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Abstract

This paper determines the distributional effects of international outsourcing in a two sector Heckscher-Ohlin type model. It is shown that the factor-biased and the sector-biased impact of international outsourcing discussed in the literature can be seen as special cases of the more general characterization presented in this paper. Concerning the welfare implications of international outsourcing, the main finding is that a Pareto-improvement cannot be excluded from a theoretical point of view.

JEL Classification: F11, F13, F19.

Keywords: international outsourcing, general equilibrium analysis, distributional effects, welfare effects.

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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 and Hanson, 1996a, 1996b; Slaughter, 2000). Moving the production of those intermediate inputs, which substitue the relatively scarce factor of the economy to foreign countries in which this factor is cheap depresses demand for the scarce factor in the source country. This conclusion has been challenged by Arndt (1997a). The intuitively appealing idea, that labor of an industiralized capital rich country 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 they expand production. According to the analysis of Arndt, the postitive employment effect resulting from the expansion of production outweighs the negative effect of substituting home labor by foreign labor. This leads to the somewhat surprising conclusion that outsourcing is beneficial for (unskilled) home labor, not harmful. However, as Egger and Egger (2001) showed in their analysis the conclusion of Arndt is not a general result but based on special assumptions, which have to be assessed empirically.[1]

It is the purpose of this study to give a full characterization of the impact of outsourcing on factor returns in the general equilibrium of an open economy which has no influence on prices in the world market. The results

[1]Compare also the discussion in Arndt (1997b), which makes clear that the factor market implications of international outsourcing depend on the relative factor intensities of the different sectors in a diversified equilibrium.

are based on the general insight of the Stolper-Samuelson theorem that factor prices are determined by the goods prices and the employed technologies alone, whereas a change in factor endowments is irrelevant as long as the economy is in a diversification equilibrium. Therefore, in an economy in which goods prices are given by the world market, outsourcing can only affect the distribution of factor incomes insofar the technology of production is changed by the outsourcing firms. Of course, things change if a specialization equilibrium is reached. In this case, factor endowments have a crucial role for the determination of factor prices and the distributional effects of international outsourcing are more subtle, as pointed out by our analysis.

We show first, that for an individual firm economical access to international outsourcing is equivalent to employing a new production technique. Thereafter, we determine the general equilibrium of a two sector economy in which the firms of one sector can choose between a traditional way of production and a new method based on international outsourcing. After having characterized factor intensities in the equilibrium with and without international outsourcing, respectively, we compare the equilibrium prices of the two primary factors resulting under outsourcing with those in an economy in which outsourcing is not feasible. The welfare implications of international outsourcing are also derived. The final step of our analysis is to discuss our main findings and to compare them to the literature. A short conclusion completes the paper.

2 Cross Border Outsourcing in a 2x2 Production Model

2.1 Definitions and Assumptions

Although in the literature the terms *fragmentation* and *outsourcing* are sometimes used synonymously there is an important difference between the two notions. Whereas fragmentation means the splitting up of a production process independent of whether this occurs within or across firms or plants, the latter one contains not only the splitting up but also the spatial separation of production. Denote by Q the set of vectors of available primary factors of production and let $X = x^1 \times ... \times x^n$ be the set of possible intermediate goods.[2] Then the following definition characterizes fragmentation.

Definition 1 *(Fragmentation) Let* $f(\mathbf{q})$, $\mathbf{q} \in Q$, *and* $\mathbf{x}(\mathbf{q}^1, ..., \mathbf{q}^n) = (x^1(\mathbf{q}^1), x^2(\mathbf{q}^2), ..., x^n(\mathbf{q}^n))$, $\mathbf{q}^1, ..., \mathbf{q}^n \in Q$, *be production functions. Then, intermediate production processes* $\mathbf{x}$ *are said to be a fragmentation of integrated production* f *if there exists a "residual" technology* $g(\mathbf{q}^0, \mathbf{x})$, *such that for all* $\mathbf{q} \in Q$

$$f(\mathbf{q}) = g\left(\mathbf{q}^0, \mathbf{x}\left(\mathbf{q}^1, ..., \mathbf{q}^n\right)\right)$$

for some $\mathbf{q}^0, \mathbf{q}^1, ..., \mathbf{q}^n \in Q$.

[2] We use the term intermediate goods in a broad sense, including services as well as products.

Residual technology g may contain production processes, final assembly or simply consist of organizational and managerial activities necessary for coordinating fragmentation. Using this characterization the definition of outsourcing directly follows.

Definition 2 *(Outsourcing) Let* $\mathbf{x}$ *be a fragmentation of* f *with residual technology* g*. Then, outsourcing of intermediate* j *means that* g *is employed at the same location as* f *whereas* $x^j(\mathbf{q}^j)$ *is spatially seperated. We say that intermediate* j *is internationally outsourced if* $x^j(\mathbf{q}^j)$ *is located abroad, whereas residual production* g *remains located at home.*

For our analysis of international outsourcing the following assumptions are made. First, we consider a small economy, so that world market prices $\mathbf{p}$ are given. Second, markets are perfectly competitive and factors are perfectly mobile between sectors but immobile across borders. Third, we focus on the familiar 2x2 production framework, with two primary factors of production, say $\mathbf{q} = (Y, Z)$, and two sectors of production, $i = 1, 2$. Let $\overline{Y}$ and $\overline{Z}$ be the respective total endowments of home and let S^i denote the output of sector i. Fourth, all firms within one sector are identical. Fifth, production functions are strictly increasing, strictly concave, linearly homogeneous and differentiable. Sixth, we do refrain from national outsourcing and within-firm fragmentation and focus on international outsourcing only. Seventh, among the outsourcing firms, we restrict the analysis to two component stages, that means that only one intermediate $x(\cdot)$ is considered.[3] In sum, our assumptions so far imply that output in sector i is given by $S^i = f^i\left(Y_f^i, Z_f^i\right)$ under

[3] If there are more than one component outsourced to foreign, $x(\cdot)$ summarizes all those components.

integrated production and by $S^i = g^i\left(Y_g^i, Z_g^i, x^i\left(Y^{i*}, Z^{i*}\right)\right)$ under fragmentation. Subscripts f and g refer to factor use in integrated and fragmented modes of production, respectively. The asterisk indicates levels of foreign factor inputs.

Before finishing the list of assumptions, note the following. Let $C_f^i \equiv w_Y Y_f^i + w_Z Z_f^i$ and $C_g^i \equiv w_Y Y_g^i + w_Z Z_g^i + w_Y^* Y^{i*} + w_Z^* Z^{i*}$ be production costs in sector i without and with international outsourcing, respectively. w_Y and w_Z are fator prices of Y and Z in home and w_Y^* and w_Z^* are the respective factor prices in foreign. Denote by $c_f^i\left(w_Y, w_Z\right)$ the minimal unit costs of production in sector i without international outsourcing. Moreover, let $k_f^i\left(w_Y, w_Z\right)$ be the optimal factor intensity Y_f^i/Z_f^i in sector i under integrated production. Cost minimization under outsourcing can be seperated into two subproblems: cost-minimal production of intermediate x^i and cost-minimal combination of x^i and home-supplied factor inputs X, Y. Let $c_x^i\left(w_Y^*, w_Z^*\right)$ be the minimal unit costs of production of intermediate x^i in foreign. Moreover, let, for production technology g and given unit costs c_x^i, $a_Y^i\left(w_Y, w_Z, c_x^i\right)$, $a_Z^i\left(w_Y, w_Z, c_x^i\right)$, $a_x^i\left(w_Y, w_Z, c_x^i\right)$ be the cost-minimal input coefficients of home factors Y, Z and intermediate x^i, respectively. Then, minimal unit costs of production in sector i under outsourcing are given by the function

$$c_g^i\left(w_Y, w_Z, c_x^{i*}\right) \equiv w_Y\, a_Y^i + w_Z\, a_Z^i + c_x^{i*}\, a_x^i,$$

with $c_x^{i*} \equiv c_x^i\left(w_Y^*, w_Z^*\right)$. w_Y^*, w_Z^* and thus c_x^{i*} are exogenously given for the considered small economy.

Perfect competition implies zero profits. Thus,

$$\min\left\{c_f^i\left(w_Y,w_Z\right),c_g^i\left(w_Y,w_Z,c_x^{i*}\right)\right\}=p^i,$$

for each sector i which is active at home. c_f^i and c_g^i have standard properties. They are linear-homogeneous in their arguments and the isocost curves in the (w_Y,w_Z)-space are negatively sloped and strictly convex. The slope $-\frac{dw_Z}{dw_Y}\Big|_{c_f^i=const}$ is given by k_f^i and the slope $-\frac{dw_Z}{dw_Y}\Big|_{c_g^i=const}$ is given by

$$k_g^i\left(w_Y,w_Z,c_x^{i*}\right)=\frac{a_Y^i\left(w_Y,w_Z,c_x^{i*}\right)}{a_Z^i\left(w_Y,w_Z,c_x^{i*}\right)}.$$

Moreover, due to the strict convexity, we have

$$\frac{d^2w_Z}{dw_Y^2}|_{c_f^i=const}>0 \quad \text{and} \quad \frac{d^2w_Z}{dw_Y^2}|_{c_g^i=const}>0.$$

Finally, the sign of $\partial k_g^i/\partial c_x^{i*}$ is ambiguous. It depends on whether the outsourced intermediate substitutes factor Y or factor Z.

Definition 3 *At given wage rates $\overline{w}_Y$, $\overline{w}_Z$ sector i has economical access to international outsourcing if*

$$c_f^i\left(\overline{w}_Y,\overline{w}_Z\right)\geq c_g^i\left(\overline{w}_Y,\overline{w}_Z,c_x^{i*}\right)$$

and $c_g^i\left(\overline{w}_Y,\overline{w}_Z,c_x^{i*}\right)\leq p^i$. International outsourcing is cost saving if

$$c_f^i\left(\overline{w}_Y,\overline{w}_Z\right)>c_g^i\left(\overline{w}_Y,\overline{w}_Z,c_x^{i*}\right).$$

(Note that access to cost-saving international outsourcing is equivalent to

$c_x^{i*} < \overline{c}_x^i$ *for some threshold* $\overline{c}_x^i$.[4] *)*

Since it can easily be shown that if international outsourcing is not cost saving, the economical access to international outsourcing does not have any impact on factor prices, we do ignore this case in the following analysis.

Concerning the factor intensity of the outsourced component, the following definition characterizes the type (with respect to its intensity) of international outsourcing.

Definition 4 *Let* $\overline{w}_Y, \overline{w}_Z$ *be a pair of factor prices fulfilling* $c_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) = p^i$. *We say outsourcing substitutes factor* Z *(factor* Y*) at* $\overline{w}_Y, \overline{w}_Z$ *if*

$$k_g^i\left(\overline{w}_Y, \overline{w}_Z, c_x^{i*}\right) > (<)\, k_f^i\left(\overline{w}_Y, \overline{w}_Z\right).$$

We also speak of Z*-outsourcing (*Y*-outsourcing, respectively) at* $\overline{w}_Y, \overline{w}_Z$. *As benchmark case we have* <u>*neutral*</u> *outsourcing if* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) = k_f^i(\overline{w}_Y, \overline{w}_Z)$.

2.2 Factor Intensities

We make the usual assumption that there is no factor intensity reversal under integrated production. Formally, if $k_f^i(w_Y, w_Z) \gtrless k_f^{-i}(w_Y, w_Z)$ for some w_Y, w_Z, then $k_f^i(w'_Y, w'_Z) \gtrless k_f^{-i}(w'_Y, w'_Z)$ for all possible factor prices w'_Y, w'_Z. (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

[4] $\overline{c}_x^i$ is implicitly defined by the equation $c_f^i(\overline{w}_Y, \overline{w}_Z) = c_g^i(\overline{w}_Y, \overline{w}_Z, \overline{c}_x^i)$. Since $\partial c_g^i / \partial c_x^{i*} > 0$, $c_f^i(\overline{w}_Y, \overline{w}_Z) \gtreqless c_g^i\left(\overline{w}_Y, \overline{w}_Z, c_x^{i*}\right)$ if $c_x^{i*} \lesseqgtr \overline{c}_x^i$.

production can only be made if outsourcing and integrated technologies can be ranked according to their factor intensities. However, it is not necessary to rank $k_g^j(w_Y, w_Z, c_x^{j*})$ relative to $k_f^i(w_Y, w_Z)$ and $k_f^{-i}(w_Y, w_Z)$ globally.[5] It is sufficient to assume that no factor intensity reversal occurs over a certain range of factor prices. Let $W^j = \left\{(w_Y, w_Z) \mid c_g^j(w_y, w_Z, c_x^{j*}) = p^j\right\}$ be the subset of factor prices defined by the zero profit condition in the outsourcing sector j. We assume that there is no factor intensity reversal over W^j, i.e.: If $k_f^i(w_Y, w_Z) \gtrless k_g^j(w_Y, w_Z, c_x^{j*})$ for some $(w_Y, w_Z) \in W^j$, then $k_f^i(w'_Y, w'_Z) \gtrless k_g^j(w'_Y, w'_Z, c_x^{j*})$ for any $(w'_Y, w'_Z) \in W^j$, $i = 1, 2$.

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 of sector i substitutes factor Z (factor Y) at factor prices $(\overline{w}_Y, \overline{w}_Z) \in W^i$, it substitutes factor Z (factor Y) at any other factor prices $(w_Y, w_Z) \in W^i$ as well.

2.3 Equilibria

Before anaylsing the distributional effects of international outsourcing we have to identify the possible equilibria without and with international outsourcing (refered to as non-outsourcing and outsourcing equilibria, respectively). The possible equilibria without international outsourcing are given

[5]Note that k_g^j may change with proportional variations in w_Y, w_Z since k_g^j is also a function of c_x^{j*}. Only if the outsourcing technology is seperable, in the sense that $g^j(Y, Z, x^j) = \widetilde{g}^j(h^j(Y, Z), x^j)$ for some linear-homogenous $\widetilde{g}^j, h^j$, k_g^j depends only on relative factor prices w_Y, w_Z.

by fact 1.

Fact 1 *Let* $\overline{k} \equiv \overline{Y}/\overline{Z}$*. Moreover, let* $\overline{w}_Y$ *and* $\overline{w}_Z$ *be defined by* $c_f^i(\overline{w}_Y, \overline{w}_Z) = p^i$*, for* $i = 1, 2$ *and* $\overline{\omega} = \overline{w}_Y/\overline{w}_Z$*. Assume that* i *denotes the* Y*-intensive sector, i.e.* $k_f^i(\overline{w}_Y, \overline{w}_Z) > k_f^{-i}(\overline{w}_Y, \overline{w}_Z)$*, then:*
(i) The non-outsourcing equilibrium is diversified if and only if at factor prices $\overline{w}_Y$ *and* $\overline{w}_Z$*,* $k_f^i(\overline{w}_Y, \overline{w}_Z) > \overline{k} > k_f^{-i}(\overline{w}_Y, \overline{w}_Z)$*. In this case equilibrium factor rewards are given by* $w_Y^f = \overline{w}_Y$ *and* $w_Z^f = \overline{w}_Z$*.*
(ii) The non-outsourcing equilibrium is specialized on the Z*-intensive sector* $-i$ *if and only if* $k_f^{-i}(\overline{w}_Y, \overline{w}_Z) > \overline{k}$*. In this case equilibrium factor rewards* w_Y^f *and* w_Z^f *are determined by the equations* $c_f^{-i}\left(w_Y^f, w_Z^f\right) = p^{-i}$ *and* $k_f^{-i}\left(w_Y^f, w_Z^f\right) = \overline{k}$*.*
(iii) The non-outsourcing equilibrium is specialized on the Y*-intensive sector* i *if and only if* $k_f^i(\overline{w}_Y, \overline{w}_Z) < \overline{k}$*. In this case equilibrium factor rewards* w_Y^f *and* w_Z^f *are determined by the equations* $c_f^i\left(w_Y^f, w_Z^f\right) = p^i$ *and* $k_f^i\left(w_Y^f, w_Z^f\right) = \overline{k}$*.*

The case $k_f^i(w_Y, w_Z) = k_f^{-i}(w_Y, w_Z)$, which would imply that technologies for integrated production in both sectors are described by the same factor intensities, is ignored. Figure 1 represents for $\overline{Y}/\overline{Z} = \overline{k}$ a situation where a diversified equilibrium exists before firms have access to international outsourcing as defined in definition 3. Point B shows for $\overline{k}' > k_f^i\left(w_Y^f, w_Z^f\right)$ a specialization equilibrium with only the Y-intensive sector being active. In contrast for $\overline{k}'' < k_f^{-i}\left(w_Y^f, w_Z^f\right)$, we have an equilibrium (point C) specialized on the Z-intensive sector.

>Figure 1<

All equilibria which are possible after firms in sector i have accesss to international outsourcing are given by fact 2.

Fact 2 *Let* $\overline{k} \equiv \overline{Y}/\overline{Z}$. *Let* $\overline{w}_Y$ *and* $\overline{w}_Z$ *be determined by the equations* $c_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) = p^i$ *and* $c_f^{-i}(\overline{w}_Y, \overline{w}_Z) = p^{-i}$ *and assume that only firms in sector i have economical access to cost saving international outsourcing, then:*

(i) The outsourcing equilibrium is diversified (with both sectors i and $-i$ *active) if at factor prices* $\overline{w}_Y, \overline{w}_Z$ *either* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) > \overline{k} > k_f^{-i}(\overline{w}_Y, \overline{w}_Z)$ *or* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) < \overline{k} < k_f^{-i}(\overline{w}_Y, \overline{w}_Z)$. *In a diversified outsourcing equilibrium factor prices are given by* $w_Y^g = \overline{w}_Y$ *and* $w_Z^g = \overline{w}_Z$.

(ii) The outsourcing equilibrium is specialized on sector i if at factor prices $\overline{w}_Y, \overline{w}_Z$ *either* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) < \overline{k}$ *and* $k_f^{-i}(\overline{w}_Y, \overline{w}_Z) < \overline{k}$ *or* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) > \overline{k}$ *and* $k_f^{-i}(\overline{w}_Y, \overline{w}_Z) > \overline{k}$. *(The case* $k_g^i(\overline{w}_Y, \overline{w}_Z, c_x^{i*}) = k_f^{-i}(\overline{w}_Y, \overline{w}_Z) = \overline{k}$ *is consistent with diversification as well as specialization.)*

(iii) If the outsourcing equilibrium is specialized on sector i, then both the integrated (f) and the outsourcing (g) technology are in use if and only if there exist factor prices $\widetilde{w}_Y, \widetilde{w}_Z$, *for which* $c_g^i(\widetilde{w}_Y, \widetilde{w}_Z, c_x^{i*}) = p^i$, $c_f^i(\widetilde{w}_Y, \widetilde{w}_Z) = p^i$ *and* $k_g^i(\widetilde{w}_Y, \widetilde{w}_Z, c_x^{i*}) < \overline{k} < k_f^i(\widetilde{w}_Y, \widetilde{w}_Z)$ *or* $k_g^i(\widetilde{w}_Y, \widetilde{w}_Z, c_x^{i*}) > \overline{k} > k_f^i(\widetilde{w}_Y, \widetilde{w}_Z)$. *In this case equilibrium wages are given by* $w_Y^g = \widetilde{w}_Y$ *and* $w_Z^g = \widetilde{w}_Z$. *Otherwise, only the outsourcing technology g is in use and equilibrium factor prices* w_Y^g *and* w_Z^g *are determined by the equations* $c_g^i(w_Y^g, w_Z^g, c_x^{i*}) = p^i$ *and* $k_g^i(w_Y^g, w_Z^g, c_x^{i*}) = \overline{k}$.

Figure 2 shows a diversified equilibrium before and after firms of the Y-intensive sector get access to cost saving international outsourcing. The cost saving effect of international outsourcing, i.e. $c_f^i\left(w_Y^f, w_Z^f\right) > c_g^i\left(w_Y^f, w_Z^f, c_x^{i*}\right)$ at given non-outsourcing equilibrium factor prices w_Y^f and w_Z^f, implies an outward shift of the (w_Y, w_Z)-combinations at which the unit production costs of the Y-intensive sector equal the given goods price p^i. Note as a first result, that technology f^i vanishes $(c_f^i(w_Y^g, w_Z^g) > c_g^i(w_Y^g, w_Z^g, c_x^{i*}) = p^i)$ in the Y-intensive sector if international outsourcing is cost saving and the outsourcing equilibrium is diversified.[6]

>Figure 2<

2.4 Distributional Effects of International Outsourcing

The aim of this paper is to identify the distributional effects of international outsourcing, i.e. its impact on the returns to the production factors in home. The following theorems give a complete characterization of this impact for diversified as well as specialized equilibria.

Theorem 1 *If both the non-outsourcing and the outsourcing equilibrium 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.*

Proof. See the appendix. ■

As an immediate consequence of theorem 1 we get the following.

[6] A border line case is $c_f^i\left(w_Y^f, w_Z^f\right) = c_g^i\left(w_Y^f, w_Z^f, c_x^{i*}\right) = p^i$. In this case firms in the Y-intensive sector are indifferent between using technology f^i and technology g^i and factor prices in the outsourcing equilibrium are equivalent to those in the non-outsourcing equilibrium.

Corollary 1 *If both the non-outsourcing and the outsourcing equilibrium are diversified, then outsourcing does not change the ranking of sectors according to their factor intensities. In particular, a diversified outsourcing equilibrium with* $k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) = \overline{k} = k_f^{-i}\left(w_Y^g, w_Z^g\right)$ *is impossible.*

Proof. See the appendix. ■

The next theorem characterizes the distributional consequences if outsourcing reduces the number of production sectors active in the economy. Note that access to cost-saving international outsourcing can lead to an elimination of the non-outsourcing sector, but not to an elimination of the outsourcing sector.

Theorem 2 *If international outsourcing leads from a diversified non-outsourcing equilibrium to an outsourcing equilibrium specialized on the outsourcing sector* i*, then the following holds.*
(i) If outsourcing substitutes the factor which is intensively used in the non-outsourcing sector $-i$*, then only technology* g *is in use in the outsourcing equilibrium and the real return to the factor used intensively in sector* i *increases, whereas the impact on the real return to the other factor is ambiguous.*
(ii) If outsourcing substitutes the factor intensively used in the outsourcing sector i*, then the real return to this factor decreases and the real return to the other factor increases, if both the integrated* (f)*and the outsourcing* (g) *technology are in use in sector* i*, whereas the impact on both factor returns is ambiguous if only the outsourcing technology survives. Nevertheless, at least one factor gains.*

Proof. See the appendix ■

Table 1 in the appendix summarizes the distributional effects of international outsourcing in a concise way. In addition to the real factor price effects given by theorems 1 and 2 it also shows the impact of international outsourcing on relative factor prices.

Implications of international outsourcing for real returns to the primary factors can also be derived if the non-outsourcing equilibrium is specialized. Theorem 3 states the distributional consequences if access to cost-saving outsourcing leads to an increase in the number of active sectors in the economy so that the outsourcing equilibrium is diversified although the non-outsourcing equilibrium was not. Theorem 4 considers the case that the economy is specialized without and with international outsourcing, where outsourcing opportunities may change the nature of specialization. Of course, the specialization in the outsourcing equilibrium can only be on the outsourcing sector. Both theorem 3 and theorem 4 focus on the main differences to the factor price implications given by theroems 1 and 2. (See tables 2 and 3 in the appendix for a complete listing of real and relative factor price effects if the non-outsourcing equilibrium was specialized.)

In the following, a factor is said to be intensively used in sector i 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. Whether the respective sector is active or not does not matter for this notion. Also the notion of Y-outsourcing and Z-outsourcing, according to definition 4, is independent of whether the respective sector was active in the non-outsourcing equilibrium.

Theorem 3 *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. If the outsourcing sector was inactive in the non-outsourcing equilibrium and outsourcing substitutes the factor which is intensively used in this sector, then the impact on both factor returns is ambiguous. Nevertheless, one factor gains and one factor loses.*

Proof. See the appendix. ■

Theorem 4 *If both the non-outsourcing and the outsourcing equilibrium are specialized, then the following holds:*
(i) If the outsourcing sector i was inactive in the non-outsourcing equilibrium, the impacts on factor prices are the same as in theorem 2.
(ii) If the outsourcing sector i was active in the non-outsourcing equilibrium the impacts on factor prices are the same as in theorem 2 apart from the following exemptions: If outsourcing substitutes the factor which is intensively used in the non-outsourcing sector $-i$ then both technologies f and g may be in use in the outsourcing equilibrium. In this case the effect on the real return to the factor intensively used in sector $-i$ is no longer ambiguous (as in theorem 2) but definitely negative. The real return to the other factor increases. If outsourcing substitutes the factor intensively used in the outsourcing sector i and only technology g is in use in the outsourcing equilibrium, then the effect on the real return to the factor intensively used in sector $-i$ is no longer ambiguous but definitely positive. The real return to the other factor remains ambiguous (as in theorem 2).

Proof. See the appendix. ■

Concerning the welfare effects of international outsourcing, the impacts on factor prices derived above directly lead to the following assessment.

Theorem 5 *In a 2x2 production framework with linear homogeneous technologies, no factor intensity reversal and given commodity prices, economical access to cost saving international outsourcing does not lead to a Pareto-improvement if at least in one sector the integrated technology is used in the outsourcing equilibrium. If integrated technologies are totally subsituted by outsourcing technologies both factors may possibly gain without redistributional measures.*

Proof. Directly follows from theorems 1-4. ■

3 Discussion

Modelling international outsourcing as cost-saving technological change which allows firms to import intermediate goods produced at lower costs abroad makes it possible to analyse the effects of international outsourcing in a uniform framework despite the many different forms that international outsourcing may have. The specific form of international outsourcing chosen by a firm depends on the set of intermediate inputs which can be produced abroad in a cost-saving way. In industrialized countries international outsourcing may substitute (unskilled) labor which can be employed relatively cheap in developing countries. However, it might well be the case that skill-intensive intermediate goods are outsourced to countries which are well-endowed with skilled labor.

In the discussion of the distributional effects of international outsourcing, in terms of relative or real factor returns the literature distinguishes between *factor-biased* and *sector-biased* impacts of international outsourcing (compare Kohler, 2001). Whereas the former is analysed within one sector models (compare Feenstra and Hanson, 1996b), the analysis in a two sector Heckscher-Ohlin 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 (compare Arndt, 1997a, 1997b). For instance if the skill-intensive sector is engaged in international outsourcing, then skilled labor gains and the real wage of unskilled labor declines. This is in line with the usual worries that the burden of international outsourcing is born by unskilled workers. In contrast, if firms in the relatively less skill-intensive sector outsource intermediate production, the unskilled labor gains whereas wages of skilled workers go down. This is the case by which Arndt (1997a) challenged the conventional wisdom that (unskilled) labor is the loser of outsourcing. However, as Kohler (2001) points out the factor-biased impact of international outsourcing arises in a two sector model if a Ricardo-Viner framework is chosen instead of a Heckscher-Ohlin model.

Our general characterization of international outsourcing in a two sector Heckscher-Ohlin type model allows for both the sector-biased and the factor-biased impact of international outsourcing. In particular, as theorem 1 makes clear, international outsourcing within one sector has a sector-biased impact on factor returns if both the non-outsourcing and the outsourcing equilibrium are diversified. In contrast, if the outsourcing equilibrium is specialized, a factor-biased impact of international outsourcing may arise. But as theorems 2-4 and tables 1-3 make clear the distinction between sector and factor-bias alone is not sufficient to give a comprehensive picture of the distributional effects that international outsourcing can have.

The following section lists the main extensions to the scientific discussion on the factor price implications of international outsourcing following from the general characterization given in this paper. First, international outsourcing has not to be complete. This means that if cost-saving international outsourcing becomes economically attractive within one sector, it may nonehteless pay for some firms in this sector to retain the integrated mode of production also in the outsourcing equilibrium. Thus, the integrated technology may survive along with the outsourcing technology. Second, international outsourcing may revive an inactive sector. Then, the factor price implications depend on the number of sectors active in the outsourcing equilibirum and the technologies used in these sectors. This is an interesting case considering for example the textile industry which after having 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, and perhaps most important for the political discussion, international outsourcing may yield a Pareto-improvement. However, as pointed out by theorem 5 a Pareto-improvement induced by international outsourcing is only possible if integrated technologies are totally substituted by outsourcing technologies. In our two sector model with only one sector having access to international outsourcing, a Pareto-improvement is only possible if the outsourcing equilibrium is specialized on the outsourcing sector with only the outsourcing technology in use in the surviving sector. In general, the outsourcing equilibrium has not to be specialized for a Pareto-improving impact of international outsourcing to occur. For instance, if both sectors are engaged in international outsourcing and outsourcing is complete, i.e. if integrated technologies are totally substituted by outsourcing technologies, the diversified outsourcing equilibrium may also be Pareto-superior to the (diversified) non-outsourcing equilibrium.

The assumptions of the Heckscher-Ohlin model are of course crucial for our conclusions. In reality, adjustment costs may cause 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 (compare Kohler, 2001). Finally, the constant price assumption makes our analysis suitable for small open economies only.

4 Conclusion

The aim of this paper was to show that the impact of international outsourcing on real and relative factor prices depends critically on different factors determining the concrete form of international outsourcing (i.e. the number of sectors being active, the factor intensities of the sectors and the outsourced component, etc.). In extension to the discussion in the literature, it was shown that the so called factor-biased and sector-biased impacts of international outsourcing are not comprehensive but may rather be seen as special cases of a more general characterization of international outsourcing presented in this paper.

Concerning the fears that mainly unskilled workers in industrialized economies will be the losers of international outsourcing, the analysis in this paper showed that at least from a theoretical point of view it may also be the skilled workers who lose from outsourcing despite the empirical evidence that mainly less skill-intensive parts of production are the object of outsourcing decisions of globalized firms. Although so far neglected in the literature, international outsourcing may as well yield a Pareto-improvement making all workers better off. However, adjustment costs which are relevant at least in the short run are ignored in this assessment.

Since theoretical predictions for the distributional effects of international outsourcing are ambiguous, empirical assessments are necessary to identify the winners and the losers of international outsourcing, and to see if there are losers at all.

Appendix

Proof of Theorem 1

In a diversified non-outsourcing equilibrium factor prices w_Y^f and w_Z^f are determined by

$$c_f^i\left(w_Y^f, w_Z^f\right) = p^i \text{ and} \tag{A1}$$

$$c_f^{-i}\left(w_Y^f, w_Z^f\right) = p^{-i}, \tag{A2}$$

according to fact 1. Assume that (only) firms in sector i have economical access to cost-saving international outsourcing. Then, factor prices w_Y^g and w_Z^g in the diversified outsouring equilibirum are determined by

$$c_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) = p^i \text{ and} \tag{A3}$$

$$c_f^{-i}\left(w_Y^g, w_Z^g\right) = p^{-i}, \tag{A4}$$

according to fact 2. Suppose without loss of generality, that i is Y-intensive, i.e. $k_f^i\left(w_Y^f, w_Z^f\right) > \overline{k} > k_f^{-i}\left(w_Y^f, w_Z^f\right)$. We show that $w_Y^g \leq w_Y^f$ (and therefore $w_Z^g \geq w_Z^f$) cannot be an equilibrium with cost-saving outsourcing. Note first, that, according to (A1)-(A4), $w_Y^g = w_Y^f$ (and thus $w_Z^g = w_Z^f$) would imply $c_g^i\left(w_Y^f, w_Z^f, c_x^{i*}\right) = c_f^i\left(w_Y^f, w_Z^f\right)$ which is a contradiction to the assumption of cost-saving outsourcing. Suppose second, $w_Y^g < w_Y^f$ (and therefore $w_Z^g > w_Z^f$). According to (A4), $c_f^{-i}\left(w_Y^g, w_Z^g\right) = p^{-i}$. $k_f^i\left(w_Y^f, w_Z^f\right) > k_f^{-i}\left(w_Y^f, w_Z^f\right)$ and single crossing of the unit isocost curves in the (w_Y, w_Z)-space imply $c_f^i\left(w_Y^g, w_Z^g\right) < c_f^i\left(w_Y^f, w_Z^f\right) = p^i$ for $w_Y^g < w_Y^f$, $w_Z^g > w_Z^f$. According to (A3), this cannot be an equilibrium with outsourcing (adoption of technology g) in sector i. Thus, $w_Y^g > w_Y^f$ (and therefore $w_Z^g < w_Z^f$) must hold in the diversified outsourcing equlibrium. ■

Proof of Corollary 1

Suppose that $k_f^i\left(w_Y^f, w_Z^f\right) > \overline{k} > k_f^{-i}\left(w_Y^f, w_Z^f\right)$ in the non-outsourcing equilibrium. According to theorem 1, $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ in the diversified outsourcing equilibrium. Moreover, $c_f^{-i}\left(w_Y^f, w_Z^f\right) = c_f^{-i}\left(w_Y^g, w_Z^g\right) = p^{-i}$, according to (A2) and (A4). Strict convexity of c_f^{-i} in the (w_Y, w_Z)-space implies that $k_f^{-i}(w_Y^g, w_Z^g) < k_f^{-i}\left(w_Y^f, w_Z^f\right)$. Thus, $k_f^{-i}(w_Y^g, w_Z^g) < \overline{k}$ and therefore $k_g^i(w_Y^g, w_Z^g, c_x^{i*}) > \overline{k}$ in equilibrium. ■

Proof of Theorem 2

If only firms in sector i have economical access to international outsourcing and, in addition, the outsourcing equilibrium is specialized on the outsourcing sector i, equilibrium factor prices w_Y^g and w_Z^g are determined by

$$c_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) = p^i \text{ and} \tag{A5}$$

$$k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) = \overline{k}, \tag{A6}$$

if in the specialized outsourcing equilibrium only outsourcing technology g is in use. If both the integrated and the outsourcing technology are in use in the specialized outsourcing equilibrium, equilibrium factor prices w_Y^g and w_Z^g are determined by

$$c_f^i(w_Y^g, w_Z^g) = p^i \text{ and} \tag{A7}$$

$$c_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) = p^i. \tag{A8}$$

(A5)-(A8) directly follow from fact 2.

Proof of part (i): Suppose without loss of generality that firms of the Y-intensive sector i are engaged in Z-outsourcing. Let γ be implicitly defined by $c_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) = p^i$. Then $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > k_f^i\left(\gamma w_Y^f, \gamma w_Z^f\right)$, according to definition 4 of Z-outsourcing and the assumption of no factor intensity reversal for $(w_Y, w_Z) \in W^i \left(\equiv \left\{(w_Y, w_Z) \,|\, c_g^i (w_y, w_Z, c_x^{i*}) = p^i\right\}\right)$. Remember that k_f^i and k_f^{-i} are homogenous of degree zero in factor prices w_Y, w_Z, i.e. $k_f^i \left(\gamma w_Y^f, \gamma w_Z^f\right) = k_f^i \left(w_Y^f, w_Z^f\right)$, and thus $k_g^i \left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > \overline{k}$ since $k_f^i \left(w_Y^f, w_Z^f\right) > \overline{k} > k_f^{-i} \left(w_Y^f, w_Z^f\right)$. Note next, that if the Y-intensive sector has economical access to international Z-outsourcing we cannot have a specialized outsourcing equilibrium with both technologies f and g in use. To see this assume that both technologies (f) and (g) would be in use in the outsourcing equilibrium. Then, according to (A1) and (A7) the factor prices w_Y^g, w_Z^g lie on the same unit isocost curve c_f^i as w_Y^f, w_Z^f. Since $k_g^i \left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > k_f^i \left(w_Y^f, w_Z^f\right) > \overline{k}$, the assumption of no factor intensity reversal (along the $c_g^i (w_Y, w_Z, c_x^{i*}) = p^i$ curve) implies that we must have $k_g^i (w_Y^g, w_Z^g, c_x^{i*}) > \overline{k} > k_f^i (w_Y^g, w_Z^g)$ and thus $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ if both f and g are in use in the outsourcing equilibrium. But this is impossible. Due to $k_f^i \left(w_Y^f, w_Z^f\right) > k_f^{-i} \left(w_Y^f, w_Z^f\right)$ and the single crossing of the unit isocost curves in the (w_Y, w_Z)-space, $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ would imply $c_f^{-i} (w_Y^g, w_Z^g) < c_f^{-i} \left(w_Y^f, w_Z^f\right) = p^{-i}$, which is not consistent with an equilibrium specialized on sector i. In sum, only the outsourcing technology is in use in the specialized outsourcing equilibrium in which firms in the Y-intensive sector have economical access to cost-saving international Z-outsourcing. Outsourcing equilibrium factor prices are therefore given by (A5) and (A6). Remember that $-\frac{dw_Z}{dw_Y}\Big|_{c_g^i = p^i}$ is given by $k_g^i (w_Y, w_Z, c_x^{i*})$ and that $\frac{d^2 w_Z}{dw_Y^2}|_{c_g^i = p^i} > 0$. Thus, condition (A6) can only be fulfilled if

$$w_Y^g / w_Z^g > w_Y^f / w_Z^f, \tag{A9}$$

since $k_g^i \left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > \overline{k}$. Moreover, the fact that sector $-i$ is no longer active in the outsourcing equilibrium implies $c_f^{-i}\left(w_Y^g, w_Z^g\right) \geq c_f^{-i}\left(w_Y^f, w_Z^f\right)$. The latter together with the cost-saving effect of outsourcing implies

$$w_Y^g > w_Y^f \text{ or } w_Z^g > w_Z^f. \tag{A10}$$

(A9) together with (A10) yields $w_Y^g > w_Y^f$, whereas $w_Z^g \gtreqless w_Z^f$ is possible.

Proof of part (ii): From the proof of theorem 1, we already know that $w_Y^f = w_Y^g$ and $w_Z^f = w_Z^g$ cannot be an equilibrium under cost-saving outsourcing. Suppose without loss of generality that firms of the Y-intensive sector i are engaged in Y-outsourcing and let γ be implicitly defined by $c_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) = p^i$. Then, by an analogous argument to part (i)

$$k_g^i\left(w_Y, w_Z, c_x^{i*}\right) < k_f^i\left(w_Y, w_Z\right), \tag{A11}$$

for all $(w_Y, w_Z) \in W^i$, since Y-outsourcing is assumed. Consider first the case that both technologies (f) and (g) are in use in the outsourcing equilibrium. Then, $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ cannot be an eqilibrium since, according to (A1), (A7) and (A2), $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ imply $c_f^{-i}\left(w_Y^g, w_Z^g\right) < p^{-i}$, due to $k_f^i\left(w_Y^f, w_Z^f\right) > k_f^{-i}\left(w_Y^f, w_Z^f\right)$ and the single crossing of the unit isocost curves in the (w_Y, w_Z)-space. For the same reason, $w_Y^g < w_Y^f$ and $w_Z^g > w_Z^f$ imply $c_f^{-i}\left(w_Y^g, w_Z^g\right) > p^{-i}$ and are therefore consistent with a specialized outsourcing equilibrium in which both technbologies (f) and (g) are in use. In this equilibrium, $k_f^i\left(w_Y^g, w_Z^g\right) > \overline{k} > k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right)$ must hold because of (A11). If only the outsourcing technology (g) is in use in the outsourcing equilibrium, factor prices in the outsourcing equilibrium are given by (A5) and (A6). The fact that $k_f^i\left(w_Y^f, w_Z^f\right) > \overline{k} > k_f^{-i}\left(w_Y^f, w_Z^f\right)$ was presumed in the non-outsourcing diversification equilibrium and that (A11) holds in the outsourcing equilibrium does not restrict the ranking of $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right)$ relative to $\overline{k}$, i.e. we can have $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) \gtreqless \overline{k}$. Thus, there is no restriction on w_Y, w_Z, like (A9) in part (i). Nonetheless, restriction (A10) still holds. It says that at least one factor gains from outsourcing. ■

A Diversified Non-outsourcing Equilibrium and Factor Price Implications of International Outsourcing

The following table summarizes the real and relative factor price implications if the non-outsourcing equilibrium is diversified. Without loss of generality we assume that outsourcing occurs within the Y-intensive sector.

>Table 1<

In this matrix "+" and "−" mean that international outsourcing has a positive or negative impact on the respective real or relative factor price. A "◯" indicates that there is no change.

Proof of Theorem 3

In the proof of theorem 3, we focus on those outcomes which are different from theorem 1. The proof of the other results is similar to the proof of theorem 1. If the non-outsourcing equilibrium is specialized on sector $-i$ factor prices w_Y^f and w_Z^f are determined by (A2) and

$$k_f^{-i}\left(w_Y^f, w_Z^f\right) = \overline{k}, \tag{A12}$$

according to fact 1. Consider that (only) firms in sector i have economical access to cost-saving international outsourcing. Then, factor prices w_Y^g and w_Z^g in the diversified outsouring equilibirum are determined by (A3) and (A4), according to fact 2. By assumption, sector i is Y-intensive, i.e. $k_f^i\left(w_Y^f, w_Z^f\right) > k_f^{-i}\left(w_Y^f, w_Z^f\right) = \overline{k}$. Let γ be implicitly defined by $c_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) = p^i$. Then, Y-outsourcing of the Y-intensive sector implies $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f\right) < k_f^i\left(w_Y^f, w_Z^f\right)$. However, $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right)$ may lie on both sides of $\overline{k}$, i.e. $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) \gtreqless \overline{k}$, so that there is no restriction on w_Y, w_Z, like (A9). Nonetheless, since sector $-i$ remains active, w_Y^f, w_Z^f and w_Y^g, w_Z^g lie on the same unit isocost curve c_f^{-i}, according to (A2) and (A4), which is only possible if $w_Y^g = w_Y^f$ and $w_Z^g = w_Z^f$ or one factor wins and the other loses. ■

Proof of Theorem 4

We prove only those outcomes (in part (ii)) which are different from theorem 2. We assume that the non-outsourcing equilibrium was specialized on outsourcing sector i, i.e.the factor prices w_Y^f and w_Z^f are determined by (A1) and

$$k_f^i\left(w_Y^f, w_Z^f\right) = \overline{k}, \tag{A13}$$

according to fact 1. Equilibrium factor prices w_Y^g and w_Z^g are determined by (A7) and (A8) if in the specialized outsourcing equilibrium both the integrated and the outsourcing technology are in use. In contrast, if only outsourcing technology g survives, equilibrium factor prices w_Y^g and w_Z^g are determined by (A5) and (A6), according to fact 2.

Suppose without loss of generality that firms of the Y-intensive sector i are engaged in Z-outsourcing. Let γ be implicitly defined by $c_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) = p^i$. Then, $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > k_f^i\left(\gamma w_Y^f, \gamma w_Z^f\right)$, according to definition 4 of Z-outsourcing and the assumption of no factor intensity reversal for $(w_Y, w_Z) \in W^i$. Remember that k_f^i is homogenous of degree zero in factor prices w_Y, w_Z, i.e. $k_f^i\left(\gamma w_Y^f, \gamma w_Z^f\right) = k_f^i\left(w_Y^f, w_Z^f\right)$ and thus $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > \overline{k}$ since $k_f^i\left(w_Y^f, w_Z^f\right) = \overline{k}$, according to (A13). Consider first the case that both technologies (f) and (g) are in use in the outsourcing equilibrium. Then, $w_Y^g < w_Y^f$ and $w_Z^g > w_Z^f$, with w_Y^g, w_Z^g being determined by (A7) and (A8) cannot be an eqilibrium. To see this note that $w_Y^g < w_Y^f$ and $w_Z^g > w_Z^f$ imply $k_f^i\left(w_Y^g, w_Z^g\right) > \overline{k}$, according to $-\frac{dw_Z}{dw_Y}\Big|_{c_f^i = p^i} = k_f^i\left(w_Y, w_Z\right)$ and $\frac{d^2 w_Z}{dw_Y^2}|_{c_f^i = p^i} > 0$. But, due to the assumption of no factor intensity reversal for $(w_Y, w_Z) \in W^i$ we have $k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) > k_f^i\left(w_Y^g, w_Z^g\right)$, since $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) > k_f^i\left(w_Y^f, w_Z^f\right)$. In sum, $w_Y^g < w_Y^f$ and $w_Z^g > w_Z^f$ would imply $k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right) > k_f^i\left(w_Y^g, w_Z^g\right) > \overline{k}$ which cannot be an equilibrium. Note next that $w_Y^f = w_Y^g$ and $w_Z^f = w_Z^g$ cannot be an equilibrium under cost-saving outsourcing since the outsourcing sector i was active in the non-outsourcing equilibrium. Finally, since unit cost functions are strictly increasing in factor prices and both (A1) and (A7) hold, $w_Y^g > w_Y^f$ and $w_Z^g < w_Z^f$ is the only possible outcome if both f and g are in use in the outsourcing equilibrium. In this outsourcing equilibrium, $k_f^i\left(w_Y^g, w_Z^g\right) < \overline{k} < k_g^i\left(w_Y^g, w_Z^g, c_x^{i*}\right)$ and $c_f^{-i}\left(w_Y^g, w_Z^g\right) \geq p^{-i}$. This concludes the first step in the proof of part (ii).

Suppose next that firms of the Y-intensive sector i are engaged in Y-outsourcing. Let γ be implicitly defined by $c_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) = p^i$. Then, by an analogous argument to above

$$k_g^i\left(w_Y, w_Z, c_x^{i*}\right) < k_f^i\left(w_Y, w_Z\right) \quad \text{(A14)}$$

for all $(w_Y, w_Z) \in W^i$, since Y-outsourcing is assumed. If only the outsourcing technology is in use in the specialized outsourcing equilibrium, factor prices are determined by (A5) and (A6). Then, in view of (A13) and (A14), condition (A6) can only be fulfilled if

$$w_Y^g / w_Z^g < w_Y^f / w_Z^f. \quad \text{(A15)}$$

(Remember that the slope $-\frac{dw_Z}{dw_Y}\Big|_{c_g^i = p^i}$ is given by $k_g^i\left(w_Y, w_Z, c_x^{i*}\right)$ and that $\frac{d^2 w_Z}{dw_Y^2}|_{c_g^i = p^i} > 0$ and use $k_g^i\left(\gamma w_Y^f, \gamma w_Z^f, c_x^{i*}\right) < k_f^i\left(w_Y^f, w_Z^f\right)$, according to (A14), and the fact that k_f^i is homogenous of degree zero in factor prices w_Y, w_Z.) Moreover, the fact that integrated technology (f) is no longer in use in the outsourcing equilibrium implies $c_f^i\left(w_Y^g, w_Z^g\right) \geq c_f^i\left(w_Y^f, w_Z^f\right)$. The latter together with the cost-saving effect of international outsourcing implies $w_Y^g > w_Y^f$ or $w_Z^g > w_Z^f$, which is identical with condition (A10). (A10) together with (A15) yields $w_Z^g > w_Z^f$, whereas $w_Y^g \gtreqless w_Y^f$ is possible. This completes the proof of theorem 4.■

Specialized Non-outsourcing Equilibria and Factor Price Implications of International Outsourcing

The following two tables summarize the real and relative factor price implications of international outsourcing if the non-outsourcing equilibrium is specialized and outsourcing occurs only within the Y-intensive sector. Table 2 gives the factor price implications if the Y-intensive sector was inactive in the non-outsourcing equilibrium.

>Table 2<

As in table 1 "$+$" and "$-$" mean that international outsourcing has a positive or negative impact on the respective real or relative factor price. A "$\bigcirc$" indicates that there is no change.

Table 3 gives the factor price implications if the Y-intensive sector was active in the non-outsourcing equilibrium.

>Table 3<

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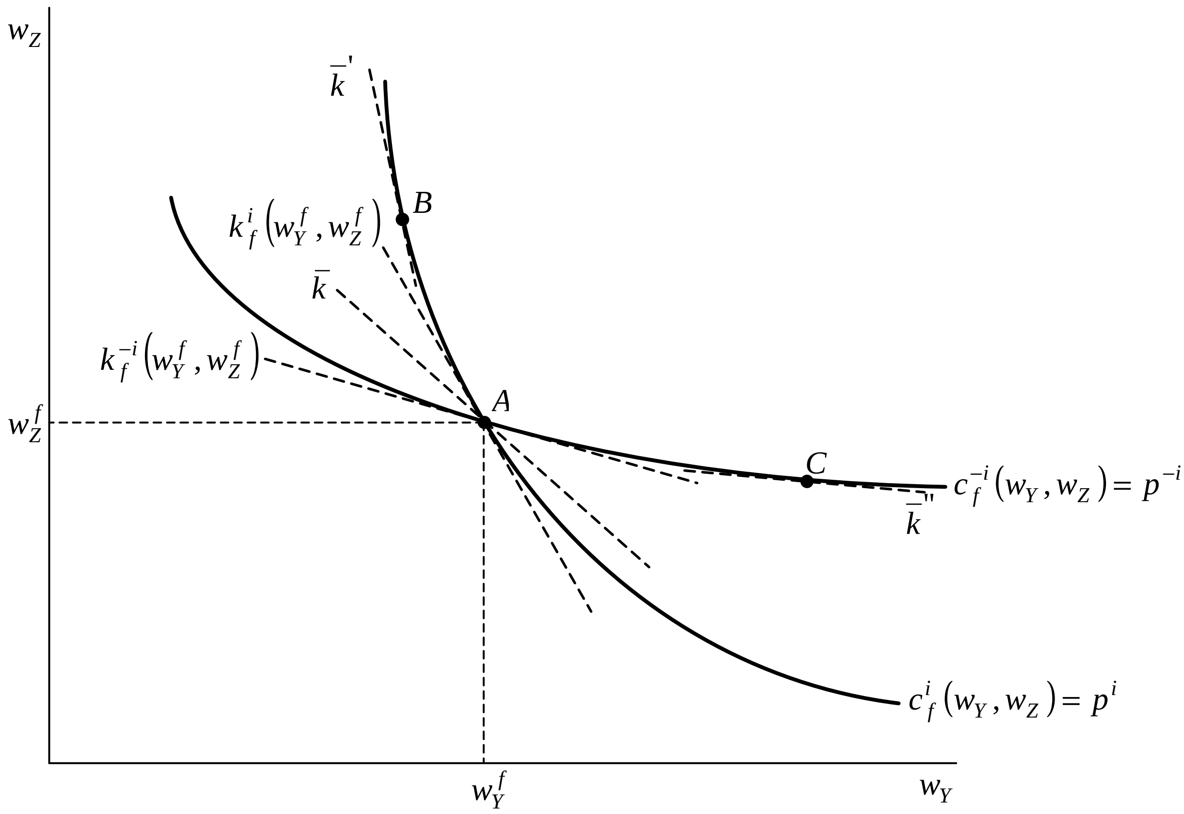

Figure 1: A diversified non-outsourcing equilibrium with sector i producing Y-intensive and sector $-i$ producing Z-intensive.

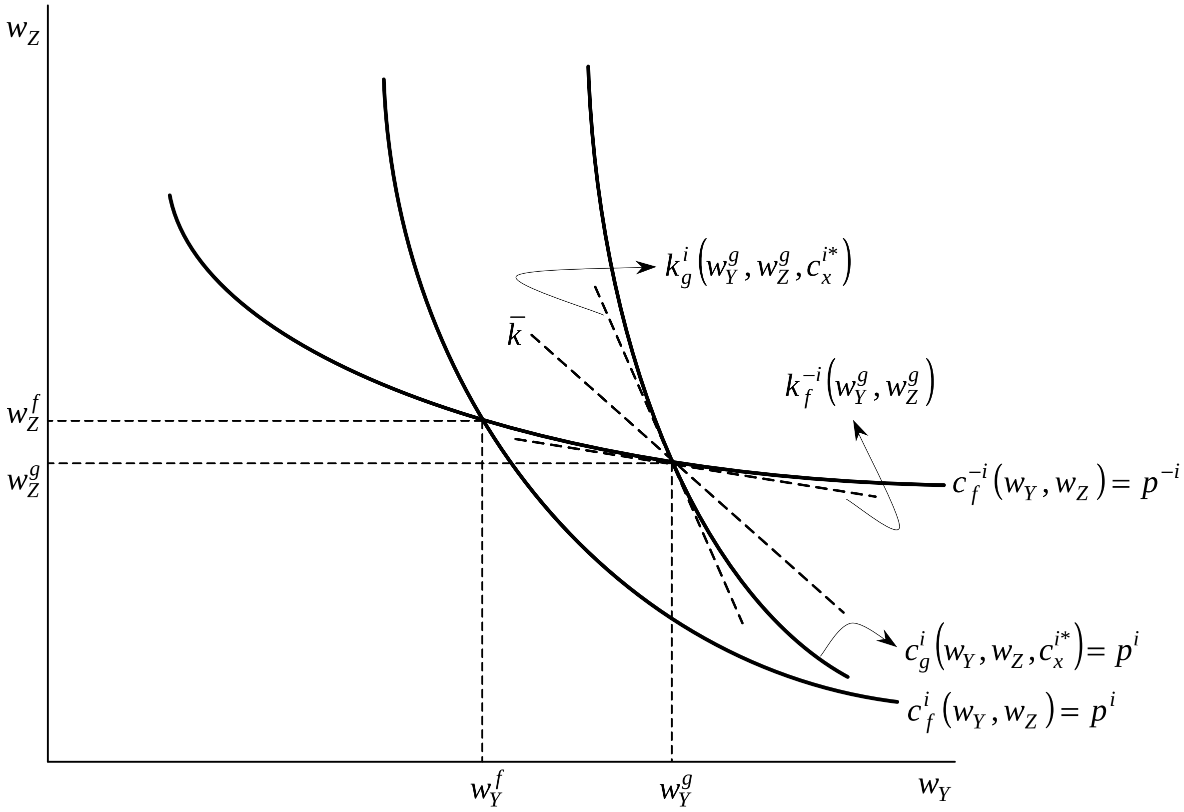

Figure 2: A diversified outsourcing equilibrium with firms of the *Y*-intensive sector *i* being engaged in international *Z*-outsourcing

	w_Y	w_Z	w_Y/w_Z
Theorem 1 (Diversified outsourcing equilibrium):	+	–	+
Theorem 2 (Specialized outsourcing equilibrium):			
Z-outsourcing [1]	+	+/O/–	+
Y-outsourcing			
(a) f and g active	–	+	–
(b) g active [2]	+/O/–	+/O/–	+/O/–

Table 1: Impacts of outsourcing of the Y-intensive sector if the non-outsourcing equilibrium is diversified

[1] Only technology *g* is in use. Factor *Y* gains relative to factor *Z* due to $k_f^i\left(w_Y^f, w_Z^f\right) > \bar{k}$ and the assumption of *Z*-outsourcing.

[2] At least one factor gains.

	w_Y	w_Z	w_Y/w_Z
(1) Diversified outsourcing equilibrium:			
Z-outsourcing	+	–	+
Y-outsourcing [1]	+/O/–	+/O/–	+/O/–
(2) Specialization on the outsourcing sector:			
Z-outsourcing [2]	+	+/O/–	+
Y-outsourcing			
(a) f and g active	–	+	–
(b) g active [3]	+/O/–	+/O/–	+/O/–

Table 2: Impacts of outsourcing of the *Y*-intensive sector if the non-outsourcing equilibrium is specialized on the *Z*-intensive sector.

[1] One factor gains one factor loses.

[2] Only technology *g* is in use. Factor *Y* gains relative to factor *Z* due to $k_f^{-i}\left(w_Y^f, w_Z^f\right) = \bar{k}$, $k_f^i\left(w_Y, w_Z\right) > k_f^{-i}\left(w_Y, w_Z\right)$ and the assumption of *Z*-outsourcing.

[3] Both factors may win in relative and absolute terms.

	w_Y	w_Z	w_Y/w_Z
(1) Diversified outsourcing equilibrium:	+	–	+
(2) Specialization on the outsourcing sector:			
Z-outsourcing			
(a) f and g active	+	–	+
(b) g active[1]	+	+/O/–	+
Y-outsourcing			
(a) f and g active	–	+	–
(b) g active[2]	+/O/–	+	–

Table 3: Impacts of outsourcing of the *Y*-intensive sector if the non-outsourcing equilibrium is specialized on the *Y*-intensive sector.

[1] Factor *Y* gains relative to factor *Z* due to $k_f^i\left(w_Y^f, w_Z^f\right)=\bar{k}$ and the assumption of *Z*-outsourcing.

[2] Factor *Z* gains relative to factor *Y* due to $k_f^i\left(w_Y^f, w_Z^f\right)=\bar{k}$ and the assumption of *Y*-outsourcing.