LEVERHULME LECTURE 2

Firms, Exports, and Innovation: A Dynamic Framework

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Issues:

- Effect of Diffusion on Welfare in an Open Economy (Krugman, Samuelson, Gomery and Baumol)

- Effect of Trade and Diffusion on the Incentive to Innovate in different countries.

- Diffusion and Trade as Substitutes

Two pieces of evidence:

- Parallel growth

- Research Concentration

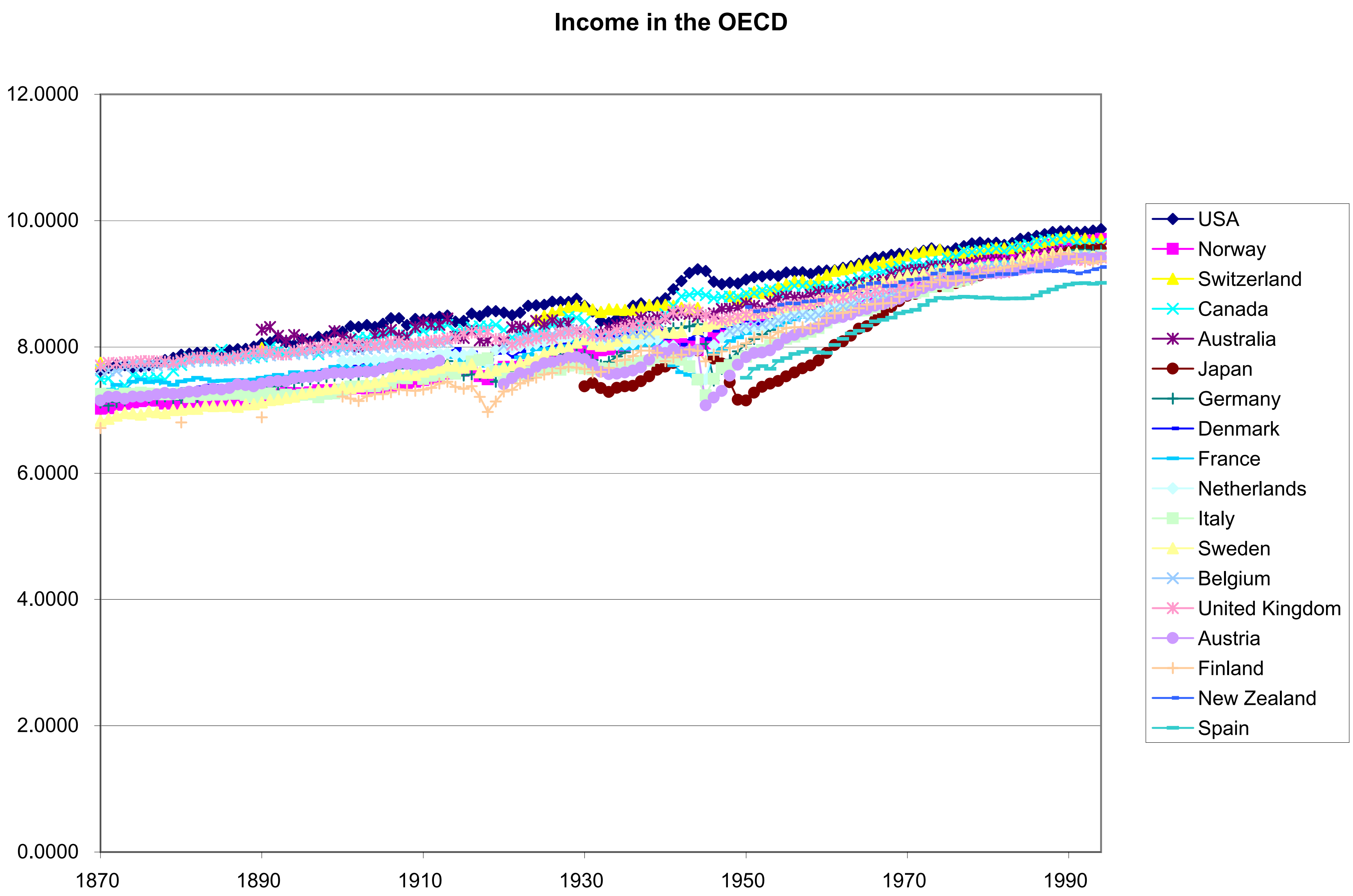
Income in the OECD
12.0000
10.0000
8.0000
6.0000
4.0000
2.0000
0.0000
1870
1890
1910
1930
1950
1970
1990
USA
Norway
Switzerland
Canada
Australia
Japan
Germany
Denmark
France
Netherlands
Italy
Sweden
Belgium
United Kingdom
Austria
Finland
New Zealand
Spain

TABLE 1

Business Sector Research Scientists
(per 1000 Industrial Workers)

COUNTRY	Scientists	Income	Population
Finland	12.2	69	5176
United States	10.2	100	275423
Japan	9.8	73	126919
Sweden	7.7	69	8871
Luxembourg	6.8	138	441
Russia	6.6	28	145555
Belgium	6.2	70	10254
Norway	6.0	90	4491
Canada	5.9	81	30750
Germany	5.5	67	82168
Singapore	5.3	80	4018
France	5.1	66	60431
Denmark	4.5	80	5338
Ireland	4.4	76	3787
Korea	4.2	42	47275
United Kingdom	4.2	68	59756
Taiwan	4.2	55	21777
Austria	3.9	70	8110
Netherlands	3.6	72	15920
Australia	2.4	76	19157
Slovenia	2.0	48	1988
Spain	1.8	53	39927
New Zealand	1.7	56	3831
Italy	1.6	64	57728
Slovak Republic	1.6	35	5401
Czech Republic	1.4	42	10272
Hungary	1.4	31	10024
Romania	1.4	14	22435
Poland	0.8	27	38646
Portugal	0.7	48	10005
China	0.7	11	1258821
Greece	0.5	44	10558
Turkey	0.2	21	66835
Mexico	0.1	27	97221

Data are for 2000 or the previous available year
Income is relative to the United States (100)
Population is in 1000's
Sources: OECD (2004) and Heston, Summers, and Aten (2002).

Previous Work:

- Krugman (1991) North-South model
- Endogenous R&D (in 1 country) and diffusion: Grossman Helpman (1991)
- Multicountry innovation EK (1999) and trade: EK (2001,2002,2005).
- Here: an integration
- Why has it taken so long?

- Two countries: $n = N, S$.

- Continuum of goods $j \in [0,1]$, as in DFS (1977).

- Three types of technologies to produce a good j: $i = N, S, C$

- TFP $z_i^h(j)$ $i = N, S, C$.

- Distributional Assumptions:

$$\Pr[Z_i \leq z] = \exp[-T_i z^{-\theta}]$$

independent across $i = N, S, C$..

Other assumptions:

- Wages w_N, w_S (= 1, sometimes). Assume a world with parameters such that $w_N \geq w_S$.

- Cobb-Douglas preferences:

$$X_n(j) = Y_n$$

where $X_n(j)$ is spending on good j in market n and Y_n is total spending in market n (easy to generalize to CES).

- Iceberg transport costs $d \geq 1$.

Inevitable Ricardian taxonomy:

1. $w_N > w_S d$: C technologies only used in S.

2. $w_N = w_S d$: C technologies used in both countries, but exported only by S.

3. $w_N < w_S d$: C technologies used in both countries, with no trade in goods made with those technologies.

Effective wage for technologies: w_{ni} $i = N, S, C$; $n = N, S$:

$$\begin{array}{ccc} w_{NN} = w_N & w_{NC} = \min\{w_N, w_S d\} & w_{NS} = w_S d \\ w_{SN} = w_N d & w_{SC} = w_S & w_{SS} = w_S \end{array}$$

- Unit costs:

$$c_N(j) = \text{min}\{w_N/z_N(j), w_{NC}/z_C(j), w_S d/z_S(j)\}$$
$$c_S(j) = \text{min}\{w_N d/z_N(j), w_S/z_C(j), w_S/z_S(j)\}$$

- Cost distribution in the North:

$$\begin{aligned} H_N(c) &= \text{Pr}[C_N(j) \leq c] \\ &= 1 - \text{Pr}[Z_N \leq w_N/c]\,\text{Pr}[Z_S \leq w_S d/c]\,\text{Pr}[Z_C \leq w_{NC}/c] \\ &= 1 - \exp\left[-\Phi_N c^{\theta}\right] \end{aligned}$$

where $\Phi_N = T_N w_N^{-\theta} + T_S(w_S d)^{-\theta} + T_C w_{NC}^{-\theta}$.

- While in the South:

$$\begin{aligned} H_S(c) &= \Pr[C_S(j) \le c] \\ &= 1 - \exp\left[-\Phi_S c^{\theta}\right] \end{aligned}$$

where $\Phi_S = T_N (w_N d)^{-\theta} + T_S w_S^{-\theta} + T_C w_S^{-\theta}$.

- Φ_n reflects market n's access to world technology, taking into account factor costs and geographic barriers.

- Probability country n uses technology i for a good:

$$\pi_{ni} = \frac{T_i w_{ni}^{-\theta}}{\Phi_n}$$

$n = N, S;\ i = N, S, C.$

Labor market equilibrium:

$$w_N L_N^E = \beta(\pi_{NN} Y_N + \pi_{SN} Y_S)$$

where β is the labor share and L_N^E the measure of N workers using N technology. Here Y_i is total spending in market i.

Different cases.

Market Structure and Profit Share

- Ideas: a way to make a good j with efficiency q, realization of a r.v. Q with Pareto distribution (Kortum 1997):

$$F(q) = \Pr[Q \leq q] = 1 - q^{-\theta}.$$

Only an idea that lowers cost somewhere will be used. Initially ideas are exclusive to the country of invention.

- To be useful at home an invention from country n of quality q for good j must satisfy:

$$\frac{w_n}{q} \leq c_n(j) = \min \left[\frac{w_{nN}}{z_N(j)}, \frac{w_{nC}}{z_C(j)}, \frac{w_{nS}}{z_C(j)} \right]$$

where $z_i(j)$ is the state of the art for technology of type $i = N, S, C$ while to lower the cost of serving the foreign market $n' \neq n$ it must satisfy:

$$\frac{w_n d}{q} \leq c_{n'}(j) = \min \left[\frac{w_{n'N}}{z_N(j)}, \frac{w_{n'C}}{z_C(j)}, \frac{w_{n'S}}{z_C(j)} \right]$$

which is tougher, since the cost of a good cannot differ by more than d, while the cost of exporting is d.

- Hence a small innovation may be used for sale only in the domestic market, while a larger one will be sold more widely.

Three Implications for firms (BEJK 2003)

1. Higher $q \longrightarrow$ more likely to export

2. Higher $q \longrightarrow$ more likely to be further ahead of the next cheapest technology, so charge a higher markup.

3. Higher $q \longrightarrow$ more likely to charge a lower price, so, with a high elasticity of substitution, sell more even at home

Ergo, the observed productivity and size advantage of exporting units.

Implications for markups and profit

- Implied distribution of the mark-up over second lowest cost:

$$G(m) = 1 - m^{-\theta}$$

- This distribution applies to all goods actually sold in a market so that total profit in market n is:

$$\Pi_{nt} = Y_{nt} \int_1^{\infty} (1 - m^{-1}) dG(m) = \frac{Y_{nt}}{1 + \theta}$$

- Expected profit for an idea from technology i in market n:

$$\frac{\pi_{ni} \Pi_{nt}}{T_{it}}.$$

Innovation, Growth, and Diffusion

- Labor force growth rate n.

- Rate of diffusion out of exclusive into common technologies ϵ.

- Ratio of exclusive technologies to labor forces:

$$t_i = T_i/L_i \quad i = N, S$$

- Research productivity α_i.

- Growth of t_i:

$$\frac{\dot{t}_i}{t_i} = \frac{\dot{T}_i}{T_i} - \frac{\dot{L}_i}{L_i} = \frac{\alpha_i r_i}{t_i} - (n + \epsilon)$$

- Steady state:

$$t_i^* = \frac{\alpha_i r_i}{n + \epsilon}$$

- Steady state ratio of common to exclusive technologies:

$$t_C^* = \frac{T_C}{T_N + T_S} = \frac{\epsilon}{n}$$

- Discount factor ρ. The s.s. value of an idea:

$$
\begin{aligned}
V_{it} &= \frac{1}{\rho+\epsilon-n/\theta}\frac{\pi_{Ni}\Pi_{Nt}+\pi_{Si}\Pi_{St}}{T_{it}} \\
&\quad + \left(\frac{1}{\rho-n/\theta}-\frac{1}{\rho+\epsilon-n/\theta}\right)\frac{\pi_{NC}\Pi_{Nt}+\pi_{SC}\Pi_{St}}{T_{Ct}}.
\end{aligned}
$$

- Labor-market equilibrium:

$$
\begin{aligned}
\alpha_i V_{it} &= w_{it} \quad r_{it}\in[0,1] \\
\alpha_i V_{it} &\leq w_{it} \quad r_{it}=0 \\
\alpha_i V_{it} &\geq w_{it} \quad r_{it}=1
\end{aligned}
$$

Steady-State Research Activity in Four Cases

1. No diffusion ($\epsilon = 0$) (EK 2001):

$$r = \frac{n}{\rho\theta}$$

Research effort is independent of size or of trade barriers.

2. Instantaneous diffusion ($\epsilon \to \infty$):

   (a) Value of ideas V the same everywhere. $w_N \leq w_S d$. Outcome depends on α_N/α_S relative to d

      i. $\alpha_N/\alpha_S < d$

$$\frac{w_N}{w_S} = \frac{\alpha_N}{\alpha_S}$$
$$r = \frac{n}{\rho\theta}$$

         A. No trade. Diffusion is a perfect substitute.

         B. Balanced trade in royalties.

ii. $\alpha_N/\alpha_S > d$

$$\begin{aligned} \frac{w_N}{w_S} &= d \\ r_S &= 0 \\ r_N &= \frac{n}{\rho\theta}\left(1+\frac{L_S}{dL_N}\right) \end{aligned}$$

Less research activity but more research output.

3. No trade ($d \rightarrow \infty$):

   (a) No clean analytical solution:

   (b) Effect of more diffusion: larger market but more competition. No unambiguous result.

   (c) Effect of market size. ditto.

   (d) Numerical examples: deviations from no diffusion case small.

4. Costless trade ($d = 1$): Depends on case.

   (a) case 2 $\longrightarrow w_N = w_S$

      i. One economy:

$$\frac{R_N + R_S}{L_N + L_S} = \frac{n}{\rho\theta}$$

      ii. Location indeterminate if $\alpha_N = \alpha_S$. All in N if $\alpha_N \geq \alpha_S$.

(b) case 1 $\longrightarrow w_N > w_S$

i. Messy.

ii. Numerical example. From no diffusion, allowing some diffusion shifts research to where research is more productive, but also to smaller market.

Conclusions

- Rapid diffusion reduces trade.
- More diffusion leads to specialization in research according to CA if trade costs are low relative to CA in research.
- Trade openness has little to do with research incentives.
- Not here: IP issues (Helpman 1993 and others).
- How to incorporate more countries?

- Going to data: a panel of firms, looking at their R and D, export, and foreign direct investment activity.