Fragmentation, Globalization and Labor Markets

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Abstract: We propose a model in which the removal of barriers to trade and factor mobility can induce an endogenous fragmentation of the value-added-chain as the conscious choice of cost structure by monopolistically competitive firms. An expansion of the integrated trading region affects globalization not only horizontally with respect to product variety, but also vertically as firms vary the specialization of production s tages. In the short run, it is likely that fragmentation will be accompanied by an increase in services employment as well as the skill premia, as observed in OECD countries. These implications are likely to be reversed, however, as new firms enter the market.

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1. Introduction

Most contributions to the debate on the role of trade versus technology in explaining labor market developments see the two forces operating separately in independent spheres. In this paper, we study the impact of trade on labor markets transmitted by its effect on choice of technology. Two observations in particular motivate our interest in this issue. First, not only final goods production but production itself is becoming increasingly global. Recent revisions of trade statistics, which give more detailed information on the nature of products traded, suggest that trade in intermediates has significantly outpaced trade in final goods. Second, a more detailed examination of labor statistics reveals that the increase in the skill premium was accompanied by substantial shifts in the structure of employment (OECD 1996; 1999; 2000). In particular, employment in service activities *rose* in tandem with the exposure of local to foreign competition. The increase in services employment was by no means limited to low-skilled, poorly paid jobs, but rather has exhibited a bimodal pattern with growth especially strong at the lower and the upper end of the wage scale. In addition, the employment of professional, management and sales-related personnel has increased substantially faster than in other high skilled groups. These developments are indicative of fundamental changes in production methods and technology as the openness of economies increases. In addition, it suggests that the impact of trade on labor markets may be underrated in studies which neglect the indirect effect that increased openness has on labor markets via technology.

The phenomenon of fragmentation is intimately related to globalization. While globalization remains the subject of endless academic and popular discussion, it is clear that the economic integration of the world's economies has risen markedly over the last few decades; the ratio of international trade to value added in the OECD rose from 24.6 percent in 1960 to 42.7 percent in 1996 (OECD (1998)).[1] Moreover, a number of fundamental

[1] Some observers have noted however that the world is no more integrated today than it was at the turn of the last century; one frequently reads of "globalization cycles" in economic history. See Bairoch (1989), Williamson

developments are changing the ways that nations interact economically with each other. Mega-mergers and cross-border firm linkages have intensified trade in intermediate goods. An especially impressive development is the rise in outsourcing, allowing enterprises to extend activities across national boundaries and tailor production strategies to idiosyncratic attributes of local production sites. The word "fragmentation" has been used to characterize these developments (e.g. Deardorff (1998); Jones/Kierzkowski (1990; 1997; 1999); Feenstra (1998); Kierzkowski (1998)).

This aspect of globalization is the focus of our paper. In particular, we ask the question: under what circumstances and to what extent can the opening up of trade itself account for the increasing fragmentation of world economic relations? In the model we propose, fragmentation is driven by Smithian division of labor and pure economies of scale, and results from cost competition among firms. To highlight these effects, we downplay the role of factor endowments or exogenous changes in technology.[2] Globalization differs markedly from that derived in models of factor proportions or horizontal trade alone. North-South models of the HOS or Ricardian type are often difficult to reconcile with product and labor market developments in industrialized countries.[3] In our model, the removal of barriers to trade and factor mobility can induce an endogenous fragmentation of the value-added-chain as the conscious choice of cost structure by monopolistically competitive firms. Trade-induced changes in production methods, rather than low wage competition, is responsible for an increase in the relative demand for skill. Furthermore, we focus our attention on

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(1998), Baldwin/Martin (1999).

[2] For a discussion of globalization related to intermediates production and outsourcing driven by factor proportions and Ricardian differences, see Sanyal/Jones (1982), Sanyal (1983), Feenstra/Hanson (1996a,b), and Deardorff (1998)); outsourcing related to factor intensities of multinationals is discussed by Slaughter (1999)).

[3] An overwhelming majority of studies from the perspective of both trade volumes (Sachs/Shatz (1996), Cooper (1994), but see also Wood (1994)) and prices have found little evidence of globalization along HOS-lines (Lücke (1998)). The predicted pattern of substitution from skilled towards unskilled labor stands in contrast to actual developments: in particular in the US, the unskilled-skilled ratio fell in virtually all industries (Berman/Bound/Machin (1998)).

fragmentation in a fully integrated economy, downplaying physical trade flows to emphasize the endogeneity of production and cost structures.

Because the model admits trade in differentiated final goods, it allows a useful distinction between horizontal and vertical globalization. An expansion of the integrated trading region affects globalization not only horizontally with respect to product variety, but also vertically as firms vary the specialization of production stages. In the short run, it is likely that fragmentation will be accompanied by an increase in services employment as well as the skill premia, as observed in OECD countries. These implications are likely to be reversed, however, as new firms enter the market.

The paper is organized as follows. Section 2 offers a brief review of the literature on fragmentation and trade. Section 3 sets out our model of endogenous fragmentation in an integrated economy and illustrates the central role of labor markets in determining the resource cost of fragmentation, which we interpret as the production of business services. Section 4 reinterprets the model as a benchmark integrated economy and presents the central comparative statics results linking the size of the trading area to globalization as we understand it in this paper. Section 5 concludes.

2. Fragmentation and Globalization: A Literature Review

A large and growing body of research confirms that the intensification of trade is best characterized as vertical rather than horizontal. Krugman (1995) argues that export to GDP ratios in the range of 30 percent can only be explained with reference to vertical specialization based trade. This applies in particular to countries with total trade exposure exceeding total economy value added. At the level of the OECD, Yeats (1998) estimates that the share of trade in parts and components within the SITC 7 category (i.e. machinery and transportation equipment) increased by 4 percentage points between 1978-95 and currently stands at more than 30 percent; Yeats considers these numbers as representative for manufactured goods in general. Yeats' estimates, based on recent revisions of trade statistics, are in line with estimates by Campa/Goldberg (1997), who examined input-output data of 20 industries on the 2-digit SIC level from the UK, the US and Canada and found that in almost all industries the imported share of inputs (in total inputs) rose in the period 1975-95. Looking at the share of imported inputs in exports, Hummels/Rapoport/Yi (1998) found similar evidence.[4]

A number of contributions have featured the fragmentation of production processes as a concomitant feature of globalization (see Francois (1990a,b), Jones/Kierzkowski (1990; 1997; 1999). Jones/Kierzkowski (1990) emphasize the role of producer services in the production process and in fragmentation without a formal model. In Jones/Kierzkowski (1997) specialization in intermediates is driven by differences in factor intensities of stages of production and endowments if fragmentation occurs (see also Feenstra/Hanson 1996a,b). In general, this work ignores the opportunity costs of resources employed in managing the fragmented value added chain. Drawing on the examples of the photo imaging and the pharmaceutical industries, Jones/Kierzkowski (1999) describe how fragmentation allows sharing of production blocks across various industries and how (due to indivisibilities and economies of scope) horizontal linkages among industries may be established as vertical specialization deepens.

Francois (1990a) explicitly accounts for services and employs a family of production functions as developed by Edwards/Starr (1987) and Francois/Nelson (1998) to display economies of scale as fragmentation is increased, but features a single (homogeneous) labor market. Most importantly, he stresses the endogeneity of the elasticity of substitution in demand along the lines of Lancaster (1979) so that via demand market size serves as a driving force for fragmentation (see also Dluhosch (2000)). In a related paper, Francois (1990b) assumes that services are produced with high skilled labor only while direct production uses

[4] The same pattern of increases in outsourcing and intra-industry trade in components is also displayed by area and industry studies (Ng/Yeats (1999); Jones/Kierzkowski (1999)).

unskilled labor but retains Lancaster preferences in demand, which he considers crucial for fragmentation (see Francois (1990b:723, fn. 6).

Another salient aspect of many models of globalization is Dixit-Stiglitz (1977) "love-of-variety" preferences (Krugman (1980; 1981), Helpman (1981)). In principle, trade in these models is also driven by the demand-side. Because consumers prefer to choose from a larger variety of goods, larger markets can sustain larger numbers of businesses; competition occurs via the number of firms, not via the scale of production.[5] Love of variety in intermediates may feature increases in productivity and scale in final goods production, but in the end this process is demand-driven as well. Some examples of this approach are Markusen (1989); Feenstra/Markusen/Zeile (1992); Feenstra/Markusen (1994); Krugman/Venables (1995); Ethier (1982), Romer (1987)), and Matusz (1996).

While retaining a framework of imperfect competition, the model we present in the next section shifts focus from demand to supply as an alternative engine of globalization. We model fragmentation as an endogenous choice of cost-competitive firms in a general equilibrium setting with two factors of production. The scale of production of individual firms changes endogenously while the production process becomes more fragmented and global sourcing increases. Labor markets segmented by skill level turn out to be crucial for integration-driven fragmentation. Business services produced with skilled labor are necessary for managing global production and therefore determine the equilibrium extent of fragmentation. Explicit modeling of the supply side of fragmentation is a central contribution of our model.

[5] Krugman (1981) tries to get around this by assuming differentiated products segmented on the demand-side along industry groups.

3. Cost Competition and Technological Choice under Monopolistic Competition in the Closed Economy

3.1. Household Preferences and Demand

We consider an economy populated by identical households which can consume a large number N of differentiated, manufactured goods in quantities x_i as well as a homogeneous consumption service x_0, which also serves as the model's numeraire. Preferences of the representative household over manufactured goods are described by the standard Dixit-Stiglitz (1977) symmetric CES function, which is nested in turn in Cobb-Douglas utility with expenditure shares of μ and $(1-\mu)$ for manufactured goods and consumer services respectively. Given income Y, utility maximization gives rise to the familiar demand functions

$$x_i = \left(\sum_{j=1}^{N} p_j^{1-\eta} \right)^{-1} \mu Y p_i^{-\eta} \quad \text{for } i\text{=1,...,N} \tag{1a}$$

$$x_0 = (1-\mu)Y \tag{1b}$$

so that for N large, the elasticity of demand for manufactured goods is approximately η.

3.2. Manufactured Goods and Technology of Cost Reduction

Each of the manufactured goods described above is produced by a single firm under conditions of monopolistic competition. A central innovation in this paper is that the supplier of each manufactured good variety can influence its own cost structure by choosing the *length* or *roundaboutness* of production, and thereby the degree of specialization of individual production stages. This aspect of technology is summarized by the positive real number z. Since we allow for noninteger values, it is best to think of z as an index of fragmentation or the degree of specialization of stages in the value added chain.[6] A small increase in fragmentation or specialization dz (or an incremental lengthening of the production process)

6 Since our model applies largely to industry or economy-wide phenomena and not to the firm, ignoring the

reduces direct production costs, but also generates overhead costs $p_z dz$, so that p_z can be thought of as the cost of adding and managing an intermediate production stage.

Direct costs in manufacturing, which are measured in terms of the numeraire good, consist of factor payments to skilled labor H_P and unskilled labor L_P arising from the efficient use of a constant returns production function $f\,(H_P,L_P)$ with the usual properties.[7] We assume that fixed direct costs $\overline{F}\; > 0$ are invariant with respect to the number of production stages z, but that variable costs are subadditive, so that total direct production costs for a representative firm in producing x are given by $\overline{F} + v(z)x$, with $v' < 0$, $v'' > 0$. This is consistent with Adam Smith's (1776) idea that the size of the market determines the extent to which specialization can increase productivity and reduce variable costs.[8] To facilitate analysis, we assume an isoelastic function $v(z) = \dfrac{\overline{v}}{(z+\overline{z})^{\gamma}}$.[9] The minimum extent of fragmentation ($\overline{z}$) implies that the impact of cost competition on labor markets will be more accentuated as the trading area expands. Total production costs for firm i are then given by

$$\overline{F} + \frac{\overline{v}}{(z_i + \overline{z})^{\gamma}} x_i + p_z z_i \,. \tag{2}$$

3.3. Optimal Firm Behavior and Partial Product Market Equilibrium

Since firms produce differentiated goods with identical technologies, describing (partial) product market equilibrium is straightforward. Profits π of the representative firm in manufacturing can be written as the difference between total revenues and total production costs:

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integer problem will not be important issue here.

7 That is, f_H , f_L >0; f_{HH}, f_{LL} <0; f_{LH}>0; and $f_{HH}\, f_{LL}$-(f_{LH})^2=0. One way of thinking about this is to regard the costly input as being supplied by a perfectly competitive manpower industry to the manufacturing sector in the form of a composite of the two labor types at minimum cost conditions, given factor prices.

8 Fixed costs might also be affected by choice of z, but since we are interested in the effect of relative cost differences we focus on variable costs.

9 This implies that marginal costs at z = 0 are given by $\overline{v}/(\overline{z}^{\gamma})$. Below we will also impose explicit bounds on

$$\pi_i = p_i x_i - \left[\overline{F} + \frac{\overline{v}}{(z_i + \overline{z})^{\gamma}} x_i + p_z z_i \right] \tag{3}$$

The i^{th} firm maximizes π_i in (3) by its choice of output level x_i and cost reduction z_i, taking p_z and its output demand curve (1a) as given. In what follows, we combine the first order conditions (not shown) with the characterization of partial product market equilibrium $p_i=p_j=p$, $x_i=x_j=x$ and $z_i=z_j=z$ for all firms i and j, which follows from the fact that manufactured goods enter utility symmetrically and are produced under identical cost conditions.

Short-run analysis: the case of no entry (n)

In a first variant of the model we explore the general equilibrium properties from a short run perspective in which entry is restricted; N is fixed at $\overline{N}$, which implies that positive economic profits are possible in the differentiated goods sector. Optimal behavior of firms in symmetric product market equilibrium yield the following expressions for the scale, the price and the extent of fragmentation in the differentiated goods sector:

$$x = \left(\frac{(\eta - 1)\mu Y}{\eta \overline{N}} \right)^{1+\gamma} \left(\frac{\gamma}{p_z} \right)^{\gamma} / \overline{v} \tag{4.1n}$$

$$p = \left(\frac{\eta}{\eta - 1} \right)^{1+\gamma} \left(\frac{p_z \overline{N}}{\gamma \mu Y} \right)^{\gamma} \overline{v} \tag{4.2n}$$

$$z = \frac{(\eta - 1)\gamma \mu Y}{\eta \overline{N} p_z} - \overline{z} \tag{4.3n}$$

Partial equilibrium values of x, p and z thus depend on the relative price of fragmentation p_z and the scale of output Y. Equations (4n) convey a number of important partial equilibrium implications of our model of cost competition in the short-run:

γ so that fragmentation is not "too effective" in cost reduction.

- production fragmentation z depends in equilibrium inversely on the costs of fragmentation, p_z, and directly on total value added Y of the economy;
- the price of manufactured output p (in terms of consumer services) depends positively on p_z and negatively on Y. While the markup remains constant, marginal costs are endogenous;
- the scale of the firm x is no longer constant as in Dixit/Stiglitz (1977) and Krugman (1980, 1981), but depends on the incentives and ability of firms to reduce costs.

Long-run analysis: the case of free entry (f)

From a long-run perspective the assumption of no entry is unrealistic; the other extreme case, free entry, is probably a more appropriate alternative. Free entry implies that profits are driven to zero by endogenous variation in product variety and the number of firms, both given by N.[10] Setting π in (3) equal to zero and substituting in (4) yields the following relationship between product variety N and income Y:

$$N = \frac{[1-\gamma(\eta-1)]\mu Y}{\eta(\bar{F} - p_Z \bar{z})}. \tag{5f}$$

To limit our attention to economically meaningful equilibria, we will assume throughout $\frac{p_Z \bar{z}}{\bar{F}} < \gamma(\eta-1) < 1$. Inserting (5f) into the equilibrium conditions (4) we obtain the following symmetric product market equilibrium conditions:

$$x = \left(\frac{(\bar{F} - p_Z \bar{z})(\eta-1)}{[1-\gamma(\eta-1)]}\right)^{1+\gamma} \left(\frac{\gamma}{p_Z}\right)^{\gamma} / \bar{v} \tag{4.1f}$$

$$p = \left(\frac{\eta}{\eta-1}\right)^{1+\gamma} \left(\frac{[1-\gamma(\eta-1)]p_Z}{\gamma\eta(\bar{F} - p_Z \bar{z})}\right)^{\gamma} \bar{v} \tag{4.2f}$$

$$z = \frac{(\eta-1)\gamma\bar{F}}{[1-\gamma(\eta-1)]p_Z} - \frac{\bar{z}}{[1-\gamma(\eta-1)]} \tag{4.3f}$$

Consulting equations (4.1f-4.3f) we can again highlight at this point the key partial equilibrium implications of our model from a long-run perspective:

- the equilibrium of production fragmentation z now depends inversely on the costs of fragmentation, p_Z *only*;
- the price of manufactured output p (in terms of consumer services) depends positively on p_Z only. While marginal costs are endogenous, the markup remains constant though and, as γ approaches zero, it converges to the familiar Lerner index of monopoly power (see Lerner (1934));
- as in the case of no entry, the scale of the firm x is not constant as in Dixit/Stiglitz (1977) and Krugman (1980, 1981), but depends on the incentives and ability of firms to reduce costs. However, from (4.1f), as γ approaches 0, x becomes constant (given the price of the fixed input), as in Krugman (1980, 1981);
- an increase in market power of the representative firm (a decline in η) reduces unambiguously both the output of firms and expenditures on cost reduction;[11]
- in partial symmetric product equilibrium, the scale of total demand Y (measured in terms of the numeraire) and the fraction spent on manufactures by consumers, μ, are irrelevant. This is because free entry allows limitless replication of production at a given cost structure, which is in turn determined by p_z.

3.4. The Supply of Business and Consumer Services

Business Services

Irrespective of whether they involve geographical reallocation of industries or the entry of new firms, the fragmentation of production requires additional resources in the form of

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[10] Again, we ignore integer issues here.

[11] To see this note that

coordination and communication. These resource requirements, which are increasing with the extent of fragmentation, are modeled explicitly as a demand for business services produced with skilled labor. It is here that the link between fragmentation and the labor market is established.[12] By suitable normalization, the length of the production process of the representative firm z gives rise to an equal demand for business services, which can be interpreted as an intermediate input to manufacturing. Economy-wide demand for business services Z is then given by Nz:

$$Z = Nz\,. \tag{6}$$

Business services are supplied in quantity Z at price p_z by competitive, profit maximizing firms which use skilled labor H_S according to an industry production function $Z = H_S{}^{\beta}$, with $0 < \beta < 1$. The derived demand for labor is $H_S = (\beta p_Z / w_H)^{1/(1-\beta)}$, where w_H denotes the skilled wage. Aggregate supply of producer services is given by

$$Z = (\beta p_Z / w_H)^{\beta/(1-\beta)}. \tag{7}$$

Consumer Services

Finally, consumer services are also supplied under conditions of perfect competition using unskilled labor with the technology $x_0 = L_S{}^{\alpha}$ with $0 < \alpha < 1$. Labor demand originating in this sector is thus $L_S = (\alpha / w_L)^{1/(1-\alpha)}$; supply of consumer services is

$$x_0 = (\alpha / w_L)^{\alpha/(1-\alpha)} \tag{8}$$

$$dz/d\eta = \frac{\gamma\bar{F}[1-\gamma(\eta-1)] + (\eta-1)\gamma^2\bar{F} - \gamma p_z \bar{z}}{[1-\gamma(\eta-1)]^2 p_z} = \frac{\gamma(\bar{F} - p_z\bar{z})}{[1-\gamma(\eta-1)]^2 p_z} > 0.$$

12 Some of these channels have been stressed by Harris (1995). Becker/Murphy (1992) point out that the division of labor is more often determined by costs of coordinating the various activities rather than size of the market. Our formulation is consistent with the fact that average compensation in business services is higher than in the overall economy (OECD 1999).

where w_L denotes the real product wage. As with business services, the assumption that consumer services are produced primarily with low-skilled labor is consistent with the fact that compensation in consumer services is generally below average (OECD 1999).

3.5 Partial Equilibrium in Labor Markets

Until now we have treated p_z as exogenous, in order to explore partial equilibrium aspects of the cost reduction technology on products markets. If Z is produced by profit-maximizing firms using resources with value in alternative uses, this assumption is untenable.[13] Yet if p_z is endogenous, the model is no longer closed: counting equations and variables, we have seven equations, (1b), (4.1n), (4.2n), (4.3n), (6), (7), (8) in nine unknowns x_0, x, p, z, Z, p_z, Y, L_S and H_S (in the no-entry case) or eight equations (1b), (4.1f), (4.2f), (4.3f), (5), (6), (7), (8) in ten unknowns x_0, x, p, z, Z, N, p_z, Y, L_S and H_S (in the free entry case). In particular, product market supply depends on what goes on in labor markets, which in turn affects the equilibrium value of p_z and the extent of (vertical) globalization (z), as we elaborate in the next section.

Labor is supplied inelastically by households in two forms, skilled $\overline{H}$ and unskilled $\overline{L}$. Labor markets are assumed to be perfectly competitive, and mobility between sectors is costless; the demand curve for each type of labor in each sector is thus the "supply price" to the other. It follows that two equilibrium conditions are the equality of wage and value marginal product for both types of labor (measured in terms of consumer services):

$$\alpha L_S^{\alpha-1} = f_L(\overline{H} - H_S, \overline{L} - L_S) \tag{9}$$

$$p_z \beta H_S^{\beta-1} = f_H\left(\overline{H} - H_S, \overline{L} - L_S\right). \tag{10}$$

[13] In the original Kennedy (1964), Samuelson (1965) and von Weizsäcker formulations on factor bias of technological change, these resource requirements were not explicitly modeled.

3.6 Closing the Model

No entry

The market price for business services is driven by demand for outsourcing services from $\overline{N}$ manufacturing firms (4.3n) and total supply (7):

$$\frac{(\eta-1)\gamma\mu Y}{\eta}-\overline{N}p_z\bar{z}=p_z^{1/(1-\beta)}\left(\frac{f_H}{\beta}\right)^{-\beta/(1-\beta)} \tag{11n}$$

Finally, the model is closed using the national accounting definition of income Y of final sales:

$$Y=L_S^{\alpha}+\overline{N}px \tag{12n}$$

We now have a system of eleven equations (1b), (4.1n), (4.2n), (4.3n), (6), (7), (8), (9), (10), (11n) and (12n) in eleven unknowns x_0, x, p, z, Z, p_z, Y, L_S, H_S, w_L and w_H. The essential information can be distilled into a system of three equations in three unknowns p_z, H_S, L_S consisting of (9), (10) and

$$\frac{(\eta-1)\gamma\mu L_S^{\alpha}}{(1-\mu)\eta}-\overline{N}p_z\bar{z}=p_z^{1/(1-\beta)}\left(\frac{f_H}{\beta}\right)^{-\beta/(1-\beta)}. \tag{13n}$$

Free entry

As in the case of barriers to entry in manufacturing we require an equilibrium condition for p_z which equates demand for outsourcing services (4.3f) and total supply from equation (7)

$$\frac{(\eta-1)\gamma\mu Y}{\eta}-Np_z\bar{z}=p_z^{1/(1-\beta)}\left(\frac{f_H}{\beta}\right)^{-\beta/(1-\beta)} \tag{11f}$$

and an equation for the national accounting definition of income Y

$$\begin{aligned}Y&=x_0+Npx\\&=L_S^{\alpha}+f\left(\overline{H}-H_S,\overline{L}-L_S\right)+Np_z z\end{aligned} \tag{12f}$$

Note that the number of firms demanding management services is now variable. In the free entry case, the model consists of twelve equations in twelve unknowns x_0, x, p, z, Z, N, p_z, Y,

H_S, L_S, w_L and w_H. Due to its recursive structure, it can be reduced to a system of three equations consisting of (9), (10) and

$$\frac{(\eta-1)\gamma\overline{F}-p_z\overline{z}}{[(\eta/(\eta-1))-\gamma]\overline{F}-p_z\overline{z}}=p_z{}^{1/(1-\beta)}\left(\frac{f_H}{\beta}\right)^{-\beta/(1-\beta)}\left(\frac{\eta-1}{f}\right) \tag{13f}$$

in three unknowns H_S, L_S, and p_z.

4. International Trade, Fragmentation and Globalization

4.1. Interpreting the Model in Terms of Trade and Globalization

Until now the model could well have described a closed economy in which fragmentation of production occurred in the home country only. Yet the present model can capture key elements of international trade in two important ways. Like conventional intraindustry trade approaches, the current model predicts that an enlargement of the trading area will have real effects on production patterns. Generally, two nations which open up to international trade and produce as an integrated economy could potentially produce twice as many differentiated goods or even more; *horizontal globalization* means that the representative household can augment the variety of its consumption basket via purchases of "foreign" goods. Trade in conventional models with differentiated goods has been used to explore the effects of opening up closed economies of similar development to trade (e.g. Brander (1981), Krugman (1980, 1981)). Since Dixit-Stiglitz preferences presume a boundless appetite for variety, the number of available goods will increase.

Yet as pointed out in the introduction, a dramatic increase in trade in intermediate inputs and a secular fragmentation of the value-added process, associated with "global sourcing," has proceeded at the same if not at a faster pace than world trade (Campa/Goldberg (1997)). Therein lies the role of the cost reduction technology: the removal of barriers to trade and mobility increases incentives of firms to achieve higher volumes by investing in production sites and economizing on variable costs; according to (5), the equilibrium effect on N is potentially indeterminate. In our framework, *vertical globalization* will reflect the process by which the fragmentation of production is achieved both within and across international boundaries. The distinction between deepening (vertical) and broadening (horizontal) globalization is an important one.[14]

There are at least two ways to relate these two dimensions of globalization to trade. One is to employ the Samuelsonian metaphor (Samuelson 1949) and ignore national boundaries; it would be sufficient to study the effects of exogenous changes in factor endowments on the integrated economy.[15] Another approach is to model trade explicitly and ask whether the integrated economy can be replicated as has been done in the intraindustry trade literature (see Helpman's (1984) chapter in the *Handbook of International Trade*). If some goods are not traded, however (i.e., services), there is no guarantee that the integrated economy can be achieved.

Our model predicts that an enlargement of the trading area – achieved for example by the removal of barriers to trade and mobility between countries – will have two effects. First, a horizontal effect reflected in the number of firms in manufacturing (N) of the traditional intra-industry sort. Second, however, an enlarged market for a given trading region, *ceteris paribus*, will increase incentives for individual firms to economize on variable costs by outsourcing or fragmenting the production process (z). In this sense, an enlarged market associated with trade can drive an endogenous evolution of technology.[16] Trade drives technology, which in turn affects the international division of labor. There is, however, no reason to believe *a priori* that increased trade will necessarily lead to more fragmentation. In the next section we explore formally in a comparative static analysis the conditions under

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[14] This paper thus extends the analysis of Krugman's (1980), who argues effectively that scale effects are impossible in a constant elasticity world (p. 200). This won't be the case in our model, because the firms' scale can even change across different zero profit equilibria as they "economize" on variable costs.

[15] This is in line with the widely-held view that intensifying trade has resulted from declining trade barriers (see Wood 1994).

[16] This possibility has been discussed in the context of outsourcing by Feenstra (1998).

which a larger trading area in the integrated economy will increase the degree of fragmentation of the representative firm, *z* and how this affects labor markets in general equilibrium.

4.2. Comparative Static Analysis of the Impact of Trading Area Size on Fragmentation and Labor Markets

As emphasized in the analysis of Section 3.3, a variable of central importance to the model economy is the price of business services – the market price of fragmentation. From equations (4), it determines the degree of vertical versus horizontal globalization in this model via its influence over the degree of fragmentation at the individual firm level (*z*), the relative price of manufactured goods (*p*) and the optimal scale of the firm (*x*). In general equilibrium, p_z will be depend on the technology of business services production as well as the opportunity cost of skilled labor in the manufacturing sector, and thus will also depend on productivity of *unskilled* labor in its alternative use, too. It will also depend on the availability of factors; intuitively an increase in the supply of skilled labor is more prone to depress the price of skilled business services than an increase in the supply of unskilled labor, because the latter would increase total demand without contributing to its supply. Only with the help of formal comparative statics analysis is it possible to show under which conditions trade increases vertical globalization.

To distinguish our approach as much as possible from traditional Heckscher-Ohlin analyses, we model the enlargement of markets as an exogenous increase in factors of production: $\hat{\bar{H}} > 0$, $\hat{\bar{L}} = \omega\hat{\bar{H}}$ with $\omega \geq 0$. The case of ω=1 corresponds to an equiproportional increase in both factors; i.e. a simple up- or downscaling of the absolute size of the economy. In what follows, we identify the conditions on ω for which cost competition leads to vertical globalization of production – an increase in the number of production sites for the representative firm ($dz > 0$), rather than merely an increase in the number of products ($dN >$

0). Since labor market implications of an increase in the integrated economy may differ we will again differentiate between the polar cases of no entry and free entry associated with the short and the long run respectively. Naturally, in the long run an increase in fragmentation for the *aggregate* economy can be achieved either via an increase in that activity at the firm level or by an increase in the number of firms.

4.3. Short-run Analysis: Comparative Statics without Entry

Log-differentiating (9), (10), and (13n) results in a system of three equations in $\hat{p}_Z$, $\hat{H}_S$, and $\hat{L}_S$, which characterizes the impact effects of an increase in the endowment of high skilled workers ($\hat{H}_S$) and an associated increase in low skilled labor ($\omega\hat{H}_S$), holding the number of firms constant. We make use of the following familiar notation from Jones (1965): percentage changes in variable are denoted by carats (e.g. $\hat{x}$ for dx/x), λ_{ij} is the share of input *i* employed by sector *j*, θ_{ij} is the elasticity of *f* with respect to *i* (with $\theta_{HP} + \theta_{LP} = 1$), and the (local) elasticity of substitution of *f* is denoted by $\sigma \equiv \frac{f_L f_H}{f_{HL} f}$. Then the total differential of the system (9), (10) and (13n) can be written in matrix form as

$$\begin{bmatrix} (1-\alpha)\sigma + \theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}} & -\theta_{HP}\frac{(1-\lambda_{HP})}{\lambda_{HP}} & 0 \\ -(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} & \sigma(1-\beta)+(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & -\sigma \\ \beta(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} - (1-\beta)\sigma\alpha\left(\frac{z+\bar{z}}{z}\right) & -\beta(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & \sigma\left[\frac{z+\bar{z}(1-\beta)}{z}\right] \end{bmatrix} \begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_Z \end{bmatrix} =$$

$$\begin{bmatrix} \theta_{HP} \\ -(1-\theta_{HP}) \\ \beta(1-\theta_{HP}) \end{bmatrix} \frac{(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}} \hat{\bar{H}}$$

This 3x3 system expresses the evolution of three central variables – skilled employment in business services, unskilled employment in consumer services and the price of business services in terms of the numeraire – as a function of a small change in the size of the market, when entry of new firms is ruled out. In what follows, the solution of the model is presented and discussed; details can be found in the appendix.

Employment in services

From a labor markets perspective, the reaction of employment in the two service sectors is of central interest for the model. They are:

$$\hat{L}_S = \frac{\theta_{HP}\left[\frac{z+\bar{z}(1-\beta)}{z}\right]}{\Delta_n}\frac{\sigma^2(1-\beta)(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \tag{18n}$$

$$\hat{H}_S = -\frac{\left(\frac{z+\bar{z}}{z}\right)(1-\theta_{HP}-\alpha)}{\Delta_n}\frac{\sigma^2(1-\beta)(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \tag{19n}$$

with

$$\Delta_n \equiv (1-\beta)\sigma^2\left\{\left(\frac{z+\bar{z}}{z}\right)\frac{(1-\lambda_{HP})}{\lambda_{HP}}(1-\alpha-\theta_{HP})+\left[\frac{z+\bar{z}(1-\beta)}{z}\right]\left[\theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}}+\sigma(1-\alpha)\right]\right\} \tag{17n}$$

The sign of the determinant Δ_n is ambiguous. But from (17n) it follows that sign($\hat{H}_S$)= sign($\hat{L}_S$)sign$(\theta_{HP}+\alpha-1)$ = sign(Δ_n)sign$(\omega\lambda_{HP}-\lambda_{LP})$, so that if $(\theta_{HP}+\alpha)>1$, then H_S and L_S move in the same direction. Moreover, an *increase* in both types of service employment will require that the determinant Δ_n and $(\omega\lambda_{HP}-\lambda_{LP})$ have the same sign. In the interest of ruling out the counterintuitive case of L_S falling while $\omega > \frac{\lambda_{LP}}{\lambda_{HP}}$, we will assume henceforth that $\Delta_n > 0$.

Market price for business services and fragmentation

By inspection of (4.3n) and (12n) the necessary and sufficient condition for vertical globalization at the firm level is $\hat{Y} > \hat{p}_Z$ or $\alpha\hat{L}_S > \hat{p}_Z$. To determine the general equilibrium effect on fragmentation we thus need to know how the market price of business services is affected as the trading area expands:

$$\hat{p}_z = \frac{\left[(1-\beta)\theta_{HP}\alpha\left(\frac{z+\bar{z}}{z}\right)+\beta(1-\theta_{HP})(1-\alpha)\right]}{\Delta_n}\frac{\sigma^2(1-\beta)(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \tag{20n}$$

After some manipulation using (18n) and (20n), the requirement that $\alpha\hat{L}_S > \hat{p}_z$ for an increase in fragmentation can be shown to reduce to the already familiar condition

$$\alpha + \theta_{HP} > 1 \Rightarrow \alpha > 1 - \theta_{HP}. \tag{21n}$$

If the output elasticity in services with respect to unskilled labor input exceeds that of manufactures, an expansion of the trading area leads to an increase in fragmentation at the firm level.

Relative wages

The effect of trade on wages is a central issue in the debate on inequality.[17] It is well-known that exogenous labor saving technical progress is a primary candidate for explaining the current labor market malaise in many OECD countries. In our model, a similar effect can be attributed to the endogenous reaction of producers to an expansion of the trading area. The impact on wage inequality can be obtained from the first order conditions for the firm:

[17] See, for example, the 1997 Symposium in the *Journal of Economic Perspectives* and the references therein.

$$\hat{w}_H - \hat{w}_L = (1-\alpha)\hat{L}_S + \hat{p}_Z - (1-\beta)\hat{H}_S$$
$$= \frac{\sigma^2(1-\alpha)(1-\beta)(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}\Delta_n}\left(\frac{z + \bar{z}(1-\beta)}{z}\right)\hat{\bar{H}} \tag{22n}$$

With Δ_n positive, the wage differential moves in the same direction as employment in services: an enlargement of the trading area with a bias towards *unskilled* labor ($\omega > \lambda_{LP}/\lambda_{HP}$) has a depressing effect on relative wages of the low skilled. As in more traditional models, an increase in the integrated economy increases wage inequality, but because technological change is induced by an expansion of the trading area, thereby shifting out the relative demand for skilled labor. If (21n) holds, this occurs alongside increased (vertical) globalization, bimodal service employment growth and skill bias in manufacturing.[18] This result is in line with the pattern recently observed in the OECD but stands in contrast to the usual Heckscher-Ohlin logic.

4.4. Long-run Analysis: Comparative Statics with Free Entry

In the case of free entry and zero profits, log-differentiating (9), (10), and (13f) yields the following matrix system in $\hat{p}_z$, $\hat{H}_S$, and $\hat{L}_S$:

$$\begin{bmatrix} (1-\alpha)\sigma + \theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}} & -\theta_{HP}\frac{(1-\lambda_{HP})}{\lambda_{HP}} & 0 \\ -(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} & \sigma(1-\beta) + (1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & -\sigma \\ -[\beta + (1-\beta)\sigma](1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} & [\beta(1-\theta_{HP}) - (1-\beta)\sigma\theta_{HP}]\frac{(1-\lambda_{HP})}{\lambda_{HP}} & \sigma[(1-\beta)Q - 1] \end{bmatrix} \begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_z \end{bmatrix} =$$

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[18] This result is in line with empirical evidence on the impact of trade on productivity (see Cortes/Jean (1997)). For a model with technology causing trade and widening skill differentials see Burda/Dluhosch (1999).

$$\left[\begin{array}{c} -\theta_{HP} \\ 1-\theta_{HP} \\ \dfrac{-(1-\beta)\sigma\lambda_{LP}}{(\lambda_{LP}-\omega\lambda_{HP})} + (1-\theta_{HP})[(1-\beta)\sigma+\beta] \end{array}\right] \frac{(\lambda_{LP}-\omega\lambda_{HP})}{\lambda_{LP}\lambda_{HP}} \hat{\bar{H}}$$

where Q is given by

$$Q \equiv \left[\frac{\gamma(\eta-1)-1}{\left[\left(\frac{\eta}{\eta-1}-\gamma\right)\bar{F}-p_z\bar{z}\right]\left[(\eta-1)\gamma\bar{F}-p_z\bar{z}\right]}\right]\frac{\eta}{\eta-1}\bar{z}\bar{F}p_z < 0$$

and is related to product market conditions. Note that $\lim_{\eta\to\infty}Q\,|_{\gamma(\eta-1)<1}=0$ (corresponding to the case of perfect competition) and $\lim_{\eta\to 1}Q\,|_{\gamma(\eta-1)<1}=-\infty$ (high levels of monopoly power). The determinant of the matrix can now be unambiguously signed:

$$\Delta_f \equiv \frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}}\left\{\begin{array}{l}\{\lambda_{HP}[(1-\beta)Q-1]-\theta_{HP}(1-\lambda_{HP})\}[(1-\alpha)\sigma\lambda_{LP}+\theta_{HP}(1-\lambda_{LP})] \\ +(1-\theta_{HP})(1-\lambda_{HP})[(1-\alpha)(Q-1)\lambda_{LP}-\theta_{HP}(1-\lambda_{LP})]\end{array}\right\} < 0 .$$

(17f)

Employment in services

When entry is free, the change in employment of low-skilled workers in services $\hat{L}_S$ is now given by:

$$\hat{L}_S = \left[\frac{\theta_{HP}(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\right]\{\lambda_{LP}[1-(1-\beta)Q]-\omega[1-\lambda_{HP}(1-\beta)Q]\}\hat{\bar{H}} \qquad (18.1f)$$

$\hat{L}_S$ is positive if and only if $\lambda_{LP}(1-(1-\beta)Q) < \omega(1-\lambda_{HP}(1-\beta)Q)$ or if ω exceeds a critical value $\underline{\omega}$:

$$\omega > \underline{\omega} = \frac{\lambda_{LP}[1-(1-\beta)Q]}{1-\lambda_{HP}(1-\beta)Q} . \qquad (18.2f)$$

Since $\underline{\omega} = \lambda_{LP}\left[1 - \frac{(1-\lambda_{HP})(1-\beta)Q}{1-\lambda_{HP}(1-\beta)Q}\right] > \lambda_{LP}$, imperfect competition in manufactures (which implies Q strictly less than zero) has the effect of increasing the lower bound for ω.

The effect of an increase in factor endowments on the employment of skilled labor in business services ($\hat{H}_S$) has the same sign as the resulting change in total fragmentation (since $\hat{Z} = \beta\hat{H}_S$), and can be derived as

$$\hat{H}_S = \frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}\Delta_f}\left\{\begin{matrix}\lambda_{LP}\left[(1-\alpha)(1-\theta_{HP})(Q-1) - \theta_{HP}\sigma(1-\alpha)\right] \\ -\theta_{HP}(1-\lambda_{LP}) - \omega\lambda_{HP}(1-\alpha)(1-\theta_{HP})(\sigma-1+Q)\end{matrix}\right\}\hat{\overline{H}} \qquad (19.1f)$$

An enlargement of the trading area leads to an increase in employment in business services as long as the term in brackets is negative. One *sufficient* condition is $\sigma > 1-Q$, or in words that the elasticity of substitution in manufacturing is high relative to the price sensitivity of z.[19] In the case that $\sigma < 1-Q$, then the necessary and sufficient condition for $\hat{H}_S > 0$ is that ω does not exceed an upper bound $\overline{\omega}$:

$$\omega < \overline{\omega} \equiv \frac{\lambda_{LP}\left[(1-\alpha)(1-\theta_{HP})(1-Q) + \theta_{HP}(1-\alpha)\sigma\right] + \theta_{HP}(1-\lambda_{LP})}{\lambda_{HP}(1-\alpha)(1-\theta_{HP})(1-Q-\sigma)} \qquad (19.2f)$$

Rewriting $\overline{\omega} = \frac{\lambda_{LP}}{\lambda_{HP}} + \frac{\lambda_{LP}(1-\alpha)\sigma + \theta_{HP}(1-\lambda_{LP})}{\lambda_{HP}(1-\alpha)(1-\theta_{HP})(1-Q-\sigma)}$, it follows that $\overline{\omega} > \lambda_{LP}/\lambda_{HP}$ strictly.

To summarize the effects of the market size on employment from a long run perspective: an increase in factor endowments expands unskilled service employment if the endowment of low skilled workers increases sufficiently. At the same time, an upper bound limits the increase in low-skilled workers consistent with an expansion of service employment of skilled workers (business services). The range of admissible ω for which *both* L_S and H_S

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[19] Alternatively, rewriting (19.1f) as

$$\hat{H}_S = \frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}\Delta_f}\left\{\begin{matrix}(1-\alpha)(1-\theta_{HP})\left[(\lambda_{LP} - \omega\lambda_{HP})(Q-1) - \omega\lambda_{HP}\sigma\right] \\ -\theta_{HP}\left[\lambda_{LP}(1-\alpha)\sigma + (1-\lambda_{LP})\right]\end{matrix}\right\}\hat{\overline{H}}$$

shows that an alternative sufficient condition for H_s to increase is $\omega < \lambda_{LP}/\lambda_{HP}$.

increase is given by $\omega \in [\underline{\omega}, \overline{\omega}]$ if $\sigma < 1 - Q$, and $\omega \in [\underline{\omega}, \infty]$ otherwise. Note that in principle, this interval could be empty.

Market price for business services and fragmentation

From (4.3f) the equilibrium extent of fragmentation is ultimately a function of the market price for business services p_z. This is given under conditions of free entry by

$$\hat{p}_z = \frac{(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f} \left\{ \begin{matrix} (1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - (1-\beta)\theta_{HP}[(1-\alpha)\lambda_{LP}\sigma + (1-\lambda_{LP})] \\ -\omega(1-\alpha)(1-\theta_{HP})[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})] \end{matrix} \right\} \hat{\bar{H}} \tag{20.1f}$$

The sign of this expression is ambiguous, but independent of Q (the magnitude does depend on Q). A necessary and sufficient condition on ω for vertical globalization at the firm level (i.e. z rising) is that p_z declines, which is equivalent to requiring that

$$\omega < \frac{(1-\alpha)(1-\theta_{HP})\lambda_{LP}\beta - \theta_{HP}(1-\beta)[\lambda_{LP}(\sigma - \alpha\sigma - 1) + 1]}{(1-\alpha)(1-\theta_{HP})[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})]} \tag{20.2f}$$

An analogous condition on σ can be derived given the other parameters as

$$\sigma < \frac{(1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - \omega(1-\alpha)(1-\theta_{HP})[1-(1-\beta)\lambda_{HP}] - \theta_{HP}(1-\beta)(1-\lambda_{LP})}{(1-\alpha)(1-\beta)[\omega(1-\theta_{HP})\lambda_{HP} + \theta_{HP}\lambda_{LP}]} \tag{20.3f}$$

For vertical globalization to occur, increases in the unskilled labor endowment must be sufficiently small or the substitutability between the unskilled and skilled labor must be sufficiently low.

Relative wages

Given the level of ambiguity characterizing results thus obtained, a more modest goal is simply to identify sufficient conditions for which an enlargement of the trading area could lead to increasing inequality in our model. In the appendix, it is shown that after some algebra:

$$\hat{w}_H - \hat{w}_L = -\frac{(1-\alpha)(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\left[(\omega - \lambda_{LP}) - (\omega\lambda_{HP} - \lambda_{LP})(1-\beta)Q\right]\hat{\bar{H}} \tag{22f}$$

By inspection, if the interval $[\underline{\omega}, \overline{\omega}]$ is nonempty and $\omega > \lambda_{LP}/\lambda_{HP}$ for some $\omega \in [\underline{\omega}, \overline{\omega}]$, then an increase in the integrated economy is associated with a widening of the wage gap.

Summary

Under what conditions will an expansion of the trading area in the long run lead to one of the symptoms we associate with globalization, that is an increase in "fragmentation of production"? The results derived above are ambiguous. Contributory factors seem to be:

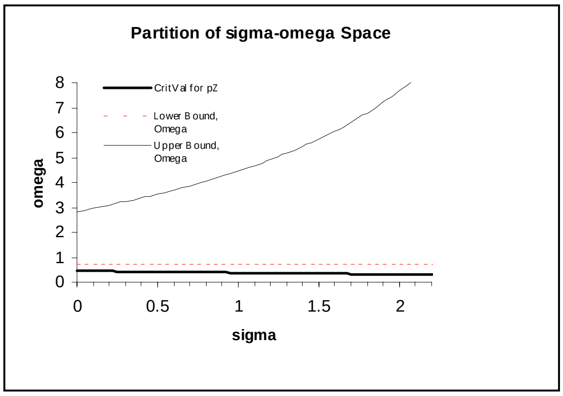
- $\beta \to 1$ (near constant returns in business services induces a flat demand curve for skill in the service sector);

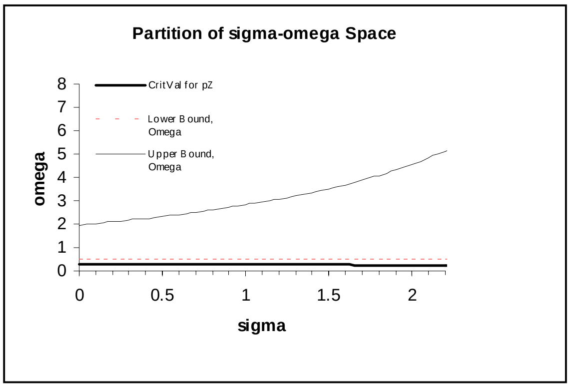
- $\alpha \to 0$ (implying high sensitivity of the marginal product of labor in consumer services to employment);

- low elasticity of substitution σ between skilled and unskilled labor in direct manufacturing.

To convey the plausibility of the restrictions on the model's parameters, we plot in the positive orthant of (σ,ω)-space the combinations of those two parameters which are consistent with our restrictions: 1) that p_z declines and z increases (vertical globalization at the firm level); 2) that L_S increases; 3) that H_S increases. While allowing σ and ω to vary, we fix the other parameters at following alternative values: α=0.6, β=0.9, λ_{HP}=0.3, λ_{LP}=0.6, θ_{HP}=0.5; and α=0.6, β=0.9, λ_{HP}=0.3, λ_{LP}=0.4, θ_{HP}=0.33. The three restrictions on σ and ω and the implied regions are plotted in Figure 1. Given reasonable parametrizations of the model, we were unable to identify any region of the (σ,ω) space which were consistent with all three conditions. Overall, short-run effects on fragmentation derived in the previous section vanish as entry is allowed, even though total fragmentation (Z) (as opposed to fragmentation at the level of the firm (z)) may increase.

Figure 1





(a) α=0.6, β=0.9, λ_{HP}=0.3, λ_{LP}=0.6, θ_{HP}=0.5

(b) α=0.6, β=0.9, λ_{HP}=0.3, λ_{LP}=0.4, θ_{HP}=0.33

5. Conclusions

The objectives of this paper are twofold: first, to model partial and general equilibrium implications of cost competition and fragmentation in a monopolistic competition model, and second, to ascertain to what extent trade alone can explain recent global trends in fragmentation and apparent skill bias in domestic labor markets.[20] We describe a general equilibrium model in which trade and fragmentation are driven not by exogenous differences in factor endowments or technology, but by the sheer size of the market. Increased openness induces firms to cut costs; under certain conditions, removal of barriers to trade and mobility can lead to a decline in costs of organizing and managing the value-added chain and in turn to more fragmented production structures. The result is a finer vertical division of labor and outsourcing similar to that observed in the process of globalization. Although trade drives technology in this model, the potential for explaining observed fragmentation in the OECD as

[20] The model lends itself to a number of extensions. It would be interesting to eliminate completely the role of decreasing in returns in services. Tracking trade flows would be an important, but potentially tedious exercise. A comparison of the consequences of expanding trade with those of exogenous technical change is an obvious extension, on which we have already reported preliminary results (Burda/Dluhosch 1999).

a function of increased trade only seems limited to the short run, when the number of firms is held constant. In the long run when free entry has driven profits to zero, firm-level fragmentation is likely to be reversed.

At any rate, by stressing cost competition, our model offers a trade explanation of labor market developments which differs from the traditional account of the Heckscher-Ohlin-Samuelson model. In our framework, globalization implies a shift in relative labor demand which can reverse the usual effects implied by the Rybczynski Theorem. In the variable entry case, it is necessary that the relative price of managing more complex production declines endogenously. With a fixed number of firms, necessary and sufficient conditions are decidedly weaker. Overall, the fact that some component of technological change in the process of globalization is induced may explain why trade and technology are empirically difficult to disentangle in their contribution to the immizeration of low skilled labor in industrialized countries.

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Appendix to "Fragmentation, Globalization and Labor Markets"
(Burda/Dluhosch) 26.6.00

A.1. Short-run Analysis: Comparative Statics without Entry

In the short run with a given number of firms $N = \overline{N}$ our system reads:

$$\left[(1-\alpha)\sigma + \theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}}\right]\hat{L}_S - \theta_{HP}\frac{(1-\lambda_{HP})}{\lambda_{HP}}\hat{H}_S = \theta_{HP}\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\overline{H}} \tag{14}$$

$$-(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}}\hat{L}_S + \left[\sigma(1-\beta)+(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}}\right]\hat{H}_S - \sigma\hat{p}_Z = -(1-\theta_{HP})\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\overline{H}} \tag{15}$$

$$\left[\beta(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} - \alpha\sigma(1-\beta)\left(\frac{z+\bar{z}}{z}\right)\right]\hat{L}_S - \beta(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}}\hat{H}_S + \sigma\left[\frac{z+\bar{z}(1-\beta)}{z}\right]\hat{p}_Z = \beta(1-\theta_{HP})\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\overline{H}} \tag{16n}$$

or in matrix form

$$\begin{bmatrix} (1-\alpha)\sigma + \theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}} & -\theta_{HP}\frac{(1-\lambda_{HP})}{\lambda_{HP}} & 0 \\ -(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} & \sigma(1-\beta)+(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & -\sigma \\ \beta(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} - (1-\beta)\sigma\alpha\left(\frac{z+\bar{z}}{z}\right) & -\beta(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & \sigma\left[\frac{z+\bar{z}(1-\beta)}{z}\right] \end{bmatrix} \begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_Z \end{bmatrix} =$$

$$\begin{bmatrix} \frac{(\omega\lambda_{HP}-\lambda_{LP})\theta_{HP}}{\lambda_{LP}\lambda_{HP}} \\ -\frac{(\omega\lambda_{HP}-\lambda_{LP})(1-\theta_{HP})}{\lambda_{LP}\lambda_{HP}} \\ \frac{\beta(1-\theta_{HP})(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}} \end{bmatrix}\hat{\overline{H}}$$

By application of Cramer's rule and a number of transformations we obtain for the determinant

$$\Delta_n = (1-\beta)\sigma^2 \left\{ \begin{array}{l} \left(\frac{z+\bar{z}}{z}\right)\frac{(1-\lambda_{HP})}{\lambda_{HP}}(1-\alpha-\theta_{HP}) \\ + \left[\frac{z+\bar{z}(1-\beta)}{z}\right]\left[\theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}} + \sigma(1-\alpha)\right] \end{array} \right\} \tag{17n}$$

The sign of the determinant is not unambiguous. For Δ_n positive $1 > \alpha + \theta$ is sufficient (but not at all necessary). A necessary and sufficient condition could be derived on z (the initial degree of fragmentation): the determinant is positive iff

$$z\left[1-\alpha-\theta_{HP}-\theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}}-\sigma(1-\alpha)\right]$$
$$>\bar{z}\left[\theta_{HP}(1-\beta)\frac{(1-\lambda_{LP})}{\lambda_{LP}}+\sigma(1-\alpha)(1-\beta)-\frac{(1-\lambda_{HP})}{\lambda_{HP}}(1-\alpha-\theta_{HP})\right]$$

Effect of the size of the trading area on employment in services

Solving for low-skilled employment in services yields

$$\hat{L}_S = \frac{\begin{vmatrix} \theta_{HP} & -\theta_{HP}\dfrac{(1-\lambda_{HP})}{\lambda_{HP}} & 0 \\ -(1-\theta_{HP}) & \sigma(1-\beta)+(1-\theta_{HP})\dfrac{(1-\lambda_{HP})}{\lambda_{HP}} & -\sigma \\ \beta(1-\theta_{HP}) & -\beta(1-\theta_{HP})\dfrac{(1-\lambda_{HP})}{\lambda_{HP}} & \sigma\left[\dfrac{z+\bar{z}(1-\beta)}{z}\right] \end{vmatrix}}{\Delta_n}\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}}$$

$$=\frac{\sigma^2(1-\beta)\left[\dfrac{z+\bar{z}(1-\beta)}{z}\right]}{\Delta_n}\frac{\theta_{HP}(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \qquad (18n)$$

This expression is unambiguous and inherits the sign of $(\omega\lambda_{HP}-\lambda_{LP})$ as long as the determinant is positive. For employment of high-skilled in services we obtain

$$\hat{H}_S = \frac{\begin{vmatrix} (1-\alpha)\sigma+\theta_{HP}\dfrac{(1-\lambda_{LP})}{\lambda_{LP}} & \theta_{HP} & 0 \\ -(1-\theta_{HP})\dfrac{(1-\lambda_{LP})}{\lambda_{LP}} & -(1-\theta_{HP}) & -\sigma \\ \beta(1-\theta_{HP})\dfrac{(1-\lambda_{LP})}{\lambda_{LP}}-(1-\beta)\sigma\alpha\left(\dfrac{z+\bar{z}}{z}\right) & \beta(1-\theta_{HP}) & \sigma\left[\dfrac{z+\bar{z}(1-\beta)}{z}\right] \end{vmatrix}}{\Delta_n}\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}}$$

$$=-\frac{\sigma^2(1-\beta)\left(\dfrac{z+\bar{z}}{z}\right)(1-\theta_{HP}-\alpha)}{\Delta_n}\frac{(\omega\lambda_{HP}-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \qquad (19n)$$

For this expression to have the same sign as $\hat{L}_S$ we need $1<(\theta_{HP}+\alpha)$. A negative determinant will flip the sign but sign $\hat{H}_S$ = –sign $\hat{L}_S$ unless $1<(\theta_{HP}+\alpha)$

Effect of the size of the trading area on the market price of business services and fragmentation

For the effect on the market price of business we obtain

$$\hat{p}_z = \frac{\begin{vmatrix} (1-\alpha)\sigma + \theta_{HP}\frac{(1-\lambda_{LP})}{\lambda_{LP}} & -\theta_{HP}\frac{(1-\lambda_{HP})}{\lambda_{HP}} & \theta_{HP} \\ -(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} & \sigma(1-\beta)+(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & -(1-\theta_{HP}) \\ \beta(1-\theta_{HP})\frac{(1-\lambda_{LP})}{\lambda_{LP}} - (1-\beta)\sigma\alpha\left(\frac{z+\bar{z}}{z}\right) & -\beta(1-\theta_{HP})\frac{(1-\lambda_{HP})}{\lambda_{HP}} & \beta(1-\theta_{HP}) \end{vmatrix}}{\Delta_n} \frac{(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}}$$

$$= \frac{\left\{(1-\beta)\theta_{HP}\alpha\left(\frac{z+\bar{z}}{z}\right) + \beta(1-\theta_{HP})(1-\alpha)\right\}}{\Delta_n} \frac{\sigma^2(1-\beta)(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} \qquad \text{(20n)}$$

This expression inherits the sign of $(\omega\lambda_{HP} - \lambda_{LP})$ as long as the determinant remains positive. From (4.3n) and (12n') we obtain the condition $\hat{Y} > \hat{p}_z$ or (equivalently) $\alpha\hat{L}_S > \hat{p}_z$ for fragmentation to increase. Plugging (18n) and (20n) into the condition gives

$$\frac{\alpha\sigma^2(1-\beta)\left[\frac{z+\bar{z}(1-\beta)}{z}\right]}{\Delta_n} \frac{\theta_{HP}(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}} > \frac{\left\{(1-\beta)\theta_{HP}\alpha\left(\frac{z+\bar{z}}{z}\right) + \beta(1-\theta_{HP})(1-\alpha)\right\}}{\Delta_n} \frac{\sigma^2(1-\beta)(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}}\hat{\bar{H}}$$

or

$$\alpha\theta_{HP}\left[\frac{z+\bar{z}(1-\beta)}{z}\right] > (1-\beta)\theta_{HP}\alpha\left(\frac{z+\bar{z}}{z}\right) + \beta(1-\theta_{HP})(1-\alpha)$$

which, after a number of transformations reduces to

$$1 < (\alpha + \theta_{HP}). \qquad \text{(21n)}$$

Effect of the size of the trading area on relative wages

$$\hat{w}_H - \hat{w}_L = (1-\alpha)\hat{L}_S + \hat{p}_z - (1-\beta)\hat{H}_S$$

$$\hat{w}_H - \hat{w}_L = \frac{\sigma^2(1-\beta)(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}\Delta_n} \left\{ \begin{aligned} &(1-\alpha)\theta_{HP}\left[\frac{z+\bar{z}(1-\beta)}{z}\right] \\ &+ (1-\beta)\theta_{HP}\alpha\left(\frac{z+\bar{z}}{z}\right) + \beta(1-\theta_{HP})(1-\alpha) \\ &+ (1-\beta)\left(\frac{z+\bar{z}}{z}\right)(1-\theta_{HP} - \alpha) \end{aligned} \right\}\hat{\bar{H}}$$

$$\hat{w}_H - \hat{w}_L = \frac{\sigma^2(1-\alpha)(1-\beta)(\omega\lambda_{HP} - \lambda_{LP})}{\lambda_{LP}\lambda_{HP}\Delta_n}\left[(1-\beta)\left(\frac{\bar{z}}{z}\right)+1\right]\hat{\bar{H}} \tag{22n}$$

A.2. Long-run Analysis: Comparative Statics with Free Entry

It is straightforward if somewhat tedious to solve the system using Cramer's rule. First note that since $Q < 0$, the determinant of the matrix Δ_f is unambiguously negative:

$$\Delta_f \equiv \frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}}\left\{\begin{matrix}\{\lambda_{HP}[(1-\beta)Q-1]-\theta_{HP}(1-\lambda_{HP})\}[(1-\alpha)\sigma\lambda_{LP}+\theta_{HP}(1-\lambda_{LP})] \\ +(1-\theta_{HP})(1-\lambda_{HP})[(1-\alpha)(Q-1)\lambda_{LP}-\theta_{HP}(1-\lambda_{LP})]\end{matrix}\right\}<0 \tag{17f}$$

Effect of the size of the trading area on employment in services

The change in employment of low-skilled workers in services $\hat{L}_S$ is given by:

$$\hat{L}_S = \frac{\left[\frac{\lambda_{LP}-\omega\lambda_{HP}}{\lambda_{LP}\lambda_{HP}}\right]\begin{vmatrix} -\theta_{HP} & -\theta_{HP}(1-\lambda_{HP})/\lambda_{HP} & 0 \\ (1-\theta_{HP}) & \sigma(1-\beta)+(1-\theta_{HP})(1-\lambda_{HP})/\lambda_{HP} & -\sigma \\ \frac{-(1-\beta)\sigma\lambda_{LP}}{(\lambda_{LP}-\omega\lambda_{HP})}+(1-\theta_{HP})[\beta+(1-\beta)\sigma] & [\beta(1-\theta_{HP})-(1-\beta)\sigma\theta_{HP}][(1-\lambda_{HP})/\lambda_{HP}] & \sigma[(1-\beta)Q-1] \end{vmatrix}}{\Delta_f}\hat{\bar{H}}$$

$$= \left[\frac{\theta_{HP}(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\right]\{\lambda_{LP}[1-(1-\beta)Q]-\omega[1-\lambda_{HP}(1-\beta)Q]\}\hat{\bar{H}} \tag{18.1f}$$

By inspection, $\hat{L}_S$ is positive if and only if $\lambda_{LP}(1-(1-\beta)Q) < \omega(1-\lambda_{HP}(1-\beta)Q)$ or if

$$\omega > \underline{\omega} = \frac{\lambda_{LP}(1-(1-\beta)Q)}{1-\lambda_{HP}(1-\beta)Q} = \lambda_{LP}\left[1-\frac{\lambda_{LP}(1-\lambda_{HP})(1-\beta)Q}{1-\lambda_{HP}(1-\beta)Q}\right]. \tag{18.2f}$$

Note that imperfect competition in manufactures (which implies Q strictly greater than zero) increases this lower bound.

Turning to employment of skill in the business services sector ($\hat{H}_S$), we obtain

$$\hat{H}_S = \frac{\left[\frac{\lambda_{LP}-\omega\lambda_{HP}}{\lambda_{LP}\lambda_{HP}}\right]\begin{vmatrix} (1-\alpha)\sigma+\theta_{HP}(1-\lambda_{LP})/\lambda_{LP} & -\theta_{HP} & 0 \\ -(1-\theta_{HP})(1-\lambda_{LP})/\lambda_{LP} & (1-\theta_{HP}) & -\sigma \\ -[\beta+(1-\beta)\sigma](1-\theta_{HP})[(1-\lambda_{LP})/\lambda_{LP}] & \frac{-(1-\beta)\sigma\lambda_{LP}}{(\lambda_{LP}-\omega\lambda_{HP})}+(1-\theta_{HP})[\beta+(1-\beta)\sigma] & \sigma[(1-\beta)Q-1] \end{vmatrix}}{\Delta_f}\hat{\bar{H}}$$

$$= \left[\frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}\Delta_f}\right]\left\{\begin{matrix}\lambda_{LP}[(1-\alpha)(1-\theta_{HP})(Q-1)-\theta_{HP}\sigma(1-\alpha)]-\theta_{HP}(1-\lambda_{LP}) \\ -\omega\lambda_{HP}(1-\alpha)(1-\theta_{HP})[\sigma-1+Q]\end{matrix}\right\}\hat{\bar{H}} \tag{19.1f}$$

An enlargement of the trading area leads to an increase in aggregate business services employment and output as long as the numerator is positive, and a *sufficient* condition for this is $\sigma > 1 - Q$, meaning that the elasticity of substitution in manufacturing is high relative to the price sensitivity of *z*. If instead $\sigma < 1 - Q$, then the necessary and sufficient condition for an increase in high-skilled service employment is

$$\omega < \frac{\lambda_{LP}\left[(1-\alpha)(1-\theta_{HP})(1-Q) + \theta_{HP}(1-\alpha)\sigma\right] + \theta_{HP}(1-\lambda_{LP})}{\lambda_{HP}(1-\alpha)(1-\theta_{HP})(1-Q-\sigma)} \tag{19.2f}$$

Alternatively, rewriting (19.1f) as

$$\hat{H}_S = \left[\frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}}\right]\frac{\{(1-\alpha)(1-\theta_{HP})\{[\lambda_{LP}-\omega\lambda_{HP}](Q-1)-\omega\lambda_{HP}\sigma\}-\theta_{HP}[\lambda_{LP}(1-\alpha)\sigma+(1-\lambda_{LP})]\}}{\Delta_f}\hat{\bar{H}} \tag{19.3f}$$

reveals that an alternative sufficient condition for H_s to increase is $\omega < \lambda_{LP}/\lambda_{HP}$. Taken together, the range of admissible ω for which both L_s and H_s increase is given by

$[\underline{\omega}, \overline{\omega}]$ if $\sigma < 1 - Q$, and
$[\underline{\omega}, \infty]$ otherwise.

Effect of the size of the trading area on the market price of business services

The expression to evaluate is

$$\hat{p}_z = \frac{\left[\dfrac{\lambda_{LP}-\omega\lambda_{HP}}{\lambda_{LP}\lambda_{HP}}\right]\begin{vmatrix} (1-\alpha)\sigma+\theta_{HP}(1-\lambda_{LP})/\lambda_{LP} & -\theta_{HP}(1-\lambda_{HP})/\lambda_{HP} & -\theta_{HP} \\ -(1-\theta_{HP})(1-\lambda_{LP})/\lambda_{LP} & \sigma(1-\beta)+(1-\theta_{HP})(1-\lambda_{HP})/\lambda_{HP} & (1-\theta_{HP}) \\ -[\beta+(1-\beta)\sigma](1-\theta_{HP})[(1-\lambda_{LP})/\lambda_{LP}] & [\beta(1-\theta_{HP})-(1-\beta)\sigma\theta_{HP}][(1-\lambda_{HP})/\lambda_{HP}] & \dfrac{-(1-\beta)\sigma\lambda_{LP}}{(\lambda_{LP}-\omega\lambda_{HP})}+(1-\theta_{HP})[\beta+(1-\beta)\sigma] \end{vmatrix}}{\Delta_f}\hat{\bar{H}}$$

which can be reduced after considerable algebra to

$$\hat{p}_z = \frac{(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\begin{Bmatrix}(1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - (1-\beta)\theta_{HP}[(1-\alpha)\lambda_{LP}\sigma + (1-\lambda_{LP})] \\ -\omega(1-\alpha)(1-\theta_{HP})[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})]\end{Bmatrix}\hat{\bar{H}} \tag{20.1f}$$

The sign of this expression is not unambiguous, but is independent of *Q* (this is not true of its magnitude). A necessary and sufficient condition on ω to get vertical globalization (ie *z* rising at the firm level) is that p_z declines, which is equivalent to requiring that

$$\omega < \frac{(1-\alpha)(1-\theta_{HP})\lambda_{LP}\beta - \theta_{HP}(1-\beta)[\lambda_{LP}(\sigma-\alpha\sigma-1)+1]}{(1-\alpha)(1-\theta_{HP})\left[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})\right]} \tag{20.2f}$$

An analogous condition on σ can be derived given the other parameters as

$$\sigma < \frac{(1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - \omega(1-\alpha)(1-\theta_{HP})[1-(1-\beta)\lambda_{HP}] - \theta_{HP}(1-\beta)(1-\lambda_{LP})}{(1-\alpha)(1-\beta)\{\omega(1-\theta_{HP})\lambda_{HP} + \theta_{HP}\lambda_{LP}\}} \tag{20.3f}$$

Vertical globalization requires either sufficiently little unskilled labor to be added to the integrated economy or the substitutability between the unskilled and skilled labor to be sufficiently low.

Effect of the size of the trading area on relative wages

We obtain the change in wage inequality from the first order conditions for the firm:

$$\hat{w}_H - \hat{w}_L = (1-\alpha)\hat{L}_S + \hat{p}_z - (1-\beta)\hat{H}_S$$

Substitute from (18.1f), (19.1f) and (20.1f):

$$\hat{w}_H - \hat{w}_L = (1-\alpha)\left[\frac{\theta_H(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\right]\{\lambda_{LP}[1-(1-\beta)Q] - \omega[1-\lambda_{HP}(1-\beta)Q]\}\hat{\bar{H}}$$

$$+\frac{(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\begin{Bmatrix}(1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - (1-\beta)\theta_{HP}[(1-\alpha)\lambda_{LP}\sigma + (1-\lambda_{LP})] \\ -\omega(1-\alpha)(1-\theta_{HP})[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})]\end{Bmatrix}\hat{\bar{H}}$$

$$-(1-\beta)\left[\frac{\sigma^2(1-\beta)}{\lambda_{LP}\lambda_{HP}\Delta_f}\right]\{(1-\alpha)(1-\theta_{HP})\{[\lambda_{LP} - \omega\lambda_{HP}](Q-1) - \omega\lambda_{HP}\sigma\} - \theta_{HP}[\lambda_{LP}(1-\alpha)\sigma + (1-\lambda_{LP})]\}\hat{\bar{H}}$$

and rewrite as

$$\hat{w}_H - \hat{w}_L = \frac{(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}\left\{\begin{array}{l}(1-\alpha)\theta_{HP}[\lambda_{LP} - \omega - (\lambda_{LP} - \omega\lambda_{HP})(1-\beta)Q] \\ +\begin{Bmatrix}(1-\alpha)\lambda_{LP}\beta(1-\theta_{HP}) - (1-\beta)\theta_{HP}[(1-\alpha)\lambda_{LP}\sigma + (1-\lambda_{LP})] \\ -\omega(1-\alpha)(1-\theta_{HP})[\beta\lambda_{HP} + (1-\beta)\sigma\lambda_{HP} + (1-\lambda_{HP})]\end{Bmatrix} \\ -(1-\beta)\begin{Bmatrix}(1-\alpha)(1-\theta_{HP})\{[\lambda_{LP} - \omega\lambda_{HP}](Q-1) - \omega\lambda_{HP}\sigma\} \\ -\theta_{HP}[\lambda_{LP}(1-\alpha)\sigma + (1-\lambda_{LP})]\end{Bmatrix}\end{array}\right\}\hat{\bar{H}}$$

or, after some algebra:

$$\hat{w}_H - \hat{w}_L = -\frac{(1-\alpha)(1-\beta)\sigma^2}{\lambda_{LP}\lambda_{HP}\Delta_f}[(\omega - \lambda_{LP}) - (\omega\lambda_{HP} - \lambda_{LP})(1-\beta)Q]\hat{\bar{H}} \qquad (22f)$$

Hence, if the interval $[\underline{\omega}, \overline{\omega}]$ is nonempty, where $\underline{\omega}$ and $\overline{\omega}$ are defined above, $\omega > \lambda_{LP}/\lambda_{HP}$ for some $\omega \in [\underline{\omega}, \overline{\omega}]$, then an increase in the integrated economy is associated with a widening of the wage gap as well as an increase in services employment of both types.