The Gravity of Knowledge

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Introduction

Traditional theories of trade focus on tangible factors, e.g. capital and labor.

Modern theories put little emphasis on these factors and instead focus on access to knowledge.

This begs the question:

How mobile is knowledge?

Introduction

Beginning premise is that knowledge moves over geographic space in one of two ways:

- **Embodied form**: trade, i.e. transporting a physical item
  - Cost of moving an item can be measured as the cost of goods trade.
- **Disembodied form**: direct communication, e.g. via teleconference
  - Movements are hard to observe and the costs of moving are difficult to assess.

Paper attacks the question by casting it in terms of the operations of multinational firms.

Literature Review

Distribution of knowledge across countries:

Lucas 1993; Aghion and Howitt 1998; and Jones 2002

Firm organization:

Antras, Garicano, and Rossi-Hansberg 2008; Krugman 1991; and Acemoglu et al. 2007

Multinational firms:

Helpman 1984; Markusen 1984.

Theory

Large number of firms in any given country where each produces a unique variety of a differentiated final good.

The firms can sell to consumers abroad in one of two ways:

- Produce the good at home and then export it.
  - Trade costs are incurred.
- Affiliate production-set up an affiliate in the foreign country, produce there, and sell locally.
  - Firm has to pay a fixed cost of opening a plant in addition to the costs of transferring its knowledge.
  - Productivity abroad is lower than at home

Theory (cont.)

Each differentiated final good is produced from a range of intermediate goods and services.

The ease of knowledge transfer varies by activity. This leads to

- Exports-versus-FDI trade-off at the level of assembly.
- Conditional on FDI, exports-versus-FDI trade-off at the level of each intermediate input.

Local production of an intermediate exposes the affiliate to efficiency losses.

- This is represented as an increase in the local labor requirement given by the function $t(z)$.

Model Overview

Trade costs vary across countries and industries.

Knowledge transfer costs due to communication failure vary across inputs of different knowledge intensities but not across foreign countries.

Model Overview (cont.)

The cost of obtaining input z of a foreign assembly plan facing trade costs of τ is

$$c(z) = \min\{t(z), \tau\}$$

There exists a marginal input

$$\hat{z}(\tau) = t^{-1}(\tau)$$

such that inputs $z < \hat{z}(\tau)$ are produced locally and inputs $z > \hat{z}(\tau)$ are imported.

This implies that the average knowledge intensity of trade between countries is increasing with trade costs.

Preview of Results

Hypothesis 1: The percentage rate of decline of the share of inputs imported from the home country in total costs as trade costs increase is slower in relatively knowledge-intensive industries.

Hypothesis 2: Holding fixed the demand level, the percentage rate of the decrease in affiliates' local revenues as trade costs increase is faster in more knowledge-intensive industries.

Estimating Equations

Affiliate's reliance on inputs imported from its home country conditional on owning an affiliate:

$$ln\frac{M^i_{wkt}}{TC^i_{wkt}} = \alpha^{CS}_{wt} + \left(\delta^{CS}_1 + \delta^{CS}_2 KI^i_t\right) ln\tau_{ki} + \beta^{CS}_X ln\mathbf{X}^i_{kt} + \varepsilon^i_{wkt}$$

According to hypothesis 1: while in general an increase in trade costs is associated with the increased offshoring of production to the affiliate, this effect should be less pronounced in more knowledge-intensive industries so that $\delta^{CS}_2 > 0$.

Estimating Equations

Local affiliate sales:

$$lnR^i_{wkt} = \alpha^R_{wt} + \left(\delta^R_1 + \delta^R_2 KI^i_t\right) ln\tau_{ki} + \beta^R_X ln\mathbf{X}^i_{kt} + \eta^i_{wkt}$$

According to hypothesis 2: the sales of affiliates in their host country is decreasing in trade costs, however this effect should be more pronounced in knowledge-intensive industries knowledge-intensive industries so that $\delta^R_2 < 0$.

Description of Data

Dataset was obtained from the US Bureau of Economic Analysis.

It includes information on sales and intermediate goods trade of individual multinationals for the years 1994, 1999 and 2004.

Final sample contains more that 1,000 US multinationals and 3,000 affiliates classified into 48 distinct industries.

Empirical Results

TABLE 1—TECHNOLOGY TRANSFER AND MULTINATIONAL ACTIVITY

	Import share				Sales			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Trade costs	−2.794	−3.786	−3.672	−0.933	−2.942	−0.770	−0.213	0.423
	[0.030]	[<0.001]	[<0.001]	[0.127]	[<0.001]	[0.085]	[0.612]	[0.279]
Trade costs × knowledge intensity	36.089	24.906	23.761	25.123	−23.110	−17.149	−19.405	−17.758
	[0.001]	[0.039]	[0.022]	[0.005]	[0.036]	[0.055]	[0.016]	[0.017]
Population		−0.628	−0.495	−0.416		−0.207	−0.218	−0.430
		[0.150]	[0.229]	[0.538]		[0.296]	[0.269]	[0.487]
GDP		0.410	0.357	−0.450		0.753	0.725	1.375
		[0.324]	[0.366]	[0.116]		[<0.001]	[<0.001]	[<0.001]
Tax rate		0.962	0.916	2.340		−0.266	−0.310	−0.737
		[0.017]	[0.010]	[0.131]		[0.075]	[0.032]	[0.557]
Skill endowment		1.004	0.685	NA		−0.390	−0.434	NA
		[0.214]	[0.381]			[0.083]	[0.034]	
Capital endowment		−0.089	0.073	0.581		0.483	0.498	0.314
		[0.661]	[0.709]	[0.303]		[<0.001]	[<0.001]	[0.607]
Intellectual property rights		−0.408	−0.420	0.060		0.179	0.137	0.071
		[0.007]	[0.001]	[0.495]		[0.018]	[0.058]	[0.382]

Summary

The authors present a model t oanalyze the structure of the international operations of US multinational firms.

Their model defines knowledge transfer through the use of trading inputs (embodied) and input production through FDI (disembodied).

The results provide evidence that the knowledge intensity of production affects the level of foreign sales as well as the composition of disembodied versus embodied technology transfer that firms use.

The Gravity of Knowledge

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