Production Relocation and Endogenous Growth in a Model with Heterogeneous Firms*

Jaewon Jung[†]

THEMA, Université de Cergy-Pontoise

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Abstract

This paper analyzes the growth and welfare effects of production relocation to the South, when the North is populated by heterogeneous firms and workers. By adapting Yeaple's (2005) heterogeneous agent framework to a North-South endogenous growth model, we show how the move from autarky to integration improves aggregate welfare, but at the cost of increased wage inequalities. In contrast, incremental globalization not only induces a welfare gain, but also generates a permanent long-run growth effect due to firms' technological switching, which enables eventually to compensate the least skilled workers for their immediate welfare losses by faster income increases over time.

Keywords: FDI; Production relocation; Firm heterogeneity; Endogenous growth

JEL classification: F23; J31; L16; O40

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[†] *THEMA, Université de Cergy-Pontoise, 33, Boulevard du Port, 95011 Cergy-Pontoise Cedex, France.*

Tel.: +33-1-34-25-62-99; fax: +33-1-34-25-62-33.

E-mail address: jwjung@u-cergy.fr.

1 Introduction

In the economic point of view, one of the major features characterizing the beginning of our third millennium would be an acceleration of the integration of emerging economies into world economy (e.g., China, India, Eastern and Central European countries). Even though most mainstream economists have tended to view globalization as a finally beneficial phenomenon for all, recent years' globalization process has sparked new debate on its effects due to its different characteristics. Differently from world tariff reduction, the very rapid emergence of low wage (and competitive) economies is increasingly provoking anti-globalization movements in developed countries, since the induced growth of production relocation to the South is directly related to loss of jobs or deindustrialization in the North. Despite an extensive research on foreign direct investment (FDI) and multinational enterprises (MNEs) during the last two decades, there is still not enough research on home effects of outward FDI. Especially concerning relocation (or fragmentation) of the production processes to low wage countries, many questions remain with incomplete answers, which generates continuous fears and political debates in developed countries. Will outward investment export production and jobs abroad and generate eventually negative welfare and growth effects in home economy as many ones fear? These are areas which have severely been under-researched so far and require urgently rigorous analyses today.

Many papers in the endogenous growth literature have tried to investigate the growth effect of globalization, which have focused on the relationship between trade and growth. Even though they have helped to understand various channels by which trade or integration can speed up the worldwide growth rate, no universally applicable conclusions seem to have been drawn. Although it seems that most papers predict positive welfare and growth effects for the autarky-to-free-trade change between symmetric countries if it stimulates the research and development (R&D) by technological spillovers or pro-competitive effects, we have still ambiguous answers for the cases of incremental globalization or integration between asymmetric countries where reallocation effect by comparative advantage dominates. See for example, Rivera-Batiz and Romer (1991 a, b), Grossman and Helpman (1990, 1991), Young (1991), Baldwin and Forslid (1999, 2000), and more recently Peretto (2003) focusing on firms' in-house R&D decisions and endogenous market structure.

Even though these approaches have highlighted many trade-and-growth links, they would say little concerning production relocation, which needs basically to incorporate MNEs into the model. One exception is found in Walz (1997) where any policy favoring MNEs creates positive growth effect, because establishing production subsidiaries in low wage countries makes it possible to allocate more resources to R&D in advanced country. However, since it is quiet for the welfare effect, it does not have much to say to policy-makers in developed countries, although the worldwide growth rate would increase.

In this paper, we try to provide a comprehensive investigation of the long-run growth effect of outward FDI as well as welfare effect by constructing a model incorporating (vertical) MNEs' production relocation decisions into an endogenous growth framework, in which firms' R&D investments and knowledge spillovers create permanent long-run growth effect. We analyze both welfare and growth effects of production relocation in the cases of both autarky-to-integration and incremental globalization. Furthermore, we incorporate heterogeneous firms and workers to overcome previous literature's simplifying assumption of homogenous agents, which is rejected by empirical researches as overly simplistic. Recent empirical research based on firm-level panel data proves that more productive firms self-select into export markets and among these the more productive ones becomes multinationals (e.g., Clerides et al. 1998, Bernard and Jensen 1999, Aw et al. 2000, Helpman et al. 2004, Germa et al. 2004), and such findings have also been incorporated very recently into theoretical trade models (e.g., Melitz

2003, Helpman et al. 2004, Antràs and Helpman 2004, Yeaple 2005).

This paper combines Yeaple's (2005) approach with a North-South endogenous growth model. Heterogeneous firms in the North make explicit delocalization decisions to the South through FDI, faced a trade-off between lower production cost in the South and higher fixed cost to engage in FDI. The move from autarky to integration improves aggregate welfare in the North by inducing more entry of low-tech firms following existing high-tech firms' (vertical) multinationalization, but raises wage inequalities and generates no growth effect. In contrast, incremental globalization not only induces a welfare gain, but also generates a permanent long-run growth effect because of low-tech firms' technological switching to high-tech. The immediate welfare losses of the least skilled workers are, then, compensated along the time by faster income increases.

The paper is organized as follows. In section 2, the basic model is layed down. In section 3, the closed economy equilibrium is derived. In section 4, the open economy equilibrium is derived and we compare autarky to open economy. In section 5, we analyze the welfare and growth effects of incremental globalization when more firms decide to relocate their manufacturing plants to the South as the fixed cost to engage in FDI reduces. The final section concludes.

2 The model

Consider an economy (home, the North) composed of a continuum of consumers with unit mass. Consumers are identical in preferences, but differentiated by their skill level Z with a distribution $G(Z)$ and support $[0, \infty)$: they have no preference for leisure so that the total effective labor supply is $\int_0^\infty Z dG(Z)$, our single primary production factor.

There is a single final good sector producing differentiated varieties. Production of each variety requires two inputs, respectively: headquarter services and intermediate components, produced entirely by domestic labors in closed economy. Following opening the economy with the South, firms, then, have to decide where to produce their intermediate components faced a trade-off between lower production cost in the South and an additional fixed set-up cost to engage in FDI. When firms are heterogeneous in technology, the more productive ones relocate first their manufacturing plants to the South and increase revenues relative to the less productive ones. This choice process in a globalizing world, and its welfare and growth effect implications will be analyzed in the subsequent sections.

We now proceed to a formal description of the model.

2.1 Demand

A representative consumer maximizes lifetime utility:

$$U_t = \int_t^{\infty} e^{-\rho(\tau - t)} \log C(\tau) d\tau, \tag{1}$$

subject to the intertemporal budget constraint:

$$\int_t^{\infty} R(\tau)E(\tau)d\tau \leq \int_t^{\infty} R(\tau)W(\tau)d\tau + A_t, \tag{2}$$

where $\rho > 0$ is the individual discount rate, $R(\tau) \equiv e^{-\int_t^{\tau} r(s)ds}$ is the cumulative discount factor from time t to time τ, E is the per capita consumption expenditure, W is the wage rate, and A is his assets holding.

Consumers have Dixit-Stiglitz preferences over a continuum of varieties, so that the consumption index $C \equiv X$ and the price index P_X are defined as:

$$X = \left[\int_{i \in N} x(i)^{\varepsilon} di \right]^{\frac{1}{\varepsilon}}, \quad 0 < \varepsilon < 1, \tag{3}$$

$$P_X = \left[\int_{i \in N} p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}, \tag{4}$$

with $\sigma = 1/(1-\varepsilon) > 1$.

Solving his dynamic optimization problem, consumers set:

$$\frac{\dot{E}}{E} = r - \rho. \tag{5}$$

Taking as given this time-path of expenditure, instantaneous demand for each variety-i is readily derived:

$$x(i) = \left(\frac{p(i)}{P_X}\right)^{-\sigma} X. \tag{6}$$

2.2 Technology

Each firm produces a single differentiated variety $x(i)$, which requires two inputs: headquarter services $h(i)$ and intermediate components $m(i)$. For simplicity, we assume a Leontief type production function: for production of any one unit of $x(i)$, one unit of headquarter's service $h(i)$ and one unit of intermediate component $m(i)$ are required:

$$x(i) = h(i) = m(i). \tag{7}$$

Both inputs are produced by labor using Ricardian technologies. Firms choose their technology upon entering the market from a set of alternatives $\{H, L\}$, where H and L stand for high and low-tech, respectively. In contrast, intermediate components are produced by a common technology $\{M\}$. Let $j \in \{H, L, M\}$ index all of these three technologies.

2.3 Heterogeneous firms

Firms are heterogeneous from their different technology choice, which requires a technology-specific fixed cost F_j, $j \in \{H, L\}$.[1] The fixed cost for adopting

[1] Every fixed cost of this paper is assumed to take the form of final goods that must be produced in order to enter and operate, but which ultimately cannot be sold.

high-tech is strictly greater than that for low-tech: $F_H > F_L$. More specifically, firms face the same entry fixed cost F_E, but adopting high-tech requires an additional fixed cost for $R\&D$, F_R, so that $F_L = F_E$ and $F_H = F_E + F_R$.

Firms are heterogeneous also because they hire heterogeneous workers, differentiated by their skill level Z. From our assumption of technology, let $\varphi_j(Z)$ denote the productivity of a worker of skill Z when working with j-tech, $j \in \{H, L, M\}$. We assume that $\varphi_j(Z)$ is continuous and increasing in Z, and satisfies:

$$0 < \frac{\partial \varphi_M(Z)}{\partial Z} \frac{1}{\varphi_M(Z)} < \frac{\partial \varphi_L(Z)}{\partial Z} \frac{1}{\varphi_L(Z)} < \frac{\partial \varphi_H(Z)}{\partial Z} \frac{1}{\varphi_H(Z)}, \tag{8}$$

where $\varphi_M(0) = \varphi_L(0) = \varphi_H(0) = 1$. Assumption (8) implies that workers have a comparative advantage based on their skill level. It follows that if both firm types exist in equilibrium, the most and the moderately skilled will be hired by high-tech and low-tech firms, respectively, for production of headquarter services, while the least talented are employed by each firm for production of intermediate components. Existence of both firm types is our initial equilibrium.

2.4 Technological progress

Each high-tech firm undertakes $R\&D$ by allocating F_R units of final good and generates the same amount of new knowledge, which allows them to keep the status of high-tech vis-à-vis low-tech firms. In addition to this firm-level benefits, the public good characteristic of knowledge induces economy-wide technological progress over time. We formalize this as follows:

$$\varphi_j(Z)_t = K_t^{\theta} \varphi_j(Z), \quad j \in \{H, L, M\}, \quad 0 < \theta < 1, \tag{9}$$

where K is the economy-wide knowledge stock, which hereafter we normalize to $K_t \equiv 1$, and is accumulated by:

$$\dot{K} = (F_R N_H)\gamma K, \quad K = K_R N_H, \quad 0 < \gamma < 1, \tag{10}$$

where K_R is knowledge stock of each high-tech firm, and γ is the parameter determining the contribution of previous total knowledge stock to the creation of new knowledge: in other words, γ represents the fraction of knowledge that becomes public.

Eqs. (9) and (10) exhibit the source of endogenous growth. Note that even though we assume exogenous *R&D* expenditure of each high-tech firm, the economy-wide knowledge accumulation, inducing technological progress over time, is determined endogenously by the number of high-tech firms, which is determined by the equilibrium conditions.

2.5 Income dynamics

Before deriving general equilibriums, let us consider briefly how the income of this economy evolve over time.

Let C_j denote the cost for producing one unit of input with j-tech, $j \in \{H, L, M\}$. Since workers are allocated to different technologies according to their comparative advantage from (8), there should be some cutoff skill level between M and L, and between L and H, which we denote respectively Z_1 and Z_2. Then, by definition of $\varphi_j(Z)$ and from (9), we have the wage distribution at time t as follows:

$$W(Z)_t = \begin{cases} C_M K_t^{\theta} \varphi_M(Z) & 0 \le Z \le Z_1 \\ C_L K_t^{\theta} \varphi_L(Z) & Z_1 \le Z \le Z_2 \\ C_H K_t^{\theta} \varphi_H(Z) & Z_2 \le Z. \end{cases} \tag{11}$$

In a competitive labor market, each unit cost should adjust over time, so that $C_M K_t^{\theta} \varphi_M(Z_1) = C_L K_t^{\theta} \varphi_L(Z_1)$ and $C_L K_t^{\theta} \varphi_L(Z_2) = C_H K_t^{\theta} \varphi_H(Z_2)$. Unit costs are then easily derived:

$$
\begin{aligned}
C_M &= 1 \quad (numeraire) \\
C_L &= \frac{\varphi_M(Z_1)}{\varphi_L(Z_1)} \; < C_M \\
C_H &= \frac{\varphi_M(Z_1)}{\varphi_L(Z_1)} \frac{\varphi_L(Z_2)}{\varphi_H(Z_2)} \; < C_L .
\end{aligned}
\tag{12}
$$

Note some characteristics of these unit costs. The unit production cost is smaller when one uses higher technology. From (8), C_L is decreasing in Z_1 (because an additional unit of worker's skill has more value with L than M), and similarly C_H decreases with Z_2, given Z_1. Note also that these unit costs are constant over time at given Z_1 and Z_2, although wages increase over time at the rate of $\theta\frac{\dot{K}}{K}$ from (11). Thus, any change in cutoff skill levels or in the number of high-tech firms undertaking in-house $R\&D$, alters relative wages and the rate of income increase over time.

3 General equilibrium in the closed economy

In this section, we derive first the closed economy equilibrium, where no firms invest abroad either because of a prohibitive set-up cost, or because of some government regulation: all home country firms, whether they use high-tech or low-tech, have to produce their intermediate components domestically.

3.1 Market structure

Given our specification of technologies, each firm maximizes the present discounted value of net cash flows:

$$
V_j(t) = \int_t^{\infty} R(\tau)\Pi_j(\tau)d\tau, \quad j \in \{H, L\}, \tag{13}
$$

where instantaneous profits are:

$$\Pi_j = p_j x_j - (C_j + C_M)(x_j + F_j), \quad j \in \{H, L\}, \tag{14}$$

where $(C_j + C_M)$ represents the total variable cost for producing one unit of final good X from (7), and $(x_j + F_j)$ represents the firm's total output inclusive of every fixed cost: $F_L = F_E$ and $F_H = F_E + F_R$.

We assume no entry and exit cost for simplicity, so that the economy jumps to the steady state instantaneously. In equilibrium, free entry of firms ensures that revenues of each firm type are equal to total costs:

$$R_j = (C_j + C_M)(x_j + F_j), \quad j \in \{H, L\}. \tag{15}$$

Assuming monopolistic-competition, each profit-maximizing firm sets its price:

$$p_j = \frac{1}{\varepsilon}(C_j + C_M), \quad j \in \{H, L\}, \tag{16}$$

with constant markup equal to $1/\sigma$. Given free entry, the markup revenues cover the fixed costs:

$$\frac{1}{\sigma} R_j = (C_j + C_M) F_j, \quad j \in \{H, L\}, \tag{17}$$

which implies from (6) and (16):

$$\frac{R_H}{R_L} = (\frac{C_H + C_M}{C_L + C_M})^{1-\sigma} = \frac{(C_H + C_M)F_H}{(C_L + C_M)F_L}, \tag{18}$$

and, using (12):

$$\frac{C_H + C_M}{C_L + C_M} = \frac{\frac{\varphi_M(Z_1)}{\varphi_L(Z_1)}\frac{\varphi_L(Z_2)}{\varphi_H(Z_2)} + 1}{\frac{\varphi_M(Z_1)}{\varphi_L(Z_1)} + 1} = (\frac{F_H}{F_L})^{-\frac{1}{\sigma}}. \tag{19}$$

Furthermore, our assumption (7) and closed economy imply:

$$\int_0^{Z_1} \varphi_M(Z)dG(Z) = \int_{Z_1}^{Z_2} \varphi_L(Z)dG(Z) + \int_{Z_2}^{\infty} \varphi_H(Z)dG(Z). \tag{20}$$

Then, the equilibrium cutoff skill levels, Z_1 and Z_2, are jointly pinned down by above two conditions (19) and (20), which determine the equilibrium industry concentration. The equilibrium numbers of each firm type solve:

$$\begin{aligned} N_H &= \frac{1}{\sigma F_H} \int_{Z_2}^{\infty} \varphi_H(Z)dG(Z), \\ N_L &= \frac{1}{\sigma F_L} \int_{Z_1}^{Z_2} \varphi_L(Z)dG(Z), \end{aligned} \tag{21}$$

where σF_j, $j \in \{H, L\}$, represents individual firm's total output from (15) and (17). Note that these firm numbers should be constant over time at given Z_1 and Z_2, since individual output and consumers' purchase of each variety increase at the same rate from (9) and (11).

Finally, substituting (16) and (21) into (4), we get the price index:

$$P_X = \frac{1}{\varepsilon} \left[\begin{array}{c} \frac{1}{\sigma F_L} \int_{Z_1}^{Z_2} \varphi_L(Z)dG(Z)(C_L + C_M)^{1-\sigma} \\ + \frac{1}{\sigma F_H} \int_{Z_2}^{\infty} \varphi_H(Z)dG(Z)(C_H + C_M)^{1-\sigma} \end{array} \right]^{\frac{1}{1-\sigma}}, \tag{22}$$

which is also constant over time at given Z_1 and Z_2.

3.2 Steady-state growth rate

We now complete our characterization of the closed economy by determining the steady-state growth rate.

The rate of growth of output is determined by (9) and (10):

$$g \equiv \theta \frac{\dot{K}}{K} = \theta \gamma (F_R N_H), \tag{23}$$

which is equal to the rate of growth of the average wage per worker $\overline{W}$.

From (11) and (12), we get:

$$\overline{W_t} = K_t^{\theta} \left[\int_0^{Z_1} \varphi_M(Z) dG(Z) + C_L \int_{Z_1}^{Z_2} \varphi_L(Z) dG(Z) + C_H \int_{Z_2}^{\infty} \varphi_H(Z) dG(Z) \right], \tag{24}$$

which is eventually equal to the aggregate firm revenues in equilibrium:

$$\overline{W}_t = N_{Ht} R_{Ht} + N_{Lt} R_{Lt}. \tag{25}$$

Thus, our model generates an endogenous rate of long-run growth, which is constant over time since the equilibrium cutoff skill levels, Z_1 and Z_2, and the number of high-tech firms, undertaking $R\&D$, are constant over time. Following Fig. 1 shows how the gross domestic production grows over time, which we obtain by log-linearization of wage distribution (11), and using (12).

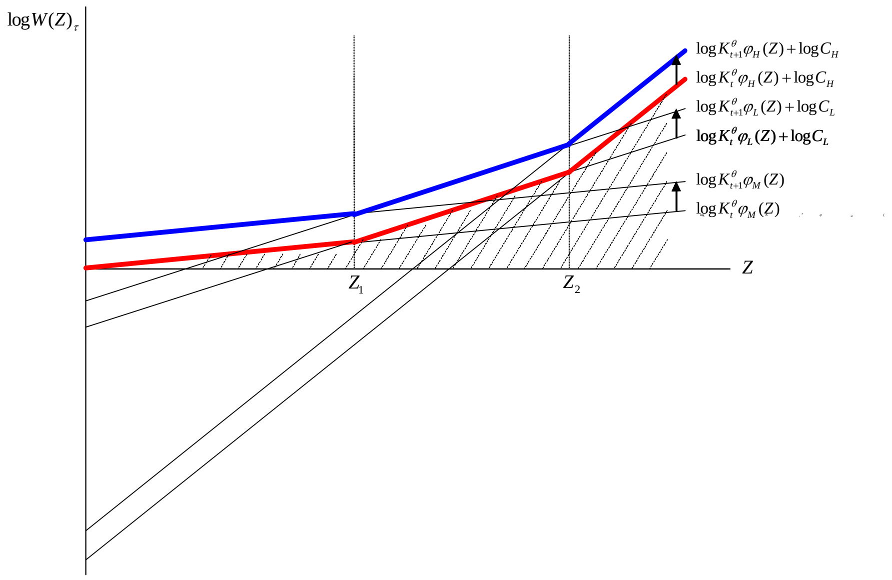

Fig. 1. Growth of GDP in closed economy

In this figure, the outer hull in bold traces the total wage distribution of the economy: the lower at time t, and the higher at time $t+1$. Workers are partitioned according to their skill levels, given the two cutoff skill levels determined by (19) and (20): each worker works where he is paid the best, so that the most skilled ($Z \in (Z_2, \infty)$) and the moderately skilled ($Z \in (Z_1, Z_2)$) choose to work in high-tech and low-tech firm, respectively, for production of headquarter services, while the least talented ($Z \in [0, Z_1)$) produce intermediate components in manufacturing plants of each firm. From (25), then, the shaded area represents log GDP at time t, which increases over time from (23).

4 FDI and production relocation

We now extend our model to the open economy case. Suppose that now firms can decide freely, given a non-prohibitive set-up cost for FDI, where to produce their intermediate components between home (the North) and abroad (the South). Firms will only engage in FDI if, doing so, their markup revenue exceeds the fixed cost: a trade-off between additional fixed set-up cost F_I to engage in FDI and lower unit production cost in the South C_M^*, for which we assume $C_M^* = \lambda C_M$ with $0 < \lambda < 1$.

Since it will be first the larger high-tech firms that can afford more fixed cost, we assume that high-tech firms engage in FDI, while low-tech firms perform all of their activities domestically (formal derivation of this condition is found in Appendix A).

Furthermore, we exclude the possibility of headquarter relocation:

$$C_H < C_L < C_M^* < C_M, \tag{26}$$

and rule out any multiproduct firms:

$$(C_H + C_M^*)(F_H + F_I) < 2(C_L + C_M)F_L, \tag{27}$$

where $(C_H + C_M^*)(F_H + F_I)$ is the total fixed cost for high-tech firms to engage in FDI, while $(C_L + C_M)F_L$ is the fixed cost to produce a variety domestically with L-technology.

4.1 Open economy equilibrium

Previous closed economy equilibrium is, then, readily adjusted to the open economy case. Now each firm's price is:

$$\begin{aligned} p_H &= \frac{1}{\varepsilon}(C_H + C_M^*), \\ p_L &= \frac{1}{\varepsilon}(C_L + C_M). \end{aligned} \tag{28}$$

The two conditions (19) and (20), which determine the two cutoff skill levels, are modified to:

$$\frac{C_H + C_M^*}{C_L + C_M} = \frac{\frac{\varphi_M(Z_1)}{\varphi_L(Z_1)}\frac{\varphi_L(Z_2)}{\varphi_H(Z_2)} + C_M^*}{\frac{\varphi_M(Z_1)}{\varphi_L(Z_1)} + 1} = (\frac{F_H + F_I}{F_L})^{-\frac{1}{\sigma}}, \tag{29}$$

$$\int_0^{Z_1} \varphi_M(Z)dG(Z) = \int_{Z_1}^{Z_2} \varphi_L(Z)dG(Z). \tag{30}$$

Eq. (30) exhibits that now the total amount of home produced intermediate components is for domestic low-tech firms. On the other hand, high-tech firms produce $\int_{Z_2}^{\infty} \varphi_H(Z)dG(Z)$ quantity of intermediate components in the South, and pay labor costs there in final goods, which is equal to:

$$C_M^* \int_{Z_2}^{\infty} \varphi_H(Z)dG(Z). \tag{31}$$

Finally, the equilibrium number of producers is adjusted from (21) and (30) to:

$$N_H = \frac{1}{\sigma(F_H + F_I)} \int_{Z_2}^{\infty} \varphi_H(Z) dG(Z),$$
$$N_L = \frac{1}{\sigma F_L} \int_{0}^{Z_1} \varphi_M(Z) dG(Z), \tag{32}$$

and the open economy price index is given by:

$$P_X^* = \frac{1}{\varepsilon} \left[\begin{array}{c} \frac{1}{\sigma F_L} \int_0^{Z_1} \varphi_M(Z) dG(Z)(C_L + C_M)^{1-\sigma} \\ + \frac{1}{\sigma(F_H + F_I)} \int_{Z_2}^{\infty} \varphi_H(Z) dG(Z)(C_H + C_M^*)^{1-\sigma} \end{array} \right]^{\frac{1}{1-\sigma}}. \tag{33}$$

4.2 Autarky versus open economy

We now compare autarky to open economy, where all high-tech firms close their manufacturing plants and relocate the production of intermediate components to the South.

For the comparison, we impose the same number of high-tech firms $\overline{N}_H$, now having become multinationals. Since relocation of production to the South requires an additional fixed set-up cost F_I, the same $\overline{N}_H$ before and after result in a decrease of Z_2 from (21) and (32). Moreover, since now every home produced intermediate component is for domestic low-tech firms, Z_1 will fall too from (20) and (30). The next proposition follows immediately.

Proposition 1 *Change from autarky to open economy, where previous high-tech firms turn to multinationals (vertical), decreases both Z_1 and Z_2.*

Following Fig. 2 shows these movements at time t.

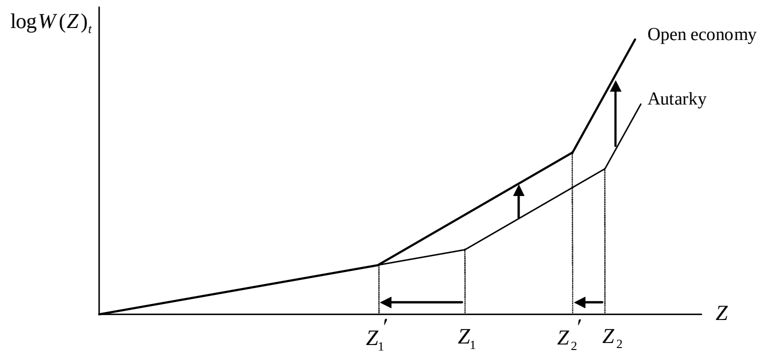

Fig. 2. Autarky versus open economy

Opening the economy affects the industry structure of the North. Both decreases of Z_1 and Z_2 lead the North to a more headquarter services intensive economy, which increases the economy-wide average productivity:[2] now workers in the range $(Z_1^{'}, Z_1)$ and $(Z_2^{'}, Z_2)$ use higher technologies than autarky.

Change from autarky to open economy induces also income redistribution. Since, from (12), a fall of both Z_1 and Z_2 increases both C_H and C_L with $dC_H > dC_L$, average wage increases so that the highest skilled working in high-tech (now multinational) firms are the primary beneficiaries. The following proposition is then immediate:

Proposition 2 *Opening the economy with the South increases average wage, thus GDP, but raises also wage inequalities in the North by increasing C_H relatively more than C_L in terms of the numeraire C_M.*

Now let us dwell on the welfare effect. A full welfare analysis requires explicit consideration on the variation of varieties as well as the total amount of final goods, available finally to home consumers after opening.

[2] Aggregate productivity effect of liberalization has already been found in many oligopoly models with variable firm scale and variable markups. Markusen (1984) highlighted also how the jointness property of knowledge capital by horizontal MNEs contributes to aggregate productivity. Here we find it in a heterogeneous firm framework with vertical MNEs and differentiated goods.

First, from comparison between (20), (21) and (30), (32), it follows immediately that N_L increases at given $\overline{N}_H$. Release of resources induced by high-tech firms' production relocation to the South leads to more entry of low-tech firms, which rises total number of varieties.

Second, consideration on total real consumption needs two comparison:

(i) one between the increase of production by high-tech firms and their more expenditure to engage in FDI, where the former is given from the equality of N_H between (21) and (32):[3]

$$\int_{Z_2'}^{Z_2} \varphi_H(Z)dG(Z) = \frac{F_I}{F_H}\int_{Z_2}^{\infty} \varphi_H(Z)dG(Z), \tag{34}$$

while the latter is:

$$F_I\overline{N}_H = \frac{F_I}{\sigma F_H}\int_{Z_2}^{\infty} \varphi_H(Z)dG(Z). \tag{35}$$

(ii) the other between more domestic production by release of resources from delocalized high-tech firms and their payment in the South, where the former is:

$$C_M \int_{Z_2'}^{\infty} \varphi_H(Z)dG(Z), \tag{36}$$

while the latter is:

$$C_M^* \int_{Z_2'}^{\infty} \varphi_H(Z)dG(Z). \tag{37}$$

Since (34)>(35) and (36)>(37), following proposition is immediate.

Proposition 3 *Opening the economy and permitting firms' production relocation to the South increase the average welfare in the North, by rising varieties and total real consumption.*

[3] Note that Z_2 of (21) has decreased to Z_2', which we replace in (32).

In contrast, movement from autarky to free investment generates no growth effect in our model, since there is no change in the number of high-tech firms, undertaking $R\&D$ and thus creating new knowledge. However, note that this result comes from our simplified assumption that only high-tech firms undertake $R\&D$ by the same exogenous amount F_R. It would be more realistic to assume that low-tech firms also perform $R\&D$ even though it would be small amount, or that high-tech firms increase their $R\&D$ expenditure after becoming multinationals. In both cases, which are in fact supported by empirical evidences, free investment will generate the growth effect from (9) and (10).

5 The effects of incremental globalization

To complete our analyses, we now analyze the effects of incremental globalization, which we shall somewhat narrowly define as a fall in F_I making delocalized production activities more attractive.

The following proposition follows directly from (29) and (30).

Proposition 4 *A fall in F_I decreases both Z_1 and Z_2 (proof is in Appendix B).*

Both decreases of Z_1 and Z_2 give graphically the same result as Fig. 2. Thus, a fall in F_I transforms the North into a more service oriented economy, due to more firms' manufacturing plant relocation to the South and concentration on headquarter services. Reallocation of workers to higher technologies, seen in the range (Z_1', Z_1) and (Z_2', Z_2), increases the economy's total production, which induces also income redistribution in the North. Proposition 2 applies in the case of incremental globalization too: more reduction in F_I rises average wage, but increases income inequalities between workers in different activities.

Now let us consider the welfare effect of incremental globalization. This needs more detailed consideration on every change of varieties, which vary in a marginal way differently from the extreme change case of autarky to open economy.

We begin by looking at the variation of varieties. Both decreases of Z_1 and Z_2 increase N_H and diminish N_L from (32). Furthermore, totally differentiating $N(= N_H + N_L)$ establishes following proposition (see Appendix C for the proof).

Proposition 5 *A fall in F_I rises the total number of varieties, by increasing N_H more than the decrease of N_L.*

We now have a type of varieties which decreases, even though the total number of varieties increases. This requires to examine more in detail the effects of each firm type on welfare. We have seen that a reduction of F_I increases the average wage by rising both C_H and C_L with $dC_H > dC_L$. This rises also prices of final goods from (28), which affects finally the price index (33) together with variations on the number of each firm type.

We complete our welfare analysis by looking at the real income of our representative consumer after change at time t. The following proposition follows directly by totally differentiating $\frac{\overline{W}}{P_X^*}$.

Proposition 6 *A fall in F_I, inducing more firms' manufacturing plant relocation, always increases the aggregate welfare in the home (the proof is found in Appendix D).*

We now turn to the growth effect of incremental globalization. Proposition 5 together with (23) establishes immediately following proposition 7.

Proposition 7 *A fall in F_I, inducing more firms to adopt high-tech and undertake R&D, speeds up growth.*

Following Fig. 3 summarizes the mechanism of Proposition 7, where the first to fourth quadrants represent:

(i) a positive relationship between $\dot{K}$ and g (from (23));

(ii) a positive relationship between F_I and Z_1, Z_2 (from Proposition 4);

(iii) a negative relationship between Z_2 and N_H (from (32));

(iv) a positive relationship between N_H and $\dot{K}$ (from (10)), respectively.

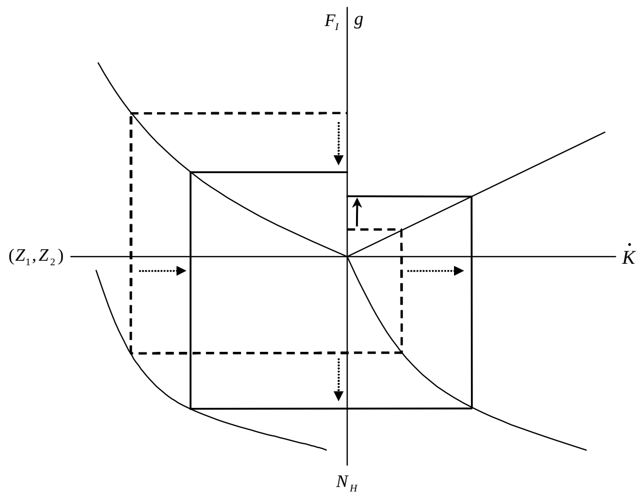

Fig. 3. Falling F_I and endogenous growth in the North

Now our remaining question is whether these movements could benefit all the workers in the North. It seems that a reduction of F_I makes possibly at first some winners and losers in the North, even though the economy-wide real income increases. This comes from the fact that both increases of C_H and C_L with $dC_H > dC_L$ rise also prices in the same way from (28). It is straightforward to show that the highest skilled workers will be the main beneficiaries, while the relative wages of the least talented decrease following this change, and possibly their real wages too. Here, let us suppose simply the worst case.[4] Even so, the induced growth effect makes it possible that all the workers benefit eventually. Following Fig. 4 shows the change in income dynamics following an incremental globalization.

[4] Note, however, that the welfare effect on the least skilled is still ambiguous. In fact, it is always possible that the least skilled gain too in real terms if the increase of varieties dominates that of prices.

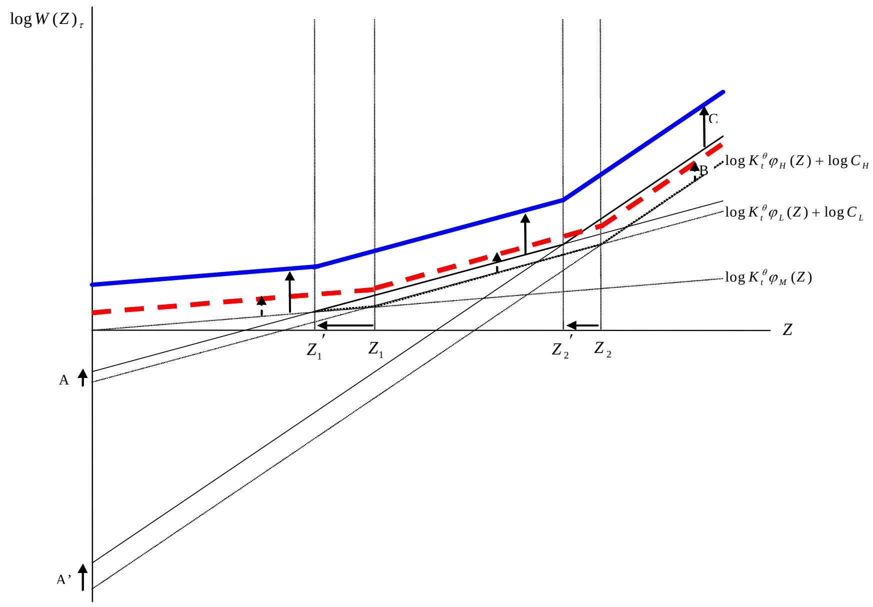

Fig. 4. The effects of incremental globalization

Fig. 4 summarizes how a reduction in F_I at time t leads to positive level and growth effects. First, A and A' show that the value of GDP increases following the shock, a positive level effect. Second, more entry of high-tech firms at time t (because of low-tech firms' switching to high-tech) generates permanent growth effect by stimulating the economy-wide knowledge accumulation: thus, the increase of C is greater at time $t+1$ compared to B, which would be the result at time $t+1$ if there were no change in F_I.

Consequently, workers in the range $[0, Z_1^{'})$ face a permanent income inequality vis-à-vis more skilled workers, which aggravates and deteriorates their real consumption immediately following the shock at time t. However, they will also see their welfare improve along the time when compared to the no change case: their wages increase more rapidly over time, while, concerning prices of final goods, there is just one shot increases at time t.

6 Conclusion

We have discussed the home effects of production relocation to the South in a model of endogenous growth, when the North is populated by heterogeneous firms and workers. Given a trade-off between lower production cost in the South and additional fixed cost to engage in FDI, the more productive firms having chosen high-tech multinationalize first and generate higher revenues than local low-tech firms. Workers differentiated in their skill level are, then, endogenously dispatched to different activities according to their comparative advantages. Incorporating MNEs and heterogeneity of agents into a North-South endogenous growth framework, the model provided a comprehensive investigation of both growth and welfare effects of outward vertical FDI in the cases of both autarky-to-open economy and incremental globalization, though at the cost of focusing only on the North.

The change from autarky to open economy permits high-tech firms to multinationalize and rationalize. The induced release of resources results in more entry of local low-tech firms, so that consumers' aggregate welfare increases. This extreme change, however, increases income inequalities and generates no growth effect in this simplified version because of no change in the total number of high-tech firms, performing in-house R&D in our model.

In contrast, we have shown that incremental globalization – defined as a lowering of FDI set-up cost – is not only welfare improving but also growth enhancing.[5] Among the low-tech firms, the most productive ones – with respect to employed workers' skill levels – transform to high-tech, so that more economy-wide R&D investment and knowledge spillovers generate permanent long-run growth effect. This enables all to benefit eventually, even with no intervention

[5] We have considered a lowering FDI set-up cost just as a natural shock. But, in real world this contains many aspects of policy choice. Any policy promoting firms' technological transformation or subsidies for R&D to the most efficient firms – even though such policies induce more firms to fragment low-tech production activities to the South – would generate the same effects.

of government for reallocation of gains: even though induced income inequalities between workers persist, the welfare of the least skilled workers increases too by faster income increases over time.

Though we believe that qualitatively we will have the same positive effects of production relocation if it reallocates more resources to higher technologies, many interesting extensions are possible: e.g., endogenizing heterogeneous firms' intertemporal in-house R&D and FDI decisions, more development of the model on the side of the South permitting competitions from the South etc. We leave such theoretical extensions, as well as empirical estimations of various transition costs, for the future research.

Appendix A: FDI decision of each firm

From (6) and the constant markup rate $1/\sigma$, firm's markup revenue is:

$$\frac{1}{\sigma}R_j = \frac{1}{\sigma}(E^* P_X^{*\sigma-1})p_j^{1-\sigma}, \quad j \in \{H, L\}, \tag{A. 1}$$

where $E^* \equiv P_X^* X^*$ is the open economy total expenditure after paying every cost in the South,[6] and $p_j = \frac{1}{\varepsilon}(C_{j+}C_M^*)$.

The total fixed cost for each firm to engage in FDI is:

$$(C_j + C_M^*)(F_j + F_I), \quad j \in \{H, L\}. \tag{A. 2}$$

Thus, firms will engage in FDI, only if (A. 1) exceeds (A. 2), which yields:

$$F_j + F_I < \frac{E^*}{\sigma}(\varepsilon P_X^*)^{\sigma-1}(C_j + C_M^*)^{-\sigma}, \quad j \in \{H, L\}. \tag{A. 3}$$

Assuming the existence of both firm types in equilibrium and from the fact that $F_L < F_H$ and $C_L > C_H$, it follows directly that if low-tech firms engage in FDI, then all firms do it, while if high-tech firms don't engage in FDI, then no firms relocate their manufacturing production to the South.

Hence, we restrict our attention to the following case:

$$\frac{E^*}{\sigma}(\varepsilon P_X^*)^{\sigma-1}(C_L + C_M^*)^{-\sigma} - F_I \leq F_L < F_H \leq \frac{E^*}{\sigma}(\varepsilon P_X^*)^{\sigma-1}(C_H + C_M^*)^{-\sigma} - F_I. \tag{A. 4}$$

Appendix B: Proof of Proposition 4

From (29), a fall in F_I has three possible effects:

(i) C_H increases and C_L decreases;

[6] X^* represents production minus exports. Thus, we impose trade balance equilibrium by assuming that labor costs in the South are paid in final goods.

(ii) both C_H and C_L decrease, and $|dC_H| < |dC_L|$;

(iii) both C_H and C_L increase, and $dC_H > dC_L$.

First, case (i) will not happen, since totally differentiating (30) reveals that Z_1 and Z_2 change in the same direction:

$$\frac{dZ_1}{dZ_2} = \frac{\varphi_L(Z_2)dG(Z_2)}{\varphi_M(Z_1)dG(Z_1) + \varphi_L(Z_1)dG(Z_1)} > 0, \tag{B. 1}$$

so that C_H and C_L move in the same direction too from (12).

Second, case (ii) cannot happen either: when Z_1 and Z_2 move in the same direction, $|dC_H|$ should be larger than $|dC_L|$.

Hence, alternative (iii) is the only possibility, which means that both Z_1 and Z_2 decrease.

Appendix C: Proof of Proposition 5

From (32), totally differentiating N with respect to Z_2, and using (B. 1) yields:

$$\frac{\varphi_M(Z_1)dG(Z_1)\varphi_L(Z_2)dG(Z_2)\left[(F_H + F_I) - \frac{\varphi_H(Z_2)}{\varphi_L(Z_2)}F_L(1 + \frac{\varphi_L(Z_1)}{\varphi_M(Z_1)})\right]}{\sigma F_L(F_H + F_I)\left\{\varphi_M(Z_1)dG(Z_1) + \varphi_L(Z_1)dG(Z_1)\right\}},$$

which, from (12), leads to:

$$\frac{\varphi_M(Z_1)dG(Z_1)\varphi_L(Z_2)dG(Z_2)\left[(F_H + F_I) - \frac{C_L+1}{C_H}F_L\right]}{\sigma F_L(F_H + F_I)\left\{\varphi_M(Z_1)dG(Z_1) + \varphi_L(Z_1)dG(Z_1)\right\}}. \tag{C. 1}$$

Since $\frac{C_L+1}{C_H} > \frac{2(C_L+C_M)}{(C_H+C_M^*)}$ from (26) and $F_H + F_I < \frac{2(C_L+C_M)}{(C_H+C_M^*)}F_L$ from (27), (C. 1) is negative:

$$\frac{dN}{dZ_2} < 0. \tag{C. 2}$$

Proposition 4 and (C. 2), then, establish Proposition 5.

Appendix D: Proof of Proposition 6

Define $S(Z_1) \equiv \frac{\varphi_M(Z_1)}{\varphi_L(Z_1)} = C_L$, $A(Z_2) \equiv \frac{\varphi_L(Z_2)}{\varphi_H(Z_2)} = \frac{C_H}{C_L}$, and $S'(Z_1)$ and $A'(Z_2)$ as their partial derivatives, which are negative from (8).

Then, we have from (24) and (30):[7]

$$\overline{W} = \Big(1 + S(Z_1)\Big) \int_0^{Z_1} \varphi_M(Z) dG(Z) + S(Z_1) A(Z_2) \int_{Z_2}^{\infty} \varphi_H(Z) dG(Z). \tag{D. 1}$$

From (32) and (33), we get:

$$\begin{aligned}\left(\frac{\overline{W}}{\varepsilon P_X^*}\right)^{\sigma-1} &= \left[\Big(1 + S(Z_1)\Big) \int_0^{Z_1} \varphi_M(Z) dG(Z) + S(Z_1) A(Z_2) \int_{Z_2}^{\infty} \varphi_H(Z) dG(Z)\right]^{\sigma-1} \\ &\cdot \left[N_L \Big(1 + S(Z_1)\Big)^{1-\sigma} + N_H \Big(S(Z_1) A(Z_2) + C_M^*\Big)^{1-\sigma}\right].\end{aligned} \tag{D. 2}$$

Totally differentiating (D. 2) with respect to Z_2 yields:

$$\begin{aligned}&\left[\begin{array}{c}(\sigma-1)\overline{W}^{\sigma-2}(\varepsilon P_X^*)^{1-\sigma}\left\{\sigma N_L F_L + \frac{C_H}{C_L}\sigma N_H (F_H + F_I)\right\} S'(Z_1) \\ +\overline{W}^{\sigma-1}\left\{N_L (C_L+1)^{-\sigma} + N_H (C_H + C_M^*)^{-\sigma}\frac{C_H}{C_L}\right\}(1-\sigma) S'(Z_1)\end{array}\right]\frac{dZ_1}{dZ_2} \\ &+\left[\begin{array}{c}(\sigma-1)\overline{W}^{\sigma-2}(\varepsilon P_X^*)^{1-\sigma}(C_L+1)\varphi_M(Z_1) dG(Z_1) \\ +\frac{\overline{W}^{\sigma-1}}{\sigma F_L}\varphi_M(Z_1) dG(Z_1)(C_L+1)^{1-\sigma}\end{array}\right]\frac{dZ_1}{dZ_2} \\ &-\left[\begin{array}{c}(\sigma-1)\overline{W}^{\sigma-2}(\varepsilon P_X^*)^{1-\sigma} C_H \varphi_H(Z_2) dG(Z_2) \\ +\frac{\overline{W}^{\sigma-1}}{\sigma(F_H+F_I)}\varphi_H(Z_2) dG(Z_2)(C_H + C_M^*)^{1-\sigma}\end{array}\right] \\ &+\left[\begin{array}{c}(\sigma-1)\overline{W}^{\sigma-2}(\varepsilon P_X^*)^{1-\sigma} C_L \sigma N_H (F_H + F_I) A'(Z_2) \\ +\overline{W}^{\sigma-1} N_H (1-\sigma)(C_H + C_M^*)^{-\sigma} C_L A'(Z_2)\end{array}\right].\end{aligned}$$

From above,

i) using (29) and the fact that $\overline{W} = (1 + C_L) N_L \sigma F_L + C_H N_H \sigma (F_H + F_I)$, the first term leads to:

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[7] We omit time index with $K_t \equiv 1$.

$C^*_M(\sigma-1)\overline{W}^{\sigma-2}\frac{N_H(F_H+F_I)}{F_L}\frac{(C_L+1)^{-\sigma}}{C_L}(\overline{W}-\sigma F_L N_L)\frac{dZ_1}{dZ_2}S'(Z_1)$;

ii) using (B. 1) and (12), the second and the third term lead to:

$-C^*_M\overline{W}^{\sigma-1}\frac{(C_H+C^*_M)^{-\sigma}}{\sigma(F_H+F_I)}\varphi_H(Z_2)dG(Z_2)$;

iii) using (29), the last term leads to:

$C^*_M(\sigma-1)\overline{W}^{\sigma-2}\frac{\sigma C_L N_H^2(F_H+F_I)}{(C_H+C^*_M)^{\sigma}}A'(Z_2)$.

We have finally:

$$\begin{aligned}&\left[C^*_M(\sigma-1)\overline{W}^{\sigma-2}\frac{N_H(F_H+F_I)}{F_L}\frac{(C_L+1)^{-\sigma}}{C_L}(\overline{W}-\sigma F_L N_L)\frac{dZ_1}{dZ_2}S'(Z_1)\right]\\&\quad+\left[C^*_M(\sigma-1)\overline{W}^{\sigma-2}\frac{\sigma C_L N_H^2(F_H+F_I)}{(C_H+C^*_M)^{\sigma}}A'(Z_2)\right]\\&\quad-\left[C^*_M\overline{W}^{\sigma-1}\frac{(C_H+C^*_M)^{-\sigma}}{\sigma(F_H+F_I)}\varphi_H(Z_2)dG(Z_2)\right],\end{aligned}\qquad \text{(D. 3)}$$

which is unambiguously negative since $S'(Z_1)<0$, $A'(Z_2)<0$ and $\frac{dZ_1}{dZ_2}>0$, so that $\frac{d(\frac{\overline{W}}{P^*_X})}{dZ_2}<0$.

Proposition 4 and (D. 3), then, establish finally Proposition 6.

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