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**Endogenization of qualified labor  
migration induced by the implantation of  
multinationals in the South.**

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**Université Paris I Panthéon Sorbonne**  
**UFR de Sciences Economiques 02**  
**MASTER Recherche : Analyse et Politiques Macroéconomiques**

**Modèles Nord-Sud:**

*Endogénéisation des comportements migratoires des travailleurs qualifiés induits par  
l'implantation des multinationales au Sud.*

**Directeur de Mémoire: Professeur Bertrand Wigniolle**

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**Short Thesis**  
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**North-South Models:**

*Indigenization of qualified labor migration induced by the implantation of multinationals in the South.*

**Advisor: Professor Bertrand Wigniolle**

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**I. A Model of Threshold for imitation to innovation, in the process of reverse-engineering imported intermediate goods from North to South, and where I introduce consumer bias.**

**A. Abstract:**

Let us follow Romer's framework (1990) for the intermediate goods sector.

We assume the following.

A North operated multinational firm is implanted in the North and the South.

The North **designs** and makes the higher quality products. In the South, its manufacturing divisions produce **intermediate** and **final** goods of lower quality competing against the South locals.

The multinational is constrained by the South government to transfer a certain amount of know-how **Hns** and technology **xns**. It also benefits from the large pool of cheaper labor, and leads the efforts of innovation in the South.

Final goods and intermediate goods are tradable, although some restrictions may apply on the part which is technologically advanced.

The countries, independently of the multinational and of its South competitor, still produce non tradable goods, to which quality rankings do not apply, because they depend on local taste. The workers in the North and the South thereby benefit from both types of goods, tradable and non tradable.

Competitors in the South reverse-engineer the goods produced in the South and compete with the North on the final goods market which may be tariff protected, selling back to the North operated multinational firm, or on the intermediate goods market in the South.

To the difference of Currie et al (1999, 1996), but similarly to our first model's assumption that the rate of absorption of the North's human capital is endogenous to the importance of foreign capital investment, the present model inspired by Ahmid Datta's model illustrates the mechanism of endogenous absorption through reverse-engineering of foreign designed goods.

Conclusions of the original Ahmid Datta's 2005 model were that a threshold of accumulated human capital knowledge must exist, before the local **human capital and imported technology become substitutes from being complements.**

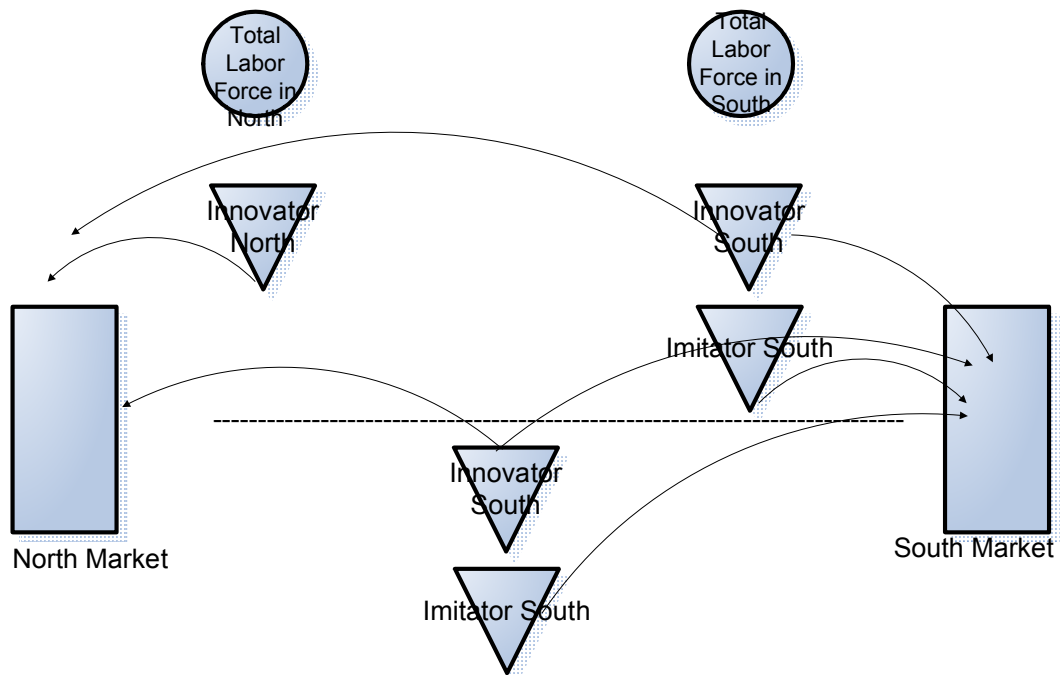
**We clearly reach to the same conclusion here.**

**This finding is consistent with the role given to human capital by Keller 1996.**

We here strive to demonstrate our first model hypothesis by analyzing:

- The effect of the multinational's decision of foreign investment on the threshold (imitation to innovation state).

- The effect of international migration of qualified workers on the threshold.
- The effect of Northern consumer's bias for local made products, on the threshold.
- **How does the constraint imposed on the multinational to transfer technology and know-how, translate on its profits, on its market share in the South?**



*In the above diagram are portrayed the activities of production, imitation and innovation. The dotted line separates the activities of the multinational from those of its south competitors.*

***From the standpoint of the multinational's activities (all actors belong to the multinational):***

*We assume that the Innovator in South has an interest in competing with its North counterpart, yet it must also compete with its local competitor in order to keep a leading edge on the innovation in the South and retain the best talent.*

*Below a certain threshold, it competes with its local competitor.*

*Past a certain threshold  $I^* > A$ , it competes with its North counterpart.*

***From the standpoint of the multinational's competitor's activities:***

*The Innovator in South past a certain threshold  $I^* > A$  competes with the multinational in the North.*

**B. Model for the (North) Multinational:**

$$Y_n = H_n^\alpha (L_N^N)^\beta \times \int_0^A x_{nn}^{1-\alpha-\beta} + (L_{S,c}^N)^\gamma \times \int_0^I (\psi \times x_{ss})^{1-\gamma} + (L_{S,i}^N)^\gamma \times \int_I^{I^*} (\zeta \times x_{sn})^{1-\gamma}$$

**(1) Consolidated Production**

This North production function of final goods is a constant returns to scale Cobb-Douglas technology where A is the index of the most recently invented good, representing the stock of knowledge in the north.

The **North multinational** employs:

- $(L_N^N)$  innovative workers in the North to produce in the North for the North using xnn technology.
- $(L_{S,c}^N)$  Imitating workers to produce in the South for the North and the South based on the South knowledge capital.
- $(L_{S,i}^N)$  Innovative workers for products no yet imitated by the South.

$k = \int_0^A x_{nn}(i)di + \int_0^I x_{ss}(i)di + \int_I^{I^*} x_{nn}(i)di$  Represents the world's stock of capital in the above production equation.

$\psi, \zeta$  represent the market shares of the multinational, in the South, of its (imposed) imported goods xns and on xss..

$K$  is measured in the units of consumption goods foregone, or  $\partial K(t)=Y(t)-C(t)=I(t)$ .

As Ahmid-Datta note in the original article, a majority of goods finding their way to the US markets from China are either final goods, or intermediate goods that are the outcome of outsourcing arrangement by US based firms, rather than exports of *cloned* intermediate goods by *independent* Chinese firms.

**In the North:**

$$\partial A = \delta_n H_{An} A$$

This knowledge, a non rival public good is available to all and the productivity of research is linearly related to the existing knowledge stock and to human capital.

The intermediate goods sector buys the innovator's designs A selling its transformed capital goods to the final good producers.



It is assumed that the intermediate sector, which is both the innovator and producer of capital goods, is monopolistically competitive, appropriating the returns from R&D.

**C. Model for the South competitors of the multinational:**

$$Y_S = (L_S^S)^\eta \times \int_0^I ((1-\psi) \times x_{SS})^{1-\eta} + (L_{N,i}^S)^\eta \times \int_I^{I^*} ((1-\zeta) \times x_{Sn})^{1-\eta} \quad (2)$$

The South competitor employs:

- $(L_S^S)$  from the South to imitate in the South for the South's consumption or the North's.
- $(L_{N,i}^S)$  from the South to innovate for the South and past a threshold to the North as well.

Here the key issue is that the process of acquiring knowledge is done through reverse engineering of imported good and through the decision to invest abroad.

Therefore the question is how to relate the production technologies  $x_{SS}$  to  $x_{Sn}$  and  $x_{Nn}$ .

We choose 
$$x_{SS}(i) = (H_{Sn} + H_{SS})^\phi x_{Sn}(i)^{1-\phi} \quad (3)$$

**The one factor over which the multinational has control is  $H_{Sn}$ , the level of human capital, which is devoted to the imitation process  $[I, I^*]$  and imposed by the South to the multinational.**

$$H_{Sn} = 1 - H_n \quad (4)$$

**Past a certain threshold in  $H_{Sn}$ , the dependence on  $x_{Sn}$  decreases and signals the onset of innovation.**

Meanwhile, the activity of innovation in the South by both the multinational and its competitor

leads to an increase in the global knowledge of the South:  $\partial I / \partial t = \delta s \times \int_0^I x_{SS}(i) di$

(5)

Or 
$$\partial I / \partial t = \delta s \times (H_{Sn} + H_{SS})^\phi \int_0^I x_{Sn}(i)^{1-\phi} di \quad (6)$$

Initially, the South lacks the know-how and resources to process A, even though A, taking the form of public knowledge is feely available.

$I < A$  measures the technology gap of the South, while  $I^* = [I, A]$ .

It is also noticeable that **when  $\phi > 1$** , the activity of innovation becomes

$$\partial I / \partial t | (\phi = 1) = \delta s \times (H_{Sn} + H_{SS}) \times I$$

**D. Preferences:**

Preferences in each country  $i$  are given by inter-temporal utility function of the Ramsey type,

$$U_i = \int_0^{\infty} C_i^{1-\sigma_i} / (1-\sigma_i) * e^{-\rho_i t} dt \tag{7}$$

where  $i = N, S$ , where  $\rho_i$  is the rate of time preference,  $\sigma_i$  is the elasticity of inter-temporal substitution and  $C_i$  is final goods consumption. Preferences enter balanced growth path through

the Euler solution to equation (7):  $\partial C_i / C_i = (r_i - \rho_i) / \sigma_i$

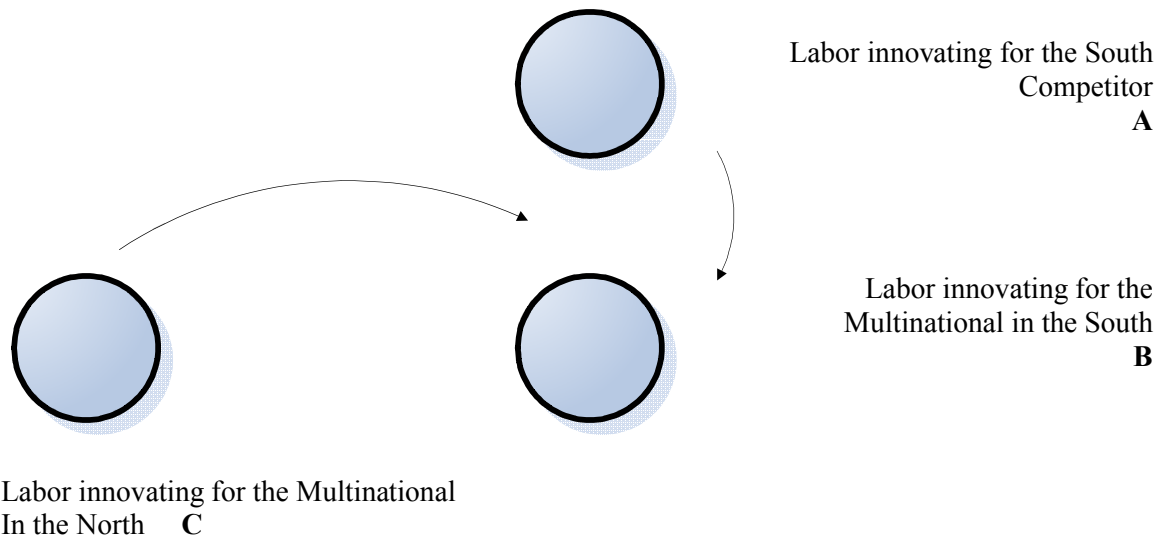
Such equation indicates that in the absence of capital movements, here only from the North to the South, the interest rates won't equalize leaving the open possibility of different growth rates.

**E. Employee Migration Patterns:**

**We now concentrate on how the decisions taken by employees of the intermediate and research sectors of the multinational affect North and South growth. The formulation is enabled because the multinational of firm which employs the latter, may facilitate their transfer from one division to another, according to its needs.**

We assume:

- To be able to work in the North, the South employee must belong to the South branch of the multinational.
- Belonging to the multinational will increase the cultural factor of the employee; thereby reducing its interest in staying in the South, since it may not find there the quality of goods it requires.
- A North employee will move to the South branch if its decrease in salary is overcompensated by its gain in utility due to the lower price of non tradable goods, xss.



**Moreover, we assume that xns is tradable: it is being imported by the multinational under constraint by the foreign government.**

The maximization of profits in this case (as seen in paragraph G.) lead to:

$$\begin{aligned} \max \pi n_{XS(j)} = & \int_0^A H_n^\alpha (L_N^N)^\beta \times xnn^{1-\alpha-\beta} - Pn, n \times xnn + \int_0^I (L_{S,c}^N)^\gamma \times xss^{1-\gamma} + \\ & \int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} - Pn, s - w_N \times L_N^N - w_S \times L_{S,C}^N - w_{N,S} \times L_{S,I}^N \end{aligned}$$

The North gets the accumulated knowledge capital in the South for free, while in counterpart it is forced to invest in innovative sectors both to take the edge in the local market and also because of the foreign government's policies.

And

$$\begin{aligned} \max \pi s_{XS(j)} = & \left[ \int_0^I (L_S^S)^\eta \times (1 - xss)^{1-\eta} - Ps, s(i) \times (1 - xss(i)) \right] di + \left[ \int_I^{I^*} (L_{N,i}^S)^\varepsilon \times (1 - xsn)^{1-\varepsilon} \right] di^* - w_S \times L_S^S - w_{N,S} \times L_N^S \\ & - Pns \times xsn \end{aligned}$$

We assume that the multinational South division and its South competitor play a competition a la Cournot on two markets, the North multinational innovative sector and its counterpart, the North multinational imitative sector and its counterpart.

**The companies play a Cournot game, based on the first mobile factor, xsn, under constraint that they maximize the budget constraint of consumers.**

**Max in xsn:**

$$\text{Log}(U_{IN} = ( \left[ \int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} di \right]^\psi + \left[ \int_I^{I^*} (L_{N,i}^S)^\varepsilon \times (1 - xsn)^{1-\varepsilon} di^* \right]^\psi \dots )^{1/\psi} ) \text{Under}$$

**constraint**

$$\begin{aligned} w_S \times L_S^S + w_{N,S} \times L_N^S + w_N \times L_N^N + w_S \times L_{S,C}^N + w_{N,S} \times L_{S,I}^N = \\ \int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} di + \int_I^{I^*} (L_{N,i}^S)^\varepsilon \times (1 - xsn)^{1-\varepsilon} di + \dots \end{aligned}$$

$$\begin{aligned} & (\psi - 1)(1 - \gamma)(L_{S,i}^N)^{\gamma\psi-\gamma} xsn^{(\psi-1)(1-\gamma)-1} - (\psi - 1)(1 - \tau)(L_{N,i}^S)^{\tau\psi-\tau} (1 - xsn)^{(\psi-1)(1-\tau)-1} \\ & = \gamma \times (L_{S,i}^N)^\gamma \times xsn^{-\gamma} - \tau \times (L_{N,i}^S)^\tau \times (1 - xsn)^{-\tau} \end{aligned}$$

**In an effort to identify the causes of migration, we determine the influence of bias on the size of technology transfers  $xsn$ .**

We take in order to simplify that  $\gamma = \tau$

$$\begin{aligned} & (\psi - 1)(1 - \gamma)[(L_{S,i}^N)^{\gamma\psi - \gamma} xsn^{(\psi - 1)(1 - \gamma) - 1} - (L_{N,i}^S)^{\gamma\psi - \gamma} (1 - xsn)^{(\psi - 1)(1 - \gamma) - 1}] \\ & = \gamma \times [(L_{S,i}^N)^{\gamma} \times xsn^{-\gamma} - (L_{N,i}^S)^{\gamma} \times (1 - xsn)^{-\gamma}] \end{aligned}$$

Moreover, we consider at the moment  $L_{S,i} = L_{N,i}$ ,  $\gamma = .5$ ,  $L = 1$

$$\begin{aligned} & (\psi - 1)(.5) \exp[(\psi - 1).5 - 1] \log xsn - \exp[(\psi - 1).5 - 1] \log(1 - xsn) \\ & = \gamma \times [xsn^{-.5} - (1 - xsn)^{-.5}] \end{aligned}$$

We take the derivative to be able to express:

$\partial xsn / \partial \psi = >$ :

$$\begin{aligned} & d\psi(.5) \exp[(\psi - 1).5 - 1] \log xsn + \\ & .5(\psi - 1) \exp[(\psi - 1).5 - 1] \log xsn (d\psi \times .5 \times \log xsn + (\psi - 1).5 - 1) / xsn \times dxsn = 0 \\ & - \exp[(\psi - 1).5 - 1] \log(1 - xsn) [(d\psi \times .5 \times \log(1 - xsn) - (\psi - 1).5 - 1) / (1 - xsn) \times dxsn] \end{aligned}$$

Rewriting:

$$\begin{aligned} & d\psi(.5) [\exp[(\psi - 1).5 - 1] \log xsn (1 + .5(\psi - 1) \times \log xsn - \exp[(\psi - 1).5 - 1] \log(1 - xsn)) \log(1 - xsn)] \\ & + dxsn \exp[(\psi - 1).5 - 1] \log xsn .5(\psi - 1)((\psi - 1).5 - 1) / xsn \\ & - \exp[(\psi - 1).5 - 1] \log(1 - xsn) (-\psi - 1).5 - 1 / (1 - xsn) \times dxsn \end{aligned}$$

**First term decreases in  $\psi$ , decreases in  $xsn$ , second decreases in  $\psi$ , increases in  $xsn$  but its contribution is smaller because of the double log., ...**

**Results of Mathematica Simulation:**

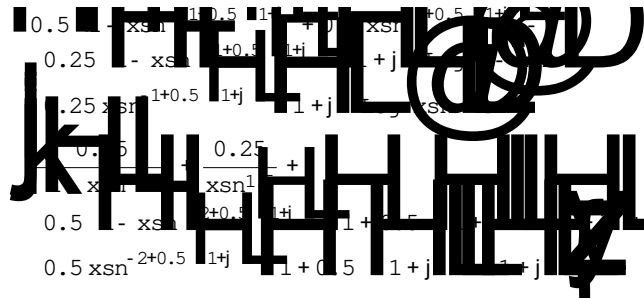
**dA/dxsn**

$$\begin{aligned} & LSI^{-g} xsn^{g^2 + LNI^{-t} - g} \\ & LSI^{-g} xsn^{-2t - g} \\ & LSI^{-t + j} xsn^{t - g} \\ & LSI^{-t} xsn^{t + j} \end{aligned}$$

**dA/dphi**

$$\begin{aligned} & LSI^{-g + gf} xsn^{g^2 + LNI^{-t} - g} \\ & LNI^{-t + tf} xsn^{t - g} \\ & LNI^{-t + tf} xsn^{t + j} \\ & LSI^{-g + gf} xsn^{-1 + LNI^{-t} - g} xsn^{t + j} \end{aligned}$$

**Dxsn/dphi**



- (\* xsn=.4  $\sigma$ =.5 B=.6
- xsn=.3  $\sigma$ =.5 B= 1.4387
- xsn=.2  $\sigma$ =.5 B= 4.9 \*)
- (\* xsn =.4  $\sigma$ =.9 B= 0.449
- xsn=.4  $\sigma$ =.7 B=.53
- xsn=.4  $\sigma$ =.3 B= 1.51
- \*)

Overall, we find that the stronger the elasticity of substitution (bias) tilts towards the multinational innovative sector in the South, and the more will technology transfers take place, and the stronger the growth of the knowledge capital of the South.

At some point the dependency on xsn technological imports reduces which reduces the flow of technology transfer, therefore self equilibrating the domination of the North or the South, on the innovative role in the North.

Second, the constraint by the foreign government to impose free technology transfers by the multinational leads to less sensitivity to bias.

A bigger (1-xsn) leads to a decrease in the rate of technology transfer to the South.  $d(xsn)/xsn$ .

One aspect to consider is also the acculturation faced by the North multinational workers in the South. Supposing that their joining of the North multinational in the South, leads to unanswered desires, xnn, intermediate goods not produced in the South. Then a negative term which is disappreciation and that could be proportional to (A-I), the quality gap and to the ratio between employees belonging the the multinational in the South and to the other locals.

$$w_S \times L_S^S + w_{N,S} \times L_N^S + w_N \times L_N^N + w_S \times L_{S,C}^N + w_{N,S} \times L_{S,I}^N =$$

$$L_{SI} / L_{NI} (A - I) \int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} di + \left[ \int_I^{I^*} (L_{N,i}^S)^\epsilon \times (1 - xsn)^{1-\epsilon} di \right] + \dots$$

Then, clearly, we obtain in our above maximization in the technology transfer xsn a more accurate expression of migration.

We find that a higher disappreciation leads to more technology transfers, which in turn reduces disappreciation by reducing the gap between the North and South.

We now look at a different perspective: we analyze how the multinational and its south competitor attract the best talent throughout the world, through the maximization of their profit in terms of population pools.

Therefore, instead of playing a Cournot game in  $xsn$ , we maximize this utility in the other essential factor:  $L_n$ ,  $L_s$  which are also limited quantities.

**Max in  $L_n$ ,  $L_s$ :**

$$\text{Log}(U_{IN} = ( [\int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} di]^\psi + [\int_I^{I^*} (L_{N,i}^S)^\varepsilon \times (1-xsn)^{1-\varepsilon} di]^*]^\psi \dots ]^{1/\psi} ) \text{Under}$$

**constraint**

$$w_S \times L_S^S + w_{N,S} \times L_N^S + w_N \times L_N^N + w_S \times L_{S,C}^N + w_{N,S} \times L_{S,I}^N =$$

$$\int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn^{1-\gamma} di + \int_I^{I^*} (L_{N,i}^S)^\varepsilon \times (1-xsn)^{1-\varepsilon} di + \dots$$

$$\frac{\partial U}{\partial L_{SI}} = w_{SI} = \gamma (L_{S,i}^N)^\gamma \times xsn^{1-\gamma}$$

$$\frac{\partial U}{\partial L_{NI}} = w_{NI} = \gamma (L_{S,i}^N)^\gamma \times xsn^{1-\gamma}$$

## F. Models of Competition:

Here are the dynamics of the model:

$$\partial L_N^N / \partial t = -A \times L_N^N(t) + B \times L_{SI}^N(t) \quad (11)$$

$$\text{In steady state, } L_N^N = L_{SI}^N \times B / A$$

$$\partial L_{SI}^N / \partial t = -C \times L_{SI}^N(t) + D \times L_N^N(t) + E \times L_{NI}^S(t) \quad (12)$$

$$\partial L_{NI}^S / \partial t = -F \times L_{NI}^S(t) + G \times L_{SI}^N(t) \quad (13)$$

At equilibrium, it must be that there is no population transfer of migrant workers from A to B and from B to C.

Moreover, the steady state populations are constant.  
Therefore we rewrite:

$$A \times L_N^N = B \times L_{SI}^N \quad C \times L_{SI}^N = D \times L_N^N + E \times L_{NI}^S \quad F \times L_{NI}^S = G \times L_{SI}^N$$

We obtain these factors maximizing the utility of consumers with respect to the different populations.

### G. Solving for balanced growth in the South:

In the range  $[0, I]$  the South competitor of the multinational uses intermediate goods produced locally xss since transaction costs would make xns more expensive. However in the range  $[I, I^*]$ , only intermediate imported goods are available, yet these are obtained for free due to the multinational's constrained transfers of technology<sup>1</sup>.

Since only the multinational creates xns, only it pays for it. Yet the South pays for xss while the multinational doesn't pay for it.

Profit maximization by the perfectly competitive final goods producers in the South is represented as:

$$\max \pi_{XS(j)} = \left[ \int_0^I (L_S^S)^\eta \times xss^{1-\eta} - P_S(i) \times xss(i) \right] di + \left[ \int_I^{I^*} (L_{N,i}^S)^\varepsilon \times xsn^{1-\varepsilon} \right] di^* - w_S \times L_S^S - w_{N,S} \times L_N^S - P_{ns}(i) \times x_{nY}^S(i)$$

which yields the demand for domestic goods xss:

$$P_S(xss) = (1 - \eta) L_S s^\eta xss^{-\eta} \quad (8)$$

$$P_{S,n}(x_{nY}^S) = (1 - \tau) L_{N,i}^S{}^\tau \times x_{nY}^S{}^{-\tau}$$

Profit maximization by the multinational in the final good sector in the North is represented as:

<sup>1</sup> Foreign Imposed transfers of Technology

$$\max \pi_{n, XS(j)} = \int_0^A H_n^\alpha (L_N^N)^\beta \times xnn^{1-\alpha-\beta} - Pn, n \times xnn + \int_0^I (L_{S,c}^N)^\gamma \times xss^{1-\gamma} +$$

$$\int_I^{I^*} (L_{S,i}^N)^\gamma \times xsn_i^{1-\gamma} - Pn, s \times x_{SI}^N - w_N \times L_N^N - w_S \times L_{S,C}^N - w_{N,S} \times L_{S,I}^N$$

which yields the demand for domestic goods  $xnn$  and for imported goods  $xns$ :

$$Pn, n(xss) = (1 - \alpha - \beta) H_n^\alpha L_N^{N\beta} xnn^{-\alpha-\beta} \quad (9)$$

$$Ps, n(x_{SI}^S) = (1 - \gamma) L_{SI}^{N\gamma} x_{SI}^{S-\gamma} \quad (10)$$

$$\text{And finally for local goods } Pss \quad (11)$$

We now come back to the local intermediate goods producers in the South.

The profit of each firm from the sale of intermediate goods to final goods producers be they the multinational or its competitors is:

$$\pi_{XS} = Ps(xss) \times xss - rs \times xss \quad (11)$$

Where  $rs \times xss$  represents the interest cost of capital.

Maximizing (11) in  $xss$  using (8) yields the monopoly price of  $xss$

$$Ps = rs / (1 - \eta) \quad (12)$$

The flow of monopoly profits at this price is  $\pi_{XS} = \eta \times Ps \times xss$

Next we determine  $P_I$  the cost of imitated design.

$$P_I = \int_t^{\infty} e^{-r\tau} \pi_{XS}(\tau) d\tau \quad (13)$$

$$\text{Differentiating in time yields } \pi_{XS} = rs \times P_I \Rightarrow \quad (14)$$

$$P_I = \eta Ps \times xss / rs = \eta \times xss / (1 - \eta)$$

$$\text{Replacing from (8) and (12) into (14)} \Rightarrow \frac{P_I}{rs} = \frac{\eta(1 - \eta)^{2-\eta/\eta} L_{S,S}}{rs^{1/\eta}}$$

We notice that a higher interest rate in the South reduces  $P_I$  as it reduces the demand for such investments and thus their reservation cost.

Next we determine the South demand for higher technology goods.

The cost of imitation includes (using)

$$xss(i) = (Hsn + Hss)^\phi xsn(i)^{1-\phi} \quad (3)$$



Since the North assumes the part of the cost for innovative designs, it chooses the demand  $x_{NS}$ .

$$x_{NS} = \frac{W_{HNS}}{const \times \alpha ((1 - H_{SN})^{\alpha-1} L_{nn})} \quad (16)$$

(See below)

Based on that demand, the South demand  $x_{SS}$  is found to be:

$$x_{SS} = \left( \frac{W_{HNS}}{const \times \alpha ((1 - H_{SN})^{\alpha-1} L_{nn})} \right)^{1-\phi} \times (H_{sn} + H_{ss})^\phi$$

We deduce that South demand is independent on its population size.

However it is negatively correlated to the North population size as the multinational will decrease its technology transfers in such a case.

The ratio  $\frac{(H_{sn} + H_{ss})^\phi}{(1 - H_{sn})^{\alpha-1}}$  will increase with  $H_{sn}$ .

#### H. Solving for Balanced Growth in the North:

The North chooses capital transfer  $H_{ns}$  versus  $H_n$ , and pays for innovative goods  $x_{n,s}$  in the South.

Let us determine the maximum profit in  $x_{nn}$  and  $x_{sn}$ .

$$P_{n,n}(x_{ss}) = (1 - \alpha - \beta) H_n^\alpha L_N^{N\beta} x_{nn}^{-\alpha-\beta} \quad (9)$$

$$P_{s,n}(x_{ss}) = (1 - \gamma) L_{SI}^{N\gamma} x_{ns}^{-\gamma} \quad (10)$$

The North's activity of imitation of higher quality goods in the South competes with that of its South competitor, therefore presents similar costs characteristics except for its transfer of (human) capital, leads to costs.

**The North clearly wishes to minimize this cost, being under constraint to transfer technology.**

**Using the fact that:**

$$\frac{P_{IN} = (\alpha + \beta)(1 - \alpha - \beta)^{2-\alpha-\beta/(\alpha+\beta)} H_n^\alpha L_{n,n}}{rn^{1/(\alpha+\beta)}}$$

$$\pi_i = -w_{HNS} H_{SN} + (P_{IS} - P_{IN}) \times x_{nl}^S \quad (15)$$

The variable of control being Hsn, the North maximizes its profit with respect to the variable Hsn.

$$\pi_i = -w_{HNS} H_{SN} + 'const \times (L_{SS} - (1 - H_{SN})^\alpha L_{nn}) \times x_{nl}^S$$

**Which leads to the demand xns:**

$$-w_{HNS} + 'const \times \alpha((1 - H_{SN})^{\alpha-1} L_{nn}) \times x_{nl}^S = 0$$

$$x_{nl}^S = \frac{w_{HNS}}{const \times \alpha((1 - H_{SN})^{\alpha-1} L_{nn})} \quad (16)$$

(where Hsn<1)

**Clearly, a higher transfer of human capital will lead to a much smaller transfer of technological goods, while a high transfer of high technology goods will reduce the transfer of human capital.**

The total demand from the South for the North's imported goods includes the ones used in the final goods production process and the ones used in imitation.

$$x_{ns} = \frac{w_{HNS}}{const \times \alpha((1 - H_{SN})^{\alpha-1} L_{nn})} + \left[ \frac{P_{S,n}(x_{nY}^S)}{(1 - \tau)L_{N,i}^S} \right]^\tau \quad (17)$$

**Such an expression allows us to write the South's inverse demand for northern intermediate goods, which is negatively correlated to import price.**

Total profits of the North's capital goods sector are based on both these sources of demand:

$$\pi_{xn} = p_n * x_n + p_{ns} * x_{ns} - rn(x_{nn} + x_{ns}) \quad (17bis)$$

**Substituting for Ps,n and Pn yields:**

$$\text{Function}(x_{n,s} ; x_{n,n}) \quad (18)$$

**Maximizing it in xsn and xnn yields equilibrium prices for both markets**



## II. A Model inspired by PAUL LEVINE and al. relative to the phases of transition between the states of Innovation, Imitation

### a. Introduction:

We wish to study in the footsteps of DAVID CURRIE, PAUL LEVINE, JOSEPH PEARLMAN, AND MICHAEL CHU the transition from the South<sup>2</sup> imitating and the North innovating, to the North innovating and the South both innovating and imitating, to the South innovating and imitating and the North innovating and imitating as well.

### b. Notation Summary:

Throughout the paper, we use: Superscript: N North S South, Subscript: i innovation c imitation.

For the variables and parameters: n number of varieties, x demand for variety, p price,  $\alpha$  taste parameter,  $\varepsilon$  elasticity of substitution. E total expenditure,  $\pi_i$  profits, w wage rate, L total labor employed, K knowledge capital,  $1/a$  efficiency parameter for innovation,  $1/ac$  efficiency parameter for copying,  $\theta$  constant of proportionality to density of varieties,  $\kappa$  rate of assimilation of knowledge capital from the other country, v value of firm, r rate of returns on risk less bond,  $\omega$  relative wage ratio ( $w_S/w_N$ ),  $\xi$  product share, c rate of copying North to South, d rate of copying South to North, g rate of growth, k ratio of Southern innovative knowledge capital in the North ( $K_S/K_N$ ),  $\rho$  discount factor.

### c. Abstract:

In the North South competition, the South (as in the Ahmid Data model<sup>3</sup>) reverse engineers North products until it reaches a state where it can itself innovate. Aside from **technical** skills, it must also incorporate **management and commercial** skills.

Imitation is based on the principle that it costs relatively less than innovating.

Knowledge transfers may be increased or impeded by:

- Limitation of exports of sensitive technologies (see military<sup>4</sup>)
- Difficulty of implantation of multinationals in the South
- Blocking access to the capital of Northern giants by the South capital, through protection measures and government intervention<sup>5</sup>.
- Restricting emigration of managers to the South, and of qualified laborers to the North
- Strengthening intellectual property rights in the South

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<sup>2</sup> South stands for developing countries like India and China, North stands for the mature developed countries.

<sup>3</sup> Ahmi-Data model will be explored further down below. To the difference of our assumption here, knowledge capital is not assimilated from one country to another through capital transfer and foreign investment, but through exports.

<sup>4</sup> The USA has passed legislation regarding sensitive technologies, industries.

<sup>5</sup> See the case Arcelor-Mittal steel.

- Government subsidies to innovation in the North and South
- The relative quantities of North and South capital
- The relative easiness of copying versus imitating.
- The rate of assimilation of one region's innovation into the capital of the other

In addition to Grossman and Helpman, we create a model which allows the South to become an accomplished innovator in its own right, and introduce the eventuality of the North that will imitate. Moreover, we model the rate of assimilation, to the difference of Paul Levine et al., with the transfers of capital from the South to the North and vice-versa, amounting to the degree in which the capital is intertwined.

We assume that taking control of a company leads by some measure to an accrued right in decision making and grants access to its technology<sup>6</sup>.

Finally, the more the capital is intertwined the higher the rate of assimilation.

The lower the parameter  $ac/a$  is, the easier it is to copy rather than innovate in the South. Thus for sufficiently low  $\kappa$  and  $ac/a$  (low assimilation and low cost of copying), a region of imitation dominates. For an intermediate range, a region of both innovation and imitation dominates. Finally, a higher range produces a region of principal innovation.

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Dans de cadre de la concurrence Nord-Sud, comme dans les modèles Ahmi-Dta <sup>7</sup>, le Sud re-ingénie les produits qu'il importe du Nord jusqu'à ce qu'il atteigne un état où il puisse innover de son propre chef.

Mis a part les compétences techniques, il doit incorporer des compétences manégeriales et commerciales.

Imiter est basé sur le principe que cela coûte moins cher qu'innover.

Les transferts de connaissances et savoir-faire sont accélérés ou restreints par:

- La limitation des exportations de technologies sensibles (militaires<sup>8</sup>).
- La difficulté d'implantation des multinationales au Sud.
- Le blocage de l'accès au capital des géants du Nord au capital du Sud, par l'intermédiaire de mesures de protection et l'intervention des gouvernements<sup>9</sup>.
- La Restriction de l'émigration de Managers vers le Sud, et de travailleurs compétents vers le Nord.
- La mise en vigueur et application des droits de la propriété intellectuelle au Sud.
- Les subsides gouvernementales à l'innovation au Nord et au Sud.
- Les quantités relatives de capital (ou indifféremment, connaissance, capital humain à la Romer) au Nord comme au Sud.
- La facilité relative d'imiter plutôt que d'innover.
- Le taux de pénétration de ce capital économique ou humain d'un pays à l'autre.

<sup>6</sup> Acquiring and Buying out competitors, in a race for technological leadership.

<sup>7</sup> Ahmi-Data model will be explored further down below. To the difference of our assumption here, knowledge capital is not assimilated from one country to another through capital transfer and foreign investment, but through exports.

<sup>8</sup> The USA has passed legislation regarding sensitive technologies, industries.

<sup>9</sup> See the case Arcelor-Mittal steel.

En complément a Grossman et Helpman, nous créons un modèle qui permet au Sud de devenir un innovateur de son propre chef, et introduisons la possibilité que le Nord puisse imiter le Sud. De plus, nous modélisons le taux de pénétration, a la différence de Paul Levine et al. , non comme variable exogène, mais endogène aux transferts de capitaux du Sud vers le Nord et vice-versa, c a d le degré auquel le capital est internationalise.

Nous estimons que la prise de contrôle d'une société amène a un droit participatif aux prises de décision, et dans l'accession a sa technologie<sup>10</sup>.

Par ailleurs, plus le capital est internationalise et plus le taux de pénétration du capital d'un pays vers l'autre est fort.

Plus le ratio ca/a est bas et plus il este facile de copier que d'imiter au Sud.

Ainsi, for un taux  $\kappa$  (taux de pénétration) suffisamment bas et de même pour ac/a, une région d'imitation domine. Pour des valeurs intermédiaires, la région imite et innove. Enfin pour des valeurs élevées, la région se spécialise dans l'innovation.

#### d. The model:

There are two regions: North and South. Both economies consist of a monopolistic competitive production sector and a competitive sector conducting R&D.  $nN$  varieties were invented and are now produced in the North.  $nS$  are produced in the South and of these  $nSi$  originated in the South from innovation and  $nSc$

were copied from the North (where the subscripts i and c represent innovation and copying respectively). The same is respectively true for the South.

Thus the total number of varieties available to consumers in both regions is  $n = nN + nS = nNi+nNc + nSi+ nSc$

The elasticity of substitution in country North  $\varepsilon=1/(1-\alpha)$  where  $\alpha$  is the taste parameter, and  $\beta$  in the South. The reason why we may differentiate between the two markets' elasticity substitution is that:

**Even though it my be freely decided that products be produced in either countries through delocalization or foreign direct investment, these products may not be freely consumed because of trade barriers, quotas, product differentiation adapted to the local market.**

Therefore markets in the North and South are clearly segmented.

As a traditional result of the cross industry and within industry static optimization we find

$$x_j = \frac{E_N p_j^{-\varepsilon}}{\int_0^{nN} p_{j'}^{1-\varepsilon} dj'} \quad j \in (0, nN \dots or \dots nS] \quad x_j = \frac{E_S p_j^{-\varepsilon}}{\int_0^{nS} p_{j'}^{1-\varepsilon} dj'} \quad (1)$$

A novel feature is the introduction of capital aside from labor as a factor of production.

Indeed, we consider that another means to acquire knowledge, apart from reverse engineering is to acquire participations in a firm's capital.

To translate this argument, we shall reason as a multinational which chooses to invest:

- A certain part of its capital in the North and the South

<sup>10</sup> Acquiring and Buying out competitors, in a race for technological leadership.

- A certain percentage of its workforce in the North and the South
- Reach or Maintain innovative and production based roles for both the North and South

**The board will optimize the maximum value of the firm.**

Let us assume by default that in bloc b (North or South), the firm belonging to the multinational produces with one unit of labor, and South capital; let us assume that a similar process occurs in bloc a, with North capital.

Then the operating profit of the multinational producing varieties in bloc b and varieties in bloc a would be given by:

$$\pi = \sum_{nm} (p_j^N - w_j^N)x_j^N - rn^N \times Kn + \sum_{ns} (p_j^S - w_j^S)x_j^S - rs^S \times (1 - Kn)$$

where  $rn$  and  $rs$  are the remuneration of North and South capital invested in the firm  $j$ .

The multinational's profit maximizing price and profits subject to demand given by (1) gives:  $p_j^N = p^N = w^N / \alpha$  and  $p_j^S = p^S = w^S / \beta$  where  $\alpha, \beta$  are local North and South elasticities of substitution.

Indeed, the taste parameter is being applied to products available locally, as products available abroad may not be accessible to each segregated market's consumers.

We now assume that the capital is intertwined in a proportion  $a, b$ .

Therefore, profit of the multinational becomes:

$$\pi = \sum_{nm} (w_j^N / \alpha - w_j^N)x_j^N - rn^N \times a * Kn + (1 - a) * (1 - Ks) + \sum_{ns} (w_j^S / \beta - w_j^S)x_j^S - rs^S \times b(1 - Kn) (1 - b) * Ks$$

**(5, 4, 3, 2)**

The investments made by the multinational take the form of direct foreign investment, delocalization. Such an investment from abroad contributes to the economic growth as is widely believed among policymakers<sup>11</sup>; indeed, it grants access to new technologies, new distribution platforms for products, new management skills.

Following Grossman Helpman, we distinguish the North-South relative wage gap:

$$\alpha w_j^N < w_j^S < w_j^N \text{ in case of a small cost advantage and } w_j^S < \alpha w_j^N \text{ for a wider gap.}$$

**Having two different taste parameters  $\beta, \alpha$ , we modify the equilibrium to be:**

$$\beta w_j^N \leq \alpha w_j^N \leq w_j^S < w_j^N \text{ in case of a small cost advantage and } w_j^S \leq \alpha w_j^N \leq \beta w_j^N \text{ in case of a large gap in international wages.}$$

The multinational is competing against local competitors or another multinational.

In case of a wider gap, the multinational may charge  $ps = wN/\alpha$ .

Otherwise, limit pricing will lead to  $ps = wS$ .

Now consider the R&D sectors:

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<sup>11</sup> Foreign investment contributes to economic growth

The rate of production of new goods in the North and the South, the transfers of production through copying, from the South to the North and from North to the South are given by:

$$\partial n_S + \partial n_N^c = L^S \times K_S / \theta$$

$$\partial n_N + \partial n_S^c = L^N \times K_N / \theta$$

(6)

$$\partial n_S^i = L_i^S \times K_S / \theta$$

$$\partial n_S^c = L_c^S \times K_S / \theta c$$

$$\partial n_N^c = L_c^N \times K_N / \theta c$$

$$\partial n_N^i = L_i^N \times K_N / \theta$$

The assumption  $ac < a$  captures the idea that copying is easier than innovation for a given stock of knowledge capital.

The general idea is that each activity in the R&D sector gives rise to both a new blueprint and an addition to society's stock of knowledge capital, which contains new ideas and information that will be useful to later generations of innovators and in our context, imitators.

We are assuming that knowledge capital is proportional to the density of varieties in the population in such a way that the scale effect coming from larger country's sizes disappear due to coefficient  $\theta$ .

In order to have a none zero innovation growth rate in either the South or the North, it is necessary to incorporate a spillover effect.

Here, the spill-over effect is being affected by the capital portion invested in the North and the South.

A general representation for innovation knowledge capital (incorporating the density as outlined above) is the following, adapted from Grossman & Helpman (1990):

$$K^N = \theta \left[ \frac{n^N + n_c^S}{L^N} + \frac{\kappa^N \int_{-\infty}^t e^{-\kappa^N(t-\tau)} n_i^S(\tau) d\tau}{L^S} \right]$$

$$K^S = \theta \left[ \frac{n_i^S + n_c^S}{L^S} + \frac{\kappa^S \int_{-\infty}^t e^{-\kappa^S(t-\tau)} n^N(\tau) d\tau}{L^N} \right]$$

In our case, these equations are different since the North copies and imitates and since THE RATE OF ASSIMILATION DEPENDS ON THE PART OF THE NORTH AND SOUTH CAPITAL INVESTED.



$\kappa^N$  increases as the Foreign part of South capital invested in the North increases and vice versa.  
 In a perfect world with freedom of capital movement,  $\kappa = \inf$   
 The equations become:

$$K^N = \theta[ni, N + nc, S / L^N + \kappa^N ni, S / L^S ]$$

(8,7)

$$K^S = \theta[ni, S + nc, N / L^S + \kappa^S ni, N / L^N ]$$

**We take  $\kappa^N$  to be a(1-a) and  $\kappa^S$  to be b(1-b). Therefore the decisions by the multinational to invest abroad affect capital assimilation rates.**

Clearly this formulation with populations sizes in the denominator remove scale effects. While the assimilation rate depends on how well evenly the North and South capital is spread in the North and the South's firms.

Let us consider the financial sectors, and the values of innovators and imitators to be:

$v_{i,N}$ ,  $v_{i,S}$  and  $v_{c,S}$   $v_{c,N}$

A new blueprint's cost in the North (South), depends positively on the difficulty of innovation and negatively on the amount of knowledge capital in the North (South).

Therefore:  $v_i^N = w^N \times a / K^N$

$$v_c^N = w^N \times ac / K^N$$

$$v_i^S = w^S \times a / K^S$$

$$v_c^S = w^S \times ac / K^S$$

(9)

In the North, the typical firm in production will be copied by the South in time interval  $dt$  with the probability  $\partial n_c^S / n^N \times dt$

This gives the no-arbitrage condition whereby the multinational operates an arbitrage between investing in risk less bonds, innovative and imitated goods.

$$\pi_i^N / v_i^N + \partial v_i^N / v_i^N = r^N = \pi_c^N / v_c^N + \partial v_c^N / v_c^N$$

(10, 11)

$$\pi_i^S / v_i^S + \partial v_i^S / v_i^S = r^S = \pi_c^S / v_c^S + \partial v_c^S / v_c^S$$

The model is closed with a labor market equilibrium condition for each region with producers, innovators dynamic equilibrium and consumer's static equilibrium:

$$L^N = n_c^N x_c^N + n_i^N x_i^N + ac / K^N \partial n_c^N + a / K^N \partial n_i^N$$

(12)

$$L^S = n_c^S x_c^S + n_i^S x_i^S + ac / K^S \partial n_c^S + a / K^S \partial n_i^S$$

Before describing the equilibrium in different phases of innovation and imitation, let us examine the effect of profit maximizing on the innovation.

Let us describe the equilibrium in four phases of development and then describe the effect on the transition between the four different phases of the multinational's choices of investment in the South capital and in the North capital.

We first want to analyze the impact of the reallocation of capital due to profit maximizing onto respective countries knowledge capital, or more precisely respective countries' innovations. Optimally, the maximization of the knowledge capital in each country would lead to maximize the expression in the knowledge capital  $\kappa n = \alpha(1 - \alpha)$ ..or..  $\kappa s = \beta(1 - \beta)$  .where this expression is the rate of assimilation of one's country knowledge capital by the other. We would find 0.5 as the optimal value for each country. How about after the profit maximization?

We obtain:

$$\begin{aligned} \pi = & \sum_{nn} (pN - w_j^N) x_j^N - rn^N \times a \theta [n_i^N + n_c^N / Ln + a(1-a)n_i^S / Ls] + (1-a)[1 - \theta(n_i^S + n_c^N / Ls + b(1-b)n_i^N / Ls] \\ & + \sum_{nn} (pS - w_j^S) x_j^S - rn^S \times b \theta [n_i^S + n_c^N / Ls + b(1-b)n_i^N / Ln] + (1-b) \times [1 - \theta(n_i^S + n_c^N / Ls + a(1-a)n_i^S / Ls] \end{aligned}$$

(13)

We clearly see that maximizing this expression in alpha amounts to the conclusion that the both country optimization is equal to one country's optimization of knowledge capital in which case we would have  $\alpha=0.5$  so as to maximize the expression in the knowledge capital  $\kappa n = a(1 - a)$ ..or..  $\kappa s = b(1 - b)$  .where this expression is the rate of assimilation of one's country knowledge capital by the other. Clearly here  $a = .5$ .. $b = .5$ .. doesn't satisfy the maximization of this equation, taken into consideration that numerical simulations give that:

$$(2a - 3a^2) n_i^S / Ls - b(b - 1) n_i^N / Ln = (2b - 3b^2) n_i^N / Ln - a(a - 1) n_i^S / Ls$$

Where this expression is the result of differentiation by  $a$ ,  $b$  and setting the equations  $f'(a)$  and  $f'(b) = 0$ .

We don't find  $a, b=0.5$  to be optimal.

Therefore inertial factors such as population size, current sector lead, and wages difference will decide on the ratio of  $a, b$  which is optimal for the multinational but not optimal for one of the host countries.

### **Proposition 1:**

The cross country allocation of knowledge capital through international investment does affect the international equilibrium of innovations.

We observe first that in case the knowledge capital in the North should have increased, to maintain a constant profit, the multinational should have re-equilibrated its portfolio with more of  $b$  and less of  $a$ , or more of  $a$  and less of  $b$  depending on the ratio of knowledge capital between the North and the South.

Second, we observe that if the difference in population size is large and if the gap between the North and the South is a large gap, then  $a$  will be negatively affected and  $b$  positively affected by an increase in these differences.

### **We next set out to study one of the 4 phases of development.**

The phase with imitation only in the South is obtained with  $n_{i,s}=0$  and suppressing the arbitrage condition (11).

The phase with innovation only in the South is obtained with  $n_{c,s}=0$  and suppressing the other arbitrage condition (11).

### **Proposition 2:**

There is no wide-gap equilibrium with both imitation and innovation in the South.

Indeed, in such a case, where the South is price-dominant, it would fix the same price for imitated or innovative goods; but since Southern innovation is more costly than in the North, the South would have no rational to innovate.

Let us now consider the case where there is a **narrow-gap** with both innovation and imitation in the South, and both innovation and imitation in the North.

Using the demand equation and pricing equations and the expression of profits, ignoring the effects of capital reallocation between countries, and ignoring the differences between the tastes parameters and elasticity of substitution due to segmentation of markets, we would obtain:

$x_c^S / x_c^N = (p_c^S / p_c^N)^{-\varepsilon} = (w^N / w^S)^{-\varepsilon}$  where both conduct limit pricing to adapt to the original leading edge competitor's price, that is one charges  $w/\alpha$  and the other charges  $w$ , to evict the former.

$$x_c^S / x_i^N = (p_c^S / p_i^N)^{-\varepsilon} = (\alpha)^{-\varepsilon}$$

$$x_i^S / x_c^N = (p_i^S / p_c^N)^{-\varepsilon} = (w^S / \alpha \times w^S)^{-\varepsilon} = (\alpha)^\varepsilon$$

$$x_i^S / x_i^N = (p_i^S / p_i^N)^{-\varepsilon} = (w^S / w^N)^{-\varepsilon}$$

(14)

K is the ratio of knowledge capital.

$$\text{Let } k = [aK^N + (1-a)(1-K^S)]/[bK^S + (1-b)(1-K^N)]$$

In steady state, product shares and k are constant, and the total market value for each production sector is constant.

Therefore we obtain the expression  $K^N = f(K^S, k, a, b)$  (14bis)

Using (19), (8) and (7) (6) (12) we may determine that the values of a, b in steady state depend on the number of steady state innovation and imitation industries, on population differential, on wage differential and not on capital previously accumulated.

### Proposition 3:

In steady state, the decisions of investing abroad are not taken on a basis of the differential of capital knowledge, but on the basis of population differences, and relative number of edge sectors, and due to the differential in wages:

A positive differential of population for the South will ceteris paribus increase the proportion of Northern capital invested in the South and decrease the proportion of Southern capital invested in the North.

A positive differential of innovative sectors for the South will ceteris paribus decrease the proportion of Northern capital invested in the South and decrease the proportion of Southern capital invested in the North.

Let us again as we did for the different elasticities of substitution, withdraw the consideration that Northern capital and Southern capital mix to produce greater assimilation rate, to focus on the four phases of development.

Now let us introduce some more notations: Let  $w = w^S / w^N$  (terms of trade of innovative goods). (15)

$$\text{Let } \zeta_i^N = n_i^N / n \dots \zeta_c^N = n_c^N / n \dots \zeta_i^S = n_i^S / n \dots \zeta_c^S = n_c^S / n \dots$$

(16)

Let  $c = \partial n_c^S / n^N$  be the rate at which the South copies the North. (17)

Let  $d = \partial n_c^N / n^S$  be the rate at which the North copies the South. (18)

In steady state,  $\partial n / n = \partial n_i^N / n_i^N = \partial n_c^N / n_c^N = \partial n_i^S / n_i^S = \partial n_c^S / n_c^S = g$  (18bis) since product shares are constant.

Moreover, since the total market value of each production sector is constant,

$$g = -\partial v_c^N / v_c^N = -\partial v_i^N / v_i^N = -\partial v_c^S / v_c^S = -\partial v_i^S / v_i^S$$

Considering that the populations are the same size, we obtain using (6) (7) and (8):

$$[n_i^N .. n_i^S] * [1 .. b(1-b)] = [\theta(\partial n^N + \partial n_c^S) - n_c^S .. [\theta(\partial n^S + \partial n_c^N) - n_c^N]] \\ \dots [a(1-a) .. 1]$$

From which:

$$[n_i^N .. n_i^S] = [1 .. b(1-b)]^{-1} [\theta(\partial n^N + \partial n_c^S) - n_c^S .. [\theta(\partial n^S + \partial n_c^N) - n_c^N]] \\ \dots [a(1-a) .. 1]$$

$$\text{Giving: } 1 - \zeta_i^S = -\theta(g \times (n_i^N + n_c^N + c \times n^N)) + \zeta_i^N + \zeta_c^S + a(1-a) \quad (19)$$

$$\text{Where clearly this becomes } 1 - \zeta_i^S = -\theta(g \times (1+c) \times n^N) + \zeta_i^N + \zeta_c^S + a(1-a).$$

Next, we differentiate  $K^S$  with respect to time, using the definition and setting  $k=0$  at steady state gives the steady state of  $k$ :

$$\partial ks / \partial kn = ks / kn$$

Resulting in:

$$\partial k_S = (\partial n_i^S + \partial n_c^N) / Ls + \kappa \left[ \int_{-\text{inf}}^t e^{-\kappa(t-t_0)} \partial n_i^N - \int_{-\text{inf}}^t \kappa e^{-\kappa(t-t_0)} n_i^N + n_i^N \right] \quad (20)$$

obtained after we have derived inside the integral and on the integral itself.

Thus, replacing  $\partial n_i^S, \partial n_c^N, \partial n_i^N$  we obtain:

$$k = 1 - \zeta_i^N . g / (g + \kappa) \quad (21)$$

In the steady state, we have  $r^N = r^S = \rho$ .

Combining the no arbitrage conditions (10,11) (2,3,4,5) with 14 and (18bis) we get a relationship between :

$$\begin{aligned}
[\pi_i^S / v_i^S] / [\pi_i^N / v_i^N] &= \\
[\pi_c^S / v_c^S] / [\pi_i^N / v_i^N] &= \\
[\pi_i^N / v_i^N] / [\pi_i^S / v_i^S] &= \\
[\pi_c^N / v_c^N] / [\pi_i^S / v_i^S] &=
\end{aligned}
\tag{22}$$

We then equate the first two relations and the next two relations.(23)

Finally putting together these equations (19), (21), (22), (23), we obtain together with the steady state of the labor market condition (12) **yields 9 equations for the steady states of the nine endogenous variables**  $k, \zeta_i^N, \zeta_i^S, \zeta_c^N, \zeta_c^S, w, g, c, d$

To examine the possibility of transition between the three equilibrium of (i) Southern imitation only, (ii) Southern imitation and innovation and (iii) Southern Innovation only, (iiii) it is useful to think in terms of changes in the parameters  $ac/a$  and  $\kappa$ , reflecting the relative cost of copying and the speed at which the South absorbs knowledge capital from the North.

**The boundary for the South between imitation only, and innovation and imitation is the values of  $ac/a$  and  $\kappa$  such that  $\zeta_i^S = 0$ .**

**The boundary for the South between imitation and innovation, and innovation only is the values of  $ac/a$  and  $\kappa$  such that  $\zeta_c^S = 0 = c$ .**

**The boundary for the North between innovation, and innovation and imitation is the values of  $ac/a$  and  $\kappa$  such that  $\zeta_c^N = 0 = d$ .**

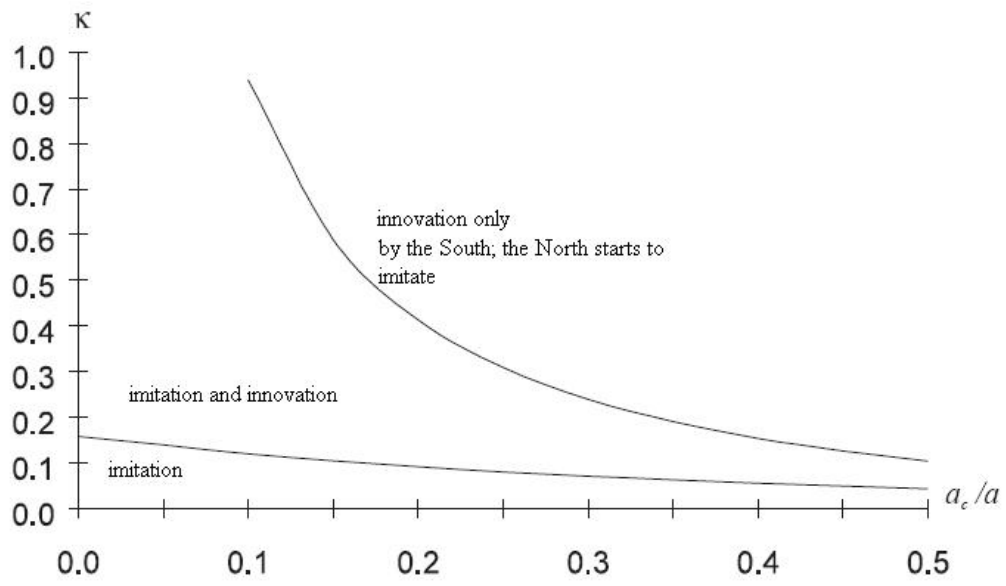


Figure 1: Equilibria for varying  $a_c$  and  $\kappa$ , and effects on South and North

### III. A theory on Human Capital versus Immigration:

The effect of jobs delocalization from the North to the South is to push wages up of skilled workers in the North and the South and increase the strain on the pool of skilled workers in the North and the South.

As South economies converge towards those of the North, **standards of living** in the South may increase more relatively than in the North, considering that **non tradable goods do not catch up quite as fast**.

This hypothesis is not taken into account into today's literature and we have tried to account for its effects.

Next, Skilled workers according to standard North-South models supposedly would be maximizing their utility according to the quantity of goods they may consume irrespectively from the North or the South.

Let us differentiate between a skilled cultural factor and a skilled non cultural factor.

The process of delocalization can be seen as delocalizing only the component which is not cultural in a product.

**Indeed, the cultural factor will be the design corresponding to the local taste.**

Acculturation is a process which is taking place during the delocalization process.

Just like products are reverse-engineered, the culture is reverse-engineered in such a way that **the pool of North cultural skilled workers in the South increase relative to the pool of non cultural skilled workers**.

It means that the South workers who become cultural adopt more expensive customs, lifestyles and find it more attractive to move to the North where they have access to better quality products.

At equilibrium, the utility of North and South skilled workers must be the same.

Yet, because the cost of living in the South remains lower than in the North, skilled workers in the South are ready to accept a lower salary, to stay in the South.

Therefore, with continued delocalization, the fact that there are non tradable goods that do not catch up as fast as other goods may induce skilled workers from the North to come back to the South.

While a counter factor would increase the relative cost of skilled non cultural workers in the South, since its acculturation, creates for the worker new needs and expectation, and it therefore may reduce delocalization.

This argumentative may lead multi-nationals to reconsider investing abroad, since their investment will induce acculturation and therefore deplete their pool of available resources in the South and therefore increase their costs.

**This leads clearly to the process of endogenous qualified labor migration.**



#### IV. North South models and Exchange rates:

We are going to study a very basic framework of North South models in which we will attempt to introduce exchange rates:

We follow the usual model of vertical ladder  $LnD(s) = \int_0^1 Ln[\sum_{m=0}^{M(j,s)} xm(j,s)]dj d\theta...$  under

constraint  $Es = \sum_{m=0}^1 xm(j,s)pm(j,s)djd\theta...$  and since  $M(j,s)$  is the M quality good at time t,

$pm / \lambda^m \geq pm_o / \lambda^{m_o}$  when  $m_o$  is the least quality, the value of the objective becomes

$\lambda^{m_o} E(j,s) / Pm_o$  This is the result of the static intra-industry optimization.

Dynamic optimization leads to :

$$L = \int_0^1 Ln(Ejs)ds + \mu(Es - \int_0^1 E(j,s)ds) \text{ Leading to } E = 1/\mu \text{ and}$$

$$H = Ln(Es) + \mu(rA + w.L - E) \text{ leads to } \partial\mu / \mu = \rho - r$$

Production:

We follow the product cycle idea by Vernon 1966, except that the equilibrium

$ws < wn < \lambda \times ws$  becomes  $R \times ws < wn < \lambda Rws$  where R is the real exchange rate between the North and the South, and where this equilibrium is being used to discriminate leaders, followers and imitators in the North and the South,

Following the definition of the Real Exchange Rate,  $R=S.Ps/Pn$

$$\text{Here } Ps = \psi(ws.S) + \omega(wn) + (1 - \psi - \omega)(\lambda \times ws.S)$$

-Where the 3 sectors are a non tradable sector  $\psi$ , tradable and non monopolistic sector  $\omega$ , tradable and monopolistic sector  $1 - \psi - \omega$ .

$$Pn = \zeta(wn) + \varphi.ws.S + (1 - \zeta - \varphi)(\lambda \times ws.S)$$

-Where the 3 sectors are a non tradable sector  $\zeta$ , tradable and non monopolistic sector  $\varphi$ , tradable and monopolistic sector  $1 - \zeta - \varphi$ .

Indeed, some goods are tradable and some are not, yet the purchasing power of currency must be equivalent on both the tradable and non tradable goods.

Let us take  $R=Ps/Pn$  and  $S=1$ , the equilibrium becomes:

$$Ps / Pn \times ws < wn < \lambda.Ps / Pn.ws$$

$$\frac{ws[\psi(ws.S) + \omega(wn) + (1 - \psi - \omega)(\lambda \times ws.S)]}{\zeta(wn) + \phi.ws.S + (1 - \zeta - \phi)(\lambda \times ws.S)} < wn < \frac{[\psi(ws.S) + \omega(wn) + (1 - \psi - \omega)(\lambda \times ws.S)]\lambda \times ws}{\zeta(wn) + \phi.ws.S + (1 - \zeta - \phi)(\lambda \times ws.S)}$$

This is equivalent to:

$$\frac{ws[\psi.ws + \omega.wn + (1 - \psi - \omega)(\lambda \times ws)]}{\zeta(wn) + \phi.ws + (1 - \zeta - \phi)(\lambda \times ws)} < wn \times [\zeta(wn) + \phi.ws + (1 - \zeta - \phi)(\lambda \times ws)]$$

$$< \frac{[\psi(ws) + \omega(wn) + (1 - \psi - \omega)(\lambda \times ws)]\lambda \times ws}{\zeta(wn) + \phi.ws + (1 - \zeta - \phi)(\lambda \times ws)}$$

This relation leads to after developing the terms and adding both unequal relations:

$$ws / wn = \frac{(\omega - \omega.\lambda)}{(\psi + (1 - \psi - \omega)\lambda - \lambda^2(1 - \psi - \omega) - \psi.\lambda)}$$

We find that an increase in  $ws$ , leads to a decrease of  $(\psi + (1 - \psi - \omega)\lambda - \lambda^2(1 - \psi - \omega) - \psi.\lambda)$ , a decrease in non tradable in the South and an increase of non monopolistic tradable.

A further topic of research, we would like to incorporate the effects of readjusting exchange rates on qualified labor migration patterns.

## V. A Review: Push-Pull Migration Laws

Following the idea of acculturation which may be seen as an incentive or even a necessity for South skilled workers to immigrate, a model of migration has been developed.

Since the Geographer's Ravenstein ideas, immigration is the resultant of a push and pull factors discounted by a distance deterrence between the places.

Push stands for local dissatisfaction while pull stands for foreign attraction.

$$M_{ij} = (R_i + E_j) / d_{ij}, i \neq j$$

*Movement M, Repulsion R, Enticing E, Distance Factor d*

Aggregating this equation over r places gives:

$$\sum_{\substack{j=1 \\ j \neq i}}^r M_{ij} = R_i \sum_{\substack{j=1 \\ j \neq i}}^r \frac{1}{d_{ij}} + \sum_{\substack{j=1 \\ j \neq i}}^r \frac{E_j}{d_{ij}} = O_i,$$

$$\sum_{\substack{i=1 \\ i \neq j}}^r M_{ij} = \sum_{\substack{i=1 \\ i \neq j}}^r \frac{R_i}{d_{ij}} + E_j \sum_{\substack{i=1 \\ i \neq j}}^r \frac{1}{d_{ij}} = I_j.$$

Where  $O_i$  and  $I_j$  are In-sums and Out-sums.

A true push factor might be a high unemployment rate, whose cost is yet reduced by the heavy inertial cost of leaving friends and families.

The overall push factor may even be negative. In the same way, an attractive place may have a large positive Push value (Lee 1966).

## VI. A Review: INNOVATION, IMITATION AND INTELLECTUAL PROPERTY RIGHTS: INTRODUCING MIGRATION IN HELPMAN'S MODEL

Debasis Mondal† and Manash Ranjan Gupta introduce **international labor mobility** into the Helpman(1993) North-South model.

They analyze the effect of strengthening the Intellectual Property Rights (IPR) protection in the South on the rate of product innovation in the North and on the North-South relative wages. **Two cases are differentiated:**

In one case South based imitated products do not contribute to the knowledge capital in the North and in the other case they do contribute. In the first case, the strengthening of IPR must produce a positive effect on the rate of innovation. In the second case, this positive effect may be obtained

Since the 1994 GATT conference, in Marrakech, the developed countries agreed some form of free trade with developing countries as long as the latter kept a tight regulation on intellectual property rights.

The North-South models are based on the Grossman and Helpman (1991a, 1991b) Product variety framework and quality ladder framework.

These models consider that innovation takes place in the North and imitation in the South, and assume a steady growth rate.

In the 1993 model and in Lai 1998 or Hassani 2005, imitation rate is exogenous, proportional to the number of goods imported from the North and reverse engineered for instance.

Grossman and Helpman (1991b) did not consider the multi nationalization of Northern firms and in their model imitation is assumed to be direct. In Lai (1998), the Southern firms can imitate only after multi nationalization of the Northern firms.

Moreover, in Grossman and Helpman, more IPR in the South leads to a fall in innovation in the North.

Finally, contrary to Lai 1998, the rate of imitation will fall due to stronger IPR protection if multi nationalization is the channel of production transfer.

Dollar(1986) in his North-South model of product cycle assumes the absence of international knowledge spillover though he does not analyze the effect of strengthening IPR on the endogenous growth rate. In this case the Southern products do not contribute to the knowledge capital formation in the North. Baldwin et. al.(2001) also considers a similar case.

### **The Model:**

The level of migration varies positively with the North-South relative wage. As opposed to Helpman(1993) who has shown that the strengthening of IPR in the South lowers the rate of innovation in the North, the model shows that the policy of strengthening of IPR in the South must raise the rate of innovation in the North in the absence of international knowledge spillover and may raise it in the case of perfect international knowledge spillover.

Model:

$$W_N = \int_t^\infty e^{-\rho(\tau-t)} \log U_N(\tau) d\tau$$

The representative consumer in the North maximizes its welfare subject to inter-temporal budget constraint:

$$\int_t^\infty e^{-r_N(\tau-t)} E_N(\tau) d\tau = \int_t^\infty e^{-r_N(\tau-t)} I_N(\tau) d\tau + A_N(t) \quad \text{for all } t$$

$$U_N(t) = \left( \int_0^{n(t)} x_N(z)^\alpha dz \right)^{\frac{1}{\alpha}} ; \quad 0 < \alpha < 1$$

$U_N$  is a C.E.S.

$n(t)$  are varieties available while  $x_N$  is the level of consumption of the  $z$ th variety. Dynamic Resolution gives

$$\frac{\dot{E}_N}{E_N} = r_N - \rho$$

While static Solving gives: and

$$x_N(z) = E_N(t) \frac{p(z)^{-\varepsilon}}{\int_0^{n(t)} p(u)^{1-\varepsilon} du} \quad \forall z \in (0, n(t))$$

Taken under the budget constraint:  $\int_0^n x(j) \times p(j)$

Here  $n = n_N + n_S$

$p_N = \frac{w_N}{\alpha}$ ,  $p_S = w_S$  since the North is a profit maximizing capitalist while the South is a Bertrand Competition player.

Here, the **volume of migration depends on relative North South wages** where  $f(w)$  and  $f'(w) > 0$ .

$$L_N = \bar{L}_N + f(\omega)$$

Therefore  $L_S = \bar{L}_S - f(\omega)$  AND  $w = w_N/w_S$

In the North, the Labor Market is  $\bar{L}_N + f(\omega) = n_N x_N + L_r$   
Of employees into the production of the Northern varieties and in Research.

$$\bar{L}_S - f(\omega) = n_S x_S$$

Since imitation is costless,

The South consumer operates the same maximization under his own utility, budget constraint, and does not operate dynamic allocation since there is no R&D, all savings go to the consumption of new varieties as the imitation cost is null.

They find an aggregate demand to be

$$x_S(z) = E_S(t) \frac{p(z)^{-\varepsilon}}{\int_0^{n(t)} p(u)^{1-\varepsilon} du} \quad \forall z \in (0, n(t))$$

Therefore

$$x_N = (E_N(t) + E_S(t)) \frac{p_N^{-\varepsilon}}{\int_0^{n(t)} p(u)^{1-\varepsilon} du} \quad \forall z \in [0, n_N]$$

$$x_S = (E_N(t) + E_S(t)) \frac{p_S^{-\varepsilon}}{\int_0^{n(t)} p(u)^{1-\varepsilon} du} \quad \forall z \in [0, n_S]$$

$$\frac{x_N}{x_S} = \left(\frac{p_N}{p_S}\right)^{-\varepsilon} = \left(\frac{w_N}{w_S \alpha}\right)^{-\varepsilon} \quad \text{and}$$

$$(\omega)^\varepsilon = \alpha^\varepsilon \left(\frac{x_S}{x_N}\right) = \alpha^\varepsilon \left(\frac{\bar{L}_S - f(\omega)}{\bar{L}_N + f(\omega) - L_r}\right) \frac{n_N}{n_S}$$

$$\dot{n} = \frac{n_N + \lambda n_S}{a_N} L_r$$

Here the main knowledge spillover is knowledge capital.

where the numerator is the

$\lambda = 1$  corresponds to Helpman while  $\lambda = 0$  corresponds to Dollar.

$$\frac{\partial \dot{n}}{\partial L_r} = \frac{n - (1 - \lambda)n_S}{a_N}$$

Finally,

And  $\partial n_s / \partial t = m^* n_N$  where  $m = m^* - \mu$

$$\pi_N = \frac{1 - \alpha}{\alpha} w_N x_N \quad v_N = \frac{w_N a_N}{n_N + \lambda n_S}$$

(cost of developing a blue print).

$$\frac{\pi_N}{v_N} + \frac{\dot{v}_N}{v_N} = r_N + m$$

The no-arbitrage condition is

$$E_N = p_N n_N x_N$$

Conclusions of steady growth:

$$g = \frac{\dot{n}}{n}, \quad \xi = \frac{n_N}{n}, \quad \theta = \frac{g}{\xi} = \frac{\dot{n}}{n_N}$$

Expressing

$$\omega = \omega(\theta, \xi) \quad \text{if } \lambda = 0 \quad \text{and} \quad \omega = \omega(g, \xi) \quad \text{if } \lambda = 1.$$

Tanking lambda =0,

At steady state,  $\dot{\theta} = 0$  and  $\dot{\xi} = 0$  and it is a saddle point.

Differentiation with respect to m  $\frac{\partial \theta}{\partial m}$  and  $\frac{\partial \xi}{\partial m}$  we find that

$$\frac{\partial \theta}{\partial m} < 0 \text{ and } \frac{\partial \xi}{\partial m} < 0 \text{ and since } g = \theta \xi \frac{\partial g}{\partial m} = \frac{\partial \theta}{\partial m} \xi + \frac{\partial \xi}{\partial m} \theta < 0.$$

$$\text{And } \frac{\partial \omega}{\partial m} = \omega_{\theta} \left( \frac{\partial \theta}{\partial m} \right) + \omega_{\xi} \left( \frac{\partial \xi}{\partial m} \right) < 0.$$

**Proposition 1:**

More IPR in the South will lead to a higher share of Nn relative to N and increase therefore North's innovation.

Moreover, more labor will flow from the South to North due to the differential in wages.

Taking lambda =1, we arrive to the conclusion that:

**Proposition 2:**

For economies that are initially in the steady state, a policy of strengthening IPR in the South will raise the rate of innovation in the North if  $\alpha \rightarrow 0$  and will lower it if  $\alpha \rightarrow 1$ .

As alpha tends towards 0, the monopolist may charge an infinitely high price, reducing the quantity produced in the North and the manufacturing labor in the North.

However since the relative wage increase in favor of the North, the **excess labor** coming from the South will move into the North research sector increasing innovation.

**VII. A Review: Dinopoulos Model:**

It differentiates an open (to trade) North and South, versus a closed South. Globalization is defined as a closed South modifying its trade policy. How can the world compete against such countries as China opening up with an extensive and qualified labor force?

Although delocalization is translated by a shift of production to the South, the North producers also beneficiate from a larger global consumer base, while consumers take advantage of lower prices and increased competition.

Which effect dominates the evolution of the relative North South wage gap?

Using

$$u(t) = \int_0^1 \left[ \sum_{m=0}^{M(j,s)} \delta^j d(j, \theta, t)^{\sigma-1/\sigma} d\theta \right]^{\sigma/\sigma-1}; \text{ A vertical quality ladder utility function;}$$

J quality product in industry  $\theta$  at time t, where the exponential for  $\delta$  traduces a wish for higher quality products.

Results are that globalization leads only to a temporary increase in the global innovation rate, on the way to steady state. Yet copying increases permanently and so does the South wage, relative to the North, since although the North has a higher consumer base, so does the South.

A second effect is the increase in IPR which decreases (North) innovation on the way to steady state, and decreases imitation and therefore the South wage relative to the North.

**VIII. A Review: A Theory of defensive Skill-Biased Innovation and Globalization**  
*Mathias Thoenig, Thierry Verdier*

**Skilled labor intensive technologies are the response of firms to globalization and induced increased threats of leapfrogging.**

The article shows that this process generates an increase in wage inequalities in both regions (North-North Trade or North-South Trade).

$$Y_{kt}(l, h) = A_t \cdot \left[ \left( \frac{l}{k} \right)^{(\sigma-1)/\sigma} + h^{(\sigma-1)/\sigma} \right]^{\sigma/(1-\sigma)} \quad (2)$$

Where l/k stands for skilled labor adjusted to human capital and h would be non skilled labor. K takes values 1 or s>1 according to the intensity of skill required in the technology.

$$C_k(w, q) = [(wk)^{1-\sigma} + q^{1-\sigma}]^{1/(1-\sigma)} \quad (3)$$

The cost function for s is higher than for K=1. Yet some firms will still be induced to use this technology as a result of trade integration.

The ratio of the minimization of the marginal cost of the unskilled and skilled workers gives the optimal ratio: (4)

$$\frac{h}{l}(k) = \left( \frac{q}{w} \right)^{-\sigma} k^{\sigma-1} \text{ for } k \in \{1, s\}$$

Hence technology s is more skill intensive than technology K=1.

Given that  $[C_1(w, q) - \delta C_1(w, q)]/C_1(w, q) = 1 - \delta$  (rate of capital depreciation; case where k=1)

And

$$\delta \left( \frac{w^{1-\sigma} s^{1-\sigma} + q^{1-\sigma}}{w^{1-\sigma} + q^{1-\sigma}} \right)^{1/(1-\sigma)} < 1 - \delta$$

, it follows that neutral technical change is a priori more efficient than biased technical change.

Suppose that in a sector i, the incumbent produces a good with technology k=1. A new monopoly uses limit pricing.



In the first case, both firms use the technology  $K = 1$ , cash flows are given by  $1 - \delta$

with a corresponding Bellman equation  $rV_t^l = \dot{V}_t^l + (1 - \delta) - \theta_t V_t^l$

In the second case, they use different technologies  $s$  and  $k=1$  with a corresponding cash flow of

$1 - \delta \frac{C_s(w_t, q_t)}{C_1(w_t, q_t)}$ . And the corresponding Bellman equation without leapfrogging

$$rV_t^s = \dot{V}_t^s + \left[ 1 - \delta \frac{C_s(w_t, q_t)}{C_1(w_t, q_t)} \right]$$

is (is independent on the loss that would be caused by innovation  $\theta$ ).

Henceforth, defensive skill based innovation depends on  $V^s < V^l$ .

Let the probability of instantaneous discovery be  $\theta$  and cost  $c\theta$ .

$$\text{Max}\{\theta \text{Max}\{V_t^l, V_t^s\} - w_R c \theta\} = 0$$

Free entry into the R&D sector ensures that  $\theta$

Where  $\alpha_t c \theta_t = H_R$  (5) the effort in R&D is concentrated on the  $k=1$  industries, the others not requiring R&D because not risking competition.

$$\dot{\alpha}_t = -v \theta_t \alpha_t$$

The dynamics of alpha is (6) (the effort will decrease if the likelihood of innovation increases and if the value of skill based production increases, since it allows to be protected from innovational changes or leapfrogging)

$$\begin{aligned} v &= 0 && \text{when } V_t^l > V_t^s \\ &= 1 && \text{when } V_t^l < V_t^s \\ &\in [0, 1] && \text{when } V_t^l = V_t^s \end{aligned}$$

$$\frac{D_H}{D_L} (z, \alpha) = \frac{H}{L} \quad (7)$$

The wage premium  $q/w = H/L$  is shown to be decreasing with alpha and

$$\frac{C_s(w, q)}{C_1(w, q)} = \left[ \frac{s^{1-\sigma} + z(\alpha)^{1-\sigma}}{1 + z(\alpha)^{1-\sigma}} \right]^{1/(1-\sigma)} = \Psi(\alpha)$$

the relative cost is also

decreasing with alpha.

Let us analyze steady state: computing  $V^s$  and  $V^l$  is straightforward and  $V^s \leq V^l$  holds.

$$1 - \delta\Psi(\alpha) \leq \frac{1 - \delta}{1 + \theta/r} \quad (8)$$

Equivalent to

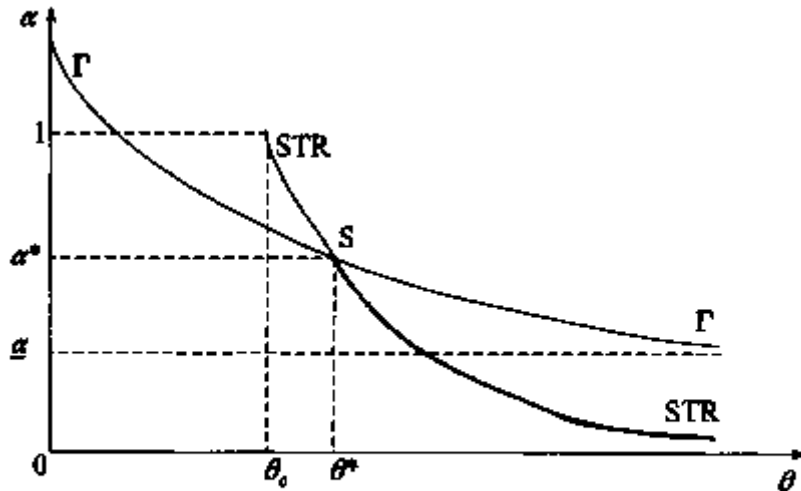


FIGURE 1. STEADY-STATE EQUILIBRIA IN TECHNOLOGIES AND INNOVATION

This figure represents a negative relationship between alpha and theta, meaning that a higher likelihood of innovation will reduce the effort in R&D.

It represents the no bias condition (8), the research resource constraint (5).

Trade integration leads to a larger endowment ( $n_c$  countries), and the research resource constraint moves up right leading to a lower equilibrium of innovation effort

### IX. A Review: Globalization and gains from variety:

Christian Broda and David Weinstein show in the path of Krugman (1979) that the increase in the number of imported varieties has been by a factor of four and that such contributed to much of the gains from trade. Moreover, estimating different elasticities of substitution across industries, through time, they obtain a price index and an upward bias in the conventional price index of 1.2% per year (adjusting for new varieties, import prices have been falling 1.2 percent per year faster). As such, this increase in imported varieties has contributed to 2.8% of the US GDP in the last 30 years.

First, consumers have low elasticities of substitution across similar goods produced in different countries; which proves the validity of Dixit-Stiglitz (1977) framework valuing variety.

How can a price reflect variety?

Hausman (1981) estimates the *price drop* in terms of a new good's apparition. Moreover, according to Romer (1994) all goods enter utility identically. Broda and al follow Feenstra (1994) which analyses the impact of variety on price index.; using a more consistent set of data, and compute estimates of elasticities of substitution.

Some results important to analysis of consumer bias for traded and non traded goods, show that *the median elasticity of substitution has fallen over time indicating that traded goods have become more differentiated.*

Elasticity of substitution is obtained by regressing bilateral trade flows on various control variables and a measure of trade costs (e.g., Romer (1994) and Hummels (1999)).

**The coefficient on trade costs is used as the elasticity of substitution among varieties.**

One issue of such assumption is that countries care about import responses when cutting bilateral tariffs, and that movements in non-tariff barriers are correlated with movements in tariffs.

**Therefore this calculation ignores wether the increase in trade costs derive from a change in the consumer demand, or wether a change in consumer demand induces a change in elasticity of substitution.**

A variety constitutes the production of a particular good in a particular country Armington (1969).

In the comparative advantage continuum of goods models, consumers are indifferent about where a good is produced as long as the price does not vary.

Therefore, at fixed price, elasticities of substitution are infinite, in sharp difference to Krugman's where elasticities of substitution are small.

For the purpose of the article, low elasticities of substitution across varieties are a necessary condition for increases in the number of varieties to be a source of potential gain.

The monopolistic competition model described in Krugman (1979 and 1980) suggests two clear channels for the **gains from trade** arising from variety growth. The first is through **reductions in trade costs**. If trade costs fall, countries will gain through the import of new varieties. The second is through **growth of the foreign country**. A rise in its labor force will produce more varieties, and this will also be a source of gain for the home country. These gains are in sharp contrast to the gains postulated by comparative advantage models. In these models, all goods are consumed in equilibrium regardless of the level of trade costs or the size of the foreign country. Hence, in comparative advantage models, all gains from reductions in trade costs or increases in the size of a foreign country are achieved through conventional movements. in prices and not through changes in the number of goods. **One of the distinguishing features of the Krugman model is that a country may gain from trade even though there are not price changes.**

Part of the explanation of the current US deficit is the rise of its imports due to reductions in trade costs, relaxations of capital controls (e.g. barriers to foreign direct investment), and the relative growth of many East Asian and other economies outside of the United States.

**The Feenstra Price Index** (1994) allows for varieties and quality changes.

As in Helpman and Krugman (1996), Ch.6:

$$U(D_t, M_{1t}, \dots, M_{N_t}) = \left( \sum_{g \in G_t} \left( b_{gt}^{\frac{1}{\gamma}} M_{gt}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \right)^{1-\alpha} D_t^\alpha ; \gamma > 1$$

Here gamma stands for the elasticity of substitution amongst 1-Nt imported goods. Bgt is taste parameter, alpha is the share of domestic goods.

When decomposing Mgt good in varieties:

$$M_{gt} = \sum_{c \in C_{gt}} \left( d_{gct}^{\frac{1}{\sigma_g}} (m_{gct})^{\frac{\sigma_g-1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g-1}} ; \sigma_g > 1 \quad \forall g \in G_t$$

Cgt is the set of countries supplying the good. A rise in gct d raises the demand for good g from country c.  $\sigma$  is the elasticity of substitution between varieties.

The minimum cost function is defined as the minimum expenditure required to buy one unit of the bundle of imported goods, Mgt, given the prices of the different import goods.

$$\phi_{gt}^M(C_{gt}, \mathbf{d}_{gt}) = \left( \sum_{c \in C_{gt}} d_{gct} (p_{gct})^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}$$

Clearly it is obtained by maximizing Mgt by mgct under constraint from  $\sum p_{gct} \times m_{gct} = 1$

Supposing Vg varieties of good g are available to consumers, and dgc=1, the cost function becomes symmetric. All varieties become equally priced at pg, and the minimum cost function

becomes 
$$\phi_g^M = V_g^{\frac{1}{1-\sigma_g}} p_g$$

$\uparrow Vg \Rightarrow$  the minimum cost to maintain utility decreases.

In turn, the minimum cost of the main utility may be expressed as:

$$\phi_t(\phi_{1t}^M, \dots, \phi_{N_t}^M, P_t^D, C_t, \mathbf{b}_t) = \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \left( \sum_{g \in G_t} b_{gt} (\phi_{gt}^M(C_{gt}))^{1-\gamma} \right)^{\frac{1-\alpha}{1-\gamma}} (P_t^D)^\alpha$$

As demonstrated in Feenstra (1994), the exact price index, where there is a set of varieties  $g \neq I$  that are available in both periods, and for which the taste parameters are

constant; depending on the change in the price of imported goods, of the difference in

$$= P_g \left( \mathbf{p}_{gt}, \mathbf{p}_{gt-1}, \mathbf{x}_{gt}, \mathbf{x}_{gt-1}, I_g \right) \left( \frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{\frac{1}{\sigma_g - 1}}$$

consumption quantities;

$$\text{where } \lambda_{gt} = \frac{\sum_{c \in I_g} P_{gct} X_{gct}}{\sum_{c \in I_{gt}} P_{gct} X_{gct}} \text{ and } \lambda_{gt-1} = \frac{\sum_{c \in I_g} P_{gct-1} X_{gct-1}}{\sum_{c \in I_{gt-1}} P_{gct-1} X_{gct-1}}$$

is therefore the price

index of the overlapping quantities  $P_g(I_g)$  times an additional term (fraction of expenditure over available varieties in both periods).

Here again the authors demonstrate that the higher the expenditure share of new varieties, the lower is  $\lambda_{gt}$ , and the smaller is the exact price index relative to the conventional price index.

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