

Lecture 18: Dynamic Trade Theory: Trade, Technology, and Growth

14.581: International Economics I

Pol Antràs

Harvard & MIT

Spring 2007

Cite as: Pol Antras, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

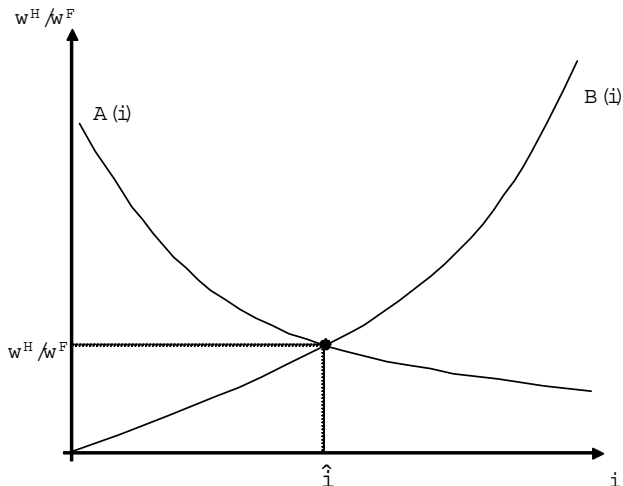
Introduction

- In this lecture we will develop dynamic models of Ricardian comparative advantage.
- We will first discuss learning-by-doing models in which technology evolves dynamically, but individual firms have no power to affect those dynamics.
- Still, just as in the literature on external effects discussed in Lecture 9, the level of technology will be endogenous to the system and thus interesting dynamic results will emerge.
- We will then proceed to discuss models in which improvements in technology follow from purposeful innovation efforts by agents.
- Growth in these models will be tightly related to the share of factors allocated to the innovating sector:
 - a key aspect will be how trade integration affects the incentives of countries to innovate.

Cite as: Pol Antras, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

DFS: A Graphical Reminder

- Remember the equilibrium in the DFS model, with a fixed relative technology function $A(i) = a^F(i) / a^H(i)$.



Cite as: Pol Antràs, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Learning by Doing: Krugman (1987)

- Now suppose that:

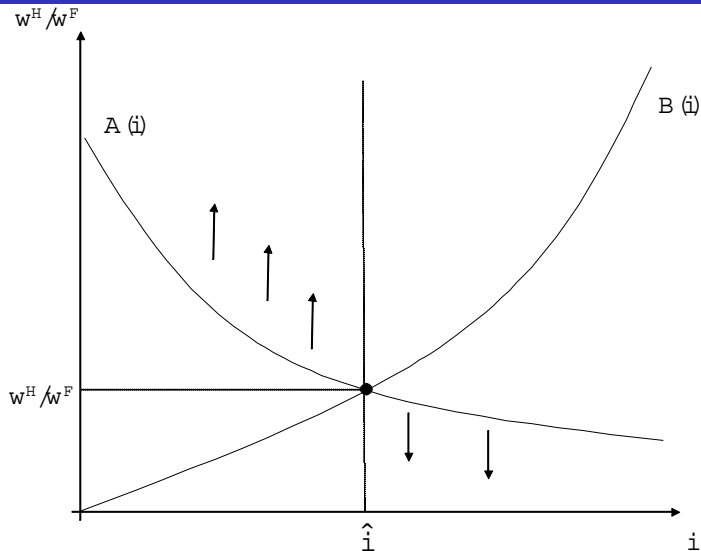
$$\begin{aligned}\frac{1}{a^H(i, t)} &= \int_0^t \left[Q^H(i, \tau) + \delta Q^F(i, \tau) \right] d\tau \\ &= \int_0^t \left[\frac{L^H(i, \tau)}{a^H(i, \tau)} + \delta \frac{L^F(i, \tau)}{a^F(i, \tau)} \right] d\tau.\end{aligned}$$

- So spillovers are sector-specific, unbounded, and for $\delta < 1$ they are disproportionately local in nature.
- Similarly, we have

$$\begin{aligned}\frac{1}{a^F(i, t)} &= \int_0^t \left[Q^F(i, \tau) + \delta Q^H(i, \tau) \right] d\tau \\ &= \int_0^t \left[\frac{L^F(i, \tau)}{a^F(i, \tau)} + \delta \frac{L^H(i, \tau)}{a^H(i, \tau)} \right] d\tau.\end{aligned}$$

- These dynamics reinforce the original forces of comparative advantage.

Learning by Doing: Krugman (1987)



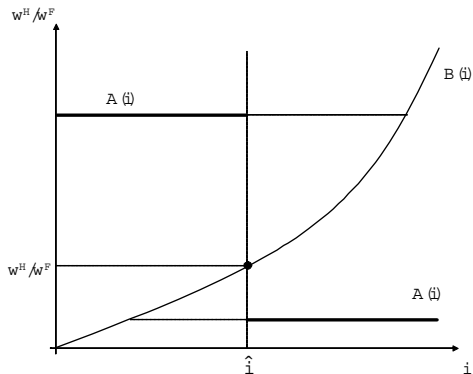
Cite as: Pol Antràs, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Krugman (1987)

- Noting that $L^H(i, \tau) > 0$ only for $i < \hat{i}$ and $L^F(i, \tau) > 0$ only for $i > \hat{i}$, we have that $A(i)$ converges to

$$A(i) = \begin{cases} 1/\delta & \text{if } 0 < i < \hat{i} \\ \delta & \text{if } \hat{i} < i < 1 \end{cases} .$$

- Graphically,



Cite as: Pol Antràs, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Krugman (1987): Implications

- Note that there is a multiplicity of equilibria (history matters):
 - a range of initial patterns of specialization are self-sustaining (can you see what is the range?)
- Suppose Home sets a prohibitive tariff to importation of goods with indices $i = \hat{i} + \varepsilon$ for a period of time.
- If Home is Large enough, Home will eventually gain comparative advantage in those goods.
 - importantly, this protection need not be sustained permanently.
 - related to infant-industry argument.
- In a similar vein, temporary terms-of-trade shocks can have long-run implications for comparative advantage
 - related to dutch-disease.

Cite as: Pol Antras, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Other Contributions to the Learning-by-Doing Literature

- The Krugman (1987) paper focuses on the implications of learning by doing for the effects of different policies *in a trade equilibrium*.
 - A different question is how trade integration will affect growth and welfare in a given country.
- As illustrated in Lecture 9, it is easy to construct examples where external effects lead to welfare losses from trade for some countries.
 - Similarly, the literature has developed models in which countries might be worse off and grow less because they specialize in the “wrong industries”.
- For instance, in section 5 of his classical 1988 paper, Lucas develops a two-sector model in which countries accumulate “knowledge capital” quicker in one of the two sectors.
 - a continuum of countries specialize in one of the two sectors;
 - whenever goods are gross substitutes, they end up growing at different steady state growth rates.
- Matsuyama (1992) develops a model in which higher agricultural productivity enhances growth in autarky, but reduces growth in the open economy (by pulling resources away from the higher learning-potential industry).
- Young (1991) develops a model with bounded learning-by-doing but cross-sectoral spillovers that generates similar results.

Cite as: Pol Antras, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Endogenous Growth

- We next turn to discussing models where the technology available to producers is the outcome of R&D efforts.
- Two main types of models have been offered in the literature:
 - horizontal innovation models à la Romer (1990)
 - quality-ladders models à la Grossman and Helpman (1991) and Aghion-Howitt (1992).
- We will discuss here only the first type, which is closer in spirit to the monopolistic competition models we have been working with:
 - love-for-variety in production → increases in n increase productivity and hence growth.
- **Key engine of growth:** why do innovators keep innovating?
 - as the number of varieties increases, the monopoly power of each supplier declines, **but**
 - as the number of varieties increase, innovators “stand on the shoulder of giants” and the costs of innovation fall in time.

Cite as: Pol Antras, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Horizontal Innovation in Closed Economies: A Brief Recap

- There is a single consumption good and agents preferences are represented by:

$$U(t) = \int_t^{\infty} e^{-\rho(\tau-t)} \ln(C(\tau)) d\tau.$$

- The good is produced according to

$$Y(\tau) = \left[\int_0^{n(\tau)} x(j, \tau)^\alpha dj \right]^{\frac{1}{\alpha}}, \quad 0 < \alpha < 1.$$

- Let E be total spending, so we have $E = P \cdot Y$, where P is the CES price index.
- Then the optimal intertemporal allocation of spending satisfies:

$$\frac{\dot{E}}{E} = r - \rho.$$

- We will follow Grossman and Helpman (1991) and set E as the numeraire, to imply that

$$r = \rho.$$

Horizontal Innovation: Intermediate Input Producers

- Inputs are produced with labor, requiring one unit of labor per unit output.
- The market for inputs is monopolistically competitive and thus profit maximization by input suppliers implies:

$$p = w/\alpha.$$

and resulting profits equal to

$$\pi = (1 - \alpha) \frac{E}{n}.$$

- As a result, the value of a typical firm at t is

$$v(t) = \int_t^{\infty} e^{-\rho(\tau-t)} \pi(\tau) d\tau.$$

- Asset market equilibrium requires

$$\frac{\pi}{v} + \frac{\dot{v}}{v} = \rho.$$

Horizontal Innovation: Creation of Varieties

- The cost of generating a new variety is $\frac{wa}{k_n}$, where k_n is the stock of knowledge, a is a constant, and k_n may vary over time.
- Free entry then implies

$$v = \frac{wa}{k_n}$$

- The factor market clearing condition is

$$\frac{a}{k_n} \dot{n} + nx = L.$$

- Let $X \equiv nx$ be aggregate input use. Then in equilibrium $Y = n^{\frac{1}{\alpha}-1}X$, which implies that the growth of output is

$$\frac{\dot{Y}}{Y} = \left(\frac{1}{\alpha} - 1 \right) \frac{\dot{n}}{n} + \frac{\dot{X}}{X},$$

of which an amount $\left(\frac{1}{\alpha} - 1 \right) \frac{\dot{n}}{n}$ corresponds to TFP growth.

Horizontal Innovation: Growth

- Grossman and Helpman (1991) show that for constant k_n , the economy necessarily converges to a steady state with $\dot{v} = 0$ and $\dot{n} = 0$.
- Romer (1990) assumed instead $k_n = n$ (cumulative experience in R&D reduces R&D costs to all innovators):
 - with this assumption we get long-run growth,
 - and in the balance growth path we have:

$$\frac{\dot{n}}{n} = (1 - \alpha) \frac{L}{a} - \alpha\rho.$$

- A higher lower discount rate ρ , a larger population L or a lower cost of innovation a will shift labor to the R&D sector and will increase growth.
 - note the presence of scale effects.
- Note: key for long-run growth is whether, as $n \rightarrow \infty$, $k_n(n) / n \rightarrow 0$ or rather converges to a positive number.
- Note also that the growth rate of output is suboptimal because innovators do not internalize the effect of their innovations on future innovators' productivity
 - business-stealing vs. consumer-surplus effects cancel each other with CES functional forms (see Grossman and Helpman, 1991)

Horizontal Innovation: Open Economy Applications

- Several potential effects of countries being a part of an integrated world economy.
- ① With international knowledge flows, we will have $k_n^j = \phi(\mathbf{n})$, where $\mathbf{n} = (n_1, \dots, n_j) \rightarrow$ growth will tend to accelerate.
- ② If you also allow for trade flows, this will tend to eliminate duplication in the creation of varieties \rightarrow again positive effect on growth.
- ③ Trade expands market size and the number of competing varieties \rightarrow overall effect on profitability of R&D seems ambiguous.
- ④ In multi-factor models, trade may affect factor prices and the allocation of factors of production to the innovating sector \rightarrow ambiguous effect on growth.
- ⑤ Trade could itself affect the function $k_n^j = \phi(\mathbf{n})$, enhancing knowledge spillovers (see Coe and Helpman, 1995, for some evidence).

International Knowledge Flows

- Assume that the world consists of two countries, H and F , with population sizes $L^H > L^F$.
- Countries do not trade and Home produces more varieties $n^H > n^F$. But there may be some duplication.
- So the common (knowledge flows are free) available stock of knowledge is:

$$k_n^j = k_n = n^H + \psi n^F, \text{ for } j = H, F.$$

- Both economies end up growing at rate

$$g^H = g^F = (1 - \alpha) \frac{L^H + \psi L^F}{a} - \alpha \rho,$$

which is higher than autarky in either country.

- Effects of international trade:
 - reduce duplication, that is increase ψ (same as in static model);
 - perhaps increase k_n proportionately, if trade is a vehicle of knowledge flows;
 - expand the market for intermediate inputs \rightarrow profitability of R&D goes up;
 - increase competition from foreign suppliers \rightarrow profitability of R&D goes up;
 - the last two effects exactly cancel each other.

Comparative Advantage and Endogenous Growth

- As in learning-by-doing models, with free trade but limited international spillovers, countries may specialize in sectors with lower growth potential.
- As an example, consider a two-sector, two-country, one factor model (as in Chapter 8 of Grossman and Helpman, 1991).
 - there is a traditional CRS sector and an innovating sector as described above with no international knowledge spillovers: $k_n^j = n^j$.
- In equilibrium, one country will eventually be the sole world producer in the innovating sector.
- Still, when the size of countries is not too different and they spend small shares of income on differentiated products, wages will be equalized on the dynamic trajectory. The required condition is:

$$\frac{L^j}{L^j + \rho} \leq \frac{1 - \mu}{\mu}, \text{ for } j = H, F,$$

where ρ is the discount rate and μ the expenditure share on differentiated products.

- When countries differ substantially in size or they spend large fractions of income on differentiated products, there may not be FPE and countries may grow at different rates.

Comparative Advantage and Endogenous Growth (cted.)

- Grossman and Helpman (1991) also develop two-factor models where the innovating sector is skill-intensive.
- Then, other things equal, in autarky a country's growth rate will be positively affected by the availability of skill workers.
 - on the other hand, an increase in the stock of unskilled workers has ambiguous effects on growth (negative for very low substitutability between H and L).
- If we now allow for international trade and free knowledge flows, the model can give rise to FPE, which will here equalize the growth rate in skill abundant and skill scarce countries.
- Skill abundant countries will eventually be net exporters of high-tech inputs, though they may not be during the transition.
- What is the effect of trade integration on growth?
 - the size effect raises g , but from the point of view of skill abundant country, L grows disproportionately, so effect is ambiguous.

Cite as: Pol Antràs, course materials for 14.581 International Economics I, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].