

Incomplete Contracts and the Product Cycle

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Broad Research Agenda

- Try to understand how firms organize production in a global economy and study its implications for industrial structure, trade and FDI flows, international income differences, welfare...
- In Antràs (2003) and Antràs and Helpman (2004) the focus was on industrial structure and trade flows. Static set-up.
- Today:
 1. Dynamics: How is production organized along the life-cycle of a good, as the good gets standardized?
 2. Study some macro and welfare implications of firms' decisions.

Introduction

- Vernon's (1966) Product Cycle Hypothesis: new goods are not only developed in high-wage countries, but they are also manufactured there for a while.
- Vernon emphasized the role of multinational firms in the production transfer.
- Subsequent empirical literature \Rightarrow much richer picture: arm's length arrangements (licensing, subcontracting), imitation...

- Evidence suggests the existence of not only product cycles but also **organizational cycles**
 - overseas assembly of new and unstandardized goods is kept within firm boundaries
 - arm's length production transfer is more frequent for older goods and for goods with less product development requirements.

Theoretical Literature on the Product Cycle

- Krugman (1979) looked at macro implications of Vernon's insights, but timing of production transfer was exogenous.
- Grossman and Helpman (1991a,b) endogenized it, but they emphasized the role of imitation (no FDI - crucial assumption).

What I do

1. Provide a micro theory of the product cycle more akin to Vernon's.
 - What slows down production transfer? Incomplete contracts.
2. Draw firm boundaries: model features both endogenous product cycles and endogenous organizational cycles.
 - Why is manufacturing of new, unstandardized goods internalized? Incomplete contracts.
3. Explore the macro and welfare implications of the model.
 - Cross-sectional picture of the model similar to Dornbusch-Fisher-Samuelson (1977). *Endogenous* comparative advantage.

Sketch of the Argument: Micro Model

- Along their life-cycle, goods require a combination of two inputs: product development (PD) and simple manufacturing (M).
- The North is much better at doing PD. Productivity in M is identical everywhere.
- Frictionless fragmentation of the production process \Rightarrow If $w^N > w^S$, M always done in South.

- In a world of incomplete contracting **in international transactions**:
 - Incomplete contracts lead to distortions in both PD and M when the production process is fragmented.
 - Lower wages in the South only reduce costs in M.
- As a result, M will be kept in the North when the good is sufficiently PD-intensive.
- Standardization process; PD intensity falls along the life cycle \Rightarrow Product cycle emerges.

Sketch of the Argument: Firm Boundaries

- Incomplete contracting opens the door to analysis of ownership structure (Grossman-Hart, 1986).
- Ex-ante efficiency \Rightarrow residual rights (= ownership) allocated to the party undertaking a relatively more important noncontractible, relationship-specific investment (cf., Antràs, 2003, and Antràs and Helpman, 2004).
- Standardization \rightarrow Only when a good is unstandardized and thus PD has a high marginal product, will its manufacturing be kept within firm boundaries \rightarrow organizational cycles.
- Obtain further testable predictions.

Sketch of the Argument: General Equilibrium

- Labor Market clearing in both countries will imply $w^N > w^S$.
- w^N/w^S is increasing in invention rate and decreasing in standardization rate (c.f. Krugman, 1979).
- A shift to complete contracting moves the terms of trade in favor of the South. This enhances welfare in the South, with the effect on Northern welfare being ambiguous (cf. Helpman, 1993).

A Simple Theory of the Product Cycle

- There are two countries: the North and South.
- Demand for good y is:

$$y = \lambda p^{-1/(1-\alpha)}, \quad 0 < \alpha < 1$$

- Production of y requires:
 - a special and distinct hi-tech input x_h (PD)
 - a special and distinct low-tech input x_l (M)
 - a fixed cost of f units of labor, wherever x_h is produced.
- Production of the final good requires no further costs and

$$y = \zeta_z x_h^{1-z} x_l^z, \quad 0 \leq z \leq 1.$$

- There are two types of producers, both facing a perfectly elastic supply of labor ($w^N > w^S$)
 - Research Center (R) controls the production of x_h (and y).
 - Manufacturing Plant (M) controls x_l .
- To produce one unit of x_h , a Northern R needs to hire one unit of labor. In the South this requires $+\infty$ units \rightarrow No R in South.
- To produce one unit of x_l , both Northern and Southern M require one unit of labor.
- Before x_h and x_l are produced, R decides whether it wants to produce y , and if so, whether to obtain x_l from a Northern M or a Southern one M .

- The location of M is chosen by R to maximize its profits (there is infinitely elastic supply of M agents, so R gets all surplus ex-ante and hence the equilibrium location also maximizes joint profits).
- Both x_h and x_l are relationship-specific: zero value outside.
- For now, assume no insourcing – M s are stand-alone firms.

Contracting Environment:

- R and Northern M can sign enforceable contracts.
- R and Southern M **cannot** sign enforceable contracts.
- In the paper, I elaborate on this [I allow parties to produce useless, bad-quality inputs at negligible cost and I assume that only when both inputs are produced in the same country can an outside party distinguish between a good-quality and a bad-quality intermediate input)]

- Ex-ante labor investments and sale revenues are not verifiable either.
- No contract ex-ante \rightarrow R and Southern M will bargain over the surplus of the relationship ex-post, when manufacturing costs are bygones.
- Symmetric Nash Bargaining leaves R and M with $1/2$ of ex-post gains from trade.
- Contract incompleteness leads to a two-sided hold-up problem.

Firm Behavior

- R chooses the location of M to maximize its profits.
- If M in North,

$$\pi^N = \arg \max_{x_h, x_l} \left\{ S(x_h, x_l) - w^N x_h - w^N x_l - w^N f \right\},$$

- If M in South,

$$\pi^S = S(x_h^O, x_l^O) - w^N x_h^O - w^S x_l^O - w^N f$$

where

$$x_h^O = \arg \max_{x_h} \frac{1}{2} S(x_h, x_l^O) - w^N x_h$$

$$x_l^O = \arg \max_{x_l} \frac{1}{2} S(x_h^O, x_l) - w^S x_l$$

The Equilibrium Choice

- Low-tech produced in the South only if

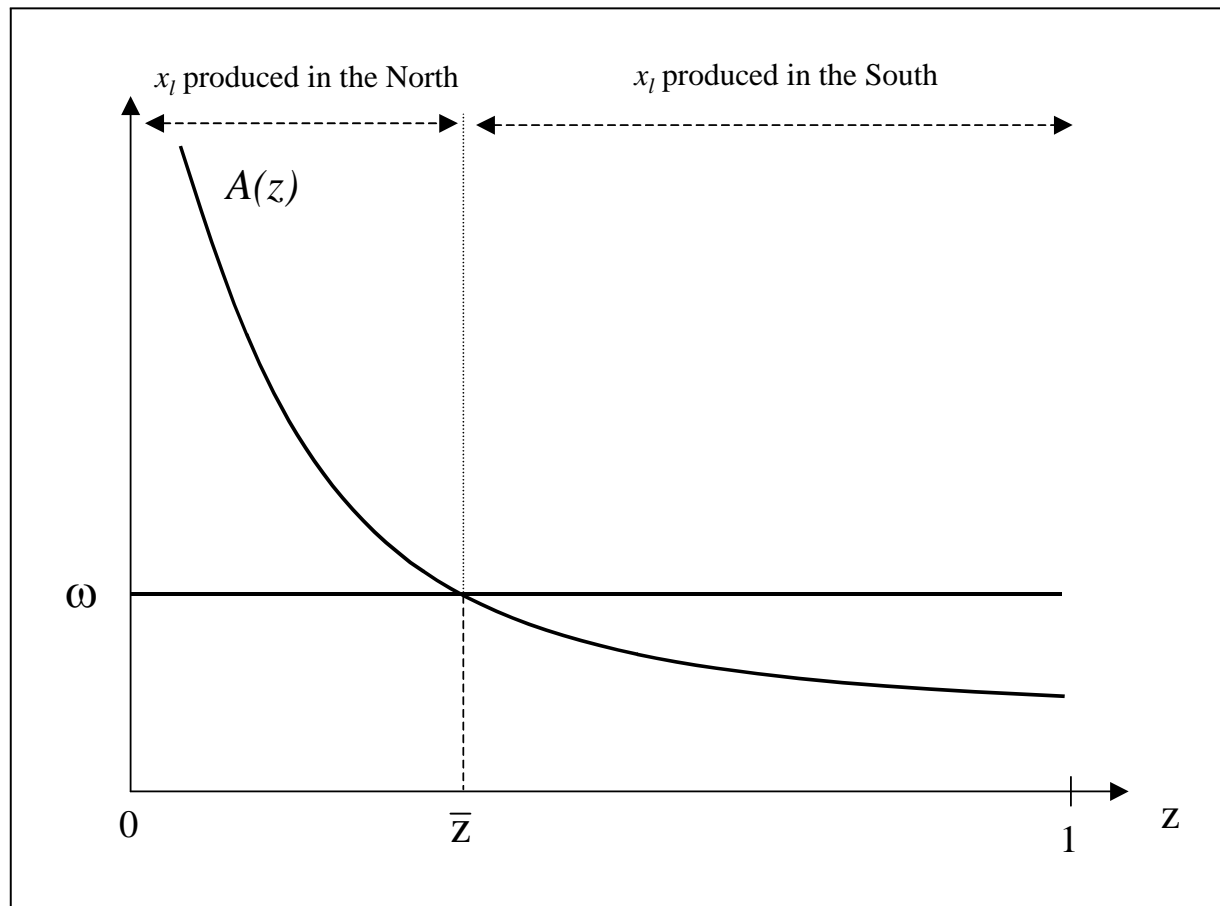
$$A(z) \leq \omega \equiv w^N/w^S$$

where

$$A(z) \equiv \left(\frac{1 - \alpha}{\left(1 - \frac{1}{2}\alpha\right) \left(\frac{1}{2}\right)^{\alpha/(1-\alpha)}} \right)^{(1-\alpha)/\alpha z}.$$

- Note $A'(z) < 0$, $\lim_{z \rightarrow 0} A(z) = +\infty$ and $A(z) > 1$ for all $z \in [0, 1] \rightarrow$ If $w^N = w^S$, never produce in the South.

Lemma 1: *If $A(1) < \omega$, there exists a unique threshold $\bar{z} \in (0, 1)$ such that the low-tech input is produced in the North if $z < \bar{z} \equiv A^{-1}(\omega)$, while it is produced in the South if $z > \bar{z} \equiv A^{-1}(\omega)$.*



The Choice of Location

Dynamics: The Product Cycle

- Time is continuous, indexed by t , with $t \in [0, \infty)$.
- Demand for y is the same at each point in time; α and ω are also time-invariant.
- Firm structure is such that reputational equilibria are not sustainable.
- Standardization: $z(t) = h(t)$, with $h'(t) > 0$, $h(0) = 0$, and $\lim_{t \rightarrow \infty} h(t) = 1$.

Proposition 1 *The model displays a product cycle. When the good is relatively new or unstandardized, i.e., $t \leq h^{-1}(\bar{z})$, the manufacturing stage of production takes place in the North. When the good is relatively mature or standardized, i.e., $t > h^{-1}(\bar{z})$, manufacturing is undertaken in the South.*

An Example

- Let $z(t) = h(t) = 1 - e^{-\frac{t}{\theta}}$, where $1/\theta$ is the rate of standardization. Then manufacturing is shifted at $\bar{t} = \theta \ln \left(\frac{1}{1-\bar{z}} \right)$. The faster the standardization, the earlier production transfer.

Comparison with Complete Contracts

- With complete contracts, if $\omega > 1$, manufacturing is shifted to the South from period 0.
- If $\omega = 1$, location of manufacturing is indeterminate. Product cycles emerge with probability zero.
- The presence of incomplete contracts is *necessary* for a product cycle to arise.

Firm Boundaries and the Product Cycle

- New feature: R is now allowed to vertically integrate his M .
- As in Grossman-Hart (1986), ownership will affect the distribution of ex-post surplus through its effect on each party's outside option.
- Since the x_l is specific to R , the outside option for M is always 0. If M is a stand-alone firm, the outside option for R is also 0.
- By integrating M , however, R obtains the residual rights of control over x_l , so R can fire the M manager and still produce the final good. But negative productivity shock δ . Assumption 1:
$$\delta \leq \left(\frac{1}{2}\right)^{1/\alpha}.$$

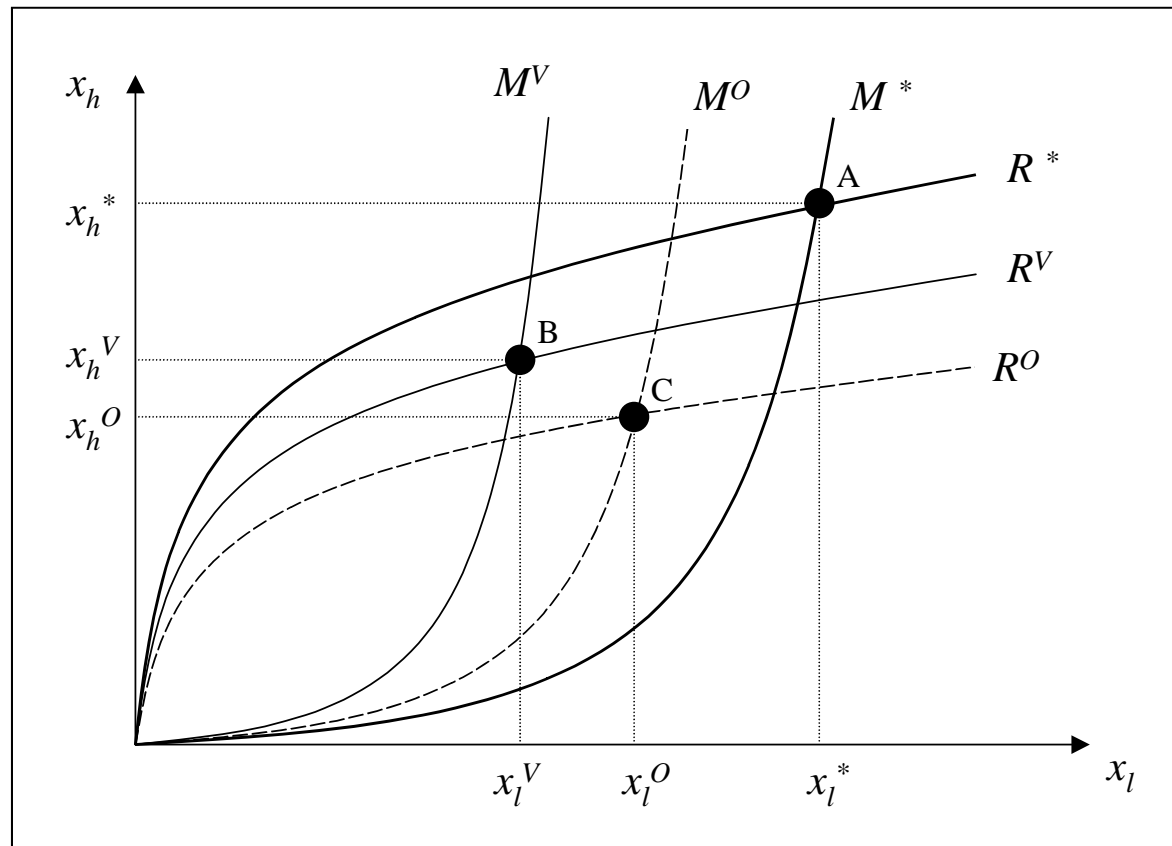
- Assembly in the South by a Vertically-Integrated Manufacturing Plant leaves RC with

$$\pi_M^S = S(x_h^V, x_l^V) - w^N x_h^V - w^S x_l^V - w^N f$$

where

$$x_h^V = \arg \max_{x_h} \frac{1}{2} (1 + \delta^\alpha) S(x_h, x_l^V) - w^N x_h$$

$$x_l^V = \arg \max_{x_l} \frac{1}{2} (1 - \delta^\alpha) S(x_h^V, x_l) - w^S x_l$$



Underproduction and Ownership Structure

Lemma 2 There exists a unique cutoff $\bar{z}_{MS} \in (0, 1)$ such that $\pi_M^S = \pi^S$. Furthermore, $\pi_M^S > \pi^S$ for $0 < z < \bar{z}_{MS}$, and $\pi_M^S < \pi^S$ for $\bar{z}_{MS} < z \leq 1$.

The Equilibrium Choice Revisited

- There are now 3 thresholds:
 - $\exists \bar{z}$ s.t. $\pi^N(z) > \pi^S(z)$ if and only if $z < \bar{z}$.
 - $\exists \bar{z}_{MN}$ s.t. $\pi^N(z) > \pi_M^S(z)$ if and only if $z < \bar{z}_{MN}$ (Assumption 1 implies the “only if” part)
 - $\exists \bar{z}_{MS}$ s.t. $\pi_M^S(z) > \pi^S(z)$ if and only if $z < \bar{z}_{MS}$ – Antràs (2003), Antràs and Helpman (2004).
- Notice that vertical integration is preferred for low z ’s. Intuition: Grossman and Hart (1986).

Dynamics: The Product Cycle

Proposition 2 *The model displays a product cycle. If $\bar{z}_{MS} < \min \{\bar{z}, \bar{z}_{MN}\}$, the product cycle is as before. If instead $\bar{z}_{MS} > \min \{\bar{z}, \bar{z}_{MN}\}$, the following three-stage product cycle emerges:*

- *When the good is relatively new, i.e., $t < h^{-1}(\bar{z}_{MN})$, the manufacturing stage of production takes place in the North.*
- *For an intermediate maturity of the good, $h^{-1}(\bar{z}_{MN}) < t < h^{-1}(\bar{z}_{MS})$, manufacturing is shifted to the South but is undertaken within firm boundaries.*
- *When the good is relatively standardized, i.e., $t > h^{-1}(\bar{z}_{MS})$, production is shifted to an unaffiliated party in the South.*

Korean Electronics

- Early 1960s - domestic producers of low-quality goods.
- Late 1960s - U.S. assembly plants, almost all wholly owned, control Korean exports.
- 1970s and 1980s - domestic Korean firms gain a lot of market share.
- BUT Korean firms were heavily dependent on Western licenses and subcontracting arrangements. As late as 1988, 60% of Korean exports were recorded as part of an OEM (subcontracting).
- Micro evidence: Hitachi vs. Goldstar; Phillips.

Other Supporting Evidence

- Cross-sectional implications:
 1. The older the good, the more licensing relative to FDI we should observe:
 - Case studies in Moran (2001, Chapter 3)
 - Mansfield and Romeo (1980), Mansfield et al. (1979), Davidson and McFetridge (1984, 1985)
 2. The higher the R&D investment of the transferor, the higher should the probability of internalization be:
 - Davidson and McFetridge (1984, 1985).

3. The higher the rate of standardization (lower θ_j), the less FDI relative to licensing:

– Wilson (1977)

4. The higher the wage in the South (lower ω), the less FDI relative to licensing:

– Davidson and McFetridge (1985), Contractor (1984).

5. Relative to arm's length transacting, the emergence of intrafirm production transfer by multinational firms accelerates the shift of production towards the South.

– Kodak in China.

The General-Equilibrium Model

- At each $t \in [0, \infty)$, North is endowed with L^N units of labor. South with L^S .
- At each $t \in [0, \infty)$, \exists a measure $N(t)$ of industries indexed by j , each producing an endogenously determined measure $n_j(t)$ of differentiated goods.
- $\dot{N}(t) = gN(t)$ and $N(0) = N_0 > 0$.
- The representative consumer maximizes

$$U = \int_0^\infty e^{-\rho t} \int_0^{N(t)} \log \left(\int_0^{n_j(t)} y_j(i, t)^\alpha di \right)^{1/\alpha} dj dt$$

- Demand for $y_j(i, t)$ is then $y_j(i, t) = \lambda_j(t) p_j(i, t)^{-1/(1-\alpha)}$.

- All producers in a given industry share the same technology with a common time-varying elasticity $z(t - t_{0j}, \theta_j)$, where t_{0j} is the date at which industry j appears.
- The industry-specific parameter θ_j is assumed to be drawn at period t_{0j} from a time-invariant distribution $G(\theta)$.
- As before, $\partial z(\cdot)/\partial t - t_{0j} > 0$, $z(0, \cdot) = 0$, $\lim_{t-t_{0j} \rightarrow \infty} z(\cdot) = 1$.
- Industries vary both in their “birth dates”, as well as in the shape of their specific standardization processes.
- Firm structure is as above + free entry at every period $t \Rightarrow$ measure $n_j(t)$ adjusts so as to make $\pi = 0$.
- No reputational equilibria \Rightarrow Focus on period-by-period analysis.

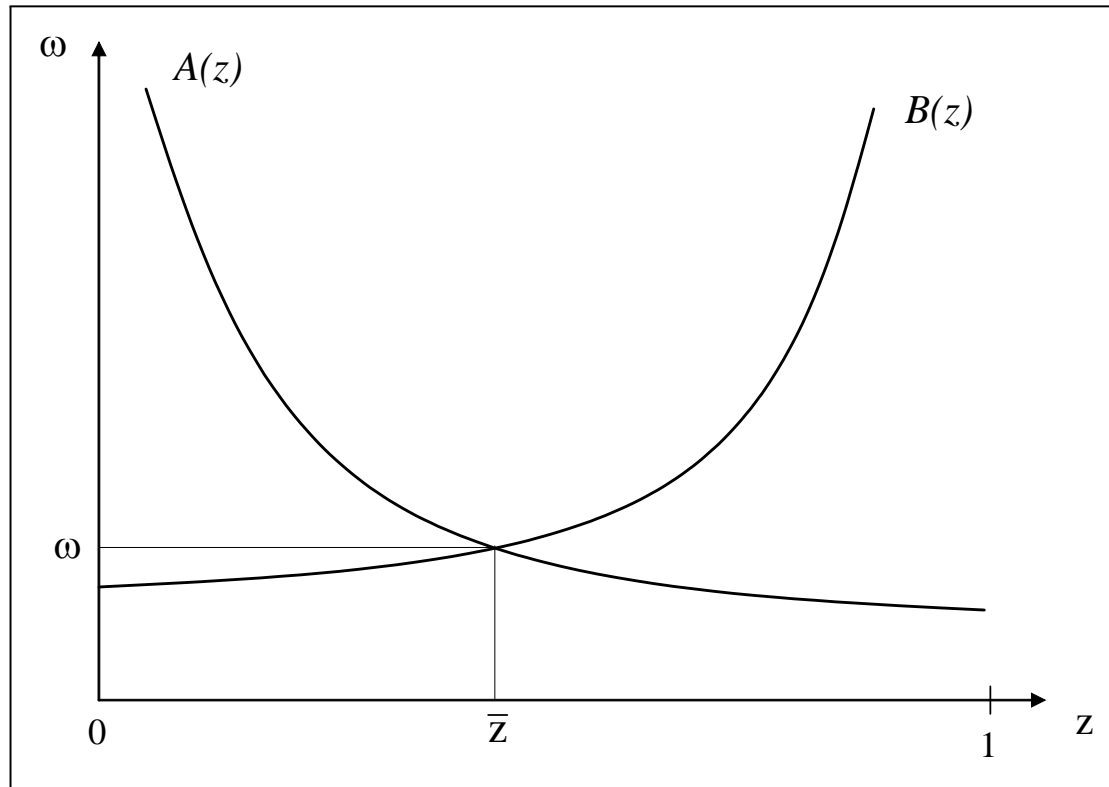
General-Equilibrium without Multinationals

- $\bar{z}(t)$ is common for all industries. All firms in all industries with $z(t - t_{0j}, \theta_j) < \bar{z}(t)$ manufacture in the North. Those with $z(t - t_{0j}, \theta_j) > \bar{z}(t)$ do so in the South. The general equilibrium need only pin down $\omega(t)$ and $\bar{z}(t)$.
- World income equals world spending

$$w^N(t)L^N + w^S(t)L^S = E(t)$$

- Labor market clearing yields

$$\omega = B_t(\bar{z}) \equiv \frac{2 - \alpha \int_{\bar{z}}^1 z f_{z,t}(z) dz}{\alpha \int_{\bar{z}}^1 z f_{z,t}(z) dz} \frac{L^S}{L^N}$$



Proposition 3 The economy converges to a stationary equilibrium in which the relative wage in the North is higher than one ($\omega > 1$).

- In spite of heterogeneity in industry product-cycle dynamics, the cross-sectional picture is very similar to Dornbusch et al. (1977).

An Example

- Let $z(t - t_{0j}, \theta_j) = 1 - e^{-(t - t_{0j})/\theta_j}$ and assume θ_j is exponentially distributed with mean θ_μ .
- The economy converges to a time-invariant c.d.f. for the z 's given by:

$$F_z(z) = \frac{g\theta_\mu \ln \left(\frac{1}{1-z} \right)}{1 + g\theta_\mu \ln \left(\frac{1}{1-z} \right)}$$

Implications of General Equilibrium

- Holding θ_j and t_{0j} constant, the relative wage in the North is higher and the shift to Southern assembly occur earlier: (i) the higher is g , (ii) the lower is $1/\theta_\mu$, (iii) the higher is L^S/L^N .
- The effects on relative wages are analogous to Krugman (1979). But the form of technological change matters and timing of transfer is affected by g and L^S/L^N .
- Relative to the steady state with incomplete contracting, in a steady state with complete contracts welfare is higher in the South. For the North, this is endogenous (ω falls).

General Equilibrium with Multinationals

- Relative to a world with only arm's length transacting, allowing for intrafirm technology transfer by multinational firms weakly accelerates the transfer of production to the South (lowers \tilde{z}), while having an ambiguous effect on the relative wage ω .
- Provided that its effect on relative wages is small enough, allowing for intrafirm production transfer by multinational firms increases steady state welfare in both countries.
- An increase in g , θ_μ or L^S/L^N again increases the relative wage in the North and reduces the timing of production transfer \tilde{z} , but these shifts also make the emergence of multinationals more likely.

Conclusions

- A new theory of *endogenous* product cycles with *endogenous* organizational cycles.
- Implications for choice between FDI and Licensing along the life cycle of a product.
- Macro implications that complement the work of Dornbusch et al. (1977) and Krugman (1979).