Gravity in the Weightless Economy

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NBER ITI Summer Institute 2010

Technology transfer and firms in international trade

- How well do ideas transfer across borders? Perfectly? Or not at all?

- There is a lot of research on trade costs for goods: how to model them, what form they take

❖ We need to know more about the nature of the costs to the transfer of ideas

Outward U.S. FDI Activity

Two ways of multinational technology transfer

1. Intermediate is produced in MNE Home country. Exports to affiliate incur shipping cost
   - Intermediate embodies technology (Grossman, Helpman)

2. Production by affiliate in host country. Instructions through direct communication, which can fail
   - Disembodied transfer (Antras, Garicano, Rossi-Hansberg)

Shipping costs: rise in distance, *not* in # of non-codified activities

Communication costs: rise in # of non-codified activities, *not* distance

Model

- Firm ω wants to sell its differentiated variety of good *i* in country *k*

- Output is produced from a continuum of firm-specific intermediates

$$q_i = \exp\left(\int_0^{\infty} \beta_i(z) \ln\left(\frac{m(z)}{\beta_i(z)}\right) dz\right),$$

  where $m(z)$ is quantity of firm-specific intermediate of **knowledge intensity** *z*

- The costs shares follow

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

  ⇨ $1/\phi_i$ is average knowledge intensity of industry *i*

Trade versus FDI choice

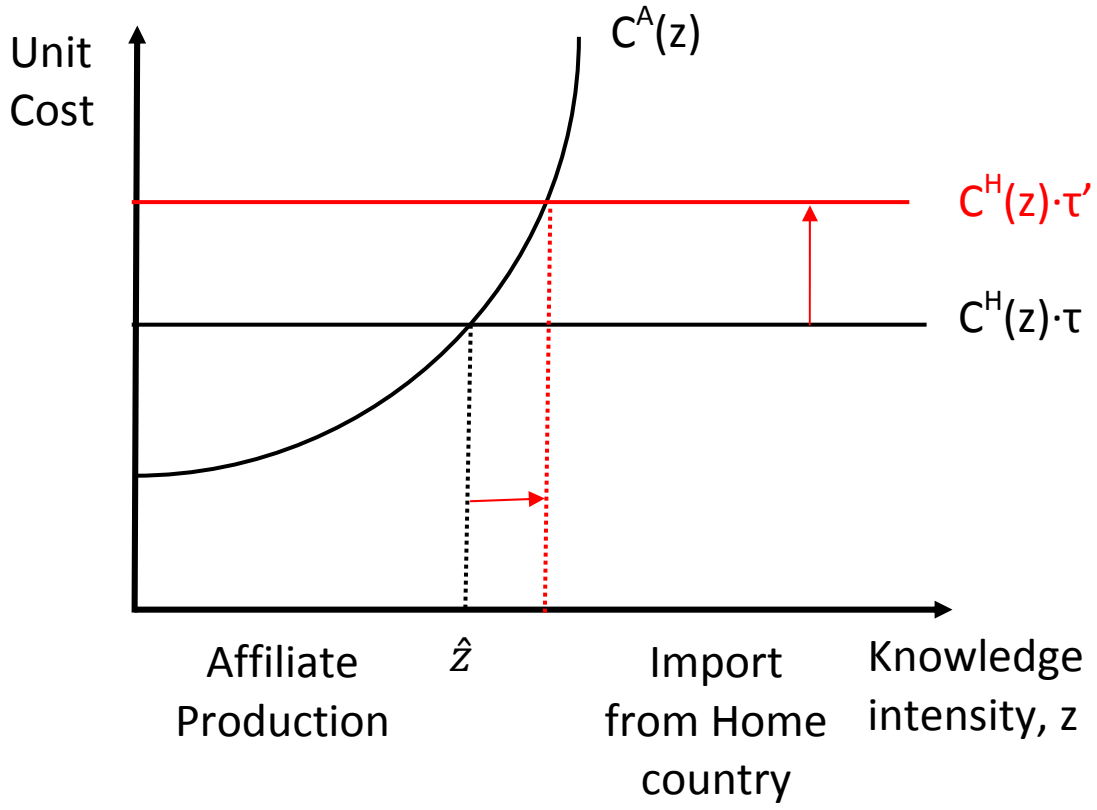
- **FDI:** To produce intermediate *z* offshore, instructions on *z* non-codified activities must be communicated
  - With Prob > 0, this fails for any one activity
    - Unit labor input requirements rise from 1 to

$$\exp(\lambda z)$$

- **Trade:** No communication failure w/ Home production ($\lambda = 0$)
  - But shipping finished intermediate costs trade cost of $\tau > 1$

Optimal Input Sourcing

1. **FDI for low-,** and **trade for high** knowledge intensity products



⇨ Average knowledge intensity of imports from Home rises w/ τ_k

Geography of Marginal Costs

Optimal input sourcing yields (1) import cost share and (2) marginal costs that depend on iceberg- and tech transfer cost parameters

$$(1) \quad \frac{M_{ik}}{TC_{ik}} = exp\left(-\frac{\phi_i}{\lambda} ln(\tau_{ik})\right) \quad (2) \; C_{ik} = \exp\left(\frac{\lambda}{\phi_i}\left(1 - (\tau_{ik})^{-\frac{\phi_i}{\lambda}}\right)\right)$$

Trade versus FDI Prediction:

The intermediate import share is decreasing in trade costs, and the rate of decline is **lowest** in knowledge-intensive (low ϕ_i) industries

Gravity for FDI Sales Prediction:

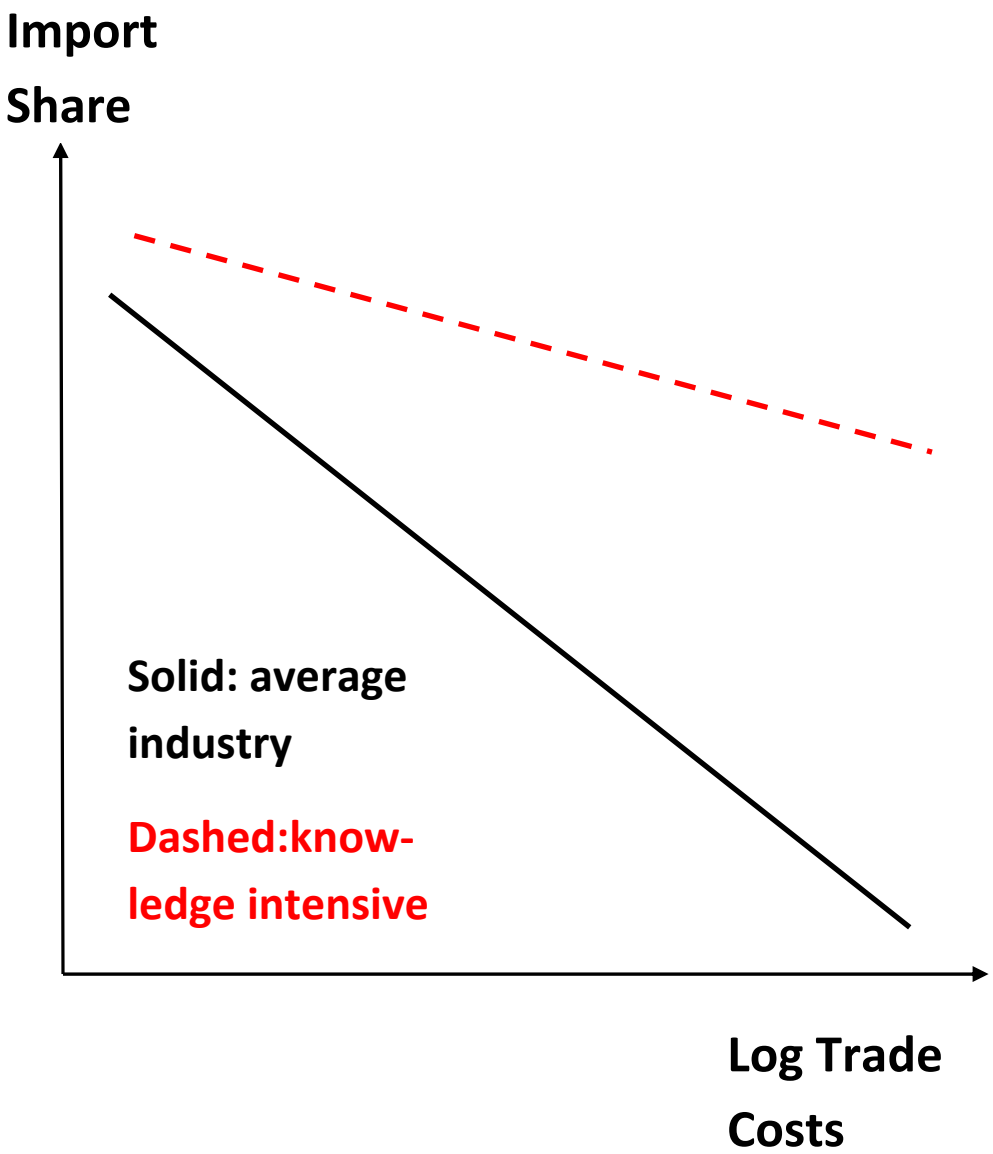
Effect of τ on marginal costs **rises** w/ knowledge intensity (low ϕ):

$$\frac{\partial C_{ik}}{C_{ik}} \Big/ \frac{\partial \tau_{ik}}{\tau_{ik}} = \exp\left(-\frac{\phi_i}{\lambda}\ln(\tau_{ik})\right) \geq 0$$

Assuming iso-elastic demand so that sales are inversely related to costs, then

Sales Prediction: Affiliate local sales are decreasing in τ_{ik}, and gravity is **highest** in knowledge-intensive (low ϕ_i) industries

Summary


Import
Share
Solid: average
industry
Dashed:know-
ledge intensive
Log Trade
Costs


Affiliate
Sales
Log Trade
Costs

Possible extensions that retain the main results

1. Vertical FDI driven by factor cost differences

2. Extensive margins across firms and within firms

3. In-house versus outsourced production

Data

- Firm-level data on U.S. outward manufacturing FDI for 1994, 1999, and 2004 from BEA
    - Affiliate sales, affiliate imports of intermediates, parent sales, parent R&D expenditures

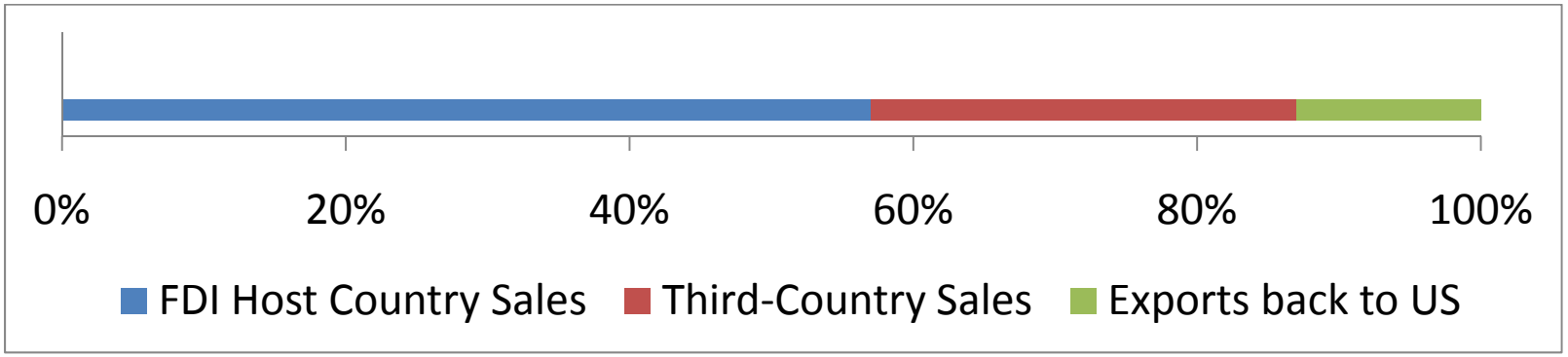
- Disaggregated information on trade among related parties (Census)

- Trade costs: transportation costs (from c.i.f./f.o.b. trade data; Feenstra et al.), tariff data (World Bank WITS)

- Other country and country-industry variables

U.S. Outward Affiliate Sales in Year 2004 in Total: $ 1.6 trillion

- Composition:



- Imports by U.S.-owned affiliates from their Home country account for close to 30% of US exports

- Parents of MNEs account for about 85% of business R&D in the U.S.

Affiliate Import Equation

Import cost share of the model: $\frac{M_{ik}}{TC_{ik}} = exp\left(-\frac{\phi_i}{\lambda} ln(\tau_{ik})\right)$

$$\ln\left(\frac{M_{ijkt}}{TC_{ijkt}}\right) = \eta_{jt} + \rho \ln X_{ikt} + (\delta_0)\ln\tau_{ikt} + \delta_1(ln\tau_{ikt} \times KI_{it}) + \mu_{ijkt},$$

- *i* is industry, *j* is firm, *t* is year, and *k* is country
- τ_{ikt} *ad-valorem* measure of freight and tariffs
- KI_{it} knowledge intensity: parent R&D over sales in industry *i*
- X_{ikt} country-, industry controls; η_{jt} firm-year fixed effects
- Error term μ_{ijkt} due to measurement error

Prediction: $\delta_1 > 0$

Affiliate Sales Equation

$$\ln R_{ijkt} = \gamma_{jt} + \kappa \ln X_{ikt} + \varsigma_0 \ln \tau_{ikt} + \varsigma_1 (ln\tau_{ikt} \times KI_{it}) + \nu_{ijkt},$$

where

- R_{ijkt} local sales of affiliate
  - We also consider sales to the U.S. and 3rd countries
- γ_{jt} firm-year fixed effects

Prediction: $\varsigma_1 < 0$

Table 2: Technology Transfer and Multinational Activity

	Import Share			Sales		
Trade Costs(TC)	**-2.73**	**-3.54**	**-3.90**	**-2.69**	**-1.14**	-0.53
TC*Know.Int.	**32.02**	**25.18**	**26.83**	**-24.80**	**-15.87**	**-20.73**
Population		**-0.20**	**-0.16**		**0.46**	**0.52**
GDP per Capita		**-0.76**	0.05		**1.02**	**0.53**
Max. TAX rate		**0.80**	**0.82**		-0.01	**-0.34**
Skill Endow			0.62			**-0.47**
Capital Endow			0.08			**0.53**
IPR			**-0.43**			**0.17**
Judicial Q			**-1.74**			-0.41
Language			**0.35**			**0.44**
Phone Call Cost			**0.42**			0.04
R-Sq	0.007	0.052	0.092	0.049	0.194	0.209
N	5,412	5,298	5,204	6,691	6,691	6,419

Note: Coefficients in bold are statistically significant at 5% level using standard errors adjusted for country-year clustering. All variables are deviations from firm-year means.

Robustness

(1) Comparative Advantage

(2) Fixed Costs and Scale Economies

(3) Communication Costs

(4) Institutions and Contracts

(5) Industry Specialization

(6) Vertical and Export Platform FDI

(7) In-house versus Outsourced Production

(8) Other Trade Cost Non-Linearities

Table 3: Comparative Advantage

	Import Share			Sales		
Trade Costs (TC)	**-3.91**	**-3.85**	**-3.98**	**-0.51**	-0.36	-0.49
TC*Know. Intens.	**26.53**	**25.59**	**28.63**	**-20.43**	**-24.66**	**-21.76**
GDP per cap.	0.05	0.05	0.03	0.54	0.53	0.54
GDP per cap*KI			0.48			-0.25
Skill Endow (SE)	0.70	0.61	0.62	-0.42	**-0.48**	**-0.47**
SE*Skill Intensity	-1.43			-0.02		
Capital Endow (KE)	0.06	0.08	0.08	**0.64**	**0.54**	**0.54**
KE*K Intensity	0.10			-0.04		
Judicial Qual. (JQ)	-1.32	-1.66	-1.74	**-1.06**	-0.20	-0.41
JQ*Contract Inten.	-0.78			**1.22**		
JQ*KI		-1.46			**-4.05**	
R-sq	0.092	0.092	0.092	0.211	0.210	0.209
N	5,204	5,204	5,204	6,419	6,419	6,419
Memo: Baseline TC*KI coefficient		26.83			-20.73	

Note: Coefficients that are statistically significant (5%) are shown in bold where standard errors allow for clustering by country-year

Table 4: The Role of Fixed Costs

	Import Share		Sales	
Trade Costs (TC)	**-4.61**	**-9.07**	**0.39**	**-0.19**
TC*Knowledge Intens.	**26.19**	**28.37**	**-19.81**	**-20.83**
TC*Skill Intensity	0.43		-0.57	
TC*Capital Intensity		**1.59**		-0.11
GDP per capita	0.06	0.07	**0.52**	**0.53**
POP	**-0.16**	**-0.16**	**0.52**	**0.52**
TAX	**0.82**	**0.82**	**-0.34**	**-0.34**
Skill Endowment	0.62	0.62	**-0.47**	**-0.47**
K Endowment	0.08	0.07	**0.54**	**0.54**
Judicial Quality	**-1.76**	**-1.75**	-0.38	-0.41
IPR	**-0.43**	**-0.43**	**0.16**	**0.17**
Language	**0.35**	**0.35**	**0.44**	**0.44**
Cost of Phone Call	**0.42**	**0.42**	0.03	0.04
R-sq	0.092	0.093	0.210	0.209
N	5,204	5,204	6,419	6,419
Baseline TC*KI coeff.	26.83		-20.73	

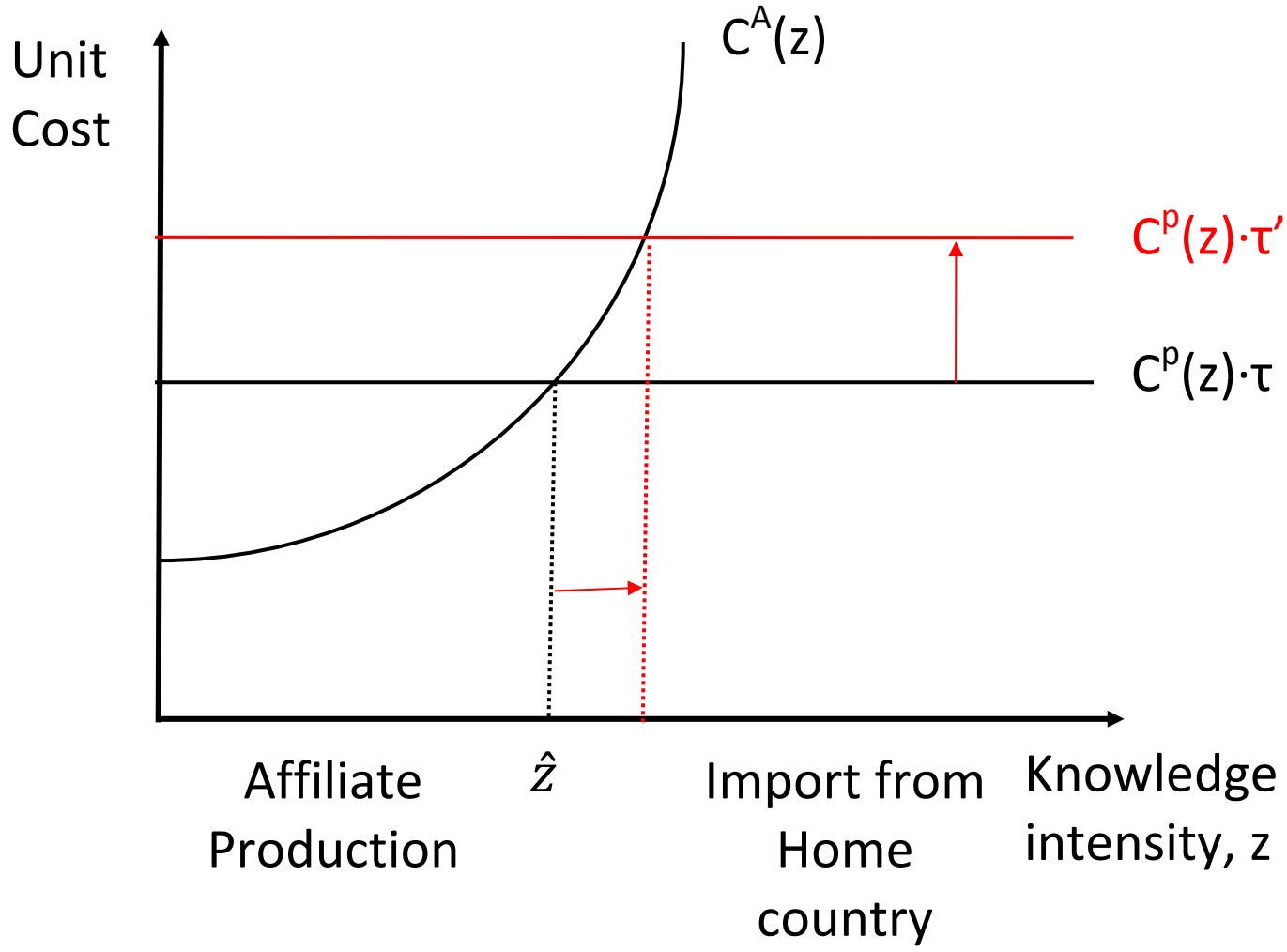
Note: Coefficients in bold are statistically significant at 5% level using standard errors adjusted for country-year clustering.

Table C: Horizontal, vertical, and export-platform FDI

	Local Sales	Export US	3rd Country	All
Trade Cost (TC)	-0.53	**-3.40**	**3.18**	0.13
TC*Know. Inten.	**-20.73**	**-58.06**	**-37.55**	**-30.53**
Phone Call	0.04	**-0.63**	**-0.72**	**-0.18**
IPR	**0.17**	0.11	**0.82**	**0.35**
GDP per Cap	**0.53**	-0.24	0.21	0.34
POP	**0.52**	-0.11	**0.27**	**0.34**
TAX	**-0.34**	**1.33**	**-1.53**	-0.19
Language	**0.44**	**0.69**	0.09	**0.41**
Skill Endowm't	**-0.47**	-0.76	**-2.17**	**-1.00**
Capital End't	**0.53**	-0.38	-0.08	**0.34**
Judicial Quality	-0.41	-0.08	**2.89**	0.38
N	6,419	3,487	3,994	6,419

Dependent variable is noted on top of column. Statistically significant coefficients shown in bold (std errors clustered by country-year).

Composition: is the knowledge intensity of trade rising with distance?



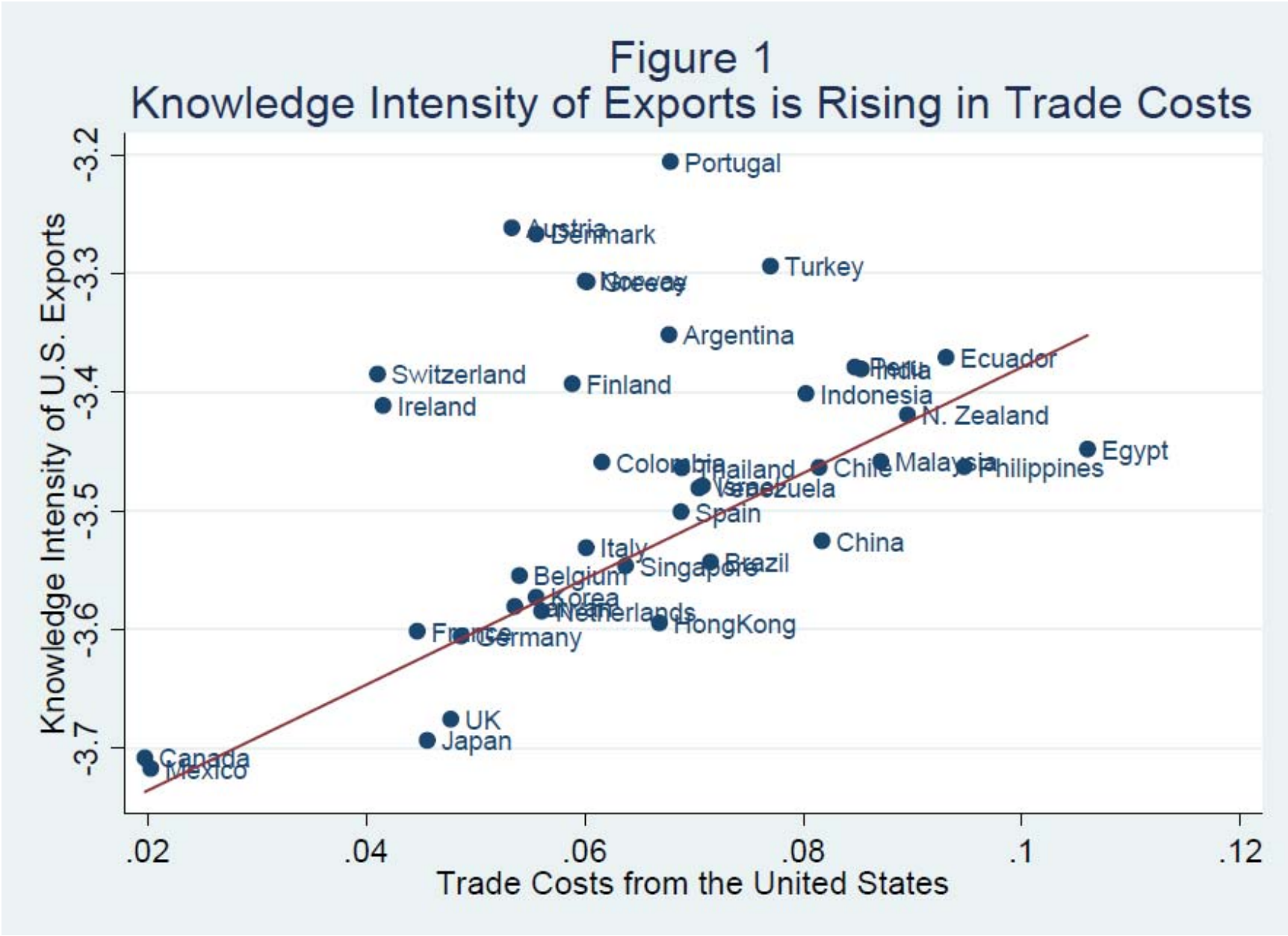


Figure 1
Knowledge Intensity of Exports is Rising in Trade Costs
Knowledge Intensity of U.S. Exports
-3.2
-3.3
-3.4
-3.5
-3.6
-3.7
Portugal
Austria
Denmark
Turkey
Argentina
Ecuador
Switzerland
Finland
Indonesia
Ireland
N. Zealand
Egypt
Chile
Malaysia
Philippines
Spain
China
Italy
Brazil
Belgium
Korea
Netherlands
HongKong
Germany
UK
Japan
Canada
Mexico
.02
.04
.06
.08
.1
.12
Trade Costs from the United States

Computation of the knowledge intensity of MNE trade

- N_K = number of six-digit NAICS industries (indexed by *i*) with positive US exports EX_{ik} to their related parties in country *k* in year 2002

$$N_k = \sum_{i=1}^{500} (1|EX_{ik} > 0)$$

- Average knowledge intensity of trade with *k*:

$$AKI_k = \frac{1}{N_k} \sum_{i=1}^{500} R_i \times (1|EX_{ik} > 0)$$

where R_i = R&D intensity of industry *i* (from *Compustat* database)

Knowledge Composition of Trade: Regression Results

	(1)	(2)	(3)
Trade Costs	**5.11**	**3.70**	**3.23**
Phone Call		0.01	0.02
IPR		0.08	0.13
GDP per capita		**-0.10**	**-0.10**
Population		**-0.06**	**-0.07**
Tax Rate		0.07	**0.09**
Language		**-0.07**	-0.02
Human Capital		-0.15	-0.22
Judicial Quality		0.25	0.15
Weight-to-Value			0.01
R-sq	0.44	0.79	0.80
N	39	36	35

Dependent variable is average knowledge intensity of U.S. multinational exports; weighted by GDP of destination country

Conclusions

- Model of multinational-led technology transfer yields contrasting predictions for three central aspects of MNE behavior

- These are confirmed using rich firm-level data

- Knowledge intensity as a barrier to offshoring

    - Technology might be weightless, but it is costly to transfer

Implications for Future Work

- Within-firm heterogeneity in geographic space due to frictions in technology transfer seems to be important
  - One possible explanation of firm heterogeneity

- When technology can be either disembodied or embodied, gravity emerges even in the world of ideas

- Costs of international commerce tied to the interaction of people
  - Here communication; other mechanisms such as reputation, trust, opportunism

Table 5: Communication Costs Varying by Location

	Import Share			Sales		
Trade Costs(TC)	**-3.90**	**-3.87**	**-4.05**	-0.53	-0.35	0.33
TC*KnowIn (KI)	**26.83**	**26.39**	**29.03**	**-20.73**	**-22.90**	**-25.23**
Population	**-0.16**	**-0.16**	**-0.16**	**0.52**	**0.51**	**0.52**
GDP per Capita	0.05	0.05	0.05	**0.53**	**0.52**	**0.53**
Max. TAX rate	**0.82**	**0.82**	**0.82**	**-0.34**	**-0.34**	**-0.34**
Skill Endow	0.62	0.62	0.63	**-0.47**	**-0.48**	**-0.47**
Capital Endow	0.08	0.08	0.08	**0.53**	**0.53**	**0.54**
IPR	**-0.43**	**-0.43**	**-0.43**	**0.17**	**0.19**	**0.16**
Judicial Q	**-1.74**	**-1.74**	**-1.73**	-0.41	-0.45	-0.42
Language	**0.35**	**0.39**	**0.35**	**0.44**	**0.66**	**0.44**
Language * KI		-0.72			**-4.38**	
Phone Call Cost	**0.42**	**0.41**	**0.47**	0.04	0.04	-0.04
Phone Call *KI			-1.09			1.40
R-sq	0.092	0.092	0.092	0.209	0.213	0.210

Table 6: Institutions, Contracts, and Knowledge Intensity

	Import Share			Sales		
Trade Costs(TC)	**-3.85**	**-4.24**	-1.03	-0.36	-0.57	0.13
TC*KnowIn (KI)	**25.59**	**33.67**	**28.12**	**-24.66**	**-19.82**	**-20.16**
TC*ContrIntens			**-6.88**			-1.58
Population	**-0.16**	**-0.16**	**-0.15**	**0.52**	**0.52**	**0.52**
GDP per Capita	0.05	0.06	0.00	**0.53**	**0.53**	**0.53**
Max. TAX rate	**0.82**	**0.82**	**0.79**	**-0.34**	**-0.34**	**-0.35**
Skill Endow	0.61	0.63	0.63	**-0.48**	**-0.46**	**-0.46**
Capital Endow	0.08	0.08	0.08	**0.54**	**0.53**	**0.53**
IPR	**-0.43**	**-0.56**	**-0.43**	**0.15**	**0.15**	**0.17**
IPR*KI		**2.32**			0.32	
Judicial Q	**-1.66**	-1.74	**-1.65**	-0.20	-0.41	-0.39
Judicial Q * KI	**-1.46**			**-4.05**		
Language	**0.35**	**0.35**	**0.34**	**0.44**	**0.44**	**0.44**
Phone Call Cost	**0.42**	**0.41**	**0.42**	0.04	0.04	0.04
R-sq	0.092	0.092	0.092	0.210	0.209	0.210