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The distributional effects of international outsourcing in a 2 × 2 production model

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Abstract

This paper examines the distributional effects of international outsourcing in a two-sector, two-factor model. The analysis allows for switches between diversified and specialized equilibria. Also, equilibria in which only some firms of a sector outsource (incomplete or partial outsourcing) are considered. It is the interplay of the cost-saving and substitution effects of international outsourcing that determines the nature of the outsourcing equilibrium and its distributional consequences.

JEL classification: F11; F13; F19

Keywords: International outsourcing; Diversification equilibrium; Distributional effects; Welfare effects

1. Introduction

After trade and skill-biased technological change, fragmentation and outsourcing have been put forward as explanations for the rising wage differential between skilled and unskilled labor (cf. Feenstra & Hanson, 1996a, 1996b; Slaughter, 2000).[1] Moving the production of intermediate inputs intensive in the relatively scarce factor of the economy to a foreign country, depresses demand for the scarce factor in the source country. This conclusion has been challenged by Arndt (1997). The intuitively appealing idea, that in an industrialized, capital-rich country labor is set free if firms have access to cheap foreign labor, may be misleading in the general equilibrium for the following reason. The mere fact that firms have access to cheap labor makes them relatively more competitive so that

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[1] The empirical findings in Feenstra and Hanson (1999) "... support the idea that both foreign outsourcing and expenditures on computers have played a role in the increase of the relative wage for nonproduction workers, ..." (p. 938).

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they expand production. According to the analysis of Arndt, the positive employment effect resulting from the expansion of production outweighs the negative effect of substituting home labor with foreign labor. This leads to the somewhat surprising conclusion that outsourcing is beneficial for (unskilled) home labor, not harmful and points to the sector bias of international outsourcing. (See also Arndt, 1998a; Egger & Egger, 2001.) In the literature, the discussion on whether it is the factor bias (Feenstra & Hanson, 1996a, 1996b, 1999) or the sector bias (Arndt, 1997, 1998a) which matters for relative factor rewards is well-known from the debate of Krugman (2000) and Leamer (1998) on how technological change matters for wages. Feenstra and Hanson (1999) speak of an "apparent conflict in the literature" (p. 908). Whereas Leamer argues that the sector bias is relevant in a small open economy, Krugman maintains that in a closed or large open economy it is the factor bias that matters.[2]

It is the purpose of this study to present a systematic analysis of the impact of outsourcing on factor returns in the general equilibrium of an open economy. For a comprehensive picture, it is important to allow for the possibility of specialization in addition to diversification equilibria.[3] We also account for the fact that in a given sector we may observe outsourcing firms and non-outsourcing firms at the same time. The results are based on the general insight of the Stolper–Samuelson theorem that in a diversification equilibrium factor prices are determined by goods prices and technologies alone, whereas a change in factor endowments is irrelevant. Therefore, in an economy in which goods prices are given by the world market, outsourcing can only affect the distribution of factor incomes insofar as the technology of production is changed by the outsourcing firms.

In the case of specialization equilibria, factor endowments have a crucial role in the determination of factor prices. In particular, if international outsourcing affects the number of active sectors, its distributional effects are more subtle. Jones and Kierzkowski (2001a) argue that "... the standard Heckscher–Ohlin logic applies to small changes in technology, whereas the process of fragmentation is definitely not a marginal phenomenon" (p. 28). Or to state it in the words of Jones (2000) "The reason that standard Heckscher–Ohlin logic fails is that such logic is appropriate for relatively small changes, those that do not induce a change in the production pattern" (p. 129). Our analysis of international outsourcing considers such large changes. In a two-sector model, a change in the pattern of production arises if the economy switches from diversified to specialized equilibria or vice versa after firms have got access to international outsourcing.[4] We provide a systematic analysis of such switches and their impacts on factor prices.

In Section 2 we show first, that for an individual firm access to international outsourcing is formally equivalent to a choice between production techniques. However, in contrast to mere technical progress which makes new techniques profitable at given factor prices, international outsourcing involves also a change in the *set* of relevant factor prices. Therefore,

[2] Xu (2001) analyzes the factor price effects of technical progress by distinguishing between factor augmenting bias, factor using bias and sector bias.

[3] Krugman (2000) points out, that under certain conditions the results of technological change for a closed economy are similar to the results found for a one-sector small open economy.

[4] The production pattern also changes if different sectors are active in the specialized non-outsourcing and the specialized outsourcing equilibrium.

international outsourcing may become attractive as progress in coordination techniques makes fragmentation and outsourced production (be it national or international) more profitable, but also when international integration gives a firm access to cheap foreign production inputs. Based on the *dual* approach of the 2×2 production model, with its diagrammatic representation of unit–isocost curves in factor price space, we formally identify the assumptions that allow us to treat international outsourcing as equivalent to technical adoption.[5] This gives us a powerful tool for determining the possible outsourcing equilibria and the distributional effects of international outsourcing in these equilibria, including specialization equilibria as well as equilibria in which only some of the firms within a sector choose the outsourcing option.

Section 3 presents the results of this analysis. Compared with other recent studies,[6] our goal is to provide in a 2×2 production model a complete picture of the effect of international outsourcing on specialization and diversification in the economy's production structure. By allowing for changes in the production pattern of an economy, we gain deeper insights about how cost-saving and substitution effects interact in determining both the type of outsourcing equilibrium and the distributional consequences of international outsourcing. In Section 4, we discuss our main findings and compare them to the literature. A short conclusion completes the paper.

Two aspects are beyond the scope of this analysis. First, we do not consider the impact of outsourcing on the rest of the world. Therefore, we are not able to address the question of international factor price equalization.[7] Second, the focus of this paper lies on vertical outsourcing.[8]

2. Cross-border outsourcing in a *2 × 2* production model

2.1. Definitions and assumptions

We consider a small open economy endowed with two types of primary inputs K and L used in the production of two sectors $i = 1, 2$. The output of sector i is denoted as S^i. All markets are perfectly competitive and primary factors are mobile across sectors but internationally immobile. Production functions are linearly homogenous and strictly increasing, and the unit–isocost curves are strictly convex. Compared to integrated production within a firm, outsourced production is based on two requirements. First, it must be technologically possible to split up the production process into several fragments. Second, external transaction costs and market conditions must be such that a firm prefers purchasing fragments

[5] As Mussa (1979) pointed out, this "diagrammatic technique ... is particularly useful in illustrating the properties of the two-sector model which are essentially concerned with prices" (p. 525). Feenstra and Hanson (1999) used the dual approach in their discussion on the impact of technologies on factor prices. See also Jones and Kierzkowski (2001b) on the relation between international outsourcing and technical progress.

[6] See Arndt (1997, 1998a), Egger (2002), Jones (2000), and Jones and Kierzkowski (2001a). Kohler (2003) provides a systematic analysis of the general $n \times m$ model, however, without the possibility that the number of active production sectors changes due to outsourcing.

[7] The issue of international factor price equalization is discussed in Deardorff (2001a, 2001b).

[8] For a comparison of trade flows under horizontal and vertical fragmentation, see Venables (1999).

from outside the firm to in-house production. The following definitions provide a formal description of these aspects.[9]

Definition 1 (Fragmentation). Let $f(K, L)$ be a production function for commodity S and let $\boldsymbol{x} = (x_j(K, L)), j = 1, \ldots, m$, denote a vector of intermediate production functions. Then, $\boldsymbol{x}$ is said to be a fragmentation of integrated production, f, if there exists a "complementing" technology $g(K, L, \boldsymbol{x})$, such that for all $(K, L) \in R^2$

$$f(K, L) = g(K_0, L_0, x_1(K_1, L_1), \ldots, x_m(K_m, L_m)),$$

for some $(K_0, L_0), (K_j, L_j) \in R^2, j = 1, \ldots, m$.

Technology g may contain production processes, final assembly or simply consist of organizational and managerial activities necessary for coordinating fragmentation. Changes from integrated to fragmented production are not limited to international outsourcing. They generally play an important role in the discussion about organizational and technological change fostered by progress in information processing, logistics and management techniques.[10]

Whereas fragmentation means the splitting up of a production process independent of whether this occurs in-house or implies input purchases from outside the firm, outsourcing is characterized by a separation of production and involves market transactions.[11] In sum, outsourcing requires a fragmentation of the production process but not vice versa.

Definition 2 (Outsourcing). Let $\boldsymbol{x}$ be a fragmentation of f with complementing technology g. Then, outsourcing by a firm of intermediate $j \in \{1, ..., m\}$ means that the firm employs g instead of f and purchases $x_j(K_j, L_j)$ from outside the firm. We say that intermediate j is internationally outsourced if $x_j(K_j, L_j)$ is purchased from abroad, while the firm operating the complementing technology g is located at home.

In this paper we do not consider within-firm fragmentation or national outsourcing and focus on international outsourcing in *one* sector only.[12] Outsourced production consists of two component stages, that is, there is one intermediate input. Thus, output in sector i is given by $S^i = f^i(K^i_f, L^i_f)$ under integrated production and by $S^i = g^i(K^i_g, L^i_g, x^i(K^{i*}, L^{i*}))$ under outsourcing. Subscripts f and g refer to factor use in integrated and fragmented modes of production, respectively. The asterisk indicates levels of foreign factor inputs.

[9] In the literature, the phenomenon of outsourcing has been labeled in various way: "slicing up the value chain" (Krugman, 1995), "disintegration of production" (Feenstra, 1998), "multi-stage production" (Dixit & Grossman, 1982), "intra-product (or super-) specialization" (Arndt, 1998b). In recent years, the terms "*fragmentation*" (Deardorff, 2001a, 2001b; Jones & Kierzkowski, 2001a) and "*outsourcing*" (Feenstra, 1998; Feenstra & Hanson, 1996a; Grossman & Helpman, 2002a; Kohler, 2001) have become common. For an overview, see Hummels, Jun, and Yi (2001).

[10] For a discussion of $g(\cdot)$ in an international context, see Kohler (2001).

[11] The interaction between separated production units could also be handled by contractual arrangements within multinational enterprises (see Markusen, 2002). In contrast to this, the notion of outsourcing refers to intermediate goods trade. For a distinction between outsourcing and intra-firm transactions of multinational enterprises, see also Grossman and Helpman (2002b).

[12] See Arndt (1997, 1998a), Jones (2000) and Jones and Kierzkowski (2001a) for a similar approach.

Let $C^i_f \equiv w_K K^i_f + w_L L^i_f$ and $C^i_g \equiv w_K K^i_g + w_L L^i_g + c^i_x(w^*_K, w^*_L)x^i$ be production costs in sector i without and with international outsourcing, respectively. Domestic prices of K and L are denoted by w_K and w_L, respectively, while $c^i_x(w^*_K, w^*_L)$ is the cost of a unit of the imported intermediate good x^i, determined by the foreign technology for x^i, by foreign factor prices, w^*_K and w^*_L, and any trade costs.[13] Foreign factor prices are taken as given.

Our analysis is based on the *dual* approach of the 2×2 production model. Therefore, we have to specify the unit–isocost curves for integrated and outsourcing production technologies. Denote by $c^i_f(w_K, w_L)$ the minimum unit cost of production in sector i without international outsourcing. Moreover, let $k^i_f(w_K, w_L)$ be the factor intensity K^i_f/L^i_f in sector i under integrated production. Cost minimization under outsourcing implies the minimum-cost combination of x^i and home-supplied factor inputs K, L. For production technology g and given unit costs c^i_x, let $a^i_K(w_K, w_L, c^i_x), a^i_L(w_K, w_L, c^i_x), a^i_x(w_K, w_L, c^i_x)$ be the minimum-cost input coefficients of home factors K, L and intermediate input x^i, respectively. Then, the minimum unit cost of production in sector i under international outsourcing is given by the function

$$c^i_g(w_K, w_L, c^{i*}_x) \equiv w_K a^i_K + w_L a^i_L + c^{i*}_x a^i_x,$$

with $c^{i*}_x \equiv c^i_x(w^*_K, w^*_L)$. w^*_K, w^*_L and thus, c^{i*}_x are exogenously given for the small economy.

Perfect competition implies zero profits. Thus, $\min\{c^i_f(w_K, w_L), c^i_g(w_K, w_L, c^{i*}_x)\} = p^i$, for each sector i. Unit–isocost functions c^i_f and c^i_g have standard properties. They are linearly homogeneous in their arguments and the isocost curves in the (w_K, w_L)-space are negatively sloped and strictly convex. The slope $-(\mathrm{d}w_L/\mathrm{d}w_K)|_{c^i_f=\text{const}}$ is given by k^i_f and the slope $-(\mathrm{d}w_L/\mathrm{d}w_K)|_{c^i_g=\text{const}}$ is given by $k^i_g(w_K, w_L, c^{i*}_x) = a^i_K(w_K, w_L, c^{i*}_x)/a^i_L(w_K, w_L, c^{i*}_x)$. Moreover, strict convexity implies $(\mathrm{d}^2 w_L/\mathrm{d}w^2_K)|_{c^i_f=\text{const}} > 0$ and $(\mathrm{d}^2 w_L/\mathrm{d}w^2_K)|_{c^i_g=\text{const}} > 0$.

The sign of $\partial k^i_g/\partial c^{i*}_x$ depends on whether domestic capital or labor is substituted by the outsourced intermediate component.

Definition 3. International outsourcing is cost-saving at domestic factor prices $\bar{w}_K, \bar{w}_L$ if $c^i_f(\bar{w}_K, \bar{w}_L) > c^i_g(\bar{w}_K, \bar{w}_L, c^{i*}_x)$.[14]

The following definition characterizes international outsourcing with respect to its factor intensity impact.

[13] Note that neither technologies nor factor prices must be identical in the two countries.

[14] Since $\partial c^i_g/\partial c^{i*}_x > 0$, international outsourcing will be attractive, if the foreign country employs a superior technology for the production of intermediate input x^i or if factor prices are lower abroad, due to endowment differences. It is worth noting that if factor price differences are large enough, and trade costs are low, the outsourcing technology (including the outsourced intermediate process) may at given factor prices be strictly more resource-demanding than the integrated production technology. This was first noted by Deardorff (2001a) and highlights the main difference from resource-saving technical progress. With respect to the dynamics of international outsourcing, Jones (2000) and Jones and Kierzkowski (2001a) point out that, besides declining tariffs and legal non-tariff barriers, declining costs for service links, which are required for coordination and communication activities, may explain why exploitation of lower foreign factor prices by outsourcing became accessible in recent years. Formally, such changes in transaction costs are reflected by a lower c^{i*}_x.

Definition 4. Let $\bar{w}_K, \bar{w}_L$ be a pair of factor prices fulfilling $c_g^i(\bar{w}_K, \bar{w}_L, c_x^{i*}) = p^i$. We say that there is labor-outsourcing (capital-outsourcing) at $\bar{w}_K, \bar{w}_L$, if $k_g^i(\bar{w}_K, \bar{w}_L, c_x^{i*}) > (<)$ $k_f^i(\bar{w}_K, \bar{w}_L)$. We also say that outsourcing substitutes labor (capital) and conserves capital (labor, respectively).

It is assumed that over the relevant range of factor prices, production techniques can be ranked according to factor intensities. Factor intensity reversals are not considered. (A formal discussion of this assumption is provided in Appendix A.)

2.2. Equilibria

Equilibria without and with international outsourcing (referred to as non-outsourcing and outsourcing equilibria, respectively) are determined by factor endowments, production technologies and by given world market prices. In Fig. 1, the different types of non-outsourcing equilibria of a small open economy are shown. The *set* of factor prices which is consistent with non-positive profits is given by Ψ^f, where ψ^f is its frontier. Equilibrium factor prices are subject to the following condition: $(w_K, w_L) \in \psi^f$. For a given frontier ψ^f, i.e., given production technologies and world market prices, p^i, p^{-i}, relative factor endowment $\bar{k}$ determines the non-outsourcing equilibrium. Point A in Fig. 1 shows a diversified non-outsourcing equilibrium with factor prices w_K^f, w_L^f. Points B and C describe specialized equilibria with factor endowments $\bar{k}' > k_f^i(w_K^f, w_L^f)$ and $\bar{k}'' < k_f^i(w_K^f, w_L^f)$, respectively.

To identify the type of equilibrium resulting when firms get access to cost-saving outsourcing, it is important to note that three technologies are relevant, namely, the two integrated

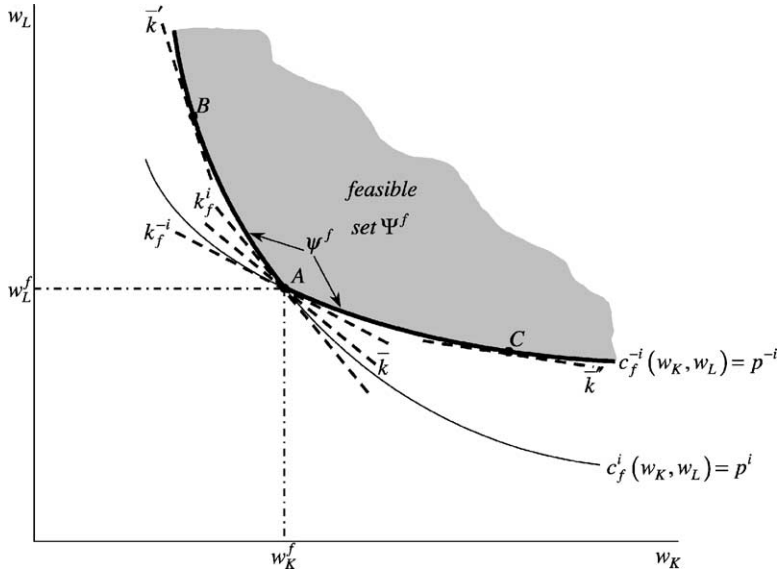

Fig. 1. Non-outsourcing equilibria with sector i producing K-intensive and sector $-i$ producing L-intensive.

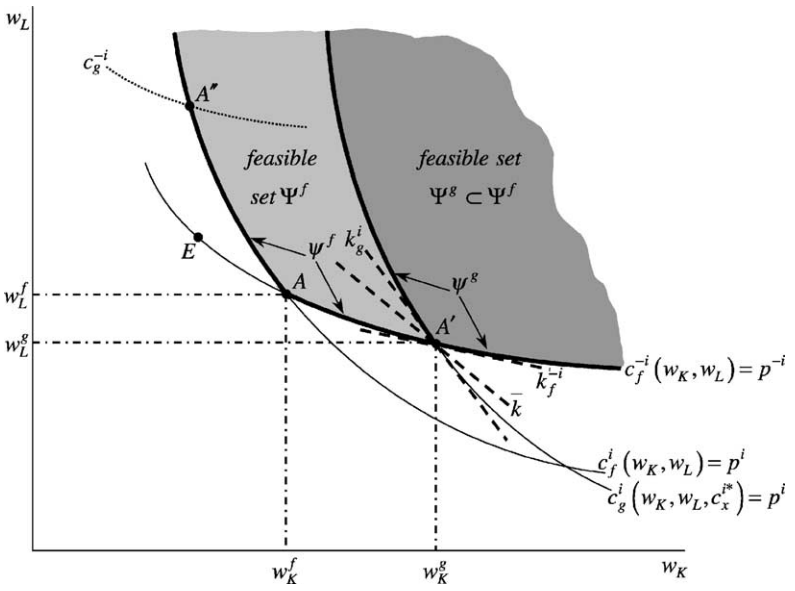

Fig. 2. A diversified equilibrium with firms of the *K*-intensive sector *i* engaged in international *L*-outsourcing.

production modes and one outsourcing technology. Let $\Psi_i^g \equiv \{(w_K, w_L) | c_g^i(w_K, w_L, c_x^{i*}) \geq p^i\}$. The set of factor prices which is consistent with non-positive profits is then determined by $\Psi^g \equiv (\Psi_i^g \cap \Psi^f)$. Let ψ^g denote the lower frontier of Ψ^g. As in the non-outsourcing case, for a given lower frontier ψ^g, i.e., given production technologies and world market prices, relative factor endowment $\bar{k}$ determines which type of outsourcing equilibrium is realized under perfect competition. The cost-saving effect of international outsourcing implies $\Psi^g \subset \Psi^f$.

Fig. 2 shows a diversified equilibrium before and after firms of the *K*-intensive sector acquire access to cost-saving international outsourcing.[15] The cost-saving effect of international outsourcing, i.e., $c_f^i(w_K^f, w_L^f) > c_g^i(w_K^f, w_L^f, c_x^{i*})$ at given non-outsourcing equilibrium factor prices w_K^f and w_L^f, implies an outward shift of the (w_K, w_L)-combinations at which the unit production costs of the *K*-intensive sector equal the given price p^i. Note, as a first result, that technology f^i vanishes ($c_f^i(w_K^g, w_L^g) > c_g^i(w_K^g, w_L^g, c_x^{i*}) = p^i$) in the *K*-intensive sector, if international outsourcing is cost-saving and the outsourcing equilibrium is diversified.

3. Distributional effects of international outsourcing

In this section, we give a systematic exposition of the distributional effects of international outsourcing for all possible equilibrium situations. We use the diversification/specialization

[15] The assumption that production technologies can be ranked according to factor intensities implies that neither the c_f^i-curve nor the c_g^i-curve can cross the c_f^{-i}-curve twice.

Table 1
Combinations of non-outsourcing and outsourcing equilibria under international outsourcing in the K-intensive sector

Outsourcing equilibrium	Non-outsourcing equilibrium		
	Diversification	Specialization in K-intensive sector	Specialization in L-intensive sector
Diversification	*DD*	*KD*	*LD*
Specialization in K-intensive sector	*DK*	*KK*	*LK*
Specialization in L-intensive sector	n.p.	n.p.	n.p.

dichotomy as an organizing principle. For a given (diversified or specialized) non-outsourcing equilibrium, the type of equilibrium depends on both cost-saving and substitution effects of international outsourcing. Graphically (Fig. 2), the first effect corresponds to the outward shift of the $c_g^i = p^i$-locus (relative to $c_f^i = p^i$), whereas the second effect is reflected by the rotation of c_g^i relative to c_f^i. In order to make it easier to keep track of the various diversification and specialization equilibria, we enumerate in Table 1 all possible combinations of non-outsourcing and outsourcing equilibria when the K-intensive sector has access to cost-saving international outsourcing. Columns characterize sectoral production patterns in the non-outsourcing equilibrium, while rows describe the outsourcing equilibrium.

3.1. A diversified outsourcing equilibrium

We start our analysis with the standard H-O set-up of diversified equilibria. This case is represented in Fig. 2 under the assumption that there is labor-outsourcing in the K-intensive sector. We see the established result that if both non-outsourcing and outsourcing equilibria are diversified, then the real return to the factor used intensively in the outsourcing sector increases whereas the real return to the other factor decreases.[16]

The result follows from the properties of frontier ψ^f and the fact that a diversified outsourcing equilibrium must lie on that segment of ψ^f which represents the zero-profit conditions for the non-outsourcing sector. This confirms the finding in the literature that the impact of international outsourcing on factor returns exhibits a sector bias. In Fig. 2, the K-intensive sector i obtains access to cost-saving international outsourcing, so that the factor price outcome lies on lower frontier ψ^f to the right of non-outsourcing equilibrium point A. As a result factor K gains, and factor L loses.[17]

Note that factor intensity rankings are preserved in the case of diversified equilibria. Under diversification, factor price combinations always lie on frontier ψ^f to the north-west of non-outsourcing equilibrium point A in Fig. 1, if the L-intensive sector has cost-saving access to international outsourcing, and to the south-east of point A, if the K-intensive sector has cost-saving access to international outsourcing. Since outsourcing is cost-saving, the $c_g^i = p^i$-locus in Fig. 2 lies above A. Therefore, $k_g^i > k_f^{-i}$ (as shown at point A′ in Fig. 2) if outsourcing occurs in the K-intensive sector i. For the same reason, $k_f^i > k_g^{-i}$ if L-intensive sector $-i$ has access to cost-saving outsourcing (see A″ where the dotted line represents c_g^{-i}).

[16] This corresponds to case *DD* in Table 1.
[17] See Arndt (1997, 1998a) for a similar finding.

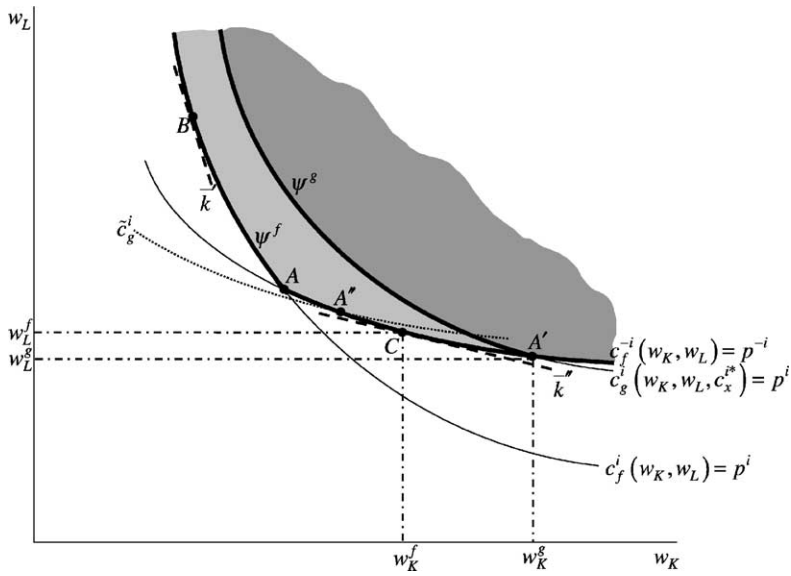

Fig. 3. A specialized non-outsourcing and a diversified outsourcing equilibrium.

Next, we analyze the effects of outsourcing, when the non-outsourcing equilibrium is specialized and the outsourcing equilibrium is diversified. This means that international outsourcing fundamentally changes the *production pattern* in the economy.[18] In the following, a sector (active or not) is said to be intensive in a factor if at given relative factor prices cost minimization implies a relatively more intensive use of the factor under the integrated technology f^i than under the integrated technology f^{-i} of the other sector.[19]

Theorem 1. (a) *If only the outsourcing sector is active in the non-outsourcing equilibrium and outsourcing substitutes the factor intensively used in the outsourcing sector, then outsourcing cannot lead to a diversified outsourcing equilibrium.* (b) *If international outsourcing leads from a specialized non-outsourcing equilibrium to a diversified outsourcing equilibrium, the impacts of outsourcing on factor prices are the same as in* Theorem 1 *except for one case, namely: If the outsourcing sector is inactive in the non-outsourcing equilibrium and outsourcing substitutes the factor which is intensive in this sector, then the impact on both factor returns is ambiguous.*

For a graphical proof,[20] Fig. 3 shows a situation where firms in the *K*-intensive sector *i* have access to cost-saving international outsourcing. A diversified outsourcing equilibrium

[18] See the discussion in Jones (2000) and Jones and Kierzkowski (2001a) on the importance of outsourcing-induced changes in production patterns.

[19] Part (a) of Theorem 1 shows that case *KD* in Table 1 is possible only if there is *L*-outsourcing. Part (b) deals with this case, as well as with *LD*.

[20] Full-length formal proofs can be found in the working paper version available from the authors.

must lie on frontier ψ^f south-east of intersection point A. We must distinguish between two cases. First, if the K-intensive outsourcing sector is active in the non-outsourcing equilibrium (like in point B), it is clear that factor K gains, whereas factor L loses, since the diversified outsourcing equilibrium lies to the south-east of A and thus, south-east of B. Moreover, capital-outsourcing cannot lead to a diversified outsourcing equilibrium, since both isocost curves would be flatter than $\bar{k}'$ at possible candidates for a diversified equilibrium. In sum, if the non-outsourcing equilibrium is specialized in the outsourcing sector i, the factor bias determines whether a diversified outsourcing equilibrium is possible. However, if there is a diversified outsourcing equilibrium, then it is the sector bias of international outsourcing, which determines the factor price developments.

Second, if the outsourcing sector i is inactive in the non-outsourcing equilibrium (as at point C), then factor price reactions are ambiguous if there is capital-outsourcing in the capital-intensive sector i. In Fig. 3, points A′ and A″ refer to two possible factor price outcomes.[21] An equilibrium like A′ results if access to cost-saving international outsourcing does not affect the ranking of sectors according to their factor intensities, and it is again the sector bias which determines the factor price effects of international outsourcing. If the economy moves from non-outsourcing equilibrium C to outsourcing equilibrium A′, factor K, which is used intensively in outsourcing sector i, gains and L loses.

Different factor price effects result in an outsourcing equilibrium like A″. Such an equilibrium is possible if the substitution effect of outsourcing is strong enough, so that it leads to a change in the factor intensity ranking of sectors, i.e., if K-intensive sector i becomes L-intensive in the outsourcing equilibrium. (In Fig. 3, this possibility is indicated by the relatively flat dotted line $\tilde{c}_g^i$ through point A″.) In this case, the factor that is intensively used in the outsourcing sector (under integrated production) loses, whereas the other factor gains. In Fig. 3, factor K loses and factor L gains, if access to international outsourcing shifts equilibrium factor price combinations from C to A″.

Finally, if there is labor outsourcing in the capital-intensive, non-outsourcing sector, i.e., if unit–isocost curve c_g^i is steeper at point C than unit–isocost curve c_f^i, then the diversified outsourcing equilibrium must lie on frontier ψ^f south-east of non-outsourcing equilibrium C, like point A′. Since a change in the ranking of sectors cannot arise, it is again the sector bias which determines factor price outcomes.

These findings are summarized in Table 2 for outsourcing in the K-intensive sector. In this matrix, "+" and "−" mean that international outsourcing has a positive or negative impact on the respective real or relative factor price. A "amb." indicates that the impact is ambiguous.

3.2. A specialized outsourcing equilibrium

This section focuses on specialized outsourcing equilibria. In the specialized outsourcing equilibrium, factor prices may be such that both the integrated technology and the outsourcing technology are consistent with zero-profits. Firms switch from integrated production to outsourcing as long as the adoption of the outsourcing technology is profitable under given

[21] Note that point C is also a candidate for a diversified outsourcing equilibrium, namely, if the two loci $c_g^i = p^i$ and $c_f^{-i} = p^{-i}$ coincide. In this border line case, factor prices are not affected by international outsourcing.

Table 2
Outsourcing in the *K*-intensive sector leading to a diversified outsourcing equilibrium

K-intensive outsourcing sector[a]	w_K		w_L		w_K/w_L	
	Inactive	Active	Inactive	Active	Inactive	Active
L-outsourcing	+	+	−	−	+	+
K-outsourcing	amb.	+[b]	amb.	−[b]	amb.[c]	+[b]

[a] Active/inactive refers to the non-outsourcing equilibrium.
[b] If the non-outsourcing equilibrium is specialized in production in the *K*-intensive sector, *K*-outsourcing does not lead to a diversified outsourcing equilibrium.
[c] One factor gains and one factor loses.

factor prices. When many firms switch, factor prices change and may settle at values at which firms are indifferent between integrated production and outsourcing. We distinguish three cases: (i) In the non-outsourcing equilibrium as well as in the outsourcing equilibrium, the country is specialized in the outsourcing sector. (ii) Cost-saving access to international outsourcing in sector i leads from a diversified non-outsourcing equilibrium to specialization in the outsourcing sector. (iii) Specialization occurs in the non-outsourcing sector in the non-outsourcing equilibrium, and shifts to the other sector in the outsourcing equilibrium. In (ii) and (iii), international outsourcing again fundamentally changes the *production pattern* in the economy. Theorem 2 states the distributional effects of cost-saving international outsourcing in sector i for case (i), i.e., if the production pattern is not altered.[22]

Theorem 2. *If the country is specialized in production in outsourcing sector i in both the non-outsourcing and the outsourcing equilibrium, then the following holds.* (a) *If outsourcing conserves the factor which is intensively used in outsourcing sector i, then the real return to that factor increases. The real return to the other factor declines if both the integrated (f) and the outsourcing (g) technology are in use. The impact on the real return to this factor is ambiguous if only the outsourcing technology g survives.* (b) *If outsourcing substitutes the factor intensively used in outsourcing sector i, then the real return to this factor decreases if both the integrated (f) and the outsourcing (g) technology are in use in sector i. The impact on the real return to this factor is ambiguous if only the outsourcing technology survives. The real return to the other factor always increases.*

Fig. 4 shows part (a) of Theorem 2 for the case of labor-outsourcing in the *K*-intensive sector. Point B represents a non-outsourcing equilibrium specialized in production in the *K*-intensive outsourcing sector i. Since the equilibrium is specialized, factor intensity at B is equal to $\bar{k}'$. Both technologies f and g can be in use only if the outsourcing equilibrium is at the intersection of the $c_g^i = p^i$-locus and the $c_f^i = p^i$-locus and the intersection (A′) lies between A and B in Fig. 4.[23] In this case, factor *K* gains and factor *L* loses. North-west of B all firms produce with higher *K*-intensity than $\bar{k}'$.

[22] Theorem 2 corresponds to case *KK* in Table 1.
[23] A represents the intersection point of the $c_f^i = p^i$-locus with the $c_f^{-i} = p^{-i}$-locus.

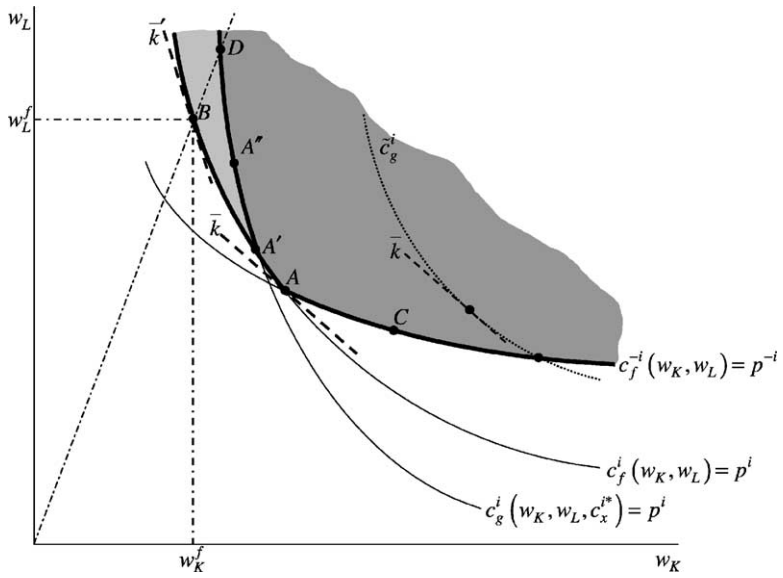

Fig. 4. *L*-outsourcing of the *K*-intensive sector and specialization in outsourcing sector *i*.

If only outsourcing technology *g* survives, then the new outsourcing equilibrium lies on frontier ψ^g within the interval A′D. (Because of *L*-outsourcing, at point D factor intensity under technology *g* is higher than factor intensity under *f* at point B.) A possible outcome is point A″, where factor *K* gains and factor *L* loses. However, w_L does not necessarily decline. Depending on the strength of the substitution (rotation) relative to the cost-saving (shift) effect, the new equilibrium factor price outcome may lie on any point on the segment A′D. As a consequence, the impact on the return to substituted factor *L* is ambiguous. Relative factor returns always increase in favor of factor *K*.

Fig. 5 shows part (b) of Theorem 2 for the case of capital-outsourcing in *K*-intensive sector *i*. Capital intensity at point D under technology *g* is lower than $\bar{k}'$. Therefore, an outsourcing equilibrium specialized in sector *i* must lie on segment A′D north-west of D. Factor *L* gains both in real and relative terms, independent of whether the integrated production technology survives in the outsourcing equilibrium. If integrated technology *f* survives, i.e., if the outsourcing equilibrium is given by intersection point A′, the return to factor *K* declines. In contrast, if only outsourcing technology *g* is in use in the outsourcing equilibrium, the impact on the return to factor *K* is ambiguous.

In sum, we find that access to international outsourcing exhibits a factor-biased effect on factor returns, if the country is specialized in the outsourcing sector in both the non-outsourcing as well as the outsourcing equilibrium. This result coincides with the findings for factor-biased technological change in one-sector models.[24]

[24] In a simple example, Krugman (2000) has shown that the factor bias of technical change identified in a one-sector model can be reproduced in a large-country two-sector model. This is in contrast to the findings for small open economies, where technical change exhibits a sector-biased effect on factor prices, see Leamer (2000).

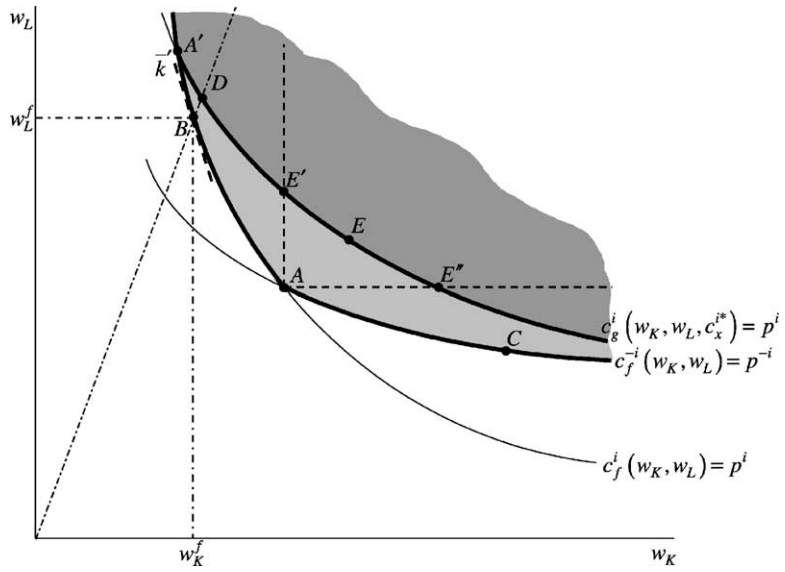

Fig. 5. *K*-outsourcing of the *K*-intensive sector and specialization in outsourcing sector *i*.

Theorem 3 characterizes the distributional effects for the remaining two cases, namely, case (ii), in which access to international outsourcing leads to a reduction in the number of active sectors, and case (iii) with non-outsourcing sector $-i$ active in the specialized non-outsourcing equilibrium. Note that the following theorem covers case (ii) as well as case (iii), since in both cases the non-outsourcing sector $-i$ is active in the non-outsourcing equilibrium.[25]

Theorem 3. *If the non-outsourcing sector* $-i$ *is active in the non-outsourcing equilibrium and the country is specialized in production in outsourcing sector* i *in the outsourcing equilibrium, then the results of* Theorem 2 *hold with the following two modifications. Under the assumptions of part* (a), *integrated technology f cannot survive in equilibrium. Under the assumptions of part* (b), *outsourcing has an ambiguous effect on both factor prices if only technology g survives in the outsourcing equilibrium.*

The first modification can be seen from Fig. 4. If the non-outsourcing equilibrium is diversified (point A) or specialized in the *L*-intensive non-outsourcing sector $-i$ (point C), cost-saving labor-outsourcing shifts the relevant $c_g^i = p^i$-locus to the right of A or C, respectively. (See, e.g., the dotted line $\tilde{c}_g^i$ with an intersection point south-east of C.) But then only outsourcing technology *g* can survive in the specialized outsourcing equilibrium.[26] This

[25] Theorem 3 corresponds to cases *DK* and *LK* in Table 1.

[26] If the integrated technology is in use in the outsourcing equilibrium, substitution of factor *L* tends to work against complete specialization. Specialization, therefore, requires that the cost-saving effect of international outsourcing is "sufficiently large" so that non-outsourcing sector $-i$ vanishes.

Table 3
Outsourcing in the K-intensive sector leading to an outsourcing equilibrium specialized on the K-intensive sector

L-intensive non-outsourcing sector[a]	w_K		w_L		w_K/w_L	
	Inactive	Active	Inactive	Active	Inactive	Active
L-outsourcing						
(a) f and g active	+	n.p.[b]	−	n.p.[b]	+	n.p.[b]
(b) only g active[c]	+	+	amb.	amb.	+	+
K-outsourcing						
(a) f and g active	−	−	+	+	−	−
(b) only g active[c]	amb.	amb.	+	amb.	−	amb.

[a] Active/inactive refers to the non-outsourcing equilibrium.
[b] If the L-intensive sector is active in the non-outsourcing equilibrium, only the outsourcing technology g is in use in a specialized outsourcing equilibrium.
[c] Both factors may gain from international outsourcing.

implies k_g^i equals relative factor endowment, which is possible at factor prices north-west of the intersection point of the $\tilde{c}_g^i$-locus with frontier ψ^f. Whereas factor K gains in both real and relative terms, the impact on the return to factor L is ambiguous. (See Theorem 2 part (a).)

The ambiguity arising under (b) can be seen in Fig. 5. Again, since the non-outsourcing sector $-i$ is active in the non-outsourcing equilibrium, we start at point A or C, respectively. Then, in the case of capital-outsourcing, the relevant $c_g^i = p^i$-locus is relatively flat compared to $c_f^i = p^i$. If the intersection point of the $c_g^i = p^i$-locus with the $c_f^i = p^i$-locus lies north-west of A, both integrated technology f as well as outsourcing technology g may be in use in the outsourcing equilibrium. In this case, the return to factor L increases, whereas the return to factor K declines, due to the factor bias of international outsourcing. In contrast, if only outsourcing technology g survives, the outsourcing equilibrium lies on frontier ψ^g, south-east of A′, and the impact of outsourcing on returns w_K and w_L as well as on relative factor returns w_K/w_L is ambiguous.

Suppose, for example, that the non-outsourcing equilibrium is diversified and, therefore, given by point A in Fig. 5. Then, the real return to factor K increases if and only if the outsourcing equilibrium lies to the right of E′. The real return to factor L increases if and only if the outsourcing equilibrium lies above E″. Due to the cost-saving effect of international outsourcing, at least one factor gains if the non-outsourcing equilibrium is diversified.[27] The ambiguity in relative factor price developments arises, since there is no clear dominance of the two effects, namely, the rotation (factor bias) and the shift (sector bias) of the relevant unit–isocost curve of outsourcing sector i.

Table 3 provides a complete listing of real and relative factor price effects if the outsourcing equilibrium is specialized. As in Table 2, outsourcing is assumed to occur in the K-intensive sector. Regarding the possible non-outsourcing equilibria, we have two cases, namely, one where the L-intensive (non-outsourcing) sector is active in the non-outsourcing

[27] If the non-outsourcing equilibrium is specialized in the non-outsourcing sector $-i$ and if the two loci $c_g^i = p^i$ and $c_f^{-i} = p^{-i}$ coincide, then point C is also a candidate for a specialized outsourcing equilibrium. In this border-line case factor prices are not affected by international outsourcing.

equilibrium and one where it is not. The first case corresponds to Theorem 3, the second case to Theorem 2.[28]

3.3. International outsourcing and the Pareto criterion

The welfare effects of international outsourcing, in terms of its impact on factor prices, may be stated as follows.

Theorem 4. *In a* 2×2*-production framework with linear homogeneous technologies, no factor intensity reversal and given commodity prices, access to cost-saving international outsourcing does not lead to a Pareto-improvement, if the integrated technology is used in at least one sector in the outsourcing equilibrium. If integrated technologies are totally replaced by outsourcing technologies both factors may possibly gain.*

Theorem 4 follows directly from the properties of frontier ψ^f and the fact that the set of Pareto-improving factor price outcomes is a strict subset of contour set Ψ^f. To see this, consider in Fig. 5 the diversified non-outsourcing equilibrium at point A. Then, the set of Pareto-improving factor price developments lies within the two dashed lines through point A. Factor price outcomes which lie on frontier ψ^f are not consistent with a Pareto-improvement. This implies that a Pareto-improving factor price effect of international outsourcing can only arise if the small country specializes in production in the outsourcing sector and if integrated technologies (f) are driven out of the market. (See the second and the fourth row of Table 3.) In particular, a Pareto-improving factor price effect of international outsourcing in sector i arises if the cost-saving and substitution effects of outsourcing are such that the outsourcing equilibrium lies within interval $E'E''$ on frontier ψ^g, like point E.

4. Discussion

In the discussion of the distributional effects of international outsourcing, the literature distinguishes between factor- and sector-biased impacts of international outsourcing (Kohler, 2001). Whereas the former is analyzed within one-sector models (Feenstra & Hanson, 1996b), the analysis in a two-sector framework shows that the factor bias of international outsourcing, i.e., the factor intensity of the outsourced intermediate input, is of no interest as long as diversified equilibria are considered. Rather, the relevant question is in which sector outsourcing occurs (Arndt, 1997, 1998a). As shown in Section 3, this result holds only if both the non-outsourcing and outsourcing equilibria are diversified. However, since the type of outsourcing equilibrium itself depends on the interplay of substitution and cost-saving effects of international outsourcing, a restriction on diversified equilibria implies a restriction on the possible forms of international outsourcing. As Theorems 1–3 make clear, the distinction between sector and factor bias alone is not sufficient to give a comprehensive picture of the distributional effects of international outsourcing.

[28] This is different from Table 2, where the inactivity/activity dichotomy refers to the K-intensive outsourcing sector.

Section 3 addresses distributional issues when international outsourcing is not *complete*. If cost-saving international outsourcing becomes available in one sector, it may nonetheless pay for some firms in this sector to retain the integrated mode of production in the outsourcing equilibrium. Thus, the integrated technology may co-exist with the outsourcing technology. This is especially relevant with respect to real-world considerations. In line with Krugman's (2000) finding for a one-sector economy, we show in Table 3 that the factor bias of international outsourcing remains the relevant force in determining factor prices if the integrated production mode survives and co-exists with the outsourcing technology.

International outsourcing may change the pattern of production (see Jones, 2000 and Jones & Kierzkowski, 2001a). Consider the case of a small open economy completely specialized in the absence of outsourcing. Then, international outsourcing opportunities in the non-viable sector may lead to diversified production in the outsourcing equilibrium. The textile industry, for example, which migrated to developing countries (mainly in Asia), has been reactivated in the industrialized world in the last few years, using fragmentation and international outsourcing opportunities.

Finally, international outsourcing is Pareto-improving only if integrated technologies are totally replaced by outsourcing technologies. With respect to the Pareto criterion, the assumptions of perfect competition and intersectoral mobility are of course crucial for our conclusions. In reality, adjustment costs may produce losers, at least in the short run. Moreover, the analysis above does not incorporate any fixed costs of international outsourcing, which may yield a welfare decline in the outsourcing economy (Kohler, 2001). Finally, the constant price assumption makes our analysis suitable for small open economies only.

5. Conclusion

In this paper we identify under which assumptions we can treat international outsourcing as technical progress. This approach and the advantages of the dual representation of the 2×2 production model allow us to distinguish two driving forces, namely, a substitution and a cost-saving effect of international outsourcing. They determine the type of outsourcing equilibrium (relative to the non-outsourcing equilibrium) and the factor price consequences of international outsourcing.

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Appendix A. Factor intensities

We make the usual assumption that there is no factor intensity reversal under integrated production. Formally, if $k_f^i(w_K, w_L) \gtrless k_f^{-i}(w_K, w_L)$ for some w_K, w_L, then $k_f^i(w'_K, w'_L) \gtrless k_f^{-i}(w'_K, w'_L)$ for all possible factor prices w'_K, w'_L. (Note that k_f^i, k_f^{-i} depend only on

relative factor prices, not on their level.) Outsourcing means that in one of the two sectors $j \in \{i, -i\}$ a new technology is available. Comparisons between integrated and outsourcing modes of production can only be made if outsourcing and integrated technologies can be ranked according to their factor intensities. Unfortunately, k_g^j may change with proportional variations in w_K, w_L since k_g^j is also a function of c_x^{j*}. Only if the outsourcing technology is separable, in the sense that $g^j(K, L, x^j) = \tilde{g}^j(h^j(K, L), x^j)$ for some linearly homogeneous $\tilde{g}^j$ and h^j, does k_g^j depend solely on relative factor prices w_K/w_L. However, it is not necessary to rank $k_g^j(w_K, w_L, c_x{}^{j*})$ relative to $k_f^i(w_K, w_L)$ and $k_f^{-i}(w_K, w_L)$ globally. It is sufficient to assume that no factor intensity reversal occurs over a certain range of factor prices. Let $W^j \equiv \{(w_K, w_L) | c_g^j(w_K, w_L, c_x^{j*}) = p^j\}$ be the subset of factor prices defined by the zero-profit condition in outsourcing sector j. We assume that there is no factor intensity reversal over W^j, i.e., if $k_f^i(w_K, w_L) \gtrless k_g^i(w_K, w_L, c_x^{j*})$ for some $(w_K, w_L) \in W^j$, then $k_f^i(w'_K, w'_L) \gtrless k_g^i(w'_K, w'_L, c_x^{j*})$ for any $(w'_K, w'_L) \in W^j$, $i = 1, 2$. This differs from the treatment of technical progress in the Heckscher–Ohlin model, where a global ranking of factor intensities is usually assumed. In the case of international outsourcing, such a global ranking is in general not possible due to the change in the set of inputs in the production process.

An immediate implication of our assumption about factor intensity rankings is that Definition 4 of the factor bias of outsourcing describes a global property in the *subset* W^i, where sector i is the outsourcing sector. If outsourcing in sector i conserves factor L (factor K) at factor prices $(\bar{w}_K, \bar{w}_L) \in W^i$, it conserves factor L (factor K) at any other factor prices $(w_K, w_L) \in W^i$ as well.

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