Abstract

Using the idea that the division of labor is limited not only by the extent of the market but also by its heterogeneity, it is proposed in this paper that 'globalisation' is redrawing the lines of division within and between countries. Our model builds on the concept of productive systems. Our results indicate that progressive trade integration among 'similar' countries lead first to disparities between countries and then to convergence between nations but also to inequalities within nations (thus possibly accounting for the deterioration of the labor market situation of the unskilled). It is also shown that trade integration among rich economies and/or rising skills therein can lead to the marginalisation of poorer countries (thus possibly accounting for the convergence of countries in the world economy towards a twin-peaked distribution and the delinking of some countries from the world trading system).

This paper was produced as part of the Centre's
International Economic Performance Programme

Globalisation, Productive Systems and Inequalities

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September 1998

Series Editor: Graham Ingham

Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

ISBN 0 7530 1234 0

Individual copy price: £5

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The Centre for Economic Performance is financed by the Economic and Social Research Council

Acknowledgements

I am grateful to Gene Grossman, Tony Venables, and seminar participants for their comments.

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1. Introduction

What is globalisation about? According to the popular opinion, globalisation entails:

i) A redistribution of the roles and the ranks of nations in the world. Some countries, mainly the developed ones along with a bunch of dynamic developing economies form the 'core' of the world trading system. Outside the core, the 'periphery' is deemed to be more and more 'excluded'.

ii) Within the core, inequalities are widening between the educated and the less educated who suffer from the competition of 'underpaid' third-world workers. (This may somewhat contradict the first assertion.)

Those two issues, namely inequalities between nations and inequalities within nations are usually examined separately by economists. On the first issue, empirical studies tend to assert a strong link between openness to trade and growth. Ben-David (1993) and Sachs and Warner (1995) have shown that fast growing countries were also countries with a high level of openness to international trade. However, the direction of the causality is not totally clear. Sachs and Warner (1995, p. 41) are cautious enough to underline that "the convergence club is the club of economies linked together by international trade". Besides, other empirical studies on the convergence issue hint at the formation of convergence clubs. Quah (1997), among others, has documented that the distribution of wealth among countries in the world was converging towards a twin-peaked distribution.

On the second issue, namely the impact of trade over inequalities within nations, the theory seems pretty clear at first sight. According to the well-established factor price equalisation theorem, trade integration should lead different countries to form only one integrated economy, for which, under relatively mild conditions, the price of factors should be the same everywhere. As a corollary, when countries abundant in skilled work remove their trade barriers with countries abundant in unskilled work, the least skilled workers in the most advanced economy should lose. This simple mechanism, then, is an obvious candidate to explain the well-documented degradation of the labor market situation of the unskilled in the rich economies (Gottschalk and Smeeding, 1997). It has been subject to intense empirical scrutiny. Despite a heated debate on the matter (Krugman and Lawrence, 1993 and Wood, 1995), there is a large agreement among academic economists that this channel can explain at best only a small share of the increase in inequalities in rich economies since most estimates range between 0 and 20% of the recent rise in inequalities. From the perspective of developing countries, the other prediction of the factor price equalisation theorem, *ie* the positive effects of trade liberalisation on the unskilled, could never be evidenced, according to the survey of Davis (1996).

In this paper we wish to propose a new theory dealing with trade integration and inequalities both between and within countries. Of course, when dealing with long-term and large-scale effects such as this one, simple explanations such as the one proposed here must be taken carefully. The effects of globalisation upon inequalities are likely to be more complex and involving more factors than in our argument. However, and despite its simplicity, the model

described in this paper might be suggestive of some of the phenomena at stake in the real world.

Before entering in the detail of the analysis, let us return to our initial question and ask ourselves what is 'globalisation'. Why is international trade different today than what it was 50 years ago? In what respect is globalisation different from trade liberalisation? An interesting definition of globalisation can be found in Castells (1996, p.92). "A global economy is something different (distinct from a world economy a la Braudel): it is an economy with the capacity to *work as a unit in real time on a planetary scale*" (italics added). To put it simply, an economy is 'global' only if 'fully integrated' and full integration involves much more than free and costless trade in final manufacturing goods. It seems that there has been a progression over time with a shift from shallow to deep integration. In the 'Braudelian' economy, trade was mainly about luxury goods and its volume was very low.[1] Later, in the 'Heckscher-Ohlin' economy, trade in final goods was more important, and it seems, to a large extent more related to the countries' factor endowments. Even later, in the 'Krugman-Helpman' economy of the new trade theory, lower trading costs allowed for intra-industry trade and some trade in intermediate goods. In today's developed economies, this trade in intermediate goods can take place at increasingly early stages of the productive process. This is what Krugman (1995) calls the "slicing-up of the value-added chain". Economic integration sometimes even enables trade in primary tasks. Among many possible examples: the programming of many US firms' software is partly made in India, the French yellow pages are typed in the Philippines and the processing of ticket coupons of some US airlines is done in Ireland. The Indian example is especially interesting in that it does not follow any obvious pattern of comparative advantage. This evolution is of course rather slow and continuous, likely to have been propelled by the decline in transport and communication costs as well as by the removal of artificial trade barriers.

However, trading intermediate goods is different from trading consumption goods. For final goods, the division of labor between firms may be primarily limited by the extent of the market. This is one of the main tenets of the 'new trade theory'. For intermediate goods, the story may be a bit more complicated. Trading intermediate goods seems more 'difficult', and this difficulty increases when the goods are at an increasingly early stage of the production process. By 'difficult', we mean that the intermediates assembled to form a final goods have a higher degree of complementarity with each other than the final goods consumed by an individual. For the buyer of intermediates, which assembles them into the final good, the *compatibility* between these intermediates is likely to matter a lot. Behind the concept of compatibility, one can put three different meanings. Firstly, *quality* is likely to be crucial. For most final goods, the overall quality can be dramatically affected by any defective component (Kremer, 1993). Secondly, different levels of *complexity* may preclude exchange. For instance, complex medical devices, even when heavily subsidized by international aid, cannot be sent to many developing countries for lack of human resources to use them there. Last but not least, in a world where commodities are increasingly dematerialized, *velocity* is becoming a key variable determining the trading opportunities and thus the volume of exchange. In many cases, transport time is more important than transport costs.[2] In conclusion, these three arguments all point in the same direction. Truly, the division of labor between firms remains limited by the extent of the markets, but because of this compatibility issue, *the division of labor is also limited by the heterogeneity of the (labor) market*. Indeed, workers with similar characteristics may choose to form a 'productive system' (*ie* the productive equivalent of a club) and segment themselves

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1. According to Bairoch (1988), inter-city trade in Europe before the 18th century concerned around 2% of the production. Of course, the figures for international trade must have been lower.

2. Even in a world of 'absolutely' zero transport costs, working as a unit in real time as suggested by Castells is likely to be difficult, be it because of time differences between countries! Moreover, even under 'free-trade', goods entering a country must often pass a border control, which is time consuming. Thus trading frictions, even if falling gradually, still exist and matter.

from the others. The cost of this secession is a lesser division of labor but the gain is a better compatibility between the intermediates they produce.

The object of this paper is to analyse this trade-off in an economy undergoing a process of trade integration. In the next section, a short case-study and a literary description of the thrust of the argument are given. Section 3 introduces our basic assumptions and solves the model in the autarchy case. In Section 4, the effects of trade integration among 'similar' countries are analysed. Section 5 is devoted to the effects of trade integration among 'unequal' countries, and finally, Section 6 offers some conclusions.

2. An Example and the Basic Story

The Car Industry

Car producers design, produce some key components, assemble and commercialize the cars. Their value-added represents around 40% of the value of the products (Wells and Rawlinson, 1994). The rest of the work is done by a myriad of component suppliers. As put by Dicken (1998, p. 317) "the automobile industry is essentially an assembly industry. It brings together an immense number and variety of components, many of which are manufactured by independent firms in other industries. It is a prime example of a producer-driven production chain."

In the early days of this industry, automobiles were assembled by highly skilled artisans who hand-fitted the various pieces. This craft organisation was soon to be replaced by what is referred to as 'Fordism'. Fordist production methods are usually characterized by the assembly line, the intensive use of Taylorist methods of job organisation, high standardisation of products and parts and the subsequent deskilling of labor (McLoughlin and Clark, 1994). This production technology dominated the sector for more than 60 years. Over the last 20 years, most of the car industry has been evolving towards new production methods usually labeled under 'lean manufacturing'. This concept refers to a set of operational principles (*eg* the elimination of wastes, continuous improvement, flexible work organisation, etc) aimed at producing more and better cars. With lean manufacturing, the supply system is sustained by a particular organisation of inter-firm delivery known as just-in-time. As Lagendijk (1993) notes, it is not only a tool to reduce stocks, but a way to facilitate immediate control of the production rhythm and the quality of the preceding production stages.

It can be argued that a more extensive adoption of lean manufacturing principles in the car industry led to higher skill requirements. We can use presswork as an example (see Wells and Rawlinson, 1994, for details). In a traditional press-shop, presses were placed in lines of 6 to 10. Around each press, unskilled workers (typically 4) would feed and remove sheets from the press. Each press-shop had a couple of technicians able to change dies as well as few other semi-skilled workers for maintenance. Changing dies was extremely time-consuming, between 3 and 6 hours, so that a line of presses would keep producing the same parts for up to 36 days. That was nearly the only operation for which skilled work was needed. With this organisation of work, the pace of production was quite slow, around 6 parts per minutes (and on the average 180 parts per hour). By contrast, modern press technology relies on automated press operations and die changing. To increase the pace of production, the space between dies was reduced. But this requires a lot of coordination between the presses. The average output is now much higher (on the average 800 parts per hour). The die changing time was reduced to 10 minutes, thus enabling shorter cycles (down to less than a day). But as a consequence, each line must be constantly monitored by skilled workers able to select the right programs and control the set-ups through computers. Thus following the adoption of a 'more' advanced technology, the demand for skilled work has dramatically increased, whereas that for unskilled workers has fallen.

One important factor behind those changes is the internationalisation of the sector (see Lagendijk, 1993). Competition from Japanese manufacturers of course played a role. But the opportunity to import components from other countries was also instrumental. The key point is that just-in-time delivery requires suppliers to be able to produce and deliver at very short notice. This constraint is of course more stringent for foreign suppliers than for local ones just because it takes time to deliver components from a distance. This forces the former to use even more sophisticated technologies. The evidence of this is documented by Lagendijk (1993) in his analysis of the car industry in Spain. He shows that the adoption of lean manufacturing techniques has occurred there, but only partially for lack of adequate workforce. This has also led to a dual system since many suppliers were not able to modernize. They are left to produce low value-added components or to make their delivery to assembly lines not yet upgraded. The other components are bought from modernized local suppliers or high-performing foreign suppliers able to deliver at very short notice despite the distance and manufacturing highly specialized components.

A Short Description of the Argument

How can we explore this issue more systematically? Let us consider a typical new trade/new economic geography type of economy *a la* Ethier (1982). There we introduce the idea that the assembly process of intermediate goods can be made with different technologies. More 'advanced' technologies are intrinsically more efficient than 'traditional' technologies but they also require the manufacturers of intermediate goods to be able to work at the same level of sophistication. We also assume that to be a more 'advanced' supplier, an upstream firm must employ workers with high-skills. In a closed economy, there is then a trade-off between advanced technologies for which the division of labor is limited and traditional technologies, less productive, but for which the market for intermediate goods is potentially larger. Thus the relative supply of high- and low-skill workers and the trading opportunities between markets are crucial to determine the equilibrium. Consider first an economy in autarchy. When forming a low proportion of the workforce, skilled workers have few incentives to delink themselves from the unskilled to use advanced technologies. The economy is then said to be 'integrated'. As this proportion rises, skilled workers start using the more productive technologies, which partition the economy into two segmented 'productive systems' of firms using the same technology. With segmentation, inequalities rise strongly since the unskilled are left on their own with poorly productive technologies and a smaller market with a lesser division of labor.

In this basic framework, trade integration between countries is viewed as a progressive reduction in transport time, that increases opportunities to export goods 'just-in-time' and to participate in each other's productive systems. Imagine first, two countries in autarchy using traditional technologies. Then, as trading costs decrease, the skilled workers of one country may have an incentive to use more advanced technologies, delink themselves from the unskilled, and export their intermediate goods in the integrated 'core' country. The world at this stage is composed of a rich and equal core and a poor and unequal periphery. As trading costs keep decreasing, skilled workers may delink themselves completely from the unskilled of the core. The two countries are, in this regime, similar and very unequal. Inequalities between groups replace inequalities between nations. In other words, *international integration can lead to the 'disintegration' of national economies*. Another decrease in trading costs may give rise to a fully integrated world economy returning to technologies with lower skill requirements if the proportion of unskilled workers remains sufficiently high.

From this perspective, the recent rise in inequalities within developed economies is not attributed to the supply of unskilled work in developing countries but, on the contrary, to the supply of skilled work in developed countries! The immediate implication is that trade

integration with developing countries in the future may propel greater wage equality in developed countries as it increases the incentive to use technologies with low skill requirements.

Relation to the Literature

This paper takes the view that inequalities within and between nations are intimately connected and analyses how trade integration affects their evolution. Our general result is that lower trading costs lead to a shift from local increasing returns (implying horizontal segmentation between nations) to global increasing returns (potentially implying vertical segmentation between skill groups). Krugman and Venables (1995) and Puga (1997) propose models where trade integration yields a non-monotonic evolution of inequalities between nations. In their papers, trading costs are equivalent to tariffs the decline in trading costs induces the 'tariffs' to fall below their optimal level, which triggers the non-monotonicity. The mechanism we propose here is completely different since it is the choice of technology which is determined by trading opportunities. Beyond this issue of inequalities between nations, we also relate trade integration to distributive issues within nations. In this direction, Flam and Helpman (1987) propose an interesting analysis, where the distribution of skills maps itself linearly in the income distribution, which in turn has an impact upon trade. Their focus is more on the demand side, whereas ours is mostly supply. Moreover, their analysis cannot be used to address our issue since inequalities within countries and comparative advantages in their paper are largely exogenous. In a similar vein, Murphy and Schleifer (1997) study the breakdown of trade, which can also arise in our model. Unlike them, for trade to collapse we do not use any demand bias associated with exogenous supply differences between nations. In our paper, different proportions of skilled workers, leading to diverging productive systems, can do the job.

3. Productive Systems in a Closed Economy

Before analysing the effects of trade in a formal model, let us introduce first the main analytical concept, *ie* that of productive system, and derive some basic results for an economy in autarchy. What follows is a simplified version of Duranton (1997). It builds on the Dixit and Stiglitz (1977) framework applied to production theory by Ethier (1982).

Population and Skills

Let us consider an economy with a population normalised to unity. There are two types of workers. Unskilled workers have a skill level equal to unity, whereas the skill level of the skilled is denoted by $H > 1$. The proportion of skilled workers is equal to b. The level of skills affects labor supply in the following sense. All workers supply inelastically one time-unit of labor, but unskilled workers cannot work with technologies whose level of advancement is above one. Skilled workers by contrast can work at a level of sophistication up to H. In order to abstract from demand effects (and from demand-driven technological bias or sectoral reallocation problems), there is only one final consumption good in the economy, used as the numeraire.

Production and Technology

The final good is produced by competitive downstream firms assembling intermediate goods produced by monopolistically competitive upstream firms according to:

$$y = V\left(\int_{i=0}^{\infty} q_i^{(\sigma-1)/\sigma}\,\mathrm{d}i\right)^{\sigma/(\sigma-1)}, \ \sigma > 1,\ V \in \Re^{+}, \qquad (1)$$

where q_i is the quantity of (non-storable) intermediate *i* and *V* the degree of advancement of the assembly process. As the production of the final good is competitive, downstream firms take the prices p_i of the intermediates as given and maximize their profits with respect to the quantity of each variety that they buy and the technology with which they choose to operate. When the downstream producer *k* operates with the technology V_k, it needs its suppliers to be able to work at least at the same degree of sophistication. That is, firm *k* can buy intermediates from upstream producer *i* only if $V_i \geq V_k$. In turn, the degree of advancement of firm *i* is given by the skill level of the least skilled worker it hires: $V_i = \mathrm{Min}\{h_i\}$. In other words there is a one-to-one mapping between the sophistication of technologies and the skills of workers and we assume that the sophistication of an upstream firm is given by its least skilled employee. Our two conditions imply $\mathrm{Min}\{h_i\} \geq V_k$ for firm *i* to be able to supply firm *k*.

Even though we speak of 'advanced' and 'traditional' technologies, by no means we suggest that technological progress must always shift skill requirements upwards in time-series. The industrial revolution and the introduction of Taylorist production methods are obvious counter-examples. What we mean here by advanced is that a given technology can be implemented as to require more skills from the workers using it. This is a major conclusion from studies in industrial relations (see Grint, 1991, for many references).[3] With respect to our case-study, our assumptions can be understood in the following way. Traditional technologies are of the Fordist type whereas more advanced technologies are synonymous with the introduction of lean manufacturing methods. The latter are more productive than the former but they require suppliers to deliver higher quality intermediate goods at shorter notice. This in turn requires more skilled workers as we have seen.

The program of the final assembler *k* can thus be written:

$$\underset{V_k, q_{i,k}}{\mathrm{Max}}\ \Pi_k = V_k\left(\int_{i=0}^{n(V_k)} q_{i,k}^{(\sigma-1)/\sigma}\,\mathrm{d}i\right)^{\sigma/(\sigma-1)} - \int_{i=0}^{n(V_k)} p_i q_{i,k}\,\mathrm{d}i, \qquad (2)$$

where $n(V_k)$ is the number of upstream firms operating with V_k. This specification implies that there is no gain for an upstream firm from being more advanced when all the assemblers work with the traditional technology. The reason is that assemblers in that case are not able to reap the benefits of better intermediate inputs (just like a Ferrari engine would not be terribly useful in a Skoda). In the monopolistically competitive upstream sector, intermediate goods are produced according to a standard production function where labor is the only input. There is a fixed requirement of labor to start the production of an intermediate good and a constant marginal quantity of labor for each additional unit. To simplify the analytical derivation of the results, we assume that the fixed cost allows the firm to operate only with a given technology, *s*. The cost

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3. Alternatively, at a given point in time, many technologies are available. Some of them require more skills than others (*eg* showing a result using a Cobb-Douglas specification is easier than proving it for increasing and concave functions). Among all existing technologies, downstream firms will consider only those on the frontier in the skill requirement - productivity plane. For simplicity, we assume here that this frontier is the 45-degree line.

function of the upstream firm i is:

$$c(q_i, s) = (\beta q_i + \alpha) w(s), \tag{3}$$

The profit function is of course:

$$\pi_i = p_i q_i - c(q_i, s). \tag{4}$$

An equilibrium is a situation whereby (i) workers maximize their wage; (ii) downstream firms maximize their profits with respect to the quantity of each intermediate they buy and the technology they use, taking prices as given; (iii) upstream firms maximize their profits with respect to the price of their intermediate good and their technology, taking wages in the other firms and downstream demand as given; (iv) no extra firm wishes to enter the market; (v) all markets clear.

Equilibrium

If we call 'productive system', a set of upstream firms using the same assemblers, our first proposition can be written as follows:

Proposition 1: In equilibrium, if $Hb^{1/(\sigma-1)} \leq 1$, there is only one productive system operating with $V = 1$ and the wage of all workers is equal to $w(S) = w(U) = \Lambda$ with $\Lambda = (1/\alpha)^{1/(\sigma-1)} \sigma^{-\sigma/(\sigma-1)} (\sigma - 1)/\beta$. If $Hb^{1/(\sigma-1)} > 1$, the economy is segmented into two productive systems operating respectively with $V = H$ and $V = 1$. The wage of the skilled workers is equal to $w(S) = Hb^{1/(\sigma-1)} \Lambda$, whereas that of the unskilled is $w(U) = (1-b)^{1/(\sigma-1)} \Lambda$. There is in general too much segmentation at the market equilibrium for production to be maximized.

Proof: Downstream firms maximize their profits with respect to the technology with which they operate and the quantity of intermediates they buy. The first-order condition in q_i is:

$$p_i = \frac{q_i^{-1/\sigma} y}{\int_{j=0}^{n(V)} q_j^{(\sigma-1)/\sigma} \mathrm{d}j}. \tag{5}$$

Plugging this inverse-demand in the profit function (4) of upstream firms, we obtain:

$$\pi_i = \frac{q_i^{-1/\sigma} y}{\int_{j=0}^{n(V)} q_j^{(\sigma-1)/\sigma} \mathrm{d}j} q_i - w(V)(\beta q_i + \alpha). \tag{6}$$

As firms are atomistic, the income effect is negligible and the first-order condition for upstream firm i operating with V implies the usual pricing rule:

$$p_i = \frac{\beta w(V)\sigma}{\sigma - 1}. \tag{7}$$

Then using free entry for upstream firms, we get:

$$q_i = \frac{\alpha(\sigma - 1)}{\beta}. \tag{8}$$

If the economy is integrated (all downstream firms work with $V = 1$), the equilibrium on the labor market is then such that:

$$n(1) = \frac{1}{\alpha\sigma}. \tag{9}$$

With free entry, we find the unique wage:

$$w(S) = w(U) = \Lambda \text{ with } \Lambda = \alpha^{-1/(\sigma-1)}\sigma^{-\sigma/(\sigma-1)}\beta^{-1}(\sigma - 1). \tag{10}$$

If the economy is segmented, we find that the numbers of firms in the advanced and traditional productive systems of the economy are:

$$n(H) = \frac{b}{\alpha\sigma} \quad \text{and} \quad n(1) = \frac{1-b}{\alpha\sigma}. \tag{11}$$

With free-entry, wages are:

$$w(S) = Hb^{1/(\sigma-1)}\Lambda \quad \text{and} \quad w(U) = (1-b)^{1/(\sigma-1)}\Lambda. \tag{12}$$

Finally, the integrated configuration is sustained in equilibrium if downstream firms make negative profits when using advanced technologies, that is when:

$$Hb^{1/(\sigma-1)} \leq 1. \tag{13}$$

Conversely, if this condition does not hold, only the segmented configuration can sustain the equilibrium. The welfare result is straightforward and thus omitted here.

In our economy, two conflicting effects are at stake. On the one hand, the gains from the division of labor tend to favor a more integrated economy due to the advantages of having larger markets. On the other hand, more advanced technologies tend to yield higher returns but at the costs of higher skill requirements. There is thus a trade-off between the division of labor and the skill requirements of technologies. The proportion of skilled workers is crucial in the determination of the equilibrium since a higher proportion of skilled workers tends to lower the costs of segmentation.

The equilibrium is inefficient and tends to exhibit too much segmentation for the following reason. Imagine a gradual increase in *b*, the proportion of skilled workers. When *b* reaches the critical value $H^{-1/(\sigma-1)}$, the economy becomes segmented. At this point, the skilled are indifferent between an integrated and a segmented economy. The unskilled, by contrast, have

a much lower income in a segmented economy as they keep using the traditional technology but with a much less extensive division of labor. Thus the intuition is that in equilibrium skilled workers will choose the technology that maximizes their income regardless of the effects of their choice upon unskilled workers.

As shown in Duranton (1997), this type of result does not depend on the specific assumptions made here such as a bimodal distribution of skills or the technology-specific fixed cost. Even the assumption of perfect complementarity can be relaxed. In the rest of this paper, we wish to introduce international trade in this simple framework.

4. Integration Among Symmetric Countries

Let us now consider two countries, domestic and foreign, indexed respectively by *D* and *F*. The two countries are ex-ante similar in every respects. By convention and without loss of generality, in case of multiple equilibria, the domestic economy is where the national income is the highest. As usual with monopolistic competition, the intermediates goods manufactured at home and abroad are assumed to be different. Trade between countries is costly as indicated in the following: an upstream firm working with the technology V in a country can have its intermediate goods assembled at most by an assembler using the technology $V-\lambda$ in the other country. In other words, the trading cost is measured by a higher technological requirement equal to λ. The idea behind this specification is that the speed at which trade is made matters. In turn slower trade may prevent the use of more sophisticated technologies. In the car industry for instance, more sophisticated technologies enable supplier to deliver their inputs at shorter notice. It is thus immediate that a supplier located far away from the assembler needs to use more advanced technologies in order to compensate for the transport time. Alternatively, it can be argued that different norms and standard of production reduce the scope for exchange internationally. Our variable λ can be taken as an index of such differences between countries. (For instance, trade between a Japanese and a German company will require both firms to use English, which means higher skill requirements for a large fraction of the staff in both companies.) A last reason for this specification is that it avoids the additional effects generated by the usual iceberg specification (see Krugman and Venables, 1995).

The Possible Regimes

The world economy can be described by the way it is partitioned into productive systems. For instance, $\{(S_D,S_F),(U_D),(U_F)\}$ denotes a world economy where the domestic and foreign skilled workers work within the same productive systems, (S_D,S_F), whereas unskilled workers in each country form their own productive systems, (U_D) and (U_F). *A priori*, the number of possible regimes for the world economy is quite high. Lemma 1 shows that only six of them can be sustained in equilibrium.

Lemma 1 *The only six possible regimes are the following:*

I: $\{(S_D),(S_F),(U_D),(U_F)\}$, ***II***: $\{(S_D,U_D),(S_F,U_F)\}$,

III: $\{(S_D,S_F),(U_D,U_F)\}$, ***IV***: $\{(S_D,S_F),(U_D),(U_F)\}$,

V: $\{(S_D,S_F,U_D),(U_F)\}$ ***VI***: $\{(S_D,S_F,U_D,U_F)\}$.

Proof: See Appendix 1 for a proof of the impossibility of the other regimes and Appendix 2 for a description of the conditions under which each regime arises.

Equilibrium

Now we can write our second result.

Proposition 2: *If b and λ are large, the world is in Regime **I**.*
*If b is small and λ is large, the world is in Regime **II**.*
*If b is large and λ is small, the world is in Regime **III**.*
*If b and λ are small, the world is in Regime **VI**.*
*Regimes **IV** and **V** can arise for intermediate values of b and λ.*

Proof: The proof and the precise meanings of 'small' and 'large' for *b* and λ are given by the conditions derived in Appendix 2.

Building on the results derived in the previous section, the intuitions for these results are pretty clear. If the trading cost λ is very large (*eg* above *H*), trade is impossible and we are back to the same intuitions as in autarchy. Consequently, if λ is large and if *b* is low (small proportion of skilled workers), the skilled will work with the unskilled within each country (Regime **II**). If *b* is large, still for λ large, the skilled in each country form a productive system of their own and we are in Regime **I**. Let us now consider the case of very small trading costs. Then the two countries will behave together like a large closed economy. With *b* close to 1, the skilled form a productive system that spreads over both countries and the unskilled do the same (Regime **III**). With *b* close to 0, there is only one world productive system since the skilled prefer to work with the unskilled (Regime **VI**). Regime **IV** arises only when (i) *b* is large enough for the skilled not to join the unskilled and (ii) λ has intermediate values. Indeed, we need the trading costs to be low enough for the skilled to work with each other internationally and high enough for the unskilled to be prevented from doing the same. Due to its many requirements, this regime may not always exist. Finally, Regime **V** arises also for intermediate values of λ. This intuition is the same as for the previous regime except that we need *b* to be lower so that the skilled have an incentive to work with the unskilled in the core country.

'Inequalities'

We can now define the following indexes: $\Delta Y = Y_D / Y_F$ is the ratio of national incomes and $\Delta W_\Sigma = W(S_\Sigma)/W(U_\Sigma)$ for $\Sigma = D, F$ is the ratio of skilled to unskilled wages.

- In Regime **I**, even though countries are not integrated, they are symmetric and thus enjoy the same national income. Within countries, the economy is segmented and thus wage inequalities are high. We find $\Delta Y = 1$ and $\Delta W = H\left(b/(1-b)\right)^{1/(\sigma-1)}$.

- In Regime **II**, countries are integrated nationally but do not trade with each other so that $\Delta Y = \Delta W = 1$.

- In Regime **III**, there are two international productive systems which group people with the same skill levels so that: $\Delta Y = 1$. We also find that $\Delta W = \left(b/(1-b)\right)^{1/(\sigma-1)} (H-\lambda)/(1-\lambda)$, which is higher than in Regime **I**. Thus an international economy segmented along skill lines is more unequal than a segmented isolated national economy since inequalities are magnified by the more extensive division of labor within each system.

- In Regime **IV**, we have again $\Delta Y = 1$. We can also see that $\Delta W = \left(2b/(1-b)\right)^{1/(\sigma-1)}(H-\lambda)$, which means more inequalities than in the previous regime. This can easily be explained since the skilled are integrated whereas the unskilled are separated.

- Regime **V** is the only regime for which countries are asymmetric:

$$\Delta Y = \frac{(1+b)^{1/(\sigma-1)}\,\mathrm{Min}(1, H-\lambda)}{b(1+b)^{1/(\sigma-1)}\,\mathrm{Min}(1, H-\lambda) + (1-b)^{1/(\sigma-1)}}. \qquad (14)$$

There is a core-periphery structure since all the intermediates produced by foreign skilled workers are assembled in the domestic economy. Thus part of the foreign economy is 'dependent' upon the domestic economy. Wage inequalities are such that:

$$\Delta W_D = 1 \text{ and } \Delta W_F = \frac{(1+b)^{1/(\sigma-1)}\,\mathrm{Min}(1, H-\lambda)}{(1-b)^{1/(\sigma-1)}}. \qquad (15)$$

In this regime, the core has a low level of wage inequalities whereas the periphery is highly unequal.

- Eventually, for Regime **VI**, we unsurprisingly find $\Delta Y = \Delta W = 1$.

Illustrations

In order to illustrate our results, let us work out a complete example. We set $\sigma = 2$. Figures 1, 2, and 3 represent the state of the world economy depending on the proportion of skilled workers b and the trading costs λ for respectively $H \geq 2$, $2 > H \geq 3/2$, and $3/2 > H$.

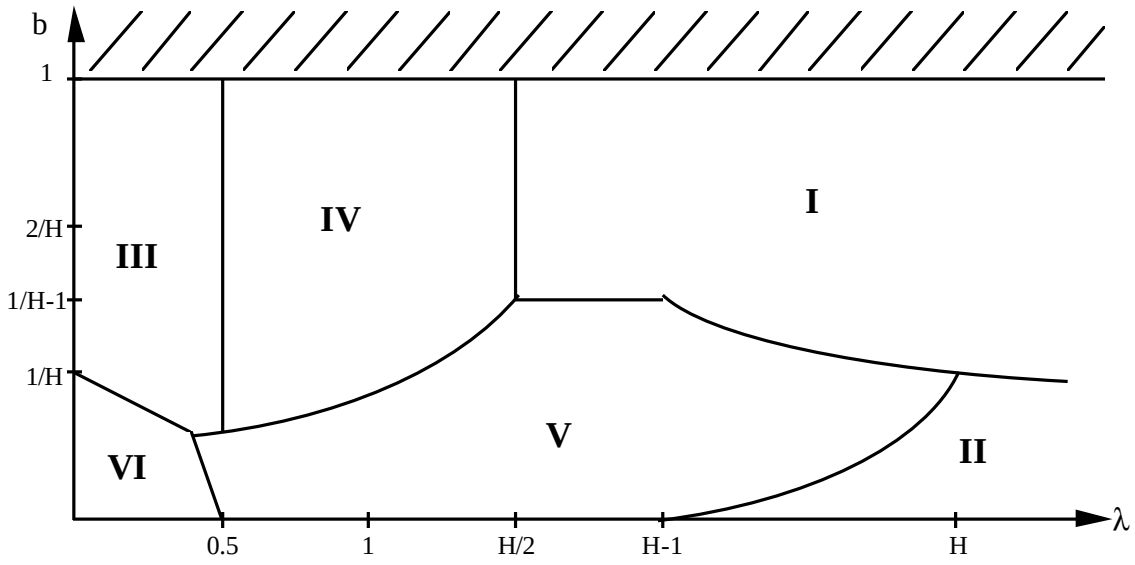

Figure 1

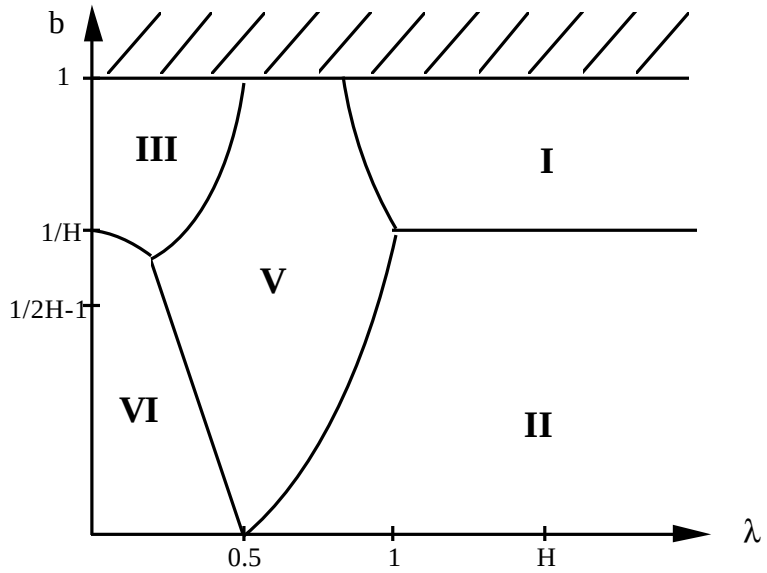

Figure 2

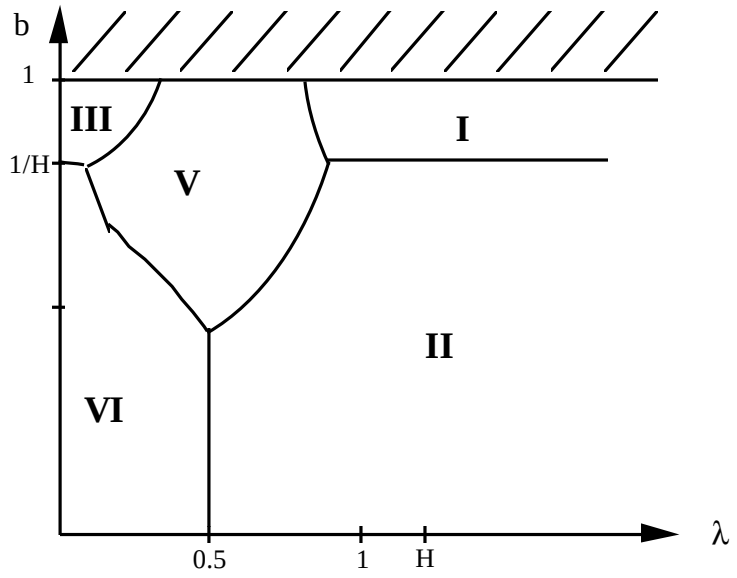

Figure 3

Concerning the recent history of many countries in the world, it seems fair to assume a double movement; one of decreasing trading costs as well as one of rising education. That is, countries are moving from the bottom right to the top left corner in the figures. The exact sequence of stages depends of course on σ and on the precise path taken in the (b,λ) plane. The general pattern is nonetheless the following one (Proposition 2). We start with autarchic and integrated national economies. Thus we can speak of horizontal segmentation and vertical integration. Then, as trading costs decrease, a core-periphery structure emerges and trade volumes increase. The core is rich and equal, whereas the periphery is poorer and unequal. The last stage is the completion of the horizontal integration that causes the breakdown of the core-periphery structure along with complete vertical segmentation. Regional inequalities are eventually replaced by inequalities between skill groups. To get this general pattern, we assumed both a rise in b and a fall in λ.[4] Thus lower trading costs and a higher proportion of skilled workers reinforce each other to create inequalities between skill groups. The relative importance of each

4. However, changes in λ only can be sufficient to generate this pattern. For instance, we could consider more than two countries or decreasing returns from the division of labor (thus leading to non-homothetic outcomes). For the sake of brevity, those two cases are not tackled here.

factor is of course to be determined empirically.

The first general message of our model is then that *trade integration can generate first horizontal inequalities, which are later replaced by vertical ones*. Contrary to the mechanics of traditional trade theory, rising wage inequalities are here induced by trade integration among similar countries and not by integration with countries whose factor endowments differ widely. In our model, unskilled workers in rich countries are not losing out because of competition from the large pool of unskilled workers in poor countries, but because of an increased supply of skilled workers. When skilled workers integrate among themselves over different countries, they delink themselves from the unskilled provided they are numerous enough. This is made possible because trade integration allows them to work with technologies with high skill requirements and still to take advantage of an extensive division of labor. In other words, *globalisation has adverse effects on the wage of the unskilled in rich countries not because of 'competition' from poor countries but because it allows the technological secession of the skilled*.

5. Integration Among Asymmetric Countries

What about developing economies then? Given the low volumes of trade between developed and developing countries, complete trade integration at the world level is still a distant prospect. To analyse the effects of trade integration with developing economies, one needs to examine the same problem as above in the general case of asymmetric countries. We denote by b_D and b_F the proportions of skilled workers respectively in the domestic and foreign economies. The general analysis is rather tedious and unlikely to be of real interest. Let us consider instead two thought experiments.

Case 1: Rising Domestic Supply of Skills With Intermediate Trading Costs

Imagine an initial situation in Regime **IV**. Such a core-periphery structure captures nicely both the inequalities between the countries and the dual structure of the economy in the periphery. The integration of the domestic skilled workers with their foreign counterparts nonetheless forces the former to operate with fairly traditional technologies. The cost of a technological secession (*ie* Regime **I**) would be a less extensive division of labor. But a rise in b_D, the proportion of domestic skilled workers, lowers the cost of segmentation. Thus a rise in b_D alone can induce the domestic skilled workers to delink themselves from the foreign skilled workers in order to operate locally with more sophisticated technologies. This naturally induces the breakdown of trade between the two countries. For instance, if $b_D = 0.6$, $b_F = 0.4$, $\sigma = 2$, $H = 3$, $\lambda = 1$, the economy is in Regime **IV**. However, if b_D increase to 0.7, the economy shifts to Regime **I** with no trade between the two countries. Note that the breakdown of trade in this case has adverse effects for the foreign country from an aggregate welfare point of view but this need not be so in general.

Case 2: Trade Integration Between Rich Countries

The breakdown of trade can also arise following trade integration between other countries. For instance imagine now three countries *D, F1* and *F2* such that $b_D = b_{F1} = b_{F2} = 0.5$, $\sigma = 2$, and $H = 3$. Assume also that initially trading costs between countries are $\lambda_{DF1} = \lambda_{DF2} = \lambda_{F1F2} = 1.5$. The equilibrium is then such that the skilled workers are integrated internationally and the unskilled in each country form separate productive systems.

Consider now a progressive reduction in λ_{DF1}, the trading cost between D and F1. Simple calculations show that the skilled workers in D and F1 keep working together and delink themselves from the skilled workers in F2 when λ_{DF1} reaches 0.75. As in the previous case, the breakdown of trade stems from an increased availability of skilled workers able to work with each other with advanced technologies in D and F1. For instance, as Western firms trade with each other using more sophisticated technologies, African firms, even in the 'formal' sectors, are unable to cope with the new requirements in the West (just-in-time, high quality, reliability) and consequently are left on their own. Thus trade integration in some areas of the world may lead to the regionalisation of the world economy. This effect must be contrasted with the trade diversion effect of standard trade theory.

Another logical implication of the model is that trade integration between developed and developing countries may favor the use of more 'integrative' (or less skill demanding) technologies. The argument is the following. The number of unskilled workers is really high in developing economies. With lower trading costs, they might become more 'accessible' and firms in developed economies may start using less demanding technologies (less strict delivery deadlines, lower quality) in order to benefit from their lower costs and their potential for a more extensive division of labor.

6. Concluding Remarks

This paper started with the necessity to clarify the concept of 'globalisation' and to see how it could be made consistent with some broad trends in the world economy. This led us to consider a theory, which emphasizes that the division of labor is limited not only by the extent of the market but also by its heterogeneity. This was introduced in this paper at the level of the labor market where the skills of workers determine their abilities to use or not more advanced technologies. This friction, embodied in a model of monopolistic competition, leads us to a trade-off between using productive technologies with high skill-requirements and the extent of the market.

The implications of this for international trade are the following. As trading costs decrease, inequalities between countries arise and a core-periphery structure emerges. Then, as trade is made even easier, the core-periphery structure collapses and inequalities between countries are replaced by inequalities within countries. Thus it is trade integration between developed economies that may lead to increasing wage differentials between skilled and unskilled workers. Trade integration between developed countries can also lead to the marginalisation of developing countries. Those results stand in sharp contrast with the predictions of traditional trade theory.

Empirically, our theory calls for some empirical work as we proposed another culprit to account for rising inequalities. It suggests a shift in our empirical focus. The attention should be on education and trade integration between developed economies and not on trade with 'low wage countries'.

Appendix 1:
Proof of Lemma 1

In the following appendix, we wish to explore systematically all the possible regimes and show that many of them cannot be sustained in equilibrium. For all the feasible regimes, the conditions under which they arise are explicitly stated in the next appendix.

1/ $\{(S_D),(S_F),(U_D),(U_F)\}$ is feasible: Regime **I**.

In both countries, the two systems operate at level H and 1. Simple calculations show that $w(S_D) = w(S_F) = Hb^{1/(\sigma-1)}\Lambda$ and $w(U_D) = w(U_F) = (1-b)^{1/(\sigma-1)}\Lambda$. The conditions under which this regime is sustained in equilibrium are given below.

2/ $\{(S_D,U_D),(S_F,U_F)\}$ is feasible: Regime **II**.

In each country, the economy is integrated and operating with $V=1$. We find that $w(S_D) = w(S_F) = w(U_D) = w(U_F) = \Lambda$.

3/ $\{(S_D,S_F),(U_D,U_F)\}$ is feasible: Regime **III**.

There are two international productive systems working with $H-\lambda$ and $1-\lambda$. This leads to $w(S_D) = w(S_F) = (H-\lambda)(2b)^{1/(\sigma-1)}\Lambda$ and $w(U_D) = w(U_F) = (1-\lambda)\left(2(1-b)\right)^{1/(\sigma-1)}\Lambda$.

4/ $\{(S_D,U_F),(S_F,U_D)\}$ is not feasible. It can be shown easily that final assemblers at home would raise their profits by operating with more traditional technologies and buying goods from foreign skilled workers.

5/ $\{(S_D,S_F),(U_D),(U_F)\}$ is feasible: Regime **IV**.
The (S_D,S_F) system operates at $H-\lambda$. The other two systems work with $V=1$. Wages are $w(S_D) = w(S_F) = (H-\lambda)(2b)^{1/(\sigma-1)}\Lambda$ and $w(U_D) = w(U_F) = (1-b)^{1/(\sigma-1)}\Lambda$.

6/ $\{(S_D,U_D),(S_F),(U_F)\}$ is not feasible. By symmetry, if the domestic economy is integrated in equilibrium, the foreign economy should be integrated as well.

7/ $\{(S_D),(U_D),(S_F,U_F)\}$ is not feasible for the same reason as above.

8/ $\{(S_D,U_F),(U_D),(S_F)\}$ is not feasible since workers in the (S_F) system would be better-off working for the (S_D,U_F) system.

9/ $\{(S_D),(U_D,S_F),(U_F)\}$ is not feasible for the same reason as above.

10/ $\{(S_D),(S_F),(U_D,U_F)\}$ is not feasible. Simple calculations show that if the unskilled workers are integrated, skilled workers should be integrated as well.

11/ $\{(S_D,S_F,U_D),(U_F)\}$ is feasible: Regime **V**.

The (S_D,S_F,U_D) system operates at $V=\text{Min}(H-\lambda,1)$ and offers $w(S_D)=w(U_D)=w(S_F)=\text{Min}(H-\lambda,1)(1+b)^{1/(\sigma-1)}\Lambda$. The (U_F) system operates with $V=1$ and yields $w(U_F)=(1-b)^{1/(\sigma-1)}\Lambda$.

12/ $\{(S_D,S_F,U_D),(U_F)\}$ is symmetric with the previous case and thus can be ignored.

13/ $\{(S_D,U_D,U_F),(S_F)\}$ is not feasible. It can be shown easily that if the foreign unskilled workers are integrated with domestic workers, foreign skilled workers would not operate a productive system on their own.

14/ $\{(S_D),(U_D,S_F,U_F)\}$ is not feasible for the same (symmetric) reason as above.

15/ $\{(S_D),(S_F),(U_D),(U_F)\}$ is feasible: Regime **VI**.

The technology in the integrated economy is $1-\lambda$ and all the wages are equal: $w(S_D)=w(S_F)=w(U_D)=w(U_F)=2^{1/(\sigma-1)}(1-\lambda)\Lambda$.

Appendix 2:
Proof of Proposition 2

Let us now turn to the conditions under which the different regimes arise in equilibrium. In equilibrium no final assembler would be willing operate with a different technology or in a different country. From Appendix 1, simple manipulations show:

Regime **I**:

$$Hb^{1/(\sigma-1)} \geq \text{Max}\left[1,(H-\lambda)(2b)^{1/(\sigma-1)},\text{Min}(H-\lambda,1)(1+b)^{1/(\sigma-1)},2^{1/(\sigma-1)}(1-\lambda)\right]. \qquad \text{(R1)}$$

Regime **II**:

$$1 \geq \text{Max}\left[Hb^{1/(\sigma-1)},(H-\lambda)(1+b)^{1/(\sigma-1)},2^{1/(\sigma-1)}(1-\lambda)\right], \qquad \text{(R2a)}$$

$$H-\lambda \geq 1. \qquad \text{(R2b)}$$

Regime **III**:

$$(H-\lambda)(2b)^{1/(\sigma-1)} \geq \text{Max}\left[(1+b)^{1/(\sigma-1)},2^{1/(\sigma-1)}(1-\lambda)\right], \qquad \text{(R3a)}$$

$$H-\lambda \geq 1, \qquad \text{(R3b)}$$

$$2^{1/(\sigma-1)}(1-\lambda) \geq 1. \qquad \text{(R3c)}$$

Regime **IV**:

$$(H-\lambda)(2b)^{1/(\sigma-1)} \geq \text{Max}\left[Hb^{1/(\sigma-1)},(1+b)^{1/(\sigma-1)}\right], \qquad \text{(R4a)}$$

$$H-\lambda \leq 1, \qquad \text{(R4b)}$$

$$2^{1/(\sigma-1)}(1-\lambda) \leq 1. \qquad \text{(R4c)}$$

Regime **V**:

$$\text{Min}(H-\lambda,1)(1+b)^{1/(\sigma-1)} \geq \text{Max}\left[1,Hb^{1/(\sigma-1)},(H-\lambda)(2b)^{1/(\sigma-1)},2^{1/(\sigma-1)}(1-\lambda)\right]. \qquad \text{(R5)}$$

Regime **VI**:

$$2^{1/(\sigma-1)}(1-\lambda) \geq \text{Max}\left[1, Hb^{1/(\sigma-1)}, (H-\lambda)(2b)^{1/(\sigma-1)}, \text{Min}(H-\lambda, 1)(1+b)^{1/(\sigma-1)}\right]. \qquad \text{(R6)}$$

Of course, multiple equilibria may be possible when some inequalities are satisfied with equality. In this case, we assume conventionally that the welfare dominant equilibrium is chosen.

References

Bairoch, P. (1988) *Cities and Economic Development*, Chicago University Press.

Ben-David, D. (1993) 'Equalizing Exchange: Trade Liberalization and Income Convergence', Quarterly Journal of Economics 108, 654-679.

Castells, M. (1996) *The Rise of the Network Economy*, Blackwell, Oxford.

Davis, D. (1996) 'Trade Liberalization and Income Distribution', National Bureau of Economic Research Working Paper: 5693.

Dicken, P. (1998) *Global Shift*, Paul Chapman Publishing, London (third edition).

Dixit, A. and Stiglitz, J. (1977) 'Onopolistic Competition and Optimal Product Diversity', American Economic Review 67, 297-308.

Duranton, G. (1997) 'The Economics of Productive Systems: Segmentation and Skill-Biased Change', mimeo.

Ethier, W. (1982) 'National and International Returns to Scale in the Modern Theory of International Trade', American Economic Review 72, 389-405.

Flam, H. and Helpman, E. (1987) 'Vertical Product Differentiation and North-South Trade', American Economic Review 77, 810-822.

Gottschalk, P. and Smeeding, T. (1997) 'Cross National Comparisons of Earnings and Income Inequality', Journal of Economic Literature 35, 633-687.

Grint, K. (1991) *The Sociology of Work: An Introduction*, Polity, Oxford.

Kremer, M. (1993) 'The O-Ring Theory of Economic Development', Quarterly Journal of Economics 108, 553-575.

Krugman, P. (1995) 'Growing World Trade: Causes and Consequences', Brookings Papers on Economic Activity, 0(1), 327-62.

Krugman, P. and Lawrence, R. (1993) 'Trade, Jobs, and Wages', National Bureau of Economic Research Working Paper 4478.

Krugman, P. and Venables, A. (1995) 'Globalisation and the Inequality of Nations', Quarterly Journal of Economics 110, 857-880.

Lagendijk, A. (1993) *The Internationalisation of the Spanish Automobile Industry and its Regional Impact*, Tinbergen Institute Research Series, Amsterdam.

McLoughlin, I. and Clark, J. (1994) *Technological Change at Work*, Open University Press, Buckingham.

Murphy, K. and Schleifer, A. (1997) 'Quality and Trade', Journal of Development Economics

53, 1-15.

Puga, D. (1997) 'The Rise and Fall of Regional Inequalities', mimeo LSE.

Quah, D. (1997) 'Empirics for growth and distribution: Stratification, polarization, and convergence clubs', Journal of Economic Growth 2, 27-59.

Sachs, J. and Warner, A. (1995) 'Economic Reform and the Process of Global Integration', Brookings Papers on Economic Activity, 0(1), 1-95.

Wells, P. and Rawlinson, M. (1994) *The New European Automobile Industry*, St Martin's Press, NY.

Wood, A. (1995) 'How Trade Hurt Unskilled Workers', Journal of Economic Perspectives 9, 57-80.

JEL Classification: J21, F12, F15
Keywords: Productive Systems, Globalisation, Inequalities.