A Framework For Fragmentation

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1. Introduction

In current discussions of *globalization*, focus has been placed on the increased freedom of international trade in goods and services, as well as greater mobility of financial assets. However, recent patterns of globalization have exhibited a further phenomenon, *viz.* the role of advances in technology and lowered costs of services in fostering a *fragmentation* of vertically integrated production processes into separate segments that may enter international trade. The production of automobiles in most countries now makes use of components such as tires made by French or Italian producers, injection systems produced in Germany, computer chips manufactured in Malaysia, with software developed in the United States. Plunging international costs of telecommunication and developments of FAX and internet technology have allowed the production process to be widespread on a global basis with much less attention paid to national boundaries.

If the term fragmentation suggests destruction, it is creative destruction in the Schumpeterian tradition. Breaking down the integrated process into separate stages of production opens up new possibilities for exploiting gains from specialization. Although such fragmentation is likely to occur first on a local or national basis, significant cuts in costs of international co-ordination often allow producers to take advantage of differences in technologies and factor prices among countries in designing more global production networks.

A number of authors have investigated various aspects of fragmentation, often using their own framework and terminology. In a series of articles Sven Arndt (1996, 1997a, 1997b) has shown how intra-product specialization can be trade-enhancing and welfare improving. Richard Harris (1993, 1995), on the other hand, concentrated on the role of tele-communications in establishing a new production paradigm. Alan Deardorff (1997) has investigated a two-country model in order to focus upon the determination of international prices in a setting in which production processes get fragmented. Gordon Hanson (1996) has illustrated the fragmentation phenomenon in the case of Mexico and its closer association with production in the United States.[1] Our discussion in the present paper builds upon our two earlier analyses of international fragmentation (1990, 1998), focussing upon the importance of service links in connecting fragmented production blocks.

The next section of this paper probes the fundamentals of the fragmentation process and how prices may adjust in global markets. The key role of services and the importance of increasing returns are highlighted in section 3. Section 4 explores in more detail possible causes of the increased degree of fragmentation now observed in world markets. A phenomenon of utmost interest in current policy debates is the effect of globalization on the distribution of income within a country, especially in the United States. Section 5 investigates the connection between fragmentation and wage rates for less skilled workers. The final section of the paper suggests various further consequences of the fragmentation phenomenon, especially as regards the changing nature of markets in the global economy.

2. Fundamentals of Fragmentation

The term, "fragmentation", refers to a splitting up of a previously integrated production process into two or more components, or "fragments". As we detail in the next section, such fragmentation is made possible by utilizing activities from the "service" sector. Here we focus more intensively on a simple characterization of the process when fragmentation takes place at the international level. Consider the technology exhibited in Figure 1. For an economy in an initial equilibrium, with commodity prices given by world markets

[1] Further contributions to the literature are found in Cairncross (1997), Borrus and Zysman (1997), Borrus (1997), Zysman, Doherty and Schwartz (1996), Davis and Meyer (1998), and Feenstra (1998).

and factor prices determined by the country's technology, endowments, and world commodity prices, suppose that internationally-traded commodity *I* is produced with rigid input coefficients of two factors, say capital and labor. Point *I* indicates the factor input bundle required to produce $1 worth of this integrated good at the going prices. Assume that production requires a combination of two segments. Points *a* and *b* illustrate the fixed input requirements for these segments, and their vector summation must be reflected in point *I*. In the initial situation the production process and conditions of trade do not allow an actual split of *I* into these two parts. There is no market price for each component, but the costs of these segments can be obtained by the presumed fixed input/output coefficients and the equilibrium values of the wage rate and return to capital. Thus points *A* and *B*, lying on the line whose slope is given by the initial factor price ratio (- w/r), show amounts of capital and labor for each segment that would add up exactly to $1. The appropriate weights for *A* and *B* in *I* would then be reflected in their share of costs in the integrated activity.

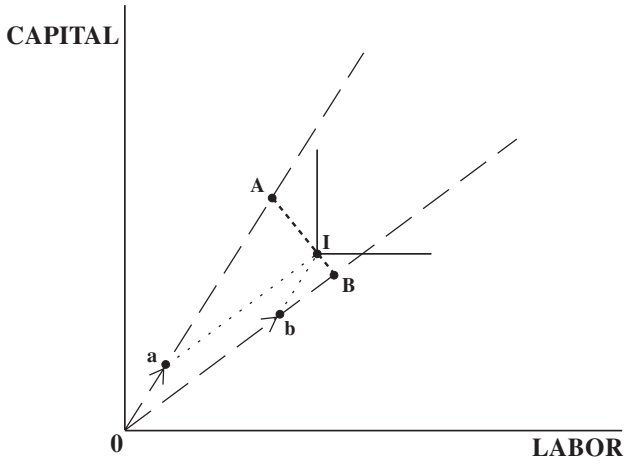

Figure 1

With fragmentation it becomes possible to trade directly in the separate segments. To simplify, we assume away here the explicit costs involved in breaking down a vertical link as well as any costs involved in assembling components *a* and *b*. If such assembly costs were to be considered, there would in effect be a tripartite fragmentation of the production process. In the spirit of much of classical trade theory, we limit the number of such fragments to two.

It is to be expected that the process of fragmentation could involve a disturbance to factor and commodity markets. We are particularly interested in the scenario in which the separate components can be traded on world markets, so that new, now explicit, *world* prices are determined. As a rough first guide it might be thought that world prices for each of the segments would fall, a reflection of the greater degree of international competition and possibilities for specialization according to Ricardian comparative advantage as, in effect, the number of tradeable items becomes larger. Assuming that physical input/output coefficients remain unaltered, a fal1 in the world price of *A*, compared to its initial imputed value at home, would be shown in Figure 1 by a movement of *A* along the ray further from the origin, because it would now take a greater quantity of each factor to earn $1 on world markets. Of course it might be the case that this country is especially good at producing fragment *A* relative to other countries so that, when international fragmentation occurs, the price of *A* is driven up beyond the imputed price (or cost) of *A* in this country's pre-trade state. Whatever the comparison of autarky and trade prices for the separate sections, we assume that the greater degree of Ricardian specialization reflecting comparative advantage in these separate fragments leads to a world price for the final commodity that falls short of its price before fragmentation. Thus in Figure 2 a ray from the origin through point *I* would hit the chord connecting the amounts of labor and capital required to produce $1 worth of the two fragments at the newly established world prices at point *I′*, lying northeast of *I*. The ratio *II′/0I* would reveal the consequent relative fall in the world price of obtaining a unit of the final integrated commodity.

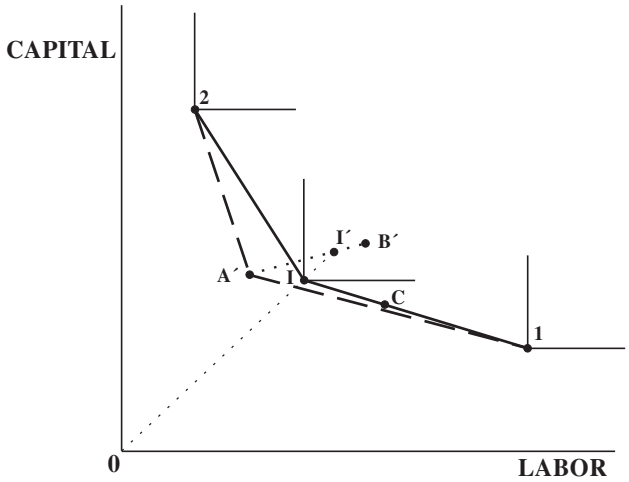

Figure 2

The Hicksian composite unit-value Isoquant for this country, such as depicted in Figure 2, serves to illustrate the possible patterns of production and factor prices before and after fragmentation. Given world prices in the initial state for commodities *1, 2* and *I*, and assuming fixed input coefficients throughout, suppose the unit-value Isoquant for these three commodities are as shown in Figure 2, with the connecting chords outlining the original Hicksian composite unit-value

Isoquant. Thus if the country's endowments are not extreme, it will originally be producing commodity *I* and commodity *1*, or *I* and *2*. (We do not consider the possibility that the country could produce only commodity 1 or commodity 2, with resulting losses in employment for capital or for labor). Also illustrated are points *A′* and *B′*, which take into account the new world prices for post-fragmentation individual segments which can now enter trade. As drawn, for this country it is no longer possible to produce fragment *B′*. There must be some one or more countries, however, whose technology in producing *B* is sufficiently superior so that for such a country point *B′* lies on *its* Hicksian unit-value composite Isoquant.

In thinking about the possible overall welfare improvement for this country as a consequence of international fragmentation, note that the new Hicksian composite Isoquant is superior to the old. This would be a probable consequence of fragmentation if the world price of a composite bundle appropriate to assembling *I* had not changed. Such a result follows because of the convexity of the original composite Isoquant and the fact that with *I* a positive convex combination of the two fragments, at least one of them must lie closer to the origin (than the original composite) by a finite amount.[2] Is this enough to guarantee that the country as a whole benefits from fragmentation? Yes, if prices of other traded goods are not disturbed (as assumed in Figure 2). However, in general with a realignment of all traded goods prices as a consequence of fragmentation, it might be the case that a country's terms of trade could sufficiently worsen so that it is made worse off.

Not considered in Figure 2 is the possibility that price falls for both fragments *A* and *B* could suffice to make it impossible for this country to produce either fragment even if initially its production pattern was heavily concentrated in commodity *I*. (That is, the country's endowment ray would pass close to point *I*.) Such a possibility is illustrated in Figure 3. In Jones and Kierzkowski (1998) the analogy is made of such a scenario with that of an Olympic gold winner in a mixed event, such as the decathlon, who might return with no medals if the integrated event were to be broken down into separate components. What is revealed is that being an effective competitor in an integrated event may result from productivity in each of the separate fragments being neither very high nor very low, but that potential rivals exist which are superior in particular fragments, only to be dragged down by low productivities in the remaining ones. In school the valedictorian may have a uniform A- average in all subjects, even though there are one or more others in the class who have received A+'s in each of the subjects but have earned only C's in others. A finer degree of specialization is possible with fragmentation, and this serves to reward those countries that are particularly good at producing some fragment, but whose superiority is not of such a caliber in others. Fragmentation allows a greater scope for application of Ricardian comparative advantage.

Must the country which is illustrated in Figure 3 be made worse off by fragmentation? The Hicksian unit-value Isoquant, which after fragmentation is clearly inferior, does not tell the whole story. The country's consumers may be heavily biased in their tastes for commodity *I*, and price falls in the components after fragmentation may more than offset the welfare effects of moving to the more limited Hicksian composite Isoquant.

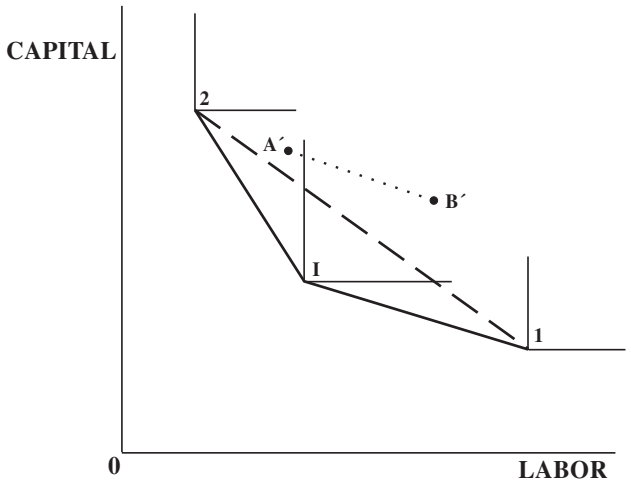

Figure 3

International fragmentation results in a realignment of production patterns among countries. Emphasized above is the possibility that the technological performance of inputs in various countries differs (as would be reflected in different Hicksian Isoquant), leading to a Ricardian emphasis on technology and comparative advantage. But Heckscher-Ohlin elements are also involved. Although Figures 2 and 3 are somewhat limited in showing only three commodities producible (prior to fragmentation), they suffice to suggest that relatively capital abundant countries will produce commodities *2* and *I* and relatively labor abundant countries commodities *1* and *I*. Ricardian comparisons are useful in differentiating among the shapes of the Hicksian composite Isoquant among countries, and Heckscher-Ohlin distinctions about endowment proportions indicate which portions of the

[2] Indeed, even if commodity *I* originally lies *within* the Hicksian composite unit-value Isoquant (so that *I* cannot be produced by this country), after fragmentation a segment such as *A'*could lie *on* the new Isoquant. An exception could be shown in Figure 2 if final commodity *I* was produced (along with the first commodity) as well as another commodity, *C*, and it was commodity *C* that was fragmented instead of commodity *I*. It might be the case that the fragments at the new world prices would lie *along* the *I1* linear segment.

Hicksian composite are relevant for a country's production. Later we shall indicate a role for the specific-factors model in the analysis of fragmentation.

We have so far established that a combination of Ricardian and Heckscher-Ohlin models can be very illuminating in explaining the phenomenon of production fragmentation and its effects on wages and other factor prices. But it is quite pertinent to ask whether another theoretical framework may not be better suited to explain the emergence of international production networks. In particular, imperfect competition could possibly provide a more realistic description and explanation of international fragmentation. It is possible to build a model of fragmentation based on imperfect competition. Indeed, the paper by Richard Harris in this volume does so in an elegant manner. However, it is hard to say whether international fragmentation of production is driven by imperfect competition ***per se***. We leave this question open hoping for an answer to come out of future empirical research and case studies. Does Nike's reallocation of sports shoe production to Malaysia require an imperfect competition model or is the old Ricardian Framework stressing productivity and wage differences across nations powerful enough to explain what is going on? Similarly, US-Mexico outsourcing in the textile industry may also be based mainly on wage/productivity differentials and a perfect competition model seems a reasonable choice in this case. Of course, computer and pharmaceutical industries could hardly be assumed to be competitive. Without in-depth case studies the question cannot be unanswered categorically.

As detailed in section 3, although increasing returns to scale and imperfect competition may or may not be relevant in modeling ***production blocks*** they appear to be crucial in ***service links***. For modeling purposes, we will assume the existence of only fixed costs in production of services connecting various stages of production. The development of the Internet comes close to justifying our assumption. The analysis of other services such as insurance, banking, transportation and coordination could rely on a monopolistic competition or oligopolistic framework.

3. The Role of Services in Fragmentation

In the Uruguay round of talks leading up to the creation of the World Trade Organization much attention was paid to the possibility of bringing services under the rubric of international agreements to liberalize trade. In Jones and Kierzkowski (1990) we suggested how integrated production processes could be characterized by a series of production blocks which are connected by various service links. The notion whereby a larger scale of output can result in a finer division of labor, promulgated two centuries ago by Adam Smith, is essential in our discussion of the role of services such as transportation, communication, and co-ordination in linking increasingly fragmented production blocks and reducing average costs.

We do not deny the importance of service activities within a simple production block since inputs have to be organized, supervised, and coordinated before production can take place. The role of services is further emphasized when more than one production block is involved, because these blocks must be linked to generate efficient output. It is this kind of service link which we wish to emphasize. We propose to accept two stylized facts about the costs of these service links: First, purely domestic service links are less costly than those required to connect production blocks located in more than one country. This could readily be the case for all individual services, but here we only assume such a cost disparity characterizes aggregate service links. Second, production of services displays strong increasing returns to scale. Indeed, we would argue that such economies of scale are more likely to be found in service activities than within production blocks.

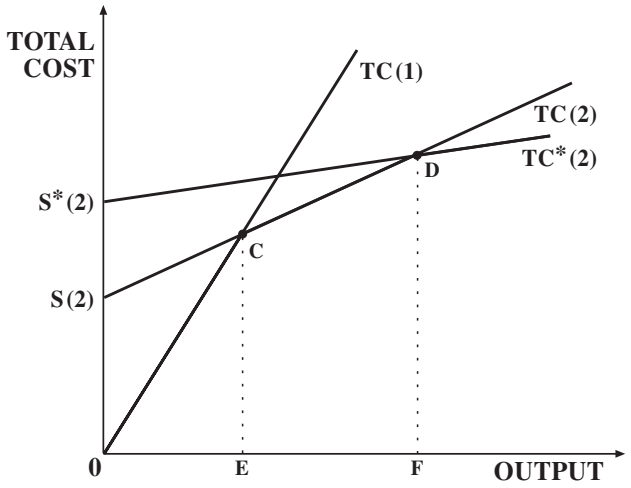

Figure 4

This pair of stylized facts is taken to extremes in our subsequent diagrammatic treatment whereby production blocks exhibit constant returns to scale (as in Figures 1 - 3) and service links involve only constant fixed costs and zero variable costs. In Figure 4 ray TC(1) represents total costs within a simple production block. Also portrayed are two possible cost configurations: TC(2) integrates two domestic production blocks, with vertical intercept measuring the constant service costs of such integration, whereas TC*(2) reflects costs for a production process combining one domestic production block with one foreign production block. The country assignment is dictated by considerations of Ricardian comparative advantage, and/or Heckscher-Ohlin

type of matching factor-intensity rankings with relative cheapness of factors. Our assumptions are reflected in the higher service costs ,OS*(2), associated with fragmentation in the international arena and the linearity of the cost functions. Also illustrated in Figure 4 is that intersection point *D* lies to the right of intersection point *C*. This is consistent with the following scenario to describe the production process as industry output expands from low levels. At first a single block is the most efficient way in which to organize production. When scale of output OE is reached, further expansion of output entails a switch to (domestically) fragmented production with costs given by the TC(2) schedule. However, after output level OF is attained, it pays to bring a foreign production block into the process; although this involves higher costs of the service links, the lower marginal costs of production reflected in TC*(2) make this route more efficient. An alternative route would entail switching to international linkages at an earlier stage, dispensing with larger-scale purely domestic operations - this would require point *D* to lie to the left of point *C*. Not illustrated in Figure 4 is an extension of the argument to greater levels of output and switches to more production blocks perhaps involving several countries and higher costs of service links.

This focus on the theory of international fragmentation of production fits well with concerns about the role of geography in explaining trade patterns. Indeed, international fragmentation of production **is** about geography. Our basic premise is that geographic parameters defining a firm are not fixed and reduced to a dimensionless point in a dimensionless country. Technological advances reduce distance separating different regions, be they home or abroad. With the death of distance, the geographic scope for modeling and organizing production processes expands. This expansion may start at home, but when it moves across national borders a new type of international trade is created. Unlike the emphasis in the current literature on geography and trade, we predict that the death of distance will not only create trade in final goods but also trade in parts, components, and producer goods.

4. Causes of Fragmentation

In the preceding account of fragmentation we assumed that some change takes place "off- stage" to allow fragments of a production process to be marketed separately whereas previously they had to be integrated with only the final product traded on world markets. Technical progress in the service sectors is perhaps the most obvious candidate. Tales abound of the fantastic reduction in the cost of international telephone calls, of reductions in transport costs and the availability of internet connections, of much greater ease and lower costs of making banking transactions, all of which make coordination of production blocks in various locations around the globe feasible.[3] As well, increased knowledge of other cultures and laws is important. In arranging arms-length transactions between countries it helps to know what legal procedures to follow in case the conditions of a contract are not met. Assurances of reliability in timing of shipments is essential if fragmentation at the global level is to be achieved.

We have argued that economies of scale in service activities can be quite pronounced. Significant set-up or fixed costs coupled with low marginal costs typify many of the service links required to support fragmentation. As a consequence, sheer growth in economic activity serves to induce higher levels of networking on a global basis. Furthermore, in many countries there has been a tendency to loosen the degree of governmental regulation domestically of service activities. In the United States, for example, airline deregulation and greater competition in telecommunications have altered the costs of business organization.

At the international level the efforts to liberalize barriers to service trade can be expected to encourage the tendency towards greater fragmentation of economic activity, and this for several reasons. If a country can for the first time obtain such services from the international market without governmental obstruction, costs of service links are obviously reduced. But more is involved. Liberalization encourages both an increase in scale of activity and an increase in the degree of market competition in the service industries. As the experience in telecommunications in the United States and Europe is revealing, greater competition induces reductions in cost.

5. Fragmentation and Income Distribution

International fragmentation of economic activity is a phenomenon associated with globalization, and in both the United States and Europe fears have been expressed in voluble tones as to the unsettling effect on the distribution of income of such trends in world production and trade. In particular, the criticism is often voiced that for such advanced countries globalization poses a threat to unskilled labor, either in the form of lower real wages or (especially in Europe) of higher levels of unemployment.

Figure 2 can usefully be harnessed to display some of the possibilities for income distribution associated with fragmentation. Think of the two categories of inputs as an amalgam of physical and human capital on the vertical axis

[3] Australia has in the past decades produced a series of notable films. It has also been host to the production end of some films co-ordinated from Hollywood. Such fragmentation has recently been further encouraged since internet transmissions have obviated the need to fly rushes from Australia to California.

and unskilled labor on the horizontal. Start by considering the situation of a country which is relatively unskilled labor-abundant in the specific sense of having an endowment ray in Figure 2 passing south-east of point *I* (and allowing production of commodities *I* and *1*). As already discussed, fragmentation for a country such as this involves the loss to global competition of the labor-intensive fragment, *B′*. It is just such a loss which prompts observers to fear that fragmentation induces a fall in the level of real wages for the unskilled, as is apparent from the lower slope of *A′1* (compared with *I1*), coupled with the magnification effect standard in Heckscher-Ohlin theory. The reasoning, as expounded in Jones and Kierzkowski (1998), is that for such a country fragmentation is like technical progress in the capital-intensive sector of the economy since at initial factor prices point *A'* represents an improvement over point *I*.

However reasonable it sounds to suggest that should a country lose the labor-intensive fragment of production to foreign competition, real wages will suffer, this need not be the outcome. Consider the case of a country whose endowment ray cuts the chord connecting 2 with *A′* in Figure 2. In such a country fragmentation has resulted in an *increase* in the real wage for unskilled workers. Indeed, it is easily seen that the level of employment of unskilled workers in the surviving capital-intensive fragment, *A′*, is even higher than originally found in the integrated activity *I*. Note that compared with the previous case considered, it is precisely a relatively capital-abundant country that has less to fear from losses of labor-intensive fragments to world markets.

Referring once again to Figure 2, the fate of a country whose endowment ray lies within a cone defined by rays OA' and OI is difficult to reconcile with standard Heckscher-Ohlin logic. Such a country initially produces commodities *2* and *I*, and fragmentation that results in the loss of segment *B′* but retention of fragment *A′* is akin to technical progress in the country's labor-intensive activity. Nonetheless, its real wage falls. The problem is that standard Heckscher-Ohlin logic applies to small changes in technology, whereas the process of fragmentation is definitely not a marginal phenomenon. Figure 5 (based on the analysis in Findlay and Jones (1998)) helps to clarify the issue. The solid locus illustrates the connection between endowments and relative factor prices in the initial pre-fragmentation state. The economy we are considering has endowment proportions shown by point *k*, with a wage/rent-ratio shown by point *D*, producing commodities *2* and *I*. The dashed locus in Figure 5 reveals that fragmentation of the type shown in Figure 2 is like technical progress that has a labor-saving bias. (The vertical dashed section labeled *A′* in Figure 5 lies to the right of the original stretch labeled *I*, since activity *A′* in Figure 2 is capital-intensive relative to *I*.) For marginal changes it is standard in trade theory to argue that bias does not matter. But clearly in Figure 5 this is no longer the case for finite changes, of the type expected with fragmentation. The shift is from point *D* in Figure 5 to point *E*.

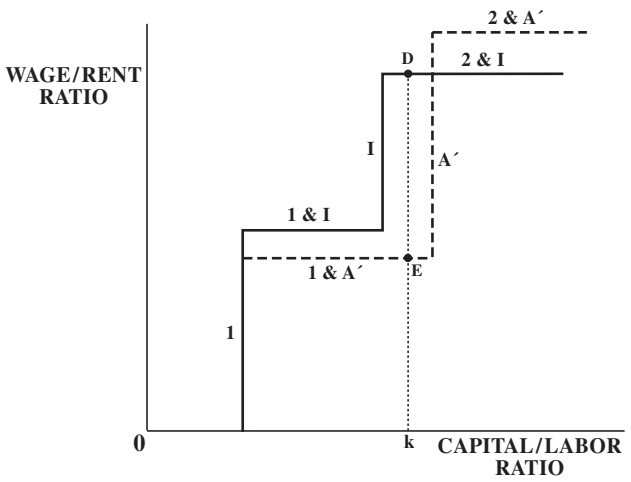

Figure 5

The example illustrated above, wherein the loss of a labor-intensive segment results in a drop in unskilled wages only for relatively labor-abundant countries, does not generalize to all cases. (Several others are discussed in Jones and Kierzkowski (1998)). For example, in Figure 3 a relatively capital abundant country, producing commodities 2 and *I*, would suffer a loss in the real wage of unskilled workers with fragmentation, but workers in more labor-abundant countries would gain. The purpose of the argument here is not to dispute the wisdom of the observation that losses of labor-intensive activities to other countries in trade spells trouble for unskilled labor, but to suggest that this is not always the case. The issue of the effects of international fragmentation on the distribution of income is more subtle than popular discourse suggests.

As a final exercise we utilize Figures 6 and 7 to discuss the possible effects of fragmentation when two countries share the same technology.[4] In both diagrams the relatively labor-abundant country initially produces commodities *1* and *I*, with its wage/rental ratio shown by the slope of the chord connecting Isoquant corners *I* and *1*, while the relatively capital-abundant country produces *2* and *I* at a higher wage/rental ratio. The capital-abundant country initially produces *I* as a convex combination of (non-traded) fragments *A′* and *B*, whereas the labor-abundant country produces *I* facing relatively lower wage rates with fragments *A* and *B′*. In addition, in Figure 6 each country produces a number of other commodities, with world prices reflective of that country's factor-price ratio as well as the commonly-shared technology. After fragmentation each country produces

[4] This is the focus of the related paper by Alan Deardorff (1998), to whom we are indebted for stimulating conversations on this topic.

one segment of the vertical process for producing *I*: *A′* in the capital-abundant country and *B′* in the labor-abundant country, assuming factor prices remain undisturbed in each country. The cost saving involved for these fragmented economies is, in relative terms, shown by II′/0I. Note that the wider the "fragmentation cone", C_F, the greater will be this savings in cost as fragmentation takes advantage of the factor-price discrepancy between countries.

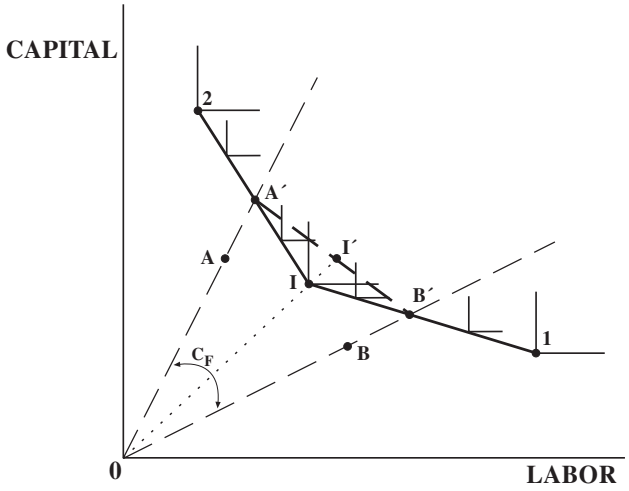

Figure 6

In Figure 7 we return to our original setting in which many countries are involved in the fragmentation process. If world prices for the fragments yield unit-value Isoquant at *A′* and *B′*, the cost of producing the final product is lowered (point *I* is no longer an option) and the new Hicksian composite unit-value Isoquant, shared by both countries, is the dashed broken line *2A′B′1*. Has fragmentation caused factor prices to converge or to move further apart? This depends upon the extent of dissimilarity in factor endowment proportions in the two countries. If this is wide (e.g. points *D* and *F* defining a "factor-endowment cone", not drawn), relative wages become higher in the high-wage country and lower in the low-wage country. On the other hand, a factor endowment cone defined, say, by points *D′* and *F′*,which is contained in the fragmentation cone for techniques, C_F, would result in fragmentation causing each country to produce both segments and their factor prices to be driven to equality. In the event that competition in world markets pushes prices of fragments even lower (say to *A″* and *B″*), a wide endowment cone (defined by rays *0D* and *0F*) would bring factor prices closer together but not all the way to equality. The economist's favorite phrase, "almost anything can happen" seems appropriate for the income-distribution fall-out of fragmentation. This implies, however, that the loss of a labor-intensive segment due to the process of fragmentation need *not* necessarily harm the interests of labor.

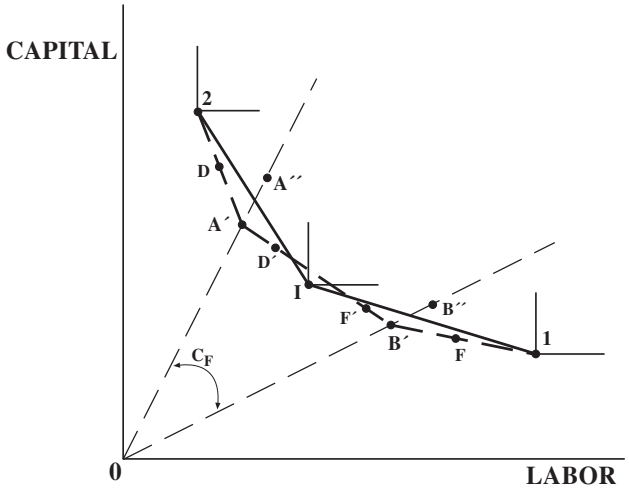

Figure 7

Wage rate behavior is sometimes analyzed in a context of the specific-factors model (e.g. as in Jones and Engerman, 1996). For example, if unskilled labor is mobile among sectors (with physical capital and skilled labor the specific factors), technological change in any sector will tend to spill over to register benefits to unskilled labor unless progress has a significant labor-saving bias. The point we wish to stress here is that the Hicksian unit-value Isoquant apparatus utilized in Figures 2 and 3 need not be restricted to the standard all-factors-mobile Heckscher-Ohlin scenario. Instead, suppose that productive activity takes place in many sectors of the economy, and in each there is a specific type of physical or human capital employed, fixed in amount. However, suppose that within each such sector there are a number of industries which employ the type of specific capital identified with that sector. Then the analysis of fragmentation in some such industry can build upon the type of Hicksian unit-value-Isoquant displayed in Figures 2 or 3. The major alteration is that the quantity of unskilled labor employed by that sector becomes endogenous.[5]

6. Consequences of Fragmentation: Concluding Remarks

The role of services has been highlighted in our discussion but not whether services themselves become internationally tradeable and subject to fragmentation. Thus production blocks could be fragmented internationally by making use of fairly integrated non-traded national service links, such as banking or accounting services. However, much of the current change in technology has allowed

[5] For an analysis of this type see Jones and Marjit (1992).

fragmentation in *international* service links. Providers of service activities in transportation and communication have made frequent use of locations in the Caribbean, say, to provide answers to queries about hotels, airline possibilities and telephone numbers from sources worldwide. A flourishing software sector has emerged in Bangalore to design new packages and trouble-shoot difficulties and problems posed to them by firms in the United States, Western Europe and elsewhere. Indeed, given the existence of different time zones, there is an advantage in being able to pose the query at the end of the day in Pacific Coast Time and have an answer ready at the start of work the next morning!

One major consequence of the process of fragmentation into more simple production blocks is that new firms can spring up to take over some such blocks and to supply a *number* of other (competing) firms with its output. Thus further economies of scale are generated and demand for the block can exhibit greater stability than would be the case if separate firms all performed identical processes.

"Since the mid-1980's, and particularly in the 1990's, large and well-known American electronics companies such as Apple, IBM, NCR, Philips, ATT, Hewlett Packard, and DEC have been abandoning their internal manufacturing operations in droves and turning to contract manufacturers such as SCI to build their products. At the same time, many younger, faster growing electronics firms, many of them based in Silicon Valley, CA, have always used contract manufacturers; few new firms have built internal manufacturing capacity even as they have grown (e.g. Sun Microsystems, Silicon Graphics, and Cisco Systems)." (Sturgeon, 1997).

Think of how wasteful it would be if each separate firm were to install its own e-mail apparatus or fax system in order to connect its own production blocks.

International fragmentation of vertical production processes into separate production blocks often results in these blocks being sufficiently simple that they find potential uses in other activities seemingly remote from the original final product. Thus computer chips are used not only in computers, but also in cars, micro-vans, cameras, etc. In addition it is now easier and more convenient for consumers to obtain what can only be described as custom-made final products without the cost of hands-on treatment at a traditional retail outlet. For example, Levi-Strauss allows customers to order jeans tailored to individual measurements "at the click of a mouse" (Cairncross, 1997). Dell Computers allows customers to skip the retail outlet and to use the Internet to order a computer with a great number of individually specified parameters and to expect this customized product to be delivered in a matter of days (Davis and Meyer, 1998). Dell passes on the order to a number of separate (mainly foreign) sub-contractors. Such fragmentation would have appeared totally strange to the IBM of the 1960's, intent on providing completely integrated products in-house.

Examples of fragmentation need not be limited to the computer industry. Nike, for example, has found that its comparative advantage lies in design and marketing, leaving unto others all the manufacturing. The famous camera, Leica, has its lenses produced in Germany, and its body and electrical parts produced in Spain, Canada, and the Far East.

In our earlier discussion of fragmentation (Jones and Kierzkowski, 1990) we pondered the role of multinationals. We stated that international fragmentation was taking place both within multinational organizations and by means of arms-length arrangements in the market. Here we suggest an update with a bias. As the price of international service links declines, and as knowledge of potential international suppliers and legal systems becomes more widespread, we now suggest that the necessity for containing various production blocks under the umbrella of a multinational organization is systematically being reduced. But we leave unto others the task of testing the proposition that there is an increasing role to be played by separate firms (perhaps smaller than in the past) connected only by the rules of the international market place.

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