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COST COMPETITION, FRAGMENTATION AND GLOBALIZATION

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Abstract

This paper proposes a model in which the removal of barriers to trade and factor mobility is associated with endogenous fragmentation of the value-added chain. Fragmentation is the outcome of cost competition – the profit-maximizing choice of cost structure by monopolistically competitive firms. An expansion of the integrated trading area can induce globalization not only in the horizontal dimension associated with love-of-variety preferences, but also in a vertical dimension as firms vary specialization of production stages. While increased trade is likely to induce fragmentation when the number of firms is fixed, free entry can either reverse or intensify this result.

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

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1. Introduction

At the outset of the new millennium, usage of the term "globalization" has become so extensive that it risks trivialization. Just exactly what globalization is remains the subject of endless academic and popular discussion, but no reasonable definition could ignore the leap in economic integration of the world's economies over the last few decades; for the OECD economies, the ratio of international trade to value added rose from 24.6 percent in 1960 to 42.7 percent in 1996 (OECD (1998)). Yet many observers have noted that on this metric, 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.[1]

The causes of globalization today appear to be fundamentally different, however, to those at the dawn of the last century. We are witnessing a wave of fundamental developments which are changing 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 has been the rise in outsourcing, which allows firms to extend activities across national boundaries and tailor manufacturing 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)).

A large and growing body of research confirms that the intensification of trade is best characterized as vertical rather than horizontal. Krugman (1995) points out that export to GDP ratios in the range of 30 percent can only be explained by trade involving vertical specialization. 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

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[1] See Bairoch (1989), Rodrick (1998), Williamson (1998), Baldwin/Martin (1999).

than 30 percent; he 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.[2]

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 exclude from our analysis any exogenous variation in technology.[3]

Globalization of this sort can differ considerably from that derived in models of 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] Endogenous changes in production methods, rather than low wage competition, are responsible in our model for an increase in the relative demand for skill. For further emphasis, we focus our attention on fragmentation in an integrated economy, bypassing for the moment physical trade flows to emphasize the endogeneity of production and cost structures.

The paper is organized as follows. Section 2 offers a brief review of the literature on fragmentation and trade. Section 3 proposes our model of endogenous fragmentation in an

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[2] 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)).

[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)).

[4] It has proven difficult to explain recent labor market developments in OECD countries. An overwhelming majority of studies from the perspective of both trade volumes (Sachs/Shatz (1996), Cooper (1994), but see also Wood (1994)) and prices (Lücke (1998) have found little evidence of globalization along HOS-lines). 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)).

integrated economy and illustrates the central role of the labor market in determining the resource cost of fragmentation, which we interpret as the production of business services. As the impact differs depending on whether one adopts a short-run or a long-run perspective we will distinguish between two model variants: one with a fixed number of firms and another with free entry. 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. Because the model allows for trade in differentiated final goods, it also permits the useful distinction between globalization in horizontal and vertical dimensions. While increased trade is likely to induce technological change in the form of fragmentation in the short run when the number of firms is fixed, free entry can either reverse or intensify this result. Section 5 concludes.

2. A Review of the Theoretical and Empirical Literature

A number of contributions have featured the fragmentation of production processes as a concomitant phenomenon 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 abstracts from opportunity costs of resources employed in managing the fragmented value added chain. Drawing on the examples of the photo-imaging and pharmaceutical industries, Jones/Kierzkowski (1999) describe how fragmentation allows sharing of production blocks across various industries and how indivisibilities and economies of scope can increase complementarities between horizontal linkages among industries and vertical specialization.

Francois (1990a) explicitly accounts for services and employs a family of production functions as developed by Edwards/Starr (1987) 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 demand and market size drive 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 models studying horizontal and vertical trade as globalization is the assumption of Dixit-Stiglitz (1977) "love-of-variety" preferences (Krugman (1980; 1981), Helpman (1981)). In principle, trade in these models is driven by the demand-side as well. Because consumers prefer greater variety of goods, larger markets 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) and Romer (1987).[6]

Our model 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. In our framework, labor markets segmented by skill level turn out to be crucial for integration-driven fragmentation. Business services produced with skilled labor are

[5] Krugman (1981) addresses this issue by assuming differentiated products segmented on the demand-side along industry groups.
[6] On labor market implications in particular see also Matusz (1996).

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.

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 good x_0, which 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 gives rise to the familiar demand functions

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

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

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 N differentiated manufactured goods is produced by a single monopolistically competitive firm. A central innovation in this paper is that the supplier of each variety can influence its own costs 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 a positive real number z. Since we allow for noninteger values, it is best to think of z as an index of fragmentation or 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 additional fixed costs p_zdz, so p_z is the cost of adding and managing an intermediate production stage.

Direct production costs of x units of the manufactured good consist of direct fixed costs $\overline{F}>0$ which are invariant with respect to the number of production stages z, and direct variable costs $v(z)x$ which are subadditive, so that total direct production costs for a representative firm of producing x at fragmentation z are given by $\overline{F}+v(z)x$, with $v'<0$, $v''>0$. This formulation 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 form $v(z)=\frac{\overline{v}}{z^g}$ with $0<g<\frac{1}{(h-1)}$.[9]

Total production costs for firm i are then given by

$$\overline{F}+\frac{\overline{v}}{z_i^g}x_i+p_Z z_i\,. \tag{2}$$

3.3. Optimal Firm Behavior and Partial Product Market Equilibrium

Because they deliver fundamentally different results, we distinguish two cases of partial product market equilibrium. In the first case, we assume that entry into the market for manufactures is impossible; markets are served by established firms in what might be regarded as a short-run analysis. The second case adopts a long-run perspective and assumes free entry so that all economic profits are competed away. In this section we derive the

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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 Fixed costs might also be affected by choice of z, but in the end it is relative cost differences that are crucial and these can be captured by focusing on variable costs.

9 This implies that marginal costs at z=0 are infinite, so demand for z will be strictly positive. The explicit bounds on g are necessary to prevent fragmentation from being "too efficient" in cost reduction.

generic partial product market equilibrium which we specialize later to the two different market situations.

Profits of the representative firm in manufacturing can be written as the difference between total revenues and total production costs:

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

Since firms produce differentiated goods with identical technologies, describing (partial) product market equilibrium without entry is straightforward. The i^{th} firm maximizes profit given by (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. Combining the first order conditions (not shown) with the fact that manufactured goods enter utility symmetrically and are produced under identical cost conditions, we have $p_i=p_j=p$, $x_i=x_j=x$ and $z_i=z_j=z$ for all firms i and j. For a given number of firms $\overline{N}$ it follows that

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

$$p = \left(\frac{h}{h-1} \right)^{1+g} \left(\frac{p_z \overline{N}}{gmY} \right)^{g} \overline{v} \tag{4b}$$

$$z = \frac{(h-1)gmY}{h\overline{N}p_Z} \tag{4c}$$

Equations (4a-c) convey a number of important partial equilibrium implications of cost competition in the short-run:

- production fragmentation z depends negatively on the costs of fragmentation, p_z and positively 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 now endogenous;

- the scale of the firm x depends both on aggregate income Y as well as incentives and ability of firms to reduce costs (p_z relative to Y).

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.[10]

3.4. Business Services

The partial equilibrium analysis of the last section treated the price of business services p_z as well as aggregate income Y as given. If Z is produced by profit-maximizing firms using resources with value in alternative uses, this is assumption is untenable.[11] To complete the model, it is necessary to incorporate explicitly the supply of labor to the business service sector as well as the other two productive sectors, consumer services and manufacturing production. In this way we can pin down the aggregate supply of business services Z and thereby its relative price p_z, and by extension the equilibrium extent of firm-level fragmentation z.

Irrespective of whether they involve geographical reallocation of industries, the fragmentation of production absorbs resources. This can take the form of additional coordination and communication capacities, but also middle management, sales and legal personnel. These resource requirements 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 z

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[10] 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. Alternatively, the intermediate can be thought of as the output of a manpower industry which is outsourced by manufacturing firms.

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

[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

of the representative firm 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 thus given by Nz:

$$Z = Nz \,. \tag{5}$$

Business services are supplied in quantity Z by perfectly competitive, profit-maximizing firms using skilled labor H_S and the constant returns production function

$$Z = AH_S \tag{6}$$

with A>1. The market price of business services in terms of the numeraire p_z is taken as given, so the derived demand for labor in this sector is infinitely elastic at Ap_z which will be the equilibrium wage in the economy for skilled labor.

3.5. Consumer Services

Competitive firms produce consumer services using unskilled labor with a constant returns technology

$$x_0 = L_S \tag{7}$$

so that labor demand is infinitely elastic at real product wage of unity. As with business services, the assumption that consumer services are produced primarily with low-skilled labor is driven by the fact that compensation in that sector is generally below average (OECD 1999).

3.6. Labor Market Equilibrium

Households supply labor inelastically in two forms, skilled $\overline{H}$ and unskilled $\overline{L}$. Labor markets are segmented by skill level; they are assumed to clear, and mobility between alternative uses (sectors) is costless; the demand curve for each type of labor in each sector is

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market. Our formulation is consistent with the fact that average compensation in business services is higher than in the overall economy while skill premia are on the rise (OECD 1999).

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:

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

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

where p_C is the market price of the intermediate input which comprises the direct costs to the manufacturing sector.

3.7. Closing the Model in the Short Run: No Entry

Since the general equilibrium impact of an increase in the size of the trading area depends on whether we assume free entry of firms or not, we distinguish two situations in closing the model: one in which we allow firms to make profits, and another in which a zero profit condition is imposed. We now characterize first the equilibrium outcome when the number of firms is fixed at `*N*.

To close the model we require two output market equilibrium conditions. The first concerns the market for business services (*Z*), equating demand of $\overline{N}$ firms given by (4c) and (5) to market supply given by (6)

$$\frac{(h-1)gmY}{hp_z} = AH_S \tag{10}$$

The second is that the value of demand of the direct cost input of manufacturing firms must equal production:

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

With the number of firms fixed at $\overline{N}$, (1b), (4a), (4b), (4c), (7) (8) (9) (10) (11) are nine equations in x_0, x, z, p, p_z, p_C, H_s, L_s, and Y. By virtue of its recursive structure, the model can be reduced to the following system of three equations in L_s,H_s, p_z,:

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

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

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

Since the right hand side of equation (14) represents total direct costs in manufacturing valued in terms of the numeraire, the left side can be interpreted as its division into fixed $\overline{NF}$ and equilibrium variable $\frac{(h-1)m}{h(1-m)} L_S$ components.

3.8. Closing the Model in the Long Run: Free Entry

In case of free entry, an additional zero profit condition is imposed on the system (4a-c). Profits are driven to zero by endogenous variation in product variety and the number of firms, both given by N.[13] Setting (3) to zero and substituting (4) yields the following relationship between product variety N and income Y:

$$N = \frac{[1-g(h-1)]mY}{h\overline{F}}. \tag{15}$$

It is now clear that in order for positive equilibrium market size, equation (15) requires $0 < g(h-1) < 1$, which we have already assumed above. Combining (15) with (4a-c) yields the following symmetric product market equilibrium conditions with free entry:

$$x = \left(\frac{\overline{F}(h-1)}{[1-g(h-1)]} \right)^{1+g} \left(\frac{g}{p_Z} \right)^{g} / \overline{v} \tag{16a}$$

$$p = \left(\frac{h}{h-1} \right)^{1+g} \left(\frac{[1-g(h-1)]p_Z}{gh\overline{F}} \right)^{g} \overline{v} \tag{16b}$$

$$z = \frac{(h-1)g\overline{F}}{[1-g(h-1)]p_Z} \tag{16c}$$

With free entry, partial product market equilibrium can be characterized exclusively in terms of p_z. Note now that:

- due to free entry and replication, aggregate income Y (measured in terms of the numeraire) as well as the fraction spent on manufactures by consumers, m, are irrelevant for the partial product market outcome;
- in contrast to Dixit/Stiglitz (1977) and Krugman (1980, 1981), the scale of the firm x is not constant under free entry, but depends in equilibrium on the cost of fragmentation (p_z). From (16a), x becomes constant as γ approaches 0, as in Krugman (1980, 1981);
- from (16b) the markup and thus the price of manufactured output p (in terms of consumer services) depends positively on p_z only. As γ approaches zero, the markup converges to the familiar Lerner index of monopoly power (see Lerner (1934));
- an increase in market power of the representative firm (a decline in $\boldsymbol{h}$) reduces unambiguously both the output of firms and expenditures on cost reduction.[14]
- the share of fixed and variable costs in direct costs at the optimum is constant.[15]

Under free entry, the model consists of the same system as that without entry *plus* the zero profit condition (15). As before, it can be reduced to a system of three equations in three unknowns L_s, H_s, and p_Z:

$$p_z A = \frac{f_H}{f_L} \tag{17}$$

$$\frac{(\boldsymbol{h}-1)gm}{\boldsymbol{h}(1-m)} = \frac{p_z A H_S}{L_S} \tag{18}$$

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[13] Again, we ignore integer issues here.

[14] To see this note that

$$dz/d\boldsymbol{h} = \frac{g\overline{F}[1-g(\boldsymbol{h}-1)]+(\boldsymbol{h}-1)g^2\overline{F}}{[1-g(\boldsymbol{h}-1)]^2 p_Z} = \frac{g\overline{F}}{[1-g(\boldsymbol{h}-1)]^2 p_Z} > 0.$$

[15] Inserting optimal behavior (16a) and (16c) in $\grave{}F + \overline{v}z^{-g}x$ yields $\dfrac{\boldsymbol{h}-g(\boldsymbol{h}-1)}{1-g(\boldsymbol{h}-1)}\overline{F}$.

$$\frac{[h - g(h-1)]m}{h(1-m)} = \frac{f}{L_S f_L}. \tag{19}$$

4. International Trade, Fragmentation and Globalization

4.1. Interpreting the Model in Terms of Trade and Globalization

Until now the model could be thought of as a closed economy in which fragmentation of production occurred only in the home country. However, the present model can capture international trade in two important ways. Like conventional trade approaches, the current model predicts that an enlargement of the trading area can 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 products goods or even more; *horizontal globalization* means that the representative household can augment the variety of its consumption basket via purchases of "foreign" goods.[16] 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 if determined endogenously.

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: increasing intra-industry trade increases incentives of firms to achieve higher volumes by investing in production sites and thereby economizing on variable costs; according to (5), the equilibrium effect on N is potentially indeterminate if profits are competed away because of entry. In our framework, *vertical*

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16 Admitting *only* intraindustry specialization, our framework is somewhat special; it is explicitly rigged to produce answers that are not related to the factor proportions model of trade, which has not fared well in explaining North-North trade in any case (Lücke 1998).

globalization will reflect the process by which the fragmentation of production is achieved within and across international boundaries. The distinction between deepening (vertical) and broadening (horizontal) globalization is an important one.[17]

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.[18] The next step would be to model trade explicitly and ask whether the integrated economy can be replicated as has been done in the intra-industry trade literature (see Helpman's (1984) paper 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. For the sake of simplicity, we adopt the first 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 drives an endogenous evolution of technology, which in turn affects the international division of labor.[19] There is, however, no reason to believe *a priori* that increased trade will necessarily lead to more fragmentation. In fact, our model suggests that while fragmentation increases in the short run, it could be reversed in the long run as firms face competition from newly entering firms. In the next section we explore formally in a

[17]This paper thus extends the analysis of Krugman's (1980), who seems to be arguing that scale effects are impossible in a constant elasticity world (p. 200). In our model, optimal scale can differ across different zero profit equilibria as firms "economize" on variable costs to varying degrees.
[18]This is in line with the widely-held view that intensifying trade has resulted from declining trade barriers (see Wood 1994).
[19] This possibility has been discussed in the context of outsourcing by Feenstra (1998).

comparative statics analysis the conditions under which a larger trading area in the integrated economy will increase the degree of fragmentation of the representative firm, z.

4.2. The Effects of an Enlarged Trading Area: No Entry

As emphasized in Section 3.3, a variable of central importance to the model economy is the price of business services – the market price of fragmentation p_Z. From equations (4a)-(4c), it determines the degree of vertical versus horizontal globalization via its influence on the demand for fragmentation at the individual firm level (z), the relative price of manufactured goods (p) and the optimal scale (x). In general equilibrium, it will be influenced by the technology of business services as well as the opportunity cost of skilled labor in the manufacturing sector, and will thus depend on elasticities of substitution and employment opportunities of *unskilled* labor, too. Only with the help of formal comparative statics analysis is it possible to show under which conditions globalization of production related to fragmentation increases due to an increase in the size of the trading area only.

We model the enlargement of markets as an exogenous increase in factors of production: $\hat{H} > 0, \hat{L} = w\hat{H}$ with $w \geq 0$. The case of $w = 1$ 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 s and w 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 ($dN > 0$). Naturally, 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.

Using notation familiar from Jones (1965), we let l_{ij} be the share of labor input i Î {*high-skilled (H), low-skilled (L)*} employed in j Î {*production (P),services (S)*}, let q_{ij} be the elasticity of f with respect to i (with $q_{HP}+q_{LP}=1$) and the local elasticity of substitution of f

as $s \equiv \frac{f_L f_H}{f_{HL} f}$. Denoting percentage changes in variable by carats (e.g. $\hat{x}$ for d*x*/*x*), we obtain by log-differentiating (12), (13), and (14) the following system of three equations in $\hat{L}_S$, $\hat{H}_S$, and $\hat{p}_Z$ for a given number of firms in manufacturing:[20]

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

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

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

Equation (20) expresses the evolution of three central variables – unskilled employment in consumer services, skilled employment in business 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. To repeat, the skill composition of this market enlargement is parameterized by w: if $w = 0$, the trading area experiences an increase of skilled labor only; $w = 1$ corresponds to the case of an equiproportional increase in both factor endowments; $w > 1$ represents the case in which proportional growth in the supply of unskilled labor exceeds that of skilled workers.

Solution of the model involves a straightforward application of Cramer's Rule to (20). It is necessary to establish the sign of the determinant Δ_N, which is given by

$$\Delta_N = -\frac{s}{l_{HP} l_{LP}} \left\{ \begin{aligned} &(1-l_{LP})(1-l_{HP}) + s q_{HP}(1-l_{HP}) l_{LP} + (S-q_{HP})(1-l_{HP}) l_{LP} \\ &+ l_{HP}(1-l_{LP})\left[q_{HP} + s(1-q_{HP})\right] + l_{HP} l_{LP} Ss \end{aligned} \right\} \tag{21}$$

[20] Details on these and other derivations in this paper can be found in an appendix available from the authors.

While not unambiguous, the determinant is almost surely negative. One sufficient condition for Δ_N<0 is that the share of variable costs in direct manufacturing is sufficiently high, or $S>q_{HP}$. Another is $(s-1)(l_{LP}-l_{HP})\geq 0$, which is fulfilled if direct manufacturing is skill-intensive *and* substitution between skilled and unskilled labor is limited. The necessary and sufficient condition can be expressed as

$$S>\frac{q_{HP}(l_{HP}-l_{LP})(s-1)-(1-l_{LP})[(1-l_{HP})+l_{HP}s]}{(1-l_{HP})l_{LP}+s\,l_{HP}\,l_{LP}} \tag{22}$$

which is likely to hold for conventional parameter values, even for small s. The intuition is that incentives to rationalize (substitute fixed for variable costs) as measured by S (the share of variable in total costs) must be sufficiently large. For the rest of the paper we will assume that this condition holds.

Skilled and Unskilled Employment in Services

The response of employment in the two service sectors to an expansion of size of the trading area (as parametrized by the endowment of inelastically supplied labor) is of central importance in this model. Equilibrium fragmentation will depend on how labor markets allocate labor to alternative uses; in particular, on how much high skilled labor is employed by the business services sector.

The log differential change in employment of low-skilled labor in services ($\hat{L}_S$) obeys:

$$\hat{L}_S=-\frac{w(1-l_{HP})+[l_{LP}q_{HP}(s-1)+[q_{HP}+(1-q_{HP})s]w\,l_{HP}]}{l_{LP}\,l_{HP}\Delta_N}s\hat{\bar{H}} \tag{23}$$

so a sufficient condition for positive $\hat{L}_S$ is $s\geq 1$. The necessary and sufficient condition is

$$s>1-\frac{w}{l_{LP}q_{HP}+w\,l_{HP}(1-q_{HP})} \tag{24}$$

which is met for plausibly small s and w. For example, any w fulfilling $w > \frac{l_{LP} q_{HP}}{1 - l_{HP}(1 - q_{HP})}$ will work for all admissible values of s.

The logarithmic change in high skilled employment in business services is given by

$$\hat{H}_S = -\frac{l_{LP}\left[q_{HP}(s-1)+S\right]+\left[(1-q_{HP})s+q_{HP}-S\right]w l_{HP}+(1-l_{LP})}{\Delta_N l_{LP} l_{HP}} s\hat{\bar{H}}$$

$$= \frac{-s}{l_{LP} l_{HP} \Delta_N}\left[\left[(1-l_{LP})+l_{LP}s\right]+(l_{LP}-w l_{HP})\left[S-(1-q_{HP})s-q_{HP}\right]\right]\hat{\bar{H}} \tag{25}$$

The necessary and sufficient condition on s for positive $\hat{H}_S$ is

$$s > 1 - \frac{S l_{LP} + (1-S) w l_{HP} + (1-l_{LP})}{\left[l_{LP} q_{HP} + (1-q_{HP}) w l_{HP}\right]} \tag{26}$$

which is met even for some large values of w, i.e. for some $w > \frac{l_{LP}}{l_{HP}}$.

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 (the Cobb-Douglas case).

Fragmentation and Market Price of Business Services

With the number of firms fixed, the extent of firm-level fragmentation (vertical globalization) can be derived directly from aggregate fragmentation ($z = Z/\bar{N}$). Since $Z=AH_S$, firm-level fragmentation increases in response to an expansion of the trading area as long as H_S increases, the conditions for which were established above. Equivalently, inspection of (4c) reveals that the necessary and sufficient condition for firm-level vertical globalization is $\hat{Y} > \hat{p}_Z$ or, since $L_S=(1-m)Y$, $\hat{L}_S > \hat{p}_z$. Thus, in the short run it is possible for the price of fragmentation to rise even while fragmentation at the level of the firm is increasing. The comparative statics result for $\hat{p}_z$ is

$$\hat{p}_z = -\frac{(w\,l_{HP} - l_{LP})S - (1 - l_{LP}) + w(1 - l_{HP})}{l_{LP}\,l_{HP}\Delta_N}\,s\hat{\bar{H}} \qquad (27)$$

To sign (27) unambiguously, it is convenient to express parameter restrictions in terms of *w*. With $\Delta_N<0$, the price of fragmentation will rise in short-run equilibrium without entry if and only if

$$w > \frac{1 - l_{LP}(1-S)}{1 - l_{HP}(1-S)} \qquad (28)$$

It is worth remarking that if both conditions (26) and (28) are met, an increase in the trading area not only leads 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.[21] This result stands in contrast to the usual Heckscher-Ohlin logic, since a relative increase in the world supply of skilled labor ($w<1$) 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.

4.3. The Effects of an Enlarged Trading Area: Free Entry

In the long run, the existence of economic profits or losses induces entry or exit from the industry. Log-differentiating the system of equations (17), (18), (19) we obtain the following system, in matrix form, setting $\hat{A} = 0$:

[21] 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).

$$\begin{bmatrix} -\frac{(1-l_{LP})}{l_{LP}} & \frac{(1-l_{HP})}{l_{HP}} & -s \\ 1 & -1 & -1 \\ s+\frac{(1-l_{LP})}{l_{LP}}[q_{HP}+(1-q_{HP})s] & -(1-s)q_{HP}\frac{(1-l_{HP})}{l_{HP}} & 0 \end{bmatrix}\begin{bmatrix} \hat{L}_S \\ \hat{H}_S \\ \hat{p}_z \end{bmatrix} = \begin{bmatrix} -\left(\frac{wl_{HP}-l_{LP}}{l_{LP}l_{HP}}\right) \\ 0 \\ \frac{l_{LP}q_{HP}(s-1)+[(1-q_{HP})s+q_{HP}]wl_{HP}}{l_{LP}l_{HP}} \end{bmatrix}\hat{\bar{H}} \tag{29}$$

Again we can calculate equilibrium changes of our three central variables. Note that the determinant of the matrix in (29), Δ_F, is now given by

$$\Delta_F = -\frac{s}{l_{HP}l_{LP}}\left\{\begin{matrix}(1-l_{LP})(1-l_{HP})+sq_{HP}(1-l_{HP})l_{LP}+(1-q_{HP})(1-l_{HP})l_{LP} \\ +l_{HP}(1-l_{LP})[q_{HP}+s(1-q_{HP})]+l_{HP}l_{LP}s\end{matrix}\right\} \tag{30}$$

which is unambiguously negative.

Skilled and Unskilled Services Employment

With free entry of firms in manufacturing, the evolution of employment of low-skilled workers in services $\hat{L}_S$ is given by :

$$\hat{L}_S = -\frac{w(1-l_{HP})+[l_{LP}q_{HP}(s-1)+[q_{HP}+(1-q_{HP})s]wl_{HP}]}{l_{LP}l_{HP}\Delta_F}s\hat{\bar{H}} \tag{31}$$

which differs from the short run (no-entry) outcome only due to different values Δ in the denominator. Since the determinant is larger in the free entry case, the increase in consumer services is unambiguously smaller in the long run than in the short run.

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 $\hat{Z} = \hat{H}_S$), and can be derived as

$$\hat{H}_S = \frac{-s}{l_{LP}\, l_{HP} \Delta_F}\left[(1-l_{LP}) + l_{LP} s + (l_{LP} - w l_{HP})(1-q_{HP})(1-s)\right]\hat{\bar{H}} \tag{32}$$

For an enlargement of the trading area to induce an increase in aggregate business services employment and output, it is sufficient that $(l_{LP} - w l_{HP})(1-s) > 0$. Given $\Delta_F < 0$, a necessary and sufficient condition on s is[22]

$$s > \frac{l_{LP} q_{HP} + w l_{HP}(1-q_{HP}) - 1}{[l_{LP} q_{HP} + w l_{HP}(1-q_{HP})]} = 1 - \frac{1}{l_{LP} q_{HP} + w l_{HP}(1-q_{HP})}$$

which is strictly less than unity.

A comparison of necessary and sufficient conditions for no-entry (S<1) versus free-entry versions (S=1) of the model is illuminating. For growth in business services employment in the short run, it is sufficient for $s > 1 - \frac{l_{LP} S + (1-S) w l_{HP} + (1-l_{LP})}{[l_{LP} q_{HP} + (1-q_{HP}) w l_{HP}]}$, so the restriction is stricter in the long run if $l_{LP} S + (1-S) w l_{HP} + (1-l_{LP}) > 1$ or $w > l_{LP} / l_{HP}$, i.e. if the relative increase in endowments exceeds the ratio of low- to high-skilled employees in direct manufacturing. Put somewhat differently, the sign of $\partial \hat{H}_S / \partial S$ in the no-entry case assumes the sign of $w l_{HP} - l_{LP}$.

To summarize the effects of the market size on employment: an increase in factor endowments expands unskilled service employment if the endowment of low skilled workers increases sufficiently. The interval of s for which *both* L_s and H_s increase under free entry is given by $\left]\max\left(1 - \frac{\min(w,1)}{l_{LP} q_{HP} + (1-q_{HP}) w l_{HP}}, 0\right), \infty\right]$. which includes the Cobb-Douglas case, and if w is not too small, also includes values less than unity usually estimated in the manufacturing sector (see Hamermesh 1993).

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[22] The analogous condition on w: $w < \frac{1-(1-s)\, l_{LP} q_{HP}}{l_{HP}(1-q_{HP})}$

Market Price of Business Services and Fragmentation

The relative price of business services p_Z – the price of coordinating fragmented production processes – is a central variable of interest. If p_Z declines in the long run, then the representative firm will have a larger scale of production and be more globalized.

$$\hat{p}_z = -\frac{(w-1)}{l_{LP}\, l_{HP}\Delta_F} s\hat{\hat{H}} \tag{33}$$

Thus in the long run a necessary and sufficient condition for an increase in firm-level fragmentation is $w < 1$. If $w > 1$, the long run is characterized by an increase in the price of and a decrease in the extent of 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 outstripped by that of high skilled workers. In the short run, in contrast, fragmentation may occur with an increase in wage inequality as well as an increase in skill intensity in manufacturing. From (26) and (33) one 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.

5. Conclusions

The objectives of this paper were twofold: first, to model general equilibrium implications of cost competition and fragmentation in a monopolistic competition environment, and second, to determine whether trade could explain recent global trends in fragmentation and apparent skill bias in domestic labor markets. In the model studied here, trade and fragmentation are driven by the size of the market. Increased openness puts pressure on firms to cut costs, and as different production techniques are associated with different cost structures, firms in fact compete by choice of production method. The result may be a finer vertical division of labor and outsourcing similar to that observed in the process of globalization.

The model suggests that the impact on fragmentation crucially depends on the time horizon one adopts. When the number of firms is constant, the removal of barriers to trade and mobility clearly induces firms to use more fragmented production structures. This is because total value added endogenously increases by more than the market price for business services. If the expansion of the trading area is sufficiently biased towards unskilled labor, the process of globalization of production may be associated with bimodal growth in high- and low-skilled employment in services. In stressing cost competition, our model thus offers a potential trade explanation for 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. However, in a long-run perspective characterized by free entry, these can be either reversed or intensified, depending on the change in relative factor supplies.

The model lends itself to a number of extensions, including a more thorough investigation of the effect of trade on wages.[23] A role for diminishing returns in services was ruled out in this paper, yet may be an aggravating factor in creating income inequality. Overall, the possibility that technological change in the process of globalization is in part 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. 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).

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

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