CESifo *Working Paper Series*

FRAGMENTATION, GLOBALIZATION AND LABOR MARKETS

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Working Paper No. 352

October 2000

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* This paper is a revised and simplified version of the one presented at the IEA conference "Globalization and Labour Markets", Nottingham 7th-8th July 2000. We thank Adrian Wood and Douglas Nelson for helpful comments. This research is supported by the Sonderforschungsbereich 373 of the Deutsche Forschungsgemeinschaft (DFG).

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Abstract

Fragmentation of the value-added-chain is modeled as the reaction of monopolistically competitive firms to the removal of barriers to trade and factor mobility in an integrated trading environment. Since fragmentation requires high-skilled labor, this form of globalization can induce labor market effects similar to those caused by skill-biased technical change. In the short run, it is likely that fragmentation will be accompanied by an increase in high and low-skilled service employment as well as in the skilled wage premia, as observed in OECD countries. These implications can be reversed, however, as new firms enter the market.

Keywords: International trade, organization of production, technology choice, division of labor

JEL Classification: F10, L23, O33

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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.[1] 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

[1] In the period March 1995 to March 2000, 54.3% of net US employment growth occurred in occupational categories managerial and professional specialty; 29.9% came in the category "executive, administrative, and managerial". During the same period, the groups "precision production, craft, and repair" and "operators, fabricators, and laborers" accounted for only 10.5% and 0.6% of new net job growth, respectively.

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)).[2] Moreover, a number of fundamental 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: can the opening up of trade itself and the increasing fragmentation of world economic relations account for current labor market developments in OECD countries? 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 suppress any role for exogenous changes in technology.[3] 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.[4] 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

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[2] 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 (1998), Baldwin/Martin (1999).

[3] 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)). In a related paper, Burda/Dluhosch (2000) investigate to what extent fragmentation of production obtains for more general constant returns production functions.

[4] 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

low wage competition, is responsible for an increase in the relative demand for skill. Furthermore, we focus our attention on 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 can 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 cost of fragmentation, which we interpret as the price 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

(1998)). Furthermore, while these models predict substitution from skilled towards unskilled labor, the unskilled-skilled ratio has in fact fallen in virtually all industries (Berman/Bound/Machin (1998)).

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; these numbers are considered representative for manufacturing in general. These estimates are consistent with those of 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.[5]

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 proposed by Edwards/Starr (1987) and Francois/Nelson (1998) to display economies of scale as fragmentation increases, but features a single (homogeneous) labor market. Most

[5] The same pattern of increases in outsourcing and intra-industry trade in components is also displayed by area

importantly, Francois (1990a) 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 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 variety of goods, larger markets can sustain larger numbers of businesses; competition occurs via the number of firms, not via the scale of production.[6] 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

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and industry studies (Ng/Yeats (1999); Jones/Kierzkowski (1999)).

[6] Krugman (1981) avoids this issue by assuming differentiated products segmented on the demand-side along industry groups.

therefore determine the equilibrium extent of fragmentation. Explicit modeling of the supply side of fragmentation is a central contribution of our model.

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

3.1. Household Preferences and Demand

The economy consists of a large number of identical households which can consume N 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 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 m and $(1-m)$ for manufactured goods and consumer services respectively. Given income Y, utility maximization for the representative household gives rise to the familiar demand functions

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

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

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

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 the production 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.[7] A small increase in fragmentation or specialization dz (or an incremental lengthening of the production process) reduces direct production costs, but also generates overhead (communication, management, organizational) costs p_zdz, so that p_z can be thought of as the cost of adding and managing an intermediate production stage.

To make the cost function consistent with a primal problem in two factors of production, we assume that direct production costs represent payments for the output of a perfectly competitive intermediate sector which employs skilled labor H_P and unskilled labor L_P using the constant returns production function $f(H_P,L_P)$ which is sold at price p_C.[8] 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.[9] To facilitate analysis, we assume an isoelastic function $v(z) = \frac{\overline{v}}{z^g}$.[10] Total production costs for firm i are then given by

$$\overline{F} + \frac{\overline{v}}{z^g} x_i + p_z z_i . \qquad (2)$$

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[7] Since our model applies largely to industry or economy-wide phenomena and not to the firm, ignoring the integer problem will not be important issue here.

[8] We assume that f has the usual properties; 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 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.

[9] 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.

[10] This implies that marginal costs at z = 0 are infinite. Below we will also impose explicit bounds on g so that fragmentation is not "too effective" in cost reduction.

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:

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

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; With N fixed at $\overline{N}$, positive economic profits in the differentiated goods sector will be assumed. 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:

$$x = \left(\frac{(h-1)mY}{h\overline{N}} \right)^{1+g} \left(\frac{g}{p_z} \right)^{g} / \overline{v} \tag{4n}$$

$$p = \left(\frac{h}{h-1} \right)^{1+g} \left(\frac{p_z \overline{N}}{gmY} \right)^{g} \overline{v} \tag{5n}$$

$$z = \frac{(h-1)gmY}{h\overline{N}p_z} \tag{6n}$$

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), (5n) and (6n) reveal the following partial equilibrium implications of our model of cost competition in the short-run:

- production fragmentation z depends in equilibrium negatively on the costs of fragmentation, p_z, and positively on total value added Y in 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)

The assumption of no entry is unrealistic, especially in the medium to long run. The other extreme, free entry, implies that profits are driven to zero by endogenous variation of N which stands for both product variety and the number of firms.[11] Setting π in (3) equal to zero and substituting in (4) yields the following relationship between product variety N and income Y:

$$N = \frac{[1-\gamma(\theta-1)]\mu Y}{\theta \bar{F}}. \qquad (7)$$

To limit attention to economically meaningful equilibria, we will assume $\gamma < \frac{1}{\theta-1}$ throughout. Inserting (7) into the equilibrium conditions (4n), (5n) and (6n) results in the following characterization of symmetric product market equilibrium:

$$x = \left(\frac{\bar{F}(\theta-1)}{[1-\gamma(\theta-1)]}\right)^{1+\gamma}\left(\frac{\gamma}{p_z}\right)^{\gamma}/\bar{v} \qquad (4f)$$

[11] Again, we ignore integer issues here.

$$p = \left(\frac{\eta}{\eta - 1}\right)^{1+\gamma} \left(\frac{[1-\gamma(\eta-1)]p_z}{\gamma\eta\bar{F}}\right)^{\gamma} \bar{v} \tag{5f}$$

$$z = \frac{(\eta-1)\gamma\bar{F}}{[1-\gamma(\eta-1)]p_z} \tag{6f}$$

On the basis of these equations we can again highlight the most important implications of our model from a perspective of partial symmetric product equilibrium:

- the free-entry equilibrium of production fragmentation z now depends inversely on the cost p_Z only; given p_Z, both total demand Y (measured in terms of the numeraire) and the fraction spent on manufactures by consumers, m, 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;
- 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, converges to the familiar Lerner index of monopoly power (Lerner (1934));
- as with the no-entry case, firm scale x is not constant, but now only depends negatively on the cost of fragmentation p_Z. As γ approaches 0, x becomes constant (given the price of the fixed input), as in Krugman (1980, 1981);
- an increase in market power (a decline in η) reduces both the output of firms and expenditures on cost reduction unambiguously.[12]

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

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.[13] 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. Business services are supplied in quantity Z at price p_z by competitive, profit maximizing firms which use skilled labor H_S according to the constant returns production technology $Z = AH_S$. The derived demand for labor is thus infinitely elastic at Ap_Z, which in a competitive labor market will equal the equilibrium wage.

Consumer Services

Consumer services are also supplied under conditions of perfect competition employing unskilled labor using the technology $x_0 = L_S$. Labor demand originating in this sector is thus infinitely elastic at 1, the value marginal product of unskilled labor in consumer services. We will assume throughout that A>1; the assumption that consumer services are produced with low-skilled labor is consistent with below-average compensation in that sector (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. Since Z is produced by profit-maximizing

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[12] To see this note that $dz/dh = \frac{g\overline{F}[1-g(h-1)]+(h-1)g^2\overline{F}}{[1-g(h-1)]^2 p_z} = \frac{g\overline{F}}{[1-g(h-1)]^2 p_z} > 0.$

[13] Some of these channels are 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

firms using resources with value in alternative uses, its price should be determined in general equilibrium.[14] If p_z is endogenous, it will be influenced by conditions in labor markets, which in turn affects the extent of (vertical) globalization (z) and the demand for labor, as we elaborate in the next section.

Labor is supplied inelastically by households in two forms, skilled $\overline{H}$ and unskilled $\overline{L}$ to perfectly competitive labor markets. Mobility between sectors is costless, so the demand curve for each type of labor in each sector is thus the "supply price" to the other. The two relevant labor market equilibrium conditions are thus the equality of wage and value marginal product for both types of labor:

$$1 = p_C f_L(\overline{H} - H_S, \overline{L} - L_S) \tag{8}$$

$$Ap_Z = p_C f_H\left(\overline{H} - H_S, \overline{L} - L_S\right). \tag{9}$$

where p_C is the market price of the intermediate input, which is produced using f and which comprises the direct costs to the manufacturing sector.

3.6 Closing the Model

No entry case

The market price for business services equates demand for outsourcing services from $\overline{N}$ manufacturing firms (6n) with total supply (7):

$$\frac{(\theta - 1)\gamma m Y}{\theta p_Z} = AH_S \tag{10}$$

Finally, the model is closed using the market clearing condition that the value of demand for the direct cost input in manufacturing equals supply:

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economy (OECD 1999).

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

$$\overline{N}\left[\overline{F}+\overline{v}z^{-g}x\right]=p_C f\left(\overline{H}-H_S,\overline{L}-L_S\right) \tag{11}$$

We now have a system of nine equations (1b), (4n), (5n), (6n), (7), (8), (9), (10) and (11) in nine unknowns $x_0, x, p, z, p_z, p_C, Y, L_S$, and H_S. The essential information can be distilled into a system of three equations in three unknowns p_z, H_S, and L_S consisting of

$$p_z A=\frac{f_H}{f_L} \tag{12}$$

$$\frac{L_S}{(1-m)}=\frac{h}{(h-1)gm}p_z AH_S \tag{13}$$

$$\overline{NF}+\frac{(h-1)m}{h(1-m)}L_S=\frac{f}{f_L} \tag{14n}$$

Since $\frac{1}{f_L}=p_C$, the right hand side of equation (14n) equals total direct costs in manufacturing (purchases of the intermediate input in terms of the numeraire), the left side can be thought of as its decomposition into fixed ($\overline{NF}$) and variable ($\frac{(h-1)m}{h(1-m)}L_S$) components.

Free entry

Under free entry, the number of firms is given by (5f), making the equilibrium number of firms a linear function of income. Substituting (7) into (14n) yields a slightly different system of three equations in L_s, H_s, and p_Z consisting of (12), (13) and

$$\frac{[h-g(h-1)]m}{h(1-m)}=\frac{f}{L_S f_L}. \tag{14f}$$

4. International Trade, Fragmentation and Globalization

4.1. Interpreting the Model in Terms of Trade and Globalization

While not modeled explicitly, the model contains two important implications for international trade. Like conventional intraindustry trade approaches, an enlargement of the trading area will have real effects on production patterns. Generally, two nations which open up to trade in differentiated output and produce as an integrated economy will demand more types of goods than in autarky; *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)). In addition, the removal of barriers to trade and mobility and higher volumes of operation induce firms to invest in more specialized production sites and economizing on variable costs; *vertical globalization* refers to the process by which fragmentation of production is achieved, both within and across international boundaries. The distinction between deepening (vertical) and broadening (horizontal) globalization is an important one.[15]

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.[16] 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,

[15] Our model thus extends Krugman (1980), who ruled out scale effects in a constant elasticity setting (p. 200). In our model, firms can change scale across different zero profit equilibria as they "economize" on variable costs.

[16] This is in line with the widely-held view that intensifying trade has resulted from declining trade barriers (see

however (i.e., services), there is no guarantee that the integrated economy can be achieved. We will take the former approach.

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, which in turn affects the international division of labor.[17] 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 the conditions under 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

A variable of central importance to the model economy is the price of business services – the market price of fragmentation. From equations (4)-(6), 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 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 alternative uses. It will also depend on the

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Wood 1994).

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

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. A formal comparative statics analysis can help reveal under which conditions trade increases vertical globalization.

The enlargement of the trading area is modeled as an exogenous increase in factors of production: $\hat{\bar{H}} > 0$, $\hat{\bar{L}} = w\hat{\bar{H}}$ with $w \geq 0$. When w=1, factor endowments are increased equiproportionally. In the analsyis which follows, conditions on w are identified for which cost competition leads to vertical globalization of production – an increase in the number of production sites for the representative firm ($dz > 0$), as opposed to 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. For the *aggregate* economy, an increase in fragmentation in the long run 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

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), l_{ij} is the share of input i employed by sector j. Log-differentiating (12), (13), and (14n) results in a system of three equations in $\hat{p}_z$, $\hat{H}_S$, and $\hat{L}_S$:

$$\begin{bmatrix} -\frac{(1-l_{LP})}{l_{LP}} & \frac{(1-l_{HP})}{l_{HP}} & -s \\ 1 & -1 & -1 \\ Ss+\frac{(1-l_{LP})}{l_{LP}}[q_{HP}+(1-q_{HP})s] & -(1-s)q_{HP}\frac{(1-l_{HP})}{l_{HP}} & 0 \end{bmatrix} \begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_z \end{bmatrix} \qquad (15)$$

$$= \begin{bmatrix} -\left(\frac{wl_{HP}-l_{LP}}{l_{LP}l_{HP}}\right) \\ 0 \\ \frac{l_{LP}q_{HP}(s-1)+[(1-q_{HP})s+q_{HP}]wl_{HP}}{l_{LP}l_{HP}} \end{bmatrix} \hat{\bar{H}}$$

where $S=\dfrac{\dfrac{(h-1)mL_S}{h(1-m)}}{\dfrac{(h-1)mL_S}{h(1-m)}+\overline{NF}}$ is the fraction of direct costs in manufacturing represented by variable costs in equilibrium.

The differential system (15) expresses the (logarithmic) 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 excluded. Because we have treated the more general case elsewhere (Burda/Dluhosch 2000), the model solution is presented in what follows only for the Cobb-Douglas specification of *f,* which obtains as $s \to 1$. The Cobb-Douglas case has the advantage of simplicity without some of the ambiguity which characterizes the model with more general production technologies.

Employment in services

From a labor markets perspective, the response of employment in the two service sectors to an expansion of the size of the trading area is of central interest. In the case of unit substitution elasticity in *f*, these are:

$$\hat{L}_S = -\frac{S\lambda_{LP} + (1-S)w\lambda_{HP} + (1-\lambda_{LP})}{\lambda_{LP}\lambda_{HP}\Delta_N}\hat{\bar{H}} > 0 \qquad (16)$$

$$\hat{H}_S = -\frac{1-\lambda_{LP}(1-S) + w\lambda_{HP}(1-S)}{\lambda_{LP}\lambda_{HP}\Delta_N}\hat{\bar{H}} > 0 \qquad (17)$$

where $\Delta_N = -\frac{1-\lambda_{LP}+S\lambda_{LP}}{\lambda_{HP}\lambda_{LP}}$, which is unambiguously negative. Under these conditions, a "bimodal growth" pattern in high and low-skill services results from *any* expansion of the market size (for all values of w).[18]

To summarize, the model yields a short term response to an increase in market size which is in line with current developments in OECD-countries which show a bimodal (high- and low-skill) increase in services employment. A requirement for this result is a sufficiently large elasticity of substitution between skilled and unskilled labor in the manufacturing sector, where the critical value is less than unity.

Market price of business services and fragmentation

As noted above, sufficient statistics for the degree of fragmentation and the associated labor market effects are the degree of firm-level fragmentation (z) and the price of fragmentation ($\hat{p}_z$). Inspection of (6n) reveals that the necessary and sufficient condition for firm-level fragmentation

[18] In the general case of nonunitary elasticity of substitution, Burda and Dluhosch (2000) show that a necessary and sufficient condition on σ for $\hat{L}_S > 0$ is

$$\sigma > 1 - \frac{w}{\lambda_{LP}q_{HP} + w\lambda_{HP}(1-q_{HP})},$$

and the corresponding necessary and sufficient condition for positive $\hat{H}_S$ is

$$\sigma > 1 - \frac{S\lambda_{LP} + (1-S)w\lambda_{HP} + (1-\lambda_{LP})}{[\lambda_{LP}q_{HP} + (1-q_{HP})w\lambda_{HP}]}$$

Since the fractions appearing on the right hand side of the two expressions are unambiguously positive, one plausible sufficient condition for both forms of service employment to increase is $\sigma \geq 1$.

is $\hat{Y} > \hat{p}_Z$ or, since L_S=(1-m)Y, $\hat{L}_S > \hat{p}_z$. Equivalently, since z is simply aggregate fragmentation divided by the number of firms $\frac{AH_S}{\bar{N}}$, condition (17) is also necessary and sufficient for firm-level fragmentation to rise. Thus, in the short run it is possible to observe fragmentation at the level of the firm is increasing, even while the price of fragmentation is rising at the same time. The Cobb-Douglas case is unambiguous in the short-run however, with H_S, Z and z all increasing.

Labor Market Effects: Relative wages

The effect of trade on wages is a central issue in the debate on inequality.[19] 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. In particular, the assumption of constant returns in the two competing uses for labor guarantees that the relative value of the output of the business services sector is the sole determinant of the relative wage structure. We thus exclude not only exogenous technical change as a source of changing wage inequality, but also any endogenous variation of the marginal physical products in the service sectors resulting from changing employment levels. Variation of the price of business services is thus the sole determinant of the wage structure. The comparative statics result for $\hat{p}_z$ is

$$\hat{p}_z = -\frac{(w l_{HP} - l_{LP})S - (1 - l_{LP}) + w(1 - l_{HP})}{l_{LP} l_{HP} \Delta_N} \hat{\bar{H}} \qquad (18)$$

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

To sign (18) unambiguously, it is convenient to express parameter restrictions in terms of ω. With $\Delta_N<0$, the price of fragmentation rises in short-run equilibrium without entry if and only if

$$w > \frac{1-l_{LP}(1-S)}{1-l_{HP}(1-S)}. \tag{19}$$

this would require $l_{LP} > l_{HP}$, or that manufacturing is relatively less skill intensive than both "services" taken together.

It is important to note that if (19) holds, an increase in the trading area leads not only to an increase in fragmentation and its market price, but also raises the skilled wage ($p_Z A$), increases income inequality and induces an apparent skill bias in manufacturing, if the business service sector is included. This result stands in contrast to the usual Heckscher-Ohlin logic, since a relative increase in the world supply of skilled labor (ω<1) could in principle lead to an *increase* in its relative wage and an increase in relative manufacturing employment, even though manufacturing uses skilled labor less intensively than business services. Given that much of world trade is "North-North", the model thus suggests that integration of skill-abundant regions could in principle also cause rising inequality, at least in the short run.

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

In the case of free entry and zero profits, log-differentiating (12), (13), and (14f) yields the following system in $\hat{p}_z$, $\hat{H}_S$, and $\hat{L}_S$:

$$\begin{bmatrix} -\frac{(1-l_{LP})}{l_{LP}} & \frac{(1-l_{HP})}{l_{HP}} & -s \\ 1 & -1 & -1 \\ s+\frac{(1-l_{LP})}{l_{LP}}[q_{HP}+(1-q_{HP})s] & -(1-s)q_{HP}\frac{(1-l_{HP})}{l_{HP}} & 0 \end{bmatrix} \begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_z \end{bmatrix} \tag{20}$$

$$= \begin{bmatrix} -\left(\dfrac{w l_{HP} - l_{LP}}{l_{LP}\, l_{HP}}\right) \\ 0 \\ \dfrac{l_{LP} q_{HP}(s-1) + [(1-q_{HP})s + q_{HP}]\, w l_{HP}}{l_{LP}\, l_{HP}} \end{bmatrix} \hat{\bar{H}}$$

Note that the determinant of the matrix in (20), Δ_F, is now given by

$$\Delta_F = -\frac{s}{l_{HP}\, l_{LP}} \left\{ \begin{array}{l} (1-l_{LP})(1-l_{HP}) + s q_{HP}(1-l_{HP})\, l_{LP} + (1-q_{HP})(1-l_{HP})\, l_{LP} \\ + l_{HP}(1-l_{LP})[q_{HP} + s(1-q_{HP})] + l_{HP}\, l_{LP}\, s \end{array} \right\} \tag{21}$$

and is unambiguously negative; in the Cobb-Douglas case with free entry, we have $\Delta_F = -\dfrac{1}{l_{HP}\, l_{LP}}$. Again, we consider below the solution of the model in the Cobb-Douglas case (σ=1).

Employment in services

When entry is unrestricted, the change in employment of services workers $\hat{L}_S$ and $\hat{H}_S$ is given by:

$$\hat{L}_S = w\hat{\bar{H}} \tag{22}$$

$$\hat{H}_S = \hat{\bar{H}} \tag{23}$$

Clearly, the economy "scales" up in the employment of both types of labor, increasing by the same percentage in which endowments are assumed to increase. In the long run with free entry, there is no evidence of bias, as sectoral employment increases homothetically.[20]

[20] With a more general constant return production function, Burda and Dluhosch (2000) show that the interval of σ

The Market Price of Business services, Fragmentation and Relative Wages

Equation (6f) implies that equilibrium fragmentation under free entry is a function of the market price for business services p_z only. For this reason, the long run behavior of the relative price of business services p_Z – the price of coordinating fragmented production processes – is of central interest. If p_Z declines in the long run, then the representative firm will have a larger scale of production and be more globalized. In the Cobb-Douglas case, solution of (20) for p_Z is given by

$$\hat{p}_z = (w-1)\hat{\bar{H}} \tag{24}$$

Thus, in the long run a necessary and sufficient condition for an increase in firm level fragmentation is $w<1$. If instead $w>1$, then the long run is characterized by an increase in the price of and a decrease in the level of fragmentation. By (23), the evolution of total employment in and output of business services depends only on the scale of the expansion of the skilled endowment, and w determines whether long run globalization is horizontal (in product variety) or vertical (in the extent of production fragmentation).

Since the variables in the differentiated goods sector depend only on $\hat{p}_z$, it follows directly from (16c) that fragmentation in the long run may be fundamentally different from the short run. In particular, firm-level fragmentation will rise with free entry if and only if growth in the endowment of low skilled workers is exceeded by that of high skilled workers. In the short run, in contrast, fragmentation may occur with an increase in wage inequality. From (17) and (24) one

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for which bimodal growth in services obtains under free entry is given by

$$\left[\max\left(1-\frac{\min(w,1)}{l_{LP}q_{HP}+(1-q_{HP})wl_{HP}},0\right),\infty\right].$$

could easily imagine a situation in which a uniform expansion of the trading area initially induces an increase in business services employment and fragmentation as well as wage inequality, all of which are reversed as new firms enter the market. In fact, overshooting of business services employment will occur if

$$\hat{H}_S = -\frac{1 - l_{LP}(1-S) + w l_{HP}(1-S)}{l_{LP}\, l_{HP} \Delta_N} \hat{\bar{H}} > \hat{\bar{H}},$$

or if $w > l_{LP} / l_{HP}$.

5. Conclusions

The objectives of this paper were twofold: first, to model partial and general equilibrium implications of cost competition and fragmentation in a model of monopolistic competition, and second, to ascertain to what extent trade alone can explain recent global trends in fragmentation and apparent skill bias in domestic labor markets. 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 thereby 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 a function of increased trade seems greater in 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 can be reversed.

This paper has studied the behavior of the integrated economy as a metaphor for trade in the world economy. We maintain that this is an informative approximation, even if trade flows

are not explicitly studied. By stressing cost competition, our model offers an trade account of labor market developments which differs from the traditional factor-proportions explanations. In our framework, globalization implies a shift in relative labor demand which can reverse the usual effects implied by the Rybczynski Theorem, at least in the short run. 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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