \delta_0 + \delta_1 RD_j$, where $RD_j =$ R&D intensity of firm j .

We estimate variants of

$$\ln \frac{M_{jk}}{TC_{jk}} = \gamma_j + \kappa \ln X_k + \left(\frac{\delta_0}{\lambda_N} + \frac{\delta_1}{\lambda_N} RD_j \right) \ln FC_k + \varepsilon_{jk}.$$

Theory implies that $\delta_0/\lambda_N < 0$ and $\delta_1/\lambda_N > 0$.

FC_k = Ad-valorem measure of trade costs btw US and k (cif/fob)

RD_j = Parent j (RD Expenditure)/(sales)

X_k = GDP per capita, population, and corporate tax rate.

Also estimate for local sales of affiliates

$$\ln R_{jk} = \eta_j + \rho \ln X_k + (\zeta_0 + \zeta_1 RD_j) \ln FC_k + \varepsilon_{jk}$$

Theory implies that $\zeta_0 < 0$ and $\zeta_1 < 0$.

Finally, entry decision: holding fixed the fixed cost, an increase in the optimal level of local sales also increase the likelihood that firm j will own an affiliate.

We estimate a linear probability model of firm entry akin to the sales equation above.

Baseline Results: Within Firm Variation

	(1)	(2)	(3)	(4)	(5)
	Import Cost Share	Import Cost Share	Import Cost Share	Local Sales	Entry Decision
FC	-13.2 (1.68)	-19.6 (2.41)	-30.3 (2.34)	-8.06 (1.17)	-0.969 (0.06)
RD*FC		111 (29.9)	79.5 (24.4)	-37.3 (13.1)	-3.00 (0.472)
GDPPC			-0.798 (0.065)	0.903 (0.034)	0.062 (0.002)
POP			-0.197 (0.028)	0.495 (0.015)	0.027 (0.001)
TAX			-0.301 (0.124)	-0.172 (0.064)	0.035 (0.030)
N	4,001	4,001	4,001	5,394	112,860
R-sq.	0.020	0.024	0.065	0.344	0.075

The variables FC, GDP, POP, and TAX are in logarithms and RD is in levels.

Robust standard errors are in parentheses below the corresponding coefficient estimates.

Within-Industry Effect of Trade Costs

	(1)	(2)	(3)	(4)
	Import Cost Share	Local Sales	Import Cost Share	Local Sales
PSALE		0.459 (0.028)		0.508 (0.024)
RD	-0.482 (1.69)	2.82 (1.02)	0.558 (1.07)	2.10 (0.729)
FC	-24.3 (10.2)	-15.2 (3.06)	-33.0 (2.31)	-6.25 (2.59)
RD*FC	108 (37.4)	-61.7 (21.2)	84.7 (23.9)	-43.3 (17.2)
GDPPC			-0.581 (0.065)	0.703 (0.077)
POP			-0.112 (0.139)	0.406 (0.035)
TAX			-0.262 (0.139)	-0.188 (0.194)
N	4,001	5,394	4,001	5,394
R-square	0.020	0.380	0.165	0.473

Assuming no offshoring to south the model implies that the cost disadvantage of an affiliate relative to its parent is

$$\frac{C^A}{C^P} = \exp \left(\frac{\lambda_N}{\phi_i} \left[1 - (\tau_N)^{-\frac{\phi_i}{\lambda_N}} \right] \right).$$

We can use the coefficient estimates from the cost share regressions and data to evaluate this expression for various levels of trade costs and technological intensity.

The implied marginal cost disadvantage of the affiliate

		R&D Intensity		
		Std Dev Below	Mean	Std Dev. Above
Trade Cost	Std Dev Below	1.028	1.031	1.035
	Mean	1.035	1.040	1.047
	Std. Dev Above	1.040	1.047	1.058
	Infinite Trade Cost	1.052	1.074	1.143

Mean (Std) $\ln(\text{FC}) = 0.058 (0.018)$, $\text{RD} = 0.051 (0.058)$

Is there an extensive margin in intra-firm trade?

Census data allows us to observe the number of 6-digit NAICs industries for which U.S. entities exported a positive number of inputs to their foreign related parties.

Let $scope_k$ be the share of industries (607 in all) for which exports between the U.S. entities and their related foreign parties are positive.

Estimate

$$scope_k = \Theta \ln X_k + \Omega \ln FC_k + e_k$$

The Effect of Trade Costs on Import Scope

	(1)	(2)	(3)	(4)
	scope	scope	Log(scope)	Log(scope)
FC	-3.05 (0.809)	-2.77 (1.09)	-5.75 (2.64)	-5.06 (2.21)
GDPPC		0.013 (0.028)		0.033 (0.060)
POP		0.037 (0.011)		0.081 (0.025)
TAX		0.001 (0.030)		-0.039 (0.077)
N	44	44	44	44
R-square	0.227	0.373	0.152	0.286

Robust standard errors are shown in parentheses. The variable, scope, is measured as the share of NAICs 6-digit industries that are positive for the country and so varies from zero to one.

Conclusion

Propose a mechanism in which technology transfer costs and shipping costs interact

- Provide a mechanism for partially quantifying the magnitude of technology transfer costs
- Provide plausible estimates of the geography of marginal costs
- Within-firm variation of U.S. multinational activity tells a remarkably consistent story

Future Work

- Impose more structure on components of individual firms' activities: imports, local sales, and entry decisions
- R&D intensity of intra-firm trade
- Structure of affiliate activity in the United States – more information on sourcing of intermediates