International Outsourcing and Factor Prices with Multistage Production

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Abstract

We develop a dual representation of the technology of international fragmentation for an industry using 2 factors in a continuum of stages. We then derive a generalised factor price frontier which incorporates an endogenous adjustment of the margin fragmentation. Using this frontier in a 2×2 general equilibrium model, we investigate the role of outsourcing in the adjustment to a decline in the final output price of the multistage industry, and the attendant factor price effects. We also explore the implications of an improved technology of international fragmentation on the margin of fragmentation and on domestic factor prices.

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1 Introduction

The 1990s have witnessed a new form of economic globalisation, often called fragmentation or outsourcing, whereby firms located in industrialised countries pursue vertical disintegration of their production processes by locating some stages in foreign countries where economic conditions are more advantageous. The WTO reports that in 1998 as much as 63 percent of the value of an "American" car was generated in widely dispersed Asian and European countries. Boeing has committed itself to outsourcing 50 percent of what goes into its "average" aircraft.[1]

On a general level, what we observe seems but an episode in a secular process of technological change and corporate restructuring. In the early days of industrialisation, corporate strategies were largely characterised by vertical integration as a means to save Coasian transactional cost, epitomised by such vertical giants as Standard Oil Trust and Ford Motor Company. At the turn of the 20th century, improvements in the technology of communication and transport, as well as better methods to manage complex supply chains, appear to have vastly reduced the role of transactional costs. Indeed, outsourcing certain stages of production to independent and specialised suppliers is now often seen as a key strategy for higher profitability, and sometimes even corporate survival.[2] A novel feature of the recent episode is that outsourcing has become a vehicle for arbitraging on international factor price differences. This often seems to hit a "raw nerve" and therefore meets resentment in countries where outsourcing takes place. Concerned with potentially unwelcome effects on domestic employment and wages, policy makers sometimes react in a defensive manner. Indeed, in some instances outsourcing seems to have given rise to a newly protectionist climate.[3]

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[1] See Grossman and Helpman (2002a), and Glass and Saggi (2001). For further evidence, see Irwin (1996), Feenstra (1998), Hummels et al. (1998), Hummels et al. (2001), and several papers in Arndt and Kierzkowski, ed. (2001), as well as Feenstra and Hanson (2003) and Yi (2003).

[2] See, for instance, The Economist, Nov. 1st, 2001 ("Will the Corporation Survive?").

[3] For instance, governments have sometimes been restrictive on visas for visits that become necessary

The political concern about outsourcing is grounded in the belief that it harms domestic low-skilled labour. Yet, from a theoretical perspective it is by no means clear why this should be the case. True, an industry's domestic production will become more capital-intensive if a relatively labour intensive stage of its production is outsourced. Ceteris paribus, this lowers labour demand and, therefore, works against domestic labour. But there is a second effect. Outsourcing implies cost savings for domestic firms, and this should generally allow them to pay higher rewards to domestic factors. Under conditions of perfect competition and given world prices, the cost reduction will indeed be passed on to *some* factor owners.[4] It is unclear, a priori, whether the outcome of these two effects is a higher wage rate or higher returns to other factors, possibly at the expense of labour. This depends on how outsourcing industries are related to other sectors of the economy, and it can, therefore, only be determined by a full general equilibrium analysis that firmly captures outsourcing as a means to arbitrage on factor price differences. This is the purpose of the present paper.

Intuitively, the rewards that a small open economy can afford to pay to its factor owners depend on its technology and on the world prices of the goods it may produce. This is usually depicted by the factor price frontier. However, for an open economy the option of outsourcing is an inherent aspect of technology. Hence, what we need is a suitable representation of an economy's technology of production that fully incorporates its options of outsourcing. For lack of such a representation, factor price frontiers have so far found relatively little use in the literature on outsourcing.[5] The general

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to maintain an optimized supply chain; see The Financial Times, April 9, 2003 ("Visas and the west's 'hidden agenda'"), and The Economist, Aug. 23rd, 2003 ("Growing Pains").

[4]The cost saving may also show up, in terms of a higher incentive for innovation and investment; see Glass and Saggi (2001). Cost reductions should then translate into higher *future* factor rewards.

[5]In empirical work, factor price frontiers have been used, more or less explicitly, to justify "mandated wage regressions"; see Leamer (1998), and Feenstra and Hanson (1999,2003). Theoretical treatments of outsourcing make rare use of duality methods. Egger and Falkinger (2003) apply factor price frontiers, but do not consider the interdependency that we emphasize here. Other treatments

argument that outsourcing shifts this frontier ignores an important interdependence, which lies at the heart of this paper: To the extent that outsourcing is a vehicle to arbitrage on international factor price differences, it *depends on* factor prices, as well as *determining* factor prices in general equilibrium. This paper develops a *generalised* factor price frontier which incorporates an *endogenous reaction of outsourcing* to variations in domestic factor prices. It does so in a Heckscher-Ohlin framework, assuming two factors (labour and capital) and two sectors, a multi-stage industry which engages in outsourcing and a standard, single-stage industry. The generalised factor price frontier is then used to determine the factor price effects in two scenarios: a change in the world price of the final good, and a reduction in the cost of outsourcing.

The paper is structured as follows. Section 2 introduces a dual representation of the technology of fragmentation for a multistage industry, featuring the notion of a margin of international fragmentation. Based on this concept, section 3 portrays production equilibrium of a fragmented industry by means of a generalised zero profit condition. Section 4 introduces a second, single-stage industry and characterises the general equilibrium of a small open economy. Section 5 uses this model to explore the outsourcing and factor price effects of competitive pressure through a decline in the world price of the final good, and section 6 does the same for an improvement in the technology of fragmentation. Section 7 deals with issues of interpretation, and section 8 concludes the paper by summarizing the results.

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of factor price effects are Feenstra and Hanson (1996,1997,1999,2003), Venables (1999), Jones (2000), Deardorff (2001a,b), Jones and Kierzkowski (2001a, 2001b), and Kohler (2001,2003a,b).

2 The Technology of Fragmentation: A Dual Representation

If production involves many stages, then the option of outsourcing single stages to foreign countries is an inherent aspect of technology. Whatever the organisational details of such fragmentation, on a fundamental level it always implies that domestic producers may draw on foreign factor markets for single stages of their production processes, taking advantage of foreign factor prices. We now introduce a *dual* representation of the fragmentation aspect for a multistage industry, in order to capture this characteristic. Dual means that we are directly focusing on factor prices, assuming that production always responds in a cost-minimizing way. This enables us to incorporate *endogenous* fragmentation in the industry's zero profit equilibrium and, ultimately, to derive the kind of generalised factor price frontier mentioned in the introduction. This section and the next will focus on the multistage industry. General equilibrium will be considered later.

With multistage production, we must distinguish between two concepts. The *extensive margin* of international fragmentation separates stages of production that draw on foreign factor markets via outsourcing from those relying on domestic inputs. The *intensive margin* of outsourcing means the extent to which a *given* stage of production (or input) relies on foreign factors (or imports).[6] This distinction is important in that the extensive margin captures the notion of moving up or down a given supply chain, which keeps reappearing in empirical accounts of outsourcing.[7] This paper allows for a

[6]Without using this terminology, the intensive margin of outsourcing is analyzed, for instance, in Feenstra and Hanson (2003). In Grossman and Helpman (2002a) it appears as the number of foreign (vs. domestic) suppliers of a *given* input.

[7]For instance, Barbados has started out as a source of "blue-collar" stages of production for American Airlines in the early 1980s, and has since moved up to "pink-collar" stages; see The Economist, March 27th, 1997 ("Cloud over Silicon Beach"). It is almost impossible to disentangle the two forms of outsourcing in the observed upsurge of vertical specialization, but it appears important enough to

continuum of stages, whence the extensive margin of outsourcing emerges as a continuous variable, which offers certain analytical advantages over outsourcing as a "regime switch".[8]

Let w and r denote the domestic wage rate and capital rental, and suppose that $f(w, r, i)$ denotes the minimum cost associated with a unit-level of stage-i production in some multistage industry. Assuming concave, constant returns to scale production functions, $f(w, r, i)$ is linearly homogeneous and concave in input prices w and r. Following Dixit and Grossman (1982), we assume that i is a continuous variable in the closed interval $[0, 1]$.[9] Without loss of generality, we assume that production moves "downstream", as i moves from 0 to 1. Moreover, we assume that a unit of the final good requires $a(i)$ units of stage-i production, thus ruling out substitution between stages. Finally, we assume that more "downstream" stages are always more capital intensive at all relevant factor price ratios. Formally, using subscript indices to denote partial derivatives, $f_r(w, r, i)/f_w(w, r, i)$ increases monotonically and continuously with i.[10] The reverse assumption is discussed below. Moreover, w and r may be replaced by the wage rate for low-skilled and high-skilled labour, if that seems a preferred interpretation; see also section 7 below.

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warrant our theoretical focus on the extensive margin of fragmentation.

[8]For examples where outsourcing occurs in the form of a "regime switch", see Bond (2001) and Egger and Falkinger (2003). Feenstra and Hanson (1996,1997) model a continuous margin of fragmentation as in this paper, but do not make use of the factor price frontier. Further crucial differences between our approach and theirs will be pointed out below. In Burda and Dluhosch (2002) fragmentation appears as "roundaboutness" of production which is determined by cost-minimizing firms. There is, however, no explicit multistage structure of production in their model, and the extent of fragmentation is not driven by international factor price arbitrage.

[9]Strictly speaking, stage i of production should be denoted by $i+\mathrm{d}i$, and its unit cost by $f(w, r, i)\mathrm{d}i$. However, for ease of notation and wording stage $i+\mathrm{d}i$ will henceforth simply be called stage i.

[10]If there is no strict vertical structure of production, the interval may be *defined* in such a way that $f_r(w, r, i)/f_w(w, r, i)$ increases with i.

Now consider international fragmentation of this multistage process. We assume a small economy, hence foreign factor prices are given as $\bar{w}$ and $\bar{r}$.[11] For simplicity, we assume that the cost of contracting, transport and communication is of the familiar iceberg-type. I.e., $\tau(i) > 1$ units of foreign stage-i production are needed for one unit of this stage to become available domestically. We shall return to this in more detail below, when considering equilibrium consequences of a change in these costs. We also allow for stage-specific Ricardian efficiency gaps. If one unit of *domestic* labour is required to secure a certain amount of stage-i output, securing that same amount via outsourcing requires $\rho(i) > 0$ units of *foreign* labour. The same applies to capital, i.e., the efficiency gaps are Hicks-neutral. Technological superiority of the home economy at stage i implies $\rho(i) > 1$.

Outsourcing now involves setting the cost of fragmentation, $\tau(i)\rho(i)$, against the cost advantage from arbitraging on international factor price differences. We may define this advantage as

$$\gamma(w, r, i) \equiv \frac{f(w, r, i)}{f(\bar{w}, \bar{r}, i)}. \tag{1}$$

Given the above factor intensity assumption, $\gamma(w, r, i)$ falls with increasing i if $w/r > \bar{w}/\bar{r}$, and it increases with i if $w/r < \bar{w}/\bar{r}$.[12] We assume for now that $w/r > \bar{w}/\bar{r}$; other cases will be dealt with below.

Combining factor price considerations with the cost of international fragmentation,

[11] This implies that the foreign economy can accommodate any additional factor demand that may arise from international fragmentation by means of Rybzcynski-type internal reallocation. The attendant output effects are, in turn, accommodated by world commodity markets at unchanged final output prices. Equivalently, the foreign economy may be interpreted as the rest of the world where any factor demand from domestic outsourcing is of negligible magnitude.

[12] This follows from the logic introduced by Jones (1956). Intuitively, for any given i the difference between domestic and foreign unit cost is determined by the factor shares of stage i, and by the factor price differences. If the home economy has relatively cheap capital, then this difference shrinks as the capital intensity increases, as it does with i according to the above assumption.

we arrive at an overall cost-advantage

$$\Gamma(w, r, i) \equiv \gamma(w, r, i)/[\tau(i)\rho(i)]. \tag{2}$$

We assume that $\Gamma(w, r, i)$ preserves the monotonicity of $\gamma(w, r, i)$ in i. If $w/r > \bar{w}/\bar{r}$, a sufficient condition for this is that $\tau(i)\rho(i)$ is non-decreasing in i. Setting $\Gamma(w, r, i) = 1$ gives a *cost-equalisation contour* for stage i. Conversely, for any pair of factor prices, $\Gamma(w, r, i) = 1$ determines the production stage i for which outsourcing and domestic production are cost-indifferent. We call this the (extensive) *margin of international fragmentation*. Fig. 1 depicts such contours for three different levels of $i \in [0, 1]$, including the two extreme cases where $i = 0$, and $i = 1$. Several points are worth mentioning. a) Points above the contour for $i = i'$ indicate domestic factor prices where domestic production of stage i' (and, a fortiori, of stages $i < i'$) is not competitive, relative to outsourcing. The opposite holds true for points below such a contour. b) Contours for higher i lie farther "north-east". c) The slope of any contour indicates the capital intensity of the corresponding production stage. For a given domestic factor price ratio, the slope is larger for higher i (more "downstream" stages). d) The radial distance between the two extreme contours along a ray $(w/r)'$ is determined by the gap between $(w/r)'$ and $\bar{w}/\bar{r}$, and by the extent to which the capital intensity increases as production moves further "downstream". e) Along the ray $w/r = \bar{w}/\bar{r}$, the contours for all $i \in [0, 1]$ have equal slopes, their distance from the unit-circle being determined by $\tau(i)\rho(i)$. f) Lower levels of foreign factor prices shift the whole set of contours towards the origin.

For future reference, we call the case depicted in Fig. 1 *case I-a*. We may briefly consider alternative assumptions. Thus, suppose that the capital intensity falls as production moves "downstream", and labour is relatively cheap in the domestic economy, $w/r < \bar{w}/\bar{r}$. With a full reversal of all assumptions, $\gamma(w, r, i)$ again falls with higher i, and it is relatively easy to see that this case – we call it *case II-a* – may be depicted by a reverse labeling of axes in Fig. 1. International fragmentation again implies outsourcing of early stages, but these are now the more capital intensive ones. If the capital

intensity increases with i and $w/r < \bar{w}/\bar{r}$, then $\gamma(w, r, i)$ is increasing in i. We may call this this *case I-b*. As in Fig. 1, on any ray through the origin the slope of contours for $\Gamma(w, r, i) = 1$ falls with i, but contours for higher i are now closer to the origin, since the foreign economy has relatively cheap capital. Therefore, international fragmentation features outsourcing of "downstream" stages. The remaining *case II-b* emerges if the capital intensity falls with i, and if domestic labour is relatively expensive. In this case, $\gamma(w, r, i)$ is monotonically rising in i, and it is formally equivalent to case I-b with reverse labeling of axes. In all of these cases, we have assumed that $\Gamma(w, r, i)$ preserves the monotonicity of $\gamma(w, r, i)$. The existence of these cases is quite obvious, less obvious is the fact that they are in fact all covered by Fig. 1 through a suitable relabeling of the axes or the Γ-contours.

The set of Γ-contours depicted in Fig. 1 is a comprehensive *dual* characterisation of the international fragmentation aspect of domestic technology. Notice that the whole set of Γ-contours is independent on the final output price. This will be crucial for the scenario considered in section 5. Moreover, it must be emphasised that they do *not* represent factor price frontiers. They will, however, be used to construct such frontiers below. Section 3 does so for the multistage industry in partial equilibrium, while section 4 will deal with the general equilibrium frontier for the economy as a whole.

3 Towards a Generalised Factor Price Frontier

To proceed towards a factor price frontier, we must look at *overall* minimum unit cost which involves all stages of production, and we must bring the final output price into the picture. We call the final output good 1, and we use i^* to denote the *cost minimizing* margin of international fragmentation. *Minimum* unit-cost of good 1 is

$$c_1(w, r, i^*) = \int_0^{i^*} a(i)\tau(i)\rho(i)f(\bar{w}, \bar{r}, i)\,\mathrm{d}i + \int_{i^*}^{1} a(i)f(w, r, i)\,\mathrm{d}i, \tag{3}$$

where i^* satisfies the first order condition

$$\Gamma(w,r,i^*) = 1 \text{ if } 0<i^*<1, \tag{4a}$$

$$\Gamma(w,r,i^*) \leq 1 \text{ if } i^*=0, \tag{4b}$$

$$\text{and} \quad \Gamma(w,r,i^*) \geq 1 \text{ if } i^*=1. \tag{4c}$$

The second order condition on the margin i^* is satisfied from the monotonicity assumption relating to 2. To simplify the notation, we shall henceforth use $\bar{v}_1(\bar{w},\bar{r},i^*)$ and $v_1(w,r,i^*)$ to denote the factor cost of foreign and domestic value-added, respectively, per unit of the final good:

$$\bar{v}_1(\bar{w},\bar{r},i^*) \equiv \int_0^{i^*} a(i)\tau(i)\rho(i)f(\bar{w},\bar{r},i)\,\mathrm{d}i \quad \text{and} \quad v_1(w,r,i^*) \equiv \int_{i^*}^1 a(i)f(w,r,i)\,\mathrm{d}i, \tag{5}$$

where i^* is again determined by (4) above.

We assume a final output price $p_1 = \bar{p}_1$, exogenously given from world markets. Perfect competition and free entry imply a production equilibrium with zero profits, i.e., $c_1(w,r,i^*) = \bar{p}_1$. Noticing that i^* depends on factor prices via (4), $i^* = i^*(w,r)$, we may write this as

$$c_1[w,r,i^*(w,r)] = \bar{p}_1, \tag{6}$$

giving combinations of domestic factor prices that are consistent with zero profits in the multistage industry 1, given its output price $\bar{p}_1$, and given its technology – including the technology of international fragmentation. We may, therefore, call these combinations an *"endogenous fragmentation factor price frontier"* for the multistage industry 1, and we shall henceforth simply refer to this frontier as ef-fpf$_1$. Of course, being restricted to industry 1, and ignoring the economy's endowment constraint, ef-fpf$_1$ is a partial equilibrium concept. Before moving on to general equilibrium, it is worth investigating how the ef-fpf$_1$ relates to the conventional zero-profit line for a parametric margin of fragmentation, which we label fpf$_1$.

Treating the margin of fragmentation as a parameter $i = i'$, the conventional zero profit line is determined by $c_1(w,r,i') = \bar{p}_1$. Thus, in view of (3) and (5), the fpf$_1$-line

satisfies

$$v_1(w, r, i') = \bar{p}_1 - \bar{v}_1(\bar{w}, \bar{r}, i'). \tag{7}$$

The right-hand side of (7) may be called the *effective price* of the domestic value-added chain per unit of the final good, given the final output price and the cost of outsourcing stages up to i'.[13] The position of fpf_1 depends on $\bar{p}_1$, as well as i'. Hence, for a constant final output price there is a whole set fpf_1-lines for different margins of outsourcing. All of these are downward sloping and convex, and the familiar envelope property implies that the slope of fpf_1 reflects the corresponding aggregate capital intensity of all *domestic* stages ($i > i'$). Fig. 1 shows fpf_1 for $i = i'$ as a dashed line. Differentiating (7), and observing (5), we obtain

$$\left|\frac{\mathrm{d}w}{\mathrm{d}r}\right|_{\text{fpf}_1} = \frac{\int_{i'}^{1} a(i) f_r(w, r, i)\,\mathrm{d}i}{\int_{i'}^{1} a(i) f_w(w, r, i)\,\mathrm{d}i}. \tag{8}$$

Confronting fpf_1 for $i = i'$ with the set of contours $\Gamma(w, r, i)$ which characterise the technology of international fragmentation, it becomes clear that, if $0 < i' < 1$, there is only one point on fpf_1 which also belongs to the ef-fpf_1-line determined by (6). This is point "b" where fpf_1 and the contour for $\Gamma(w, r, i') = 1$ intersect. In other words, at point "b" we have $i' = i^*(w, r)$. Since by assumption all interior domestic stages are more capital intensive than the marginal stage i', the $\Gamma(w, r, i')$-contour is flatter at point "b" than the fpf_1-line. All points on fpf_1 to the left of b are not part of the ef-fpf_1, since they violate the optimality condition (4). More specifically, such points lie above the contour for $\Gamma(w, r, i') = 1$, where $\Gamma(w, r, i') > 1$ implies that firms would forego the possibility of reducing unit-costs by outsourcing further stages of production. Similar reasoning applies to points on fpf_1 to the right of point "b", where costs can be reduced by reducing the margin below i'.

How does the slope of ef-fpf_1 at point "b" compare with the slope of fpf_1? Based

[13] The analogy to the theory of effective protection is obvious; see Kohler (2003) for a more details.

on (3), ef-fpf$_1$ satisfies $\mathrm{d}c_1(w,r,i^*)=0$, i.e.,

$$\begin{aligned}\int_{i^*}^{1} a(i)f_w(w,r,i)\mathrm{d}w\,\mathrm{d}i+\int_{i^*}^{1} a(i)f_r(w,r,i)\mathrm{d}r\,\mathrm{d}i \\ +a(i^*)\tau(i^*)\rho(i^*)f(\bar{w},\bar{r},i^*)-a(i^*)f(w,r,i^*) &= 0.\end{aligned} \tag{9}$$

For interior i^*, the first order condition (4a) guarantees that the two terms in the second line cancel, hence

$$\left|\frac{\mathrm{d}w}{\mathrm{d}r}\right|_{\text{ef-fpf}_1}=\frac{\int_{i^*}^{1} a(i)f_r(w,r,i)\,\mathrm{d}i}{\int_{i^*}^{1} a(i)f_w(w,r,i)\,\mathrm{d}i}. \tag{10}$$

At point "b" we have $i'=i^*(w,r,\bar{p}_1)$, hence the slopes of fpf$_1$ and ef-fpf$_1$ are equal. In other words, efp$_1$ as defined in (7) is *tangent* from below to ef-fpf$_1$ as defined in (6). A corresponding tangency of course obtains for any other point on ef-fpf$_1$. This is a reflection of the envelope property with respect to the equilibrium margin of fragmentation i^*. We may also note that ef-fpf$_1$ is *convex* and *continuous*.

As i^* adjusts in line with (4), ef-fpf$_1$ crosses successive Γ-contours, until i^* reaches its upper or lower limit at $i^*=1$ or $i^*=0$, respectively. For $i^*=1$, with a wage rental ratio equal to $(w/r)^1$, ef-fpf$_1$ smoothly pastes with the $\Gamma(w,r,1)$-contour at point "c", while for $i^*=0$ it pastes with the traditional fpf$_1$-line for $c_1(w,r,0)=\bar{p}_1$ at point "a", where all stages are produced domestically with a wage rental ratio equal to $(w/r)^0$. It is important to realise that, unlike the set of Γ-contours, these limiting wage-rental ratios depend on the final goods price; see section 5 below. Notice again that the whole set of Γ-contours changes as the foreign wage-rental ratio changes.

While ef-fpf$_1$ exhibits the same slope as the conventional fpf$_1$ for a corresponding margin of fragmentation, the aforementioned tangency implies that it features a *higher elasticity of substitution* between capital and labour. Any increase in the wage-rental ratio, in addition to causing a substitution of capital for labour for all domestic stages of production, also causes an endogenous adjustment of the margin of fragmentation whereby the least labour intensive stages are relocated abroad, which reinforces the traditional substitution effect. In other words, endogenous international fragmentation makes capital and labour closer substitutes. It has often been conjectured that glob-

alisation has increased the elasticity of labour demand. That elasticity is equal to the capital share times the elasticity of substitution, hence this result suggests a rigorous theoretical rationale for the conjecture, expressed for instance in Fabbri, Haskel and Slaughter (2002). One must, however, be cautious in drawing conclusions. The ef-fpf$_1$-line is a partial equilibrium device in that it looks only at the multistage sector 1. In general equilibrium, the overall elasticity of labour demand depends on possibilities of factor reallocation between the multistage sector and other sectors of the economy; see below.

Endogenous fragmentation, by making capital and labour closer substitutes in the multistage process, also increases the elasticity of substitution along the economy's production possibility frontier. It is well known that the Ricardian case with constant opportunity cost generates much more pronounced (horizontal) specialisation effects than the neoclassical case with increasing opportunity cost. What we now find is that the possibility of outsourcing decreases the curvature of the production possibility frontier, thus making the economy "more Ricardian". Hence, there is a *complementarity* relationship between the *possibility of* outsourcing and horizontal specialisation: Endogenous outsourcing generates more pronounced specialisation effects. Notice, however, that endogenous reaction of outsourcing may also mean that the actual level of outsourcing shrinks ("insourcing"), depending on the scenario considered; see below.

4 General Equilibrium

A single ef-fpf alone is not enough to uniquely determine factor prices. This requires a general equilibrium analysis which highlights factor reallocation between sectors, and which takes into account the economy's factor endowment. This section therefore extends the analysis by adding a single-stage (numéraire) sector and introducing an

endowment constraint.[14] The general equilibrium factor price frontier depicts different factor price combinations that a small open economy can "afford", given its technology and the world prices of *all* goods it *may* produce, allowing for cases where some industries shut down for lack of competitiveness. It is simply the outer envelope of the zero-profit-lines for all sectors. We can therefore use the ef-fpf$_1$ introduced above to derive a *generalised*, economy wide frontier that incorporates *endogenous outsourcing* in industry 1 as an integral part of domestic technology. The economy's factor endowment then determines those points on this frontier that are consistent with general equilibrium. This section presents the full set of equilibrium conditions to pave the ground for subsequent comparative static analyses.

Using $c_2(w,r)$ to denote the minimum unit-cost function for the numéraire good 2, and allowing for complete specialisation, zero profits imply

$$c_1[w,r,i^*(w,r)] \geq \bar{p}_1 \tag{11a}$$

$$\text{and} \quad c_2(w,r) \geq 1, \tag{11b}$$

where equality obtains if a sector is to be viable (positive output) domestically, and the inequality implies zero output. Full employment of endowments K^0 and L^0 requires

$$v_{1w}[w,r,i^*(w,r)]\, q_1 + c_{2w}(w,r)q_2 = L^0 \tag{12a}$$

$$\text{and} \quad v_{1r}[w,r,i^*(w,r)]\, q_1 + c_{2r}(w,r)q_2 = K^0, \tag{12b}$$

where q_j denotes final output in sector j. Equations (12) make use of Shephard's Lemma, subscripts w and r again denoting partial derivatives, whence $v_{1w}[w,r,i^*(w,r)]$ indicates labour demand per unit of final good 1, based on definitions (5). Analogous interpretations hold for $v_{1r}[w,r,i^*(w,r)]$, as well as for $c_{2w}(w,r)$ and $c_{2r}(w,r)$. Factor demands in sector 1 also depend on the margin of international fragmentation i^* which is in turn a function of w and r.

[14] Assuming single-stage production for sector 2 captures the obvious fact that sectors are not equally amenable to international fragmentation.

The two zero profit conditions (11) plus the two full employment conditions (12) form a simultaneous system of 4 equations determining equilibrium values for w, r, q_1 and q_2. Moreover, since cost-minimisation implies $i^* = i^*(w, r)$, the equilibrium margin of fragmentation is also determined by $\bar{p}_1$, and by endowments. Since both $c_2(w, r)$ and $v_1[w, r, i^*(w, r)]$ are homogeneous of degree 1 in w and r, (11) and (12) imply the usual equality between the value of output and aggregate income:

$$\bar{p}_1 q_1 + q_2 = wL^0 + rK^0 + \bar{v}_1(\bar{w}, \bar{r}, i^*)q_1 \tag{13a}$$

$$\text{or} \quad \bar{\pi}_1[\bar{p}_1, \bar{w}, \bar{r}, i^*(w, r)]\, q_1 + q_2 = wL^0 + rK^0, \tag{13b}$$

where $\bar{\pi}_1[\bar{w}, \bar{r}, i^*(w, r)] = \bar{p}_1 - \bar{v}_1[\bar{w}, \bar{r}, i^*(w, r)]$ is the effective price of domestic value-added per unit of the final good. Notice that $\bar{\pi}_1$ varies with domestic factor prices through $i^*(w, r)$, even for constant foreign factor prices and a constant final goods price. Introducing Marshallian demand functions $d_1(wL^0 + rK^0, \bar{p}_1)$ and $d_2(wL^0 + rK^0, \bar{p}_1) = wL^0 + rK^0 - d_1(wL^0 + rK^0, \bar{p}_1)$, we have the trade balance equation

$$d_2 - q_2 + \bar{v}_1(\bar{w}, \bar{r}, i^*)q_1 = \bar{p}_1(q_1 - d_1), \tag{14}$$

stating that imports of good 2 plus the value of outsourcing in sector 1 are equal to the value of final good 1 exports. Note that equations (13) and (14) are no independent equilibrium conditions, but implied by the aforementioned set of equilibrium conditions.

Fig. 2 depicts general equilibrium for some initial price $\bar{p}_1^0$ by combining the corresponding factor price frontier ef-fpf$_1^0$ with a frontier representing (11b), labeled fpf$_2$; the superscripts A, B and C will be explained shortly. With good 2 being our numéraire, the position of fpf$_2$ is independent on goods prices. Assuming that both sectors are viable, equilibrium factor prices w^{*0} and r^{*0} are found at the intersection of fpf$_2$ with ef-fpf$_1^0$ at point E^0, which also determines the margin of international fragmentation i^{*0}. We assume an interior margin, $0 < i^{*0} < 1$. The *aggregate* capital intensity of *all domestic stages* of industry 1, henceforth denoted by k_1^v, is equal to the slope of ef-fpf$_1^0$. Given our assumptions (case I-a above), this exceeds the *marginal* capital intensity at stage i^{*0} which we shall now denote k_1^m, and which is equal to the slope of the line

$\Gamma(w, r, i^{*0}) = 1$. The technology of sector 2 is captured by its factor price frontier (fpf_2), with a slope equal to its factor intensity k_2. We can now consider three alternative types of equilibria:

$$\text{Case A: } k_2 > k_1^v > k_1^m. \quad \text{Case B: } k_2 < k_1^m < k_1^v. \quad \text{Case C: } k_1^m < k_2 < k_1^v. \tag{15}$$

While cases A and B feature unambiguous factor intensity rankings, in case C sector 2 lies between the marginal and aggregate capital intensity of sector 1. In all cases the general equilibrium ef-fpf can be found as the outer envelope of fpf_2 and ef-fpf_1.

5 Outsourcing under Competitive Pressure

Outsourcing is often portrayed as a means to guarantee corporate survival which may, in turn, come under threat from a decline in final output prices. Indeed, this is a characteristic feature of recent developments in classic outsourcing industries, such as the car industry, textiles, and the electronics industry. Will a multistage industry respond by means of outsourcing, i.e., by extending the margin of fragmentation? If so, does this harm domestic labour? Since the model developed above features outsourcing as an endogenous reaction to exogenous shocks, it allows us to address such questions through a comparative static analysis.

The essential results are conveniently derived by means of a diagrammatic analysis. We use Fig. 2 by indexing the initial and the new general equilibrium by 0 and 1, respectively. Suppose the relative change is $\hat{p}_1 < 0$. Note that the whole set of contours for $\Gamma(w, r, i) = 1$ remains unaffected by such a change. To see how the ef-fpf_1 shifts, it is again convenient to first look at the traditional factor price frontier for a parametric $i = i^{*0}$, as determined by (7) above. To avoid clutter, no fpf_1-lines are drawn in Fig. 2, but it is easily seen from differentiating (7) that fpf_1 shifts towards the origin by a factor equal to $(1 + \hat{p}_1/\theta_{1v}^0) < 1$, where $\theta_{1v}^0 \equiv v_1(w^{*0}, r^{*0}, i^{*0})/c_1(w^{*0}, r^{*0}, i^{*0})$ is the initial share of domestic value added in overall output. In other words, the *effective* price of domestic value added declines by $100 \times \hat{p}_1/\theta_{1v}^0$ percent. Writing π_1^0

for the initial effective price, the new fpf_1-line is determined by $v_1(w, r, i^{*0}) = \bar{\pi}_1^0(1 + \hat{p}_1/\theta_{1v}^0)$. Due to homothetic technology, this line and the initial fpf_1, which is determined by $v_1(w, r, i^{*0}) = \bar{\pi}_1^0$, have a common slope, if evaluated at a common wage-rental ratio, such as for instance the initial wage-rental ratio w^{*0}/r^{*0}. However, passing on the effective price proportionally to both factors in the form of lower rewards would violate the ef-fpf_1, because it moves the economy below the $\Gamma(w, r, i^{*0})$-contour, which remains unchanged by $\hat{p}_1$, as emphasised above. Hence, a point which corresponds to a proportional decrease of both w and r by a factor $(1 + \hat{p}_1/\theta_{1v}^0) < 1$ is comparable to a point in Fig. 1 on the fpf_1-line to the right of point "b". This implies that, for a wage-rental ratio equal to w^{*0}/r^{*0}, the new ef-fpf_1 passes through a point above the new fpf_1-line, where it is also flatter than at the initial equilibrium. Intuitively, if domestic factor owners were to take the burden of adjustment by proportionally lower rewards, firms would gain competitiveness at the initial margin of fragmentation i^{*0}. At a notionally unchanged wage-rental ratio, the new ef-fpf_1 therefore features a lower equilibrium level of outsourcing, and domestic value-added becomes a less capital intensive process.

The general equilibrium effect on outsourcing and factor prices can now be determined by applying this ef-fpf_1-shift to the unchanged fpf_2-line in Fig. 2. Looking at the three cases introduced in (15) above, we arrive at the following proposition.

Proposition 1 *A lower world market price for the final good of industry 1, $dp_1 < 0$, has the following effects, depending on the type of initial equilibrium (see 15 above):*

Case A *($k_2 > k_1^v > k_1^m$):* $di^* < 0$ *("insourcing"),* $dw < 0$, *and* $dr > 0$.

Case B *($k_2 < k_1^m < k_1^v$):* $di^* < 0$ *("insourcing"),* $dw > 0$, *and* $dr < 0$.

Case C *($k_1^m < k_2 < k_1^v$):* $di^* > 0$ *(outsourcing),* $dw > 0$, *and* $dr < 0$.

All effects are reversed if the scenario holds an increase in the final output price. As regards the factor intensity assumption and factor price difference, this proposition is based on case I-a introduced above. However, a little reflection reveals that the other

cases (I-b, IIa and II-b) are easily dealt with by analogous reasoning. For shortage of space, this is left to the reader.

The proposition reveals that outsourcing may be a "friend" or an "enemy" to domestic labour. The crucial point is not only whether the single-stage sector is less capital intensive than domestic value-added (in which case a fall in p_1 always works in favour of labour), but also whether its capital intensity is lower than the *marginal* capital intensity of domestic value-added in the multistage industry. If this latter condition is violated (case C), then a fall in p_1 still benefits labour, while there is further outsourcing.

In case C, outsourcing seems to drive international factor prices further apart.[15] However, outsourcing and factor prices are *jointly endogenous*, hence divergence cannot be attributed to outsourcing as such. It is relatively easy to see that for an opposite scenario (increase in p_1) outsourcing is associated with relative factor price convergence. Hence, the principal insight is that, if fragmentation is endogenous, the relationship between outsourcing and relative factor price convergence depends on the nature of the exogenous shock.

We know from the Stolper-Samuelson theorem that in such a scenario some factors suffer a real income loss, others a real income gain. This is due to the Jonesian magnification effect. In case A, for instance, this means that with a parametric margin of fragmentation $i = i^{*0}$ we have $\hat{w} < \hat{p}_1/\theta^0_{1v} < 0 < \hat{r}$.[16] Does this magnification effect change if the margin varies endogenously?

The answer may again be found by comparing the fpf_1-shift for a parametric margin of fragmentation with the ef-fpf_1-shift under endogenous adjustment of the margin. The reasoning is relatively straightforward, hence we may abstain from drawing fpf_1-lines in Fig. 2. We assume that both sectors are viable before and after the price change.

[15] This possibility has also been pointed out by Deardorff (2001b).

[16] See Jones and Scheinkman (1977). The dual logic that we apply to identify magnification effects of the Stolper-Samuelson theorem has been introduced by Mussa (1979).

The crucial point is that in all possible cases the intersection point between the new fpf_1-line and the fpf_2-line is a fragmentation *dis*equilibrium. Hence the magnification effect must change, at least in magnitude. Consider first the case C. We know from the standard magnification effect that a parametric margin i^{*0} leads to an intersection point where $w < w^{*0}(1 + \hat{p}_1/\theta^0_{1v})$ and $r > r^{*0}$. This is the reference point, labeled "f"' in Fig. 2. However, at this point we have $\Gamma(w, r, i^{*0}) > 1$, and firms will be able to lower cost by increasing the margin of fragmentation. In other words, the fpf_1-line, having been shifted towards the origin by the price cut, now shifts out due to the cost saving effect of endogenous fragmentation, and for any wage-rental ratio it also becomes steeper because outsourcing makes domestic value added more capital intensive. From the tangency property emphasised in section 3, it then follows that the new equilibrium position of ef-fpf_1 must be such that its intersection point with fpf_2 is to the right of f'. The magnification effect still arises, but it is *mitigated* by endogenous fragmentation. It is relatively easy to see that an analogous argument holds for cases A and B, the difference being that cost savings are now achieved through a reduction in fragmentation ("insourcing"). But the result is again a mitigation of the magnification effect.

A little reflection reveals that in the opposite scenario of a rise in the final output price the magnification effect is *reinforced*, since the cost savings due to endogenous outsourcing now reinforce the output price changes from the input side. And this is again true for all cases. We can therefore state the following proposition.

Proposition 2 *Then the magnification effects from the Stolper-Samuelson theorem are upheld under endogenous fragmentation. Compared with the case of a parametric margin of fragmentation, an endogenous adjustment of the margin mitigates (reinforces) the magnification effects for both factors, if the final goods price declines (rises).*

Notice that the proposition makes no reference to whether endogenous adjustment of fragmentation implies a higher or lower level of outsourcing. This is a reflection of the above mentioned ambiguity as regards the "enemy or friend" relationship of

outsourcing to labour. On the other hand, in case A ($k_1^v < k_2$) labour ends up better off under endogenous than under parametric fragmentation, irrespective of whether $\hat{p}_1 < 0$ or $\hat{p}_1 > 0$. The reverse is true for cases B and C ($k_1^v > k_2$). Case A may spell some good news for labour in the globalisation debate. If a country hosts the relatively labour intensive multistage industry (textiles, say), then competitive pressure for this industry does mean that the wage rate falls, but endogenous outsourcing mitigates this effect. On the other hand, if the multistage industry is relatively capital intensive as in case C (the auto industry, say), then the wage increase that would normally (if somewhat counter-intuitively) accrue to domestic labour, is partly dissipated by endogenous outsourcing.

One is inclined to interpret any decline in the final goods price at unchanged prices of imported intermediate inputs as having a "disprotective" effect on that sector. In the present model, this is unambiguously true if we judge the protective effect from the direction of *resource reallocation*. This follows from the general equilibrium property that a rise in the capital intensity of both sectors requires a reallocation of both factors towards the less capital intensive activity, and vice versa. However, introducing the number of *stages produced domestically* as an alternative measure of the protective effect, we can state the following proposition.

Proposition 3 *In case C ($k_1^m < k_2 < k_1^v$), a decline in the world price of the final good 1 "disprotects" industry 1 in terms of both, the final output of good 1 and the range of stages produced domestically. In cases A ($k_2 > k_1^v > k_1^m$) and B ($k_2 < k_1^m < k_1^v$), a decline in p_1, while causing both factors to move from into industry 1 to industry 2, actually protects the marginal value added stage in industry 1, whence a contraction is paralleled by an increasing range of domestic stages.*

The somewhat counter-intuitive protective effect in cases A and B is easily explained. As factor prices adjust to accommodate a lower effective price, the domestic multistage industry becomes more competitive at the marginal stage. Referring to Fig. 2, the movements along fpf_2^A or fpf_2^B attendant upon the inward shift of the ef-fpf_1-line

lead the economy to the south-west of the $\Gamma(w, r, i^{*0})$-line (points "e" and "d"). It is interesting to envisage a series of consecutive price cuts for the final product. In case A, adjustment requires that capital and labour leave sector 1, but at the same time sector 1 produces an ever *broader* set of stages.

6 Lower Costs of International Fragmentation

The preceding section has treated outsourcing as an integral part of adjustment to an adverse price shock, assuming that the technology of fragmentation as such remains unchanged. However, assuming a constant technology of fragmentation appears to defy the very hallmark of recent globalisation, viz. the enormous advances in information and communication technology that have vastly reduced the economic barrier effect of geographic distance as well as national borders. Indeed, much of the policy concern about the upsurge of outsourcing evolves around the direct impact of these advances on the ease with which firms may engage in fragmentation to arbitrage on international factor price differences. Partly induced by technological change, improved methods of supply chain management and the emergence of markets for logistics services have reinforced the effect of globalisation on the technology of international fragmentation. And finally, liberalisation of trade in all services relevant for supply chain management is an independent and potentially powerful mechanism for easier fragmentation and outsourcing; see Deardorff (2001c). In this section, we therefore explore the implications of improvements in the technology of fragmentation, utilizing the dual representation of this technology developed above.

The "iceberg-cost-term" $\tau(i)$ in (2) incorporates a host of different aspects. The literature addressing the specific *organisational form* of outsourcing emphasises costs arising from lack of complete contracts; see Grossman and Helpman (2002a,b;2003). Placing the emphasis squarely on the *locational* aspect, we assume that $\tau(i)$ captures the minimum cost of whatever is the most efficient contracting arrangement. The locational dimension emphasises costs of communication and transport; see Jones and

Kierzkowski (1990,2001a), and Harris (1995,2001). A further interpretation of $\tau(i)$ is tariffs and non-tariff barriers. We now explore the general equilibrium effects of a reduction in $\tau(i)$.

Whatever its cause, a reduction in $\tau(i)$ must shift our set of cost-equalisation contours defined by $\Gamma(w, r, i) = 1$. Suppose that $\tau(i)$ can be decomposed according to $\tau(i) = \tau_0 \zeta(i)$. We take the simplest case where the improvement only affects the general term, such that for all $i \in [0, 1]$ we have $\mathrm{d}\tau(i) = \mathrm{d}\tau_0 \zeta(i) < 0$. Given homotheticity of $\gamma(w, r, i)$, this leads to a proportional inward shift of each $\Gamma(w, r, i)$-contour. Looking at interior contours where $0 < i < 1$, this can equivalently be expressed by saying that each of these contours now represents a different margin of international fragmentation i. In other words, for any point on an interior contour in a diagramme like Fig. 1, we have

$$\mathrm{d}i = -\frac{\zeta(i)\rho(i)}{\gamma_i(w, r, i)}\,\mathrm{d}\tau_0, \tag{16}$$

where we have so far assumed $\gamma_i < 0$; see case I-a in section 2 above.

The immediate effect is that the initial equilibrium E^0 in Fig. 2 is now a fragmentation *dis*equilibrium, because the contour formerly labeled $\Gamma(w, r, i^{*0})$ now represents

$$\Gamma\left(w, r, i^{*0} - \mathrm{d}i\right) = 1, \tag{17}$$

where $\mathrm{d}i$ is taken from (16). Given that $\mathrm{d}i$ in (16) is negative, this is an alternative way of saying that E^0 lies above the new Γ-contour for i^{*0}. Unit-cost may be lowered by extending the margin of fragmentation beyond i^{*0}. But there is an additional effect stemming from infra-marginal stages $i < i^{*0}$. These are now obtained cheaper than before, the cost-effect being

$$\int_{i=0}^{i^{*0}} \zeta(i)\rho(i) f(\bar{w}, \bar{r}, i)\mathrm{d}\tau_0\,\mathrm{d}i < 0.$$

According to (5) and (7), the fpf_1-line for the initial level of fragmentation i^{*0} shifts out in a proportional way.

It is readily seen that the direct effect on the Γ-contours and the fpf_1-shift reinforce each other towards an increase in the margin of fragmentation. Indeed, applying the

logic used above we realise that the ef-fpf$_1$-line shifts outward, while at the same time rotating it in a clockwise fashion. We arrive at the following proposition.

Proposition 4 *An equal reduction of the costs of international fragmentation across all stages unambiguously raises the equilibrium margin of international fragmentation i^*. It leads to a lower real wage rate and a higher real capital rental if factor intensities are as in cases B ($k_2 < k_1^m < k_1^v$) and C ($k_1^m < k_2 < k_1^v$), while opposite factor price effects arise in case A ($k_2 > k_1^v > k_1^m$).*

This proposition again refers to case I-a, but cases with other intensity assumptions are easily dealt with by analogous reasoning, which we leave to the reader.

The crucial difference to proposition 1 is that i^* *always* increases. The reason is that, in addition to the rotated shift in the ef-fpf$_1$-line, we now also observe a change in the set of Γ-contours. Comparing with the literature, two points are worth mentioning. First, a Pareto improvement is ruled out, the crucial point being the presence of a viable single-stage sector. This impossibility is quite independent on the driving force behind the change in i^*.[17] Absent a non-fragmentation activity, a Pareto improvement is possible, since the scenario features a saving in real resource use.[18] Secondly, the distributional change associated with an increase in fragmentation is ambiguous. Again, it is the presence of a viable single-stage sector which makes the difference. If the single-stage sector were non-viable, then the rotated shift in the ef-fpf$_1$-line caused by $\mathrm{d}\tau_0 < 0$ would unambiguously lower the domestic wage-rental ratio. This follows from the fact that full employment now requires that the slope of the ef-fpf$_1$-line must be equal to the given domestic capital-labour endowment ratio.[19]

[17] See Kohler (2003) for a general statement.

[18] Feenstra and Hanson (1996,1997) emphasize this possibility for a single-sector economy. In their scenario, an increase in i^* is brought about by international capital movement. Obviously, this must increase productivity of both types of labor in the capital-receiving country, which acts exactly like a downward-shift in $\tau(i)$.

[19] Kohler (2003) presents a general result on the distributional consequences of international frag-

7 Issues of Interpretation

With relatively little extra effort it can be shown that the above insights carry over to a more general 3-factor-model with *high-skilled* and *low-skilled* labour, alongside *physical capital*. Suppose, for instance, that production in industry 1 is separable between a multistage process, using the two types of labour, and physical capital. Assuming perfect international capital mobility and a given world interest rate, the long-run equilibrium stock of capital is determined by the usual no-arbitrage condition, stating that the marginal value productivity of capital is equal to its user cost which is, in turn, equal to the acquisition price of capital times the world interest rate plus the depreciation rate. If the final output and the capital good are the same, then the marginal productivity of capital is determined by the world interest rate. But this also uniquely determines the marginal productivity of the multistage process which uses high-skilled and low-skilled labour, and which can be modeled as above.[20] Zero profits in industry 1 imply that minimum cost of the multistage process be equal to its marginal productivity which is determined via endogenous capital formation from the given world interest rate. Competitive pressure from a decline in the final output price operates precisely as analysed above, with an appropriate re-interpretation of factor prices. We may also note that an increase in the world interest rate is equivalent to a decline in p_1, and vice versa.

We have mentioned above that international fragmentation is likely to be plagued by problems of incomplete contracts, which determine whether it emerges with arms-length transactions or within the hierarchy of a firm. But there are further open questions. One is why production of the final good should be restricted to the domestic economy. If the final good is a differentiated good, then producers may be located

mentation which encompasses the results obtained by Feenstra and Hanson (1996,1997) as special cases.

[20] For a similar approach focusing on only one industry, see Feenstra and Hanson (1996,1997).

in both countries, in line with the well known paradigm of intra-industry trade, and outsourcing may occur in *both directions* within an industry. In case I-a, labour intensive stages (upstream) are being outsourced from the domestic to the foreign economy, and vice versa for capital intensive ("downstream") stages.

Alternatively, an asset which is specific to domestic firms, most likely some variant of knowledge capital, may preclude production of the final good in the foreign country, at least in the short run. These issues are dealt with in the theory of the multinational firm; see Markusen (2002). What transpires from the above analysis is that outsourcing may be a vehicle towards a more *gradual* change in the international pattern of specialisation, driven by underlying long-term changes in comparative advantage. The more the margin of fragmentation moves "downstream" the production process, the more attractive and easy it may become for firms in the foreign country to develop and accumulate the relevant firm-specific asset. When this happens, shipment of the final good will also take place from the foreign country, without, however, any significant change in the production location of the various stages. It is obvious that such a process might equally arise in all of the other cases considered above. In case II-b, for instance, where "downstream" stages and assembly are more labour intensive, emergence of the multistage industry in the labour abundant foreign economy would happen "from downstream". Similar interpretations can be found for the remaining cases I-b and II-a.

8 Conclusions

International outsourcing is a new vehicle of arbitrage on international factor price differences, over and above trade in final goods, that often seems to hit a "raw nerve" in industrial countries who fear unwelcome wage effects. This fear is grounded in the direct effect of outsourcing on domestic labour demand. However, there is an indirect effect which is less visible, but by no means less important: outsourcing entails cost savings for domestic industries that should generally mandate higher domestic

factor rewards. Combining both effects in a general equilibrium analysis reveals that outsourcing may benefit domestic labour, even in the case where labour intensive stages are moved "offshore".

When attempting to identify the precise conditions under which this is the case, it is important to fully incorporate a key interdependency: Outsourcing is a determinant of, as well as a reaction to, domestic factor prices. To facilitate a theoretical investigation that incorporates this interdependency, this paper has first developed a dual representation of the technology of international fragmentation, assuming that production takes place in a continuum of stages with different capital intensity. Cost-minimizing firms then determine the margin up to which these stages are outsourced to the foreign economy, depending on domestic and foreign factor prices. This margin will change under almost any exogenous shock. In general equilibrium, outsourcing and factor prices are, thus, jointly endogenous, and the direction of their co-movement depends on the type of exogenous shock, as well as on the factor intensity details of the industries involved. Considering the inter-relationship between outsourcing industries and the rest of the economy is of crucial importance for a full understanding of the factor price effects.

In a 2×2 model with a multistage and a single-stage industry, both of which draw on mobile labour and capital, we have found that competitive pressure on the multistage industry in the form of a declining world price for the final good may well give rise to both, a higher level of outsourcing and a higher domestic wage rate. This outcome obtains if the multistage industry is less capital intensive than the other industry at the margin where outsourcing occurs, while at the same time being more capital intensive than the other industry if judged by all stages produced domestically. It also obtains if the outsourcing industry is clearly more capital intensive, both at the margin and in its total domestic value added. As regards real income, we have found that endogenous outsourcing generally mitigates (reinforces) the magnification effect behind the Stolper-Samuelson theorem, if there is a decline (rise) in the final output price.

While a decline in the final output price always leads to a reallocation of factors

towards the other industry, the multistage industry may react to such pressure by concentrating its domestic production on a narrower, or a broader range of stages. The range of domestic stages increases if the multistage industry is either clearly more capital intensive, or more labour intensive, than the other industry, whether judged by its overall domestic value added or at the margin. It falls, as perhaps expected, only in the case where the capital intensity at the margin of outsourcing lies in-between the industry's overall domestic capital intensity and the other industry's capital intensity.

We have also looked at a globalisation scenario involving lower costs of outsourcing. While this unambiguously increases the margin of outsourcing, the factor price effect is again ambiguous: Outsourcing may occur at the labour intensive margin of the multistage industry, yet domestic workers will benefit, provided overall domestic value added of the multistage industry is more labour intensive than in the other industry.

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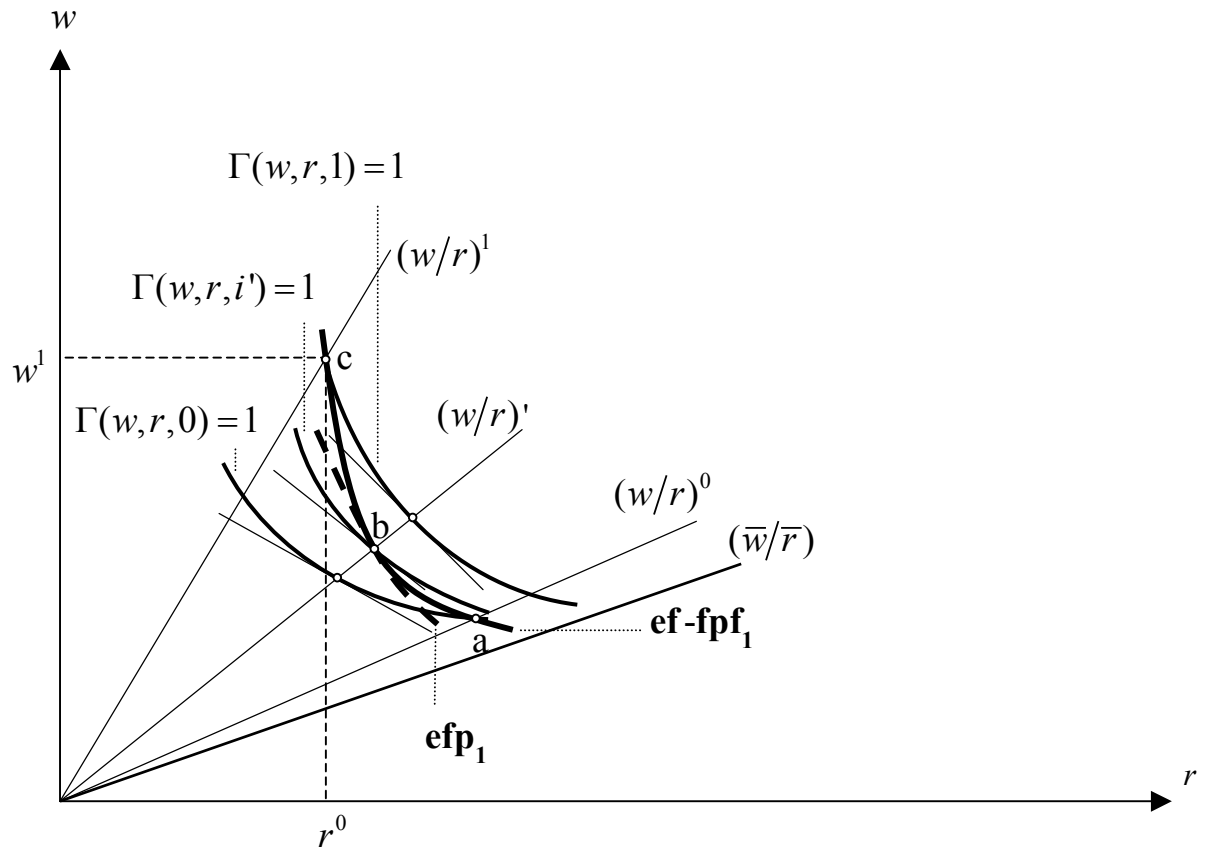

Figure 1: *The factor price frontier for a multistage industry with endogenous fragmentation.*

The factor price frontier with parametric fragmentation, fpf_1, is defined by $c_1\left(w,r,i'\right)=\overline{p}_1$ or, equivalently, by $v_1\left(w,r,i'\right)=\overline{p}_1-\overline{v}_1\left(\overline{w},\overline{r},i'\right)$. The "endogenous fragmentation factor price frontier", ef-fpf_1 ,is defined by $c_1\left[w,r,i^*\left(w,r\right)\right]=\overline{p}_1$.

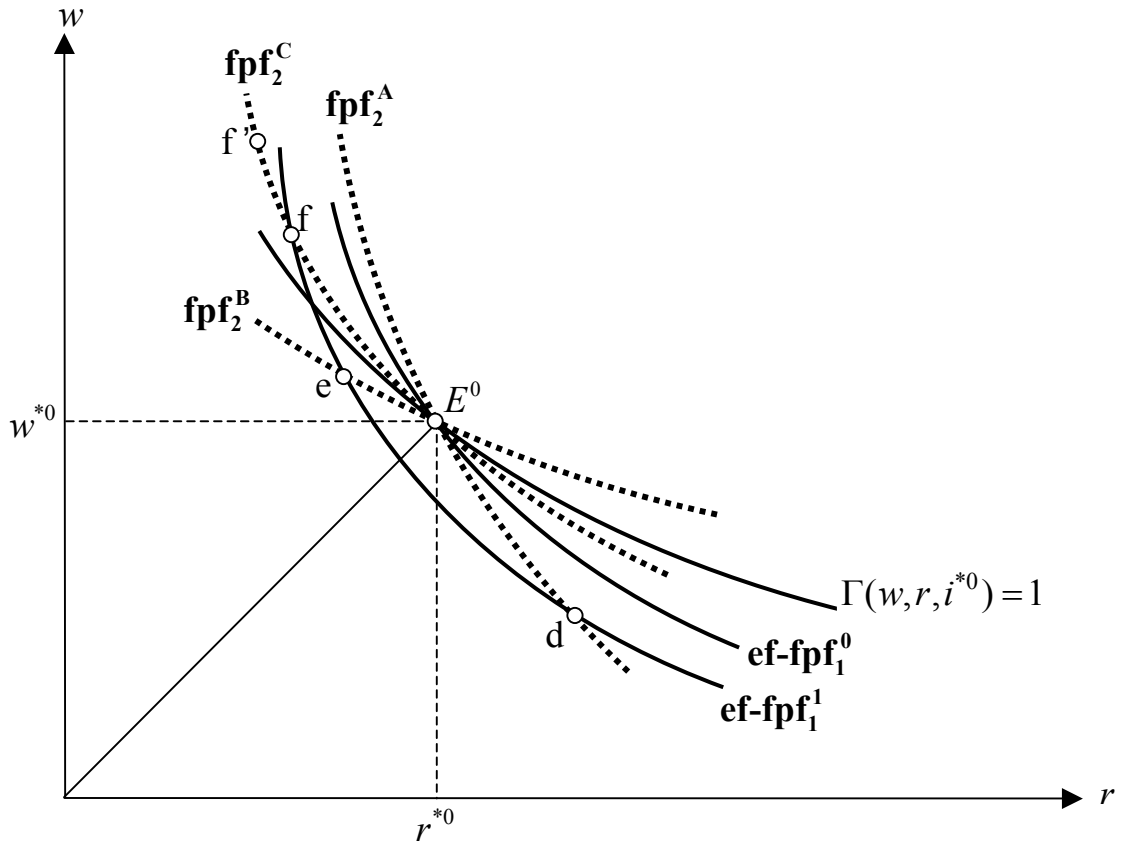

Fig. 2: *Factor price frontiers and comparative staitcs in general equilibrium.*

The "endogenous fragmentation factor price frontier" for sector 1, ef-fpf$_1$, takes two positions. ef - fpf$_1^0$**:** $c_1\left[w,r,i^*(w,r)\right]=\overline{p}_1^0$, and ef - fpf$_1^1$: $c_1\left[w,r,i^*(w,r)\right]=\overline{p}_1^1 < \overline{p}_1^0$.