The Relationship between Outsourcing and Wage Inequality under Sector-Specific FDI Barriers

Abstract

We develop a general equilibrium model in which two final goods are assembled from a continuum of intermediate goods that differ in intensity between skilled and unskilled labor. A range of intermediate goods are outsourced from North to South through foreign direct investment (FDI). Outsourcing shifts demand toward skilled labor in the sector where it occurs *and* toward unskilled labor in the other sector; the net demand shift depends on sectoral differences in FDI barriers and sector specificity of FDI liberalization. We find that outsourcing and wage inequality may be positively or negatively related and identify the conditions for each case.

Key words: Outsourcing; Wage inequality; Foreign direct investment

JEL classification: F11; F23

1 Introduction

International outsourcing by multinational firms represents an important new aspect of modern world trade (Krugman, 1995; Feenstra, 1998). Recently this phenomenon has received increasing attention because of its labor-market implications.[1] In particular, Feenstra and Hanson (1996, 1997, 1999) have written a series of papers providing evidence that international outsourcing has played a significant role in raising wage inequality between skilled and unskilled labor in the United States and in Mexico.

A theoretical link between outsourcing and wage inequality is established in a simple general equilibrium model in Feenstra and Hanson (1996). In the model, a manufacturing sector assembles a final good from a continuum of intermediate inputs whose production requires skilled and unskilled labor and capital. Ranking inputs by skill intensity they show that, in a trading equilibrium with unequal factor prices between countries, the South produces a range of unskilled-intensive inputs and the North a range of skilled-intensive inputs. International outsourcing shifts a portion of input production from the North to the South. This portion is the most skilled-intensive in the South but the most unskilled-intensive in the North; hence outsourcing causes skill-biased demand shifts in both countries. As Feenstra (1998, p. 41) points out, "outsourcing has a qualitatively similar effect on reducing the demand for unskilled relative to skilled labor within an industry as does skill-biased technological change."

The Feenstra-Hanson model provides an account for the observed positive relationship between outsourcing and wage inequality in cases such as Mexico after 1985. However, it does not explain an observed negative relationship in some other cases. For example, in Singapore, wage inequality had been declining between 1966 and 1990 except for the period 1981-1986 (Wood, 1994, Fig. 6.3), while the share of foreign companies in GDP rose from 15.7 percent in 1966-1977

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[1]Recent studies of international outsourcing include Lawrence and Slaughter (1993), Berman, Bound, and Griliches (1994), and Feenstra and Hanson (1996, 1997, 1999). Other studies of the phenomenon have used different names such as "kaleidoscope comparative advantage" (Bhagwati and Dehejia, 1994), "slicing the value chain" (Krugman, 1995), "delocalization" (Leamer, 1998), and "international fragmentation" (Jones and Kierzkowski, 1997; Deardorff, 1998).

to 28.1 percent in 1980-1984, a large part being foreign outsourcing in electrical and electronics industries (Lim and Fong, 1991, pp. 51-63). In Mexico, wage inequality had declined for the two decades before 1985, while foreign outsourcing had increased moderately between 1978 and 1985 (Fig. 1 and Fig. 5 of Feenstra and Hanson, 1997).

The empirical relationship between outsourcing and wage inequality in different countries during different periods requires a more careful study, but is not the subject of the paper. The purpose of this paper is to identify conditions for the relationship to be positive or negative in a simple general equilibrium model. What prevents the Feenstra-Hanson model from explaining the negative relationship is its lack of a sectoral dimension; in a one-sector world with countries specializing in different intermediate inputs, international outsourcing necessarily leads to skill-biased labor-demand shifts in both countries. In this paper we develop a model identical to that of Feenstra and Hanson (1996) but with two manufacturing sectors, each producing a final good from a continuum of intermediate inputs. We examine an equilibrium in which the North outsources input production to the South in both sectors through foreign direct investment (FDI). With two sectors, we find that international outsourcing does not necessarily lead to a skill-biased labor-demand shift in either the source country or the recipient country of FDI. In particular, we show that FDI liberalization will cause outsourcing to increase in the sector where it occurs but decrease in the other sector, implying a skilled-biased demand shift in the former *and* an unskilled-biased demand shift in the latter.

What determines the economy-wide labor-demand shift? We find that sectoral differences in FDI barriers are the key. To see the intuition, consider a sector in the South that has a high tax on FDI. To overcome the high capital cost implied by the tax, outsourcing activities in the sector must be more unskilled-intensive. Indeed, with a sufficiently high tax, outsourcing activities, though always the more skilled-intensive in the *sector* of the South, will be unskilled-intensive relative to the *country*'s skill abundance. In this case, an expansion of outsourcing activities in the high-barrier sector implies an increase in the relative demand for *unskilled* labor and hence a negative relationship between outsourcing and wage inequality.

The role of sector-specific FDI barriers is most clearly seen in the case of across-the-board FDI liberalization. When the South reduces FDI barriers in all sectors at the same rate, there will be skill-biased demand shifts in all sectors. However, skill-biased demand shifts in all sectors do not necessarily imply skill-biased demand shift in the country. Why? Because the increased outsourcing activities may be (on average) unskilled-intensive in the country. Indeed, if FDI barriers are sufficiently different between sectors, the high-barrier sector in the South will see an increase in outsourcing activities that are unskilled-intensive relative to its skill abundance, whose effect may outweigh that of the increase in outsourcing activities in the low-barrier sector, which are skilled-intensive. In this case, outsourcing and wage inequality in the South may be negatively related despite demand shifts being skill-biased in all sectors.

It is worth noting that the skill-intensity ranking of the two final goods is not essential in our analysis. What is crucial is the skill-intensity ranking of the two sectors at the joint production points between the two countries, or the "borderline goods". In the model, sectoral differences in FDI barriers endogenously determine the skill intensities of the borderline goods, which in turn determine how outsourcing impacts wage inequality.

Our analysis identifies the Feenstra-Hanson result as a special case of our model. In a two-sector world, if FDI liberalization applies to all sectors at the same rate, *and* if FDI barriers are sufficiently similar between sectors, then outsourcing and wage inequality are positively related in both the South and the North. In various other cases, however, the Feenstra-Hanson result may not apply. Our results serve the purpose of clarifying the relationship between outsourcing and wage inequality in a setting more general than Feenstra and Hanson (1996). These results might be useful for empirical researchers and policy makers concerned with the issue.

We organize the remainder of the paper as follows. Section 2 develops a two-country, two-sector, three-factor general equilibrium model, which extends Feenstra and Hanson (1996). Section 3 shows the effects of FDI liberalization on outsourcing. Section 4 shows the effects of FDI liberalization on relative wages and the relationship between outsourcing and wage inequality. Section 5 concludes. An appendix presents a proof of the lemmas stated in the paper.

2 The Model

2.1 A North-South World Economy

Consider a world with two countries, North and South. There are two final goods, X and Y, each assembled from a continuum of intermediate goods indexed by $i \in [0,1]$. Production of an intermediate good requires unskilled and skilled labor, and capital. For simplicity we follow Feenstra and Hanson (1996) to assume that unskilled and skilled labor do not substitute for each other, while capital substitutes for labor with a unitary substitution elasticity. Choosing output units such that one unit of intermediate good i requires one unit of unskilled labor and $h(i)$ of skilled labor, we specify the unit cost function of intermediate good i as

$$c(i) = [w_L + w_H h(i)]^\alpha r^{1-\alpha}, \tag{1}$$

where w_L and w_H denote wages of unskilled and skilled labor, r denotes rate of return to capital, and α is a parameter.[2] Throughout the paper we use an asterisk to denote North's variables. Thus, the unit cost function for the South is equation (1) and the unit cost function for the North is $c^*(i) = [w_L^* + w_H^* h(i)]^\alpha r^{*1-\alpha}$.

We denote x and y as indices of intermediate goods used in the production of final goods X and Y. As a benchmark we assume that both final goods are produced from the same range of intermediate goods, $x \in [0,1]$ and $y \in [0,1]$.[3] Arranging intermediate goods in an ascending order of skill intensity, we have $h'(x) > 0$ and $h'(y) > 0$. Following Feenstra and Hanson (1996), we assume that final goods are assembled costlessly from the intermediate goods according to Cobb-Douglas production functions:[4]

$$\ln X = \int_0^1 \ln q(x)dx, \qquad \ln Y = \int_0^1 \ln q(y)dy, \tag{2}$$

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[2]The corresponding production function is $q(i) = A_i[\min\{L(i), H(i)/h(i)\}]^\alpha [K(i)]^{1-\alpha}$, where $L(i)$, $H(i)$, and $K(i)$ denote unskilled labor, skilled labor, and capital employed in producing i, and A_i is a parameter.

[3]This assumption implies that the two final goods have identical skill intensity. The skill-intensity ranking of the two final goods is not essential to our result, as we will see later.

[4]For simplicity we assume identical shares for all intermediate goods in the total cost of a final good. Assuming different shares would not affect our result.

where $q(x)$ and $q(y)$ are quantities of intermediate goods x and y.

The two countries have fixed factor supplies.[5] Let L, H, and K denote endowments of unskilled labor, skilled labor, and capital. We assume that the labor endowments are sufficiently dissimilar between the North and South so that international trade in goods does not equalize wages between countries. In the trading equilibrium, the South has a relatively high wage of skilled labor $(w_H/w_L > w_H^*/w_L^*)$ and therefore specializes in a range of intermediate goods that are less skill-intensive; the North specializes in a range of intermediate goods that are more skill-intensive. Final goods may be produced in either country since assembly is costless.

2.2 Sector-Specific FDI Barriers

Foreign direct investment (FDI) takes place as a result of differences in rates of return to capital. In computing the differences, one must consider barriers toward FDI. There are natural barriers (e.g. transport cost), technical barriers (e.g. technology transfer cost), and policy barriers (e.g. FDI taxes). Empirical studies have found that these barriers differ between sectors (United Nations, 1991). In our model, we capture sector-specific FDI barriers by introducing two *ad valorem* taxes on rates of return to FDI: t_x for sector X and t_y for sector Y.

For simplicity we assume that the South is small in the world capital market and takes r^*, the North's rate of return to capital, as a parameter. Thus, the rate of return to capital in the South equals $(1 + t_x)r^*$ in sector X and $(1 + t_y)r^*$ in sector Y. We assume that t_x and t_y are sufficiently low that FDI flows from the North to the South. The rates t_x and t_y may differ. If $t_x > t_y$, then all Southern capital will be employed in sector X, and *vice versa*. We assume the South's capital endowment is sufficiently small that FDI enters both sectors in the South. In the model FDI means "outsourcing" since the intermediate goods multinational firms produce in the South would be produced in the North in the absence of FDI.

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[5]Allowing labor supplies to be functions of relative wages as in Feenstra and Hanson (1996) would not change our main result.

With wages unequal between countries, each country specializes in a range of intermediate goods. Figure 1 illustrates the pattern of specialization. The horizontal axis labels the index of intermediate goods. In the North, $c^*(x) = c^*(y)$ for all $x = y$; hence goods x and y share a common unit-cost locus C^*C^*. In the South, if $t_x = t_y$, then $c(x) = c(y)$ for all $x = y$. However, if $t_x \neq t_y$, then the unit-cost loci of goods x and y will differ. In Figure 1 we depict the case in which $t_x < t_y$. In this case, $c(x) < c(y)$ for all $x = y$; hence C_xC_x lies below C_yC_y. Since the South has a comparative advantage in intermediate goods that are relatively unskilled-intensive (those with smaller indices of x and y) and the North has a comparative advantage in intermediate goods that are relatively skilled-intensive (those with larger indices of x and y), C_xC_x and C_yC_y must be steeper than C^*C^*.

Assuming both x and y are produced in each country, C^*C^* crosses C_xC_x as well as C_yC_y. In this equilibrium, there exist two borderline goods indexed by $\tilde{x}$ and $\tilde{y}$ such that

$$[w_L + w_H h(\tilde{x})]^\alpha (1 + t_x)^{1-\alpha} = [w_L^* + w_H^* h(\tilde{x})]^\alpha, \tag{3}$$

$$[w_L + w_H h(\tilde{y})]^\alpha (1 + t_y)^{1-\alpha} = [w_L^* + w_H^* h(\tilde{y})]^\alpha. \tag{4}$$

With the help of Figure 1, we establish:

Lemma 1. $\tilde{x} = \tilde{y}$ if $t_x = t_y$, $\tilde{x} > \tilde{y}$ if $t_x < t_y$, and $\tilde{x} < \tilde{y}$ if $t_x > t_y$.

Lemma 1 leads to a useful corollary:

Corollary 1. $h(\tilde{x}) = h(\tilde{y})$ if $t_x = t_y$, $h(\tilde{x}) > h(\tilde{y})$ if $t_x < t_y$, and $h(\tilde{x}) < h(\tilde{y})$ if $t_x > t_y$.

Corollary 1 indicates that sector-specific FDI barriers give rise to different skill intensities of borderline goods. The skill intensity of the borderline good is lower in the sector where the FDI barrier is higher. Intuitively, when the FDI barrier is higher in a sector, the production of its borderline good must be more unskilled-intensive to offset the higher capital cost.

2.3 Market Equilibrium

We now turn to the general-equilibrium determination of $\tilde{x}$ and $\tilde{y}$ as well as factor prices. Consider labor markets first. Applying Shephard's lemma, we obtain the demand for each type of labor by differentiating the cost function of each intermediate good with respect to the wage, and integrating over all intermediate goods produced in the country. For the South, the full-employment conditions for the two types of labor are given by

$$\int_0^{\tilde{x}} \alpha\left[\frac{(1+t_x)r^*}{w_L + w_H h(x)}\right]^{1-\alpha} q(x)dx + \int_0^{\tilde{y}} \alpha\left[\frac{(1+t_y)r^*}{w_L + w_H h(y)}\right]^{1-\alpha} q(y)dy = L, \tag{5}$$

$$\int_0^{\tilde{x}} \alpha\left[\frac{(1+t_x)r^*}{w_L + w_H h(x)}\right]^{1-\alpha} h(x)q(x)dx + \int_0^{\tilde{y}} \alpha\left[\frac{(1+t_y)r^*}{w_L + w_H h(y)}\right]^{1-\alpha} h(y)q(y)dy = H. \tag{6}$$

There are two analogous full-employment equations for the North.

Turning to commodity markets, we assume identical and Cobb-Douglas preferences with λ as the expenditure share on good X. Letting E denote total world expenditure on final goods, the demand for intermediate goods x and y satisfies

$$q(x)[w_L + w_H h(x)]^\alpha [(1+t_x)r^*]^{1-\alpha} = \lambda E, \tag{7}$$

$$q(y)[w_L + w_H h(y)]^\alpha [(1+t_y)r^*]^{1-\alpha} = (1-\lambda)E. \tag{8}$$

By choosing E as numéraire, we normalize world expenditure at unity, $E = 1$. Substituting (7) and (8) into (5) and (6) yields

$$\int_0^{\tilde{x}} \frac{\lambda\alpha}{w_L + w_H h(x)}dx + \int_0^{\tilde{y}} \frac{(1-\lambda)\alpha}{w_L + w_H h(y)}dy = L, \tag{9}$$

$$\int_0^{\tilde{x}} \frac{\lambda\alpha h(x)}{w_L + w_H h(x)}dx + \int_0^{\tilde{y}} \frac{(1-\lambda)\alpha h(y)}{w_L + w_H h(y)}dy = H. \tag{10}$$

There are two analogous equations for the North.

We can solve $\tilde{x}$, $\tilde{y}$, w_H, and w_L from four equations, (3), (4), (9), and (10). To examine wage inequality, we define $\omega \equiv w_H/w_L$ and $h \equiv H/L$. Dividing (10) by (9) we obtain:

$$h^d(\omega, \tilde{x}, \tilde{y}) \equiv \frac{\int_0^{\tilde{x}} \frac{\lambda h(x)}{1+\omega h(x)} dx + \int_0^{\tilde{y}} \frac{(1-\lambda)h(y)}{1+\omega h(y)} dy}{\int_0^{\tilde{x}} \frac{\lambda}{1+\omega h(x)} dx + \int_0^{\tilde{y}} \frac{1-\lambda}{1+\omega h(y)} dy} = h, \tag{11}$$

where $h^d(\omega, \tilde{x}, \tilde{y})$ denotes the relative demand for skilled labor in the South. Analogously we have $h^{*d}(\omega^*, \tilde{x}, \tilde{y}) = h^*$ in the North. Partially differentiating h^d and h^{*d} with respect to ω and ω^*, we establish:

Lemma 2. $\partial h^d/\partial \omega < 0$ and $\partial h^{*d}/\partial \omega^* < 0$.[6]

Lemma 2 establishes that the relative demand for skilled labor decreases in the relative wage of skilled labor at any given product mix defined by $\tilde{x}$ and $\tilde{y}$. In Figure 2 we illustrate the labor-market equilibrium in the South. The DD curve shows the relative demand for skilled labor, while the SS curve shows the relative supply. The intersection of the two curves determines the equilibrium value of ω.

We can partially differentiate h^d and h^{*d} with respect to $\tilde{x}$ and $\tilde{y}$ to establish:

Lemma 3. (i) $\partial h^d/\partial \tilde{i} > 0$ if $h(\tilde{i}) > h$, and $\partial h^d/\partial \tilde{i} < 0$ if $h(\tilde{i}) < h$;

(ii) $\partial h^{*d}/\partial \tilde{i} > 0$ if $h(\tilde{i}) < h^*$, and $\partial h^{*d}/\partial \tilde{i} < 0$ if $h(\tilde{i}) > h^*$, where $\tilde{i} = \tilde{x}, \tilde{y}$.

Lemma 3 shows how the DD curve shifts in response to a change in $\tilde{x}$ or $\tilde{y}$. The shift follows a general rule: if a country expands its production toward the goods that are skill-intensive relative to its skill abundance, then the relative demand for skilled labor will increase at fixed wages, and *vice versa*. Note that an increase in $\tilde{x}$ means a decrease in the range of x produced in the North. Thus, if $h(\tilde{x}) < h^*$, then an increase in $\tilde{x}$ implies that the North stops producing certain goods that are unskilled-intensive relative to its skill abundance; hence $\partial h^{*d}/\partial \tilde{x} > 0$.

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[6]The proof is similar to that of Lemma 6.1 in Feenstra and Hanson (1996) and is omitted here.

3 FDI Liberalization and Outsourcing

In this section we examine how FDI liberalization (a decrease in t_x and/or t_y) affects outsourcing at sectoral and aggregate levels. We begin by establishing a lemma that summarizes the general-equilibrium effects of FDI liberalization on borderline goods:

Lemma 4. $d\tilde{x}/dt_x < 0$, $d\tilde{y}/dt_x > 0$, $d\tilde{x}/dt_y > 0$, and $d\tilde{y}/dt_y < 0$.

Lemma 4 is obtained from totally differentiating the system of equations of the model (see the appendix). It takes into account both the direct effect of FDI liberalization on capital cost and the indirect effect through wages. According to Lemma 4, FDI liberalization will increase the range of intermediate goods in the sector where it occurs, *and* decrease the range of intermediate goods in the other sector. This result is easily understood in our general equilibrium model where labor is mobile between sectors. When the South reduces the FDI barrier in sector X, for example, capital cost falls in the sector; as a result, labor reallocates from sector Y to sector X, causing an expansion of sector X and a shrinkage of sector Y.

Lemma 4 leads to a useful corollary:

Corollary 2. (i) $dh(\tilde{y})/d(t_y - t_x) < 0$ and $dh(\tilde{x})/d(t_y - t_x) > 0$;

(ii) if $(t_y - t_x)$ is sufficiently large, then $h(\tilde{y}) < h$ and $h(\tilde{x}) > h^*$.

Corollary 2(i) says that the skill intensity of the borderline good rises with the FDI barrier of its own sector and falls with the FDI barrier of the other sector. Corollary 2(ii), which follows immediately from (i), identifies an important scenario: when the FDI barrier is sufficiently higher in sector Y than in sector X, the borderline good $\tilde{y}$, which is the most skilled-intensive of all y produced in the South, will be unskilled-intensive *relative to the South's skill abundance;* the borderline good $\tilde{x}$, which is the most unskilled-intensive of all x produced in the North, will be skilled-intensive *relative to the North's skill abundance.*[7]

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[7]The critical value of $(t_y - t_x)$ is usually different for $h(\tilde{y}) < h$ and $h(\tilde{x}) > h^*$.

Having examined the effect of FDI liberalization on borderline goods, we turn to its effect on outsourcing. We start by deriving an expression for the total amount of FDI. Applying Shephard's lemma, we obtain K^d, the demand for capital in the South. By definition, FDI is the difference between K^d and K, which is given by

$$
\begin{aligned}
FDI &\equiv K^d - K \\
&= \int_0^{\tilde{x}} (1-\alpha)[\frac{w_L + w_H h(x)}{(1+t_x)r^*}]^\alpha q(x)dx + \int_0^{\tilde{y}} (1-\alpha)[\frac{w_L + w_H h(y)}{(1+t_y)r^*}]^\alpha q(y)dy - K \\
&= \frac{(1-\alpha)\lambda\tilde{x}}{(1+t_x)r^*} + \frac{(1-\alpha)(1-\lambda)\tilde{y}}{(1+t_y)r^*} - K.
\end{aligned}
\tag{12}
$$

The last expression is obtained by substituting (7) and (8).

Next we examine the distribution of FDI between sectors. Denote FDI_j as the amount of FDI in sector $j = X, Y$. We have:

$$
FDI_X = \frac{(1-\alpha)\lambda\tilde{x}}{(1+t_x)r^*} - \mu K, \quad FDI_Y = \frac{(1-\alpha)(1-\lambda)\tilde{y}}{(1+t_y)r^*} - (1-\mu)K,
\tag{13}
$$

where μ is the fraction of K employed in sector X. As we mentioned earlier, if $t_x > t_y$, then all domestic capital is employed in sector X, i.e., $\mu = 1$. Similarly, if $t_x < t_y$, then $\mu = 0$. In the case of $t_x = t_y$, μ may take any value between zero and one; we assume that the value of μ is independent of FDI liberalization. Differentiating FDI, FDI_X, and FDI_Y with respect to t_x and t_y, we establish (see the appendix):

Lemma 5. (i) $d(FDI)/dt_x < 0$, and $d(FDI)/dt_y < 0$;

(ii) $d(FDI_X)/dt_x < 0$, and $d(FDI_Y)/dt_y < 0$;

(iii) $d(FDI_X)/dt_y > 0$, and $d(FDI_Y)/dt_x > 0$.

Lemma 5(i) says that FDI liberalization, whether in sector X or Y, will increase the total amount of FDI in the South. Lemma 5(ii) says that FDI liberalization will increase the amount of FDI in the sector where the liberalization occurs. Lemma 5(iii) says that FDI liberalization in one sector will cause a decrease in the amount of FDI in the other sector.

In our model FDI means outsourcing of intermediate goods. Using Lemmas 4 and 5 we obtain the effects of FDI liberalization on outsourcing, which we summarize in:

Proposition 1. FDI liberalization will

(i) increase the total amount of outsourcing;

(ii) increase the amount of outsourcing in the sector where the liberalization occurs, and decrease the amount of outsourcing in the other sector;

(iii) increase the skill intensity of outsourcing activities in the sector where the liberalization occurs, and decrease the skill intensity of outsourcing activities in the other sector.

It is useful to compare our result with that of Feenstra and Hanson (1996). In their one-sector model, FDI liberalization increases outsourcing and shifts production toward more skill-intensive goods in both countries. In our two-sector model, FDI liberalization causes outsourcing to increase in one sector but decrease in the other, although total outsourcing rises. As a result, there is a skilled-biased labor-demand shift in the sector where the liberalization occurs and an unskilled-biased demand shift in the other sector. This feature is important in understanding the effects of FDI liberalization on wage inequality, which we turn to next.

4   FDI Liberalization and Wage Inequality

In this section we examine the effects of FDI liberalization on relative wages in the two countries. From Lemma 4 we know that a decrease in t_x or t_y will cause both $\tilde{x}$ and $\tilde{y}$ to change. From Figure 2 we know that changes in $\tilde{x}$ and $\tilde{y}$ will affect the relative demand for skilled labor and hence the wage inequality. Algebraically we can derive the relative-wage effects of FDI liberalization from the following two equations:

$$h^d(\omega, \tilde{x}(t_x, t_y), \tilde{y}(t_x, t_y)) = h, \tag{14}$$

$$h^{*d}(\omega^*, \tilde{x}(t_x, t_y), \tilde{y}(t_x, t_y)) = h^*. \tag{15}$$

Applying the Implicit Function Theorem to equation (14) yields

$$\frac{d\omega}{dt_x} = -\frac{\partial h^d/\partial t_x}{\partial h^d/\partial \omega}, \quad \frac{d\omega}{dt_y} = -\frac{\partial h^d/\partial t_y}{\partial h^d/\partial \omega}. \tag{16}$$

From Lemma 2 we know $\partial h^d/\partial \omega < 0$. Partially differentiating h^d with respect to t_x and t_y yields

$$\frac{\partial h^d}{\partial t_x} = \underbrace{\frac{\partial h^d}{\partial \tilde{x}} \frac{d\tilde{x}}{dt_x}}_{(-)} + \underbrace{\frac{\partial h^d}{\partial \tilde{y}} \frac{d\tilde{y}}{dt_x}}_{(+)}, \quad \frac{\partial h^d}{\partial t_y} = \underbrace{\frac{\partial h^d}{\partial \tilde{x}} \frac{d\tilde{x}}{dt_y}}_{(+)} + \underbrace{\frac{\partial h^d}{\partial \tilde{y}} \frac{d\tilde{y}}{dt_y}}_{(-)}, \tag{17}$$

where the signs of $d\tilde{x}/dt_x$, $d\tilde{y}/dt_x$, $d\tilde{x}/dt_y$, and $d\tilde{y}/dt_y$ are determined by Lemma 4. It is clear that sector-specific FDI liberalization will cause $\tilde{x}$ and $\tilde{y}$ to change in opposite directions. Does this imply that the effect on h^d will be ambiguous? Not necessarily. In what follows, we discuss one particular case to illustrate the mechanism of the effect on h^d, and then present the complete results in a proposition.

First recall Lemma 3. The lemma states that the effect of a change in $\tilde{x}$ or $\tilde{y}$ on the *economy-wide* relative skill demand depends on the skill intensity of the borderline good relative to the skill abundance of the country. Next recall Corollary 2. The corollary states that the skill intensity of the borderline good depends on the difference in FDI barriers between sectors. Without loss of generality, we assume that $t_x \leq t_y$. Let us consider a particular case in which t_x is significantly lower than t_y. According to Corollary 1, if $t_x < t_y$, then the skill intensity of good $\tilde{x}$ is higher than that of good $\tilde{y}$. Thus, good $\tilde{x}$ is the most skill-intensive in the South; an increase in $\tilde{x}$ implies that the South adds skilled-intensive goods to its production, which raises h^d. According to Corollary 2, if $(t_y - t_x)$ is sufficiently large, then the skill intensity of good $\tilde{y}$ will be lower than the skill abundance of the South. Thus, an increase in $\tilde{y}$ implies that the South adds to its production goods that are unskilled-intensive *in the country,* although these goods are skilled-intensive *in the sector.* To summarize, we have $\partial h^d/\partial \tilde{x} > 0$ and $\partial h^d/\partial \tilde{y} < 0$ in this case. Now we can see the effect of FDI liberalization from the following equation:

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$$\frac{\partial h^d}{\partial t_x} = \frac{\partial h^d}{\partial \tilde{x}} \frac{d\tilde{x}}{dt_x} + \frac{\partial h^d}{\partial \tilde{y}} \frac{d\tilde{y}}{dt_x}, \qquad \frac{\partial h^d}{\partial t_y} = \frac{\partial h^d}{\partial \tilde{x}} \frac{d\tilde{x}}{dt_y} + \frac{\partial h^d}{\partial \tilde{y}} \frac{d\tilde{y}}{dt_y}.$$

$$(+)(-) \quad (-)(+) \qquad\qquad (+)(+) \quad (-)(-) \qquad\qquad (18)$$

Equation (18) shows that FDI liberalization has an unambiguous effect on the relative demand for skilled labor and hence the wage inequality. Moreover, the direction of the effect depends on the *sector bias* of FDI liberalization. If FDI liberalization occurs in the low-barrier sector X, then the South's wage inequality will rise; if it occurs in the high-barrier sector Y, then the South's wage inequality will fall. Following the same procedure we derive results for other cases. We summarize the results in:

Proposition 2. In the presence of sector-specific FDI barriers $(t_x \le t_y)$,

(i) if $(t_y - t_x)$ is large enough that $h(\tilde{y}) < h$, Southern wage inequality will increase if FDI liberalization in the South occurs in sector X and decrease if it occurs in sector Y;

(ii) if $(t_y - t_x)$ is large enough that $h(\tilde{x}) > h^*$, Northern wage inequality will decrease if FDI liberalization in the South occurs in sector X and increase if it occurs in sector Y;

(iii) if $(t_y - t_x)$ is small enough that $h < h(\tilde{y}) \le h(\tilde{x}) < h^*$, FDI liberalization in the South will have an ambiguous effect on wage inequality in both the South and the North.

What is the intuition for Proposition 2? The key is to recognize that FDI liberalization in one sector will affect skill demand in *both* sectors, and the direction of the demand shift in each sector depends on the skill intensity of the *borderline good*, which in turn depends on the sectoral difference in FDI barriers. In case (i), when the South has a high FDI barrier in sector Y, outsourcing in the sector must be unskilled-intensive (relative to h) to be profitable. If the South reduces the barrier in sector Y, then the sector expands. A small expansion of sector Y adds unskilled-intensive goods to the South's production, implying a *decrease* in the South's skill demand. In a general equilibrium, an expansion of sector Y is accompanied by a shrinkage of sector X. Because the borderline good in sector X is skill-intensive in the South, the shrinkage of sector X also implies a decrease in the South's skill demand. Thus, skill demand moves in

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the same direction in the two sectors; whether skill demand will increase or decrease depends on which sector FDI liberalization occurs. The same intuition applies to case (ii). One may think of case (ii) as one in which the South "subsidizes" FDI in sector X such that the borderline good $\tilde{x}$ is skill-intensive even in the North's product mix. In this case, outsourcing of x will decrease the North's skill demand and outsourcing of y will increase its skill demand.

In case (iii), sectoral FDI liberalization causes labor demand to move in opposite directions in the two sectors. When the South's FDI barriers are similar in the two sectors, the borderline goods in both sectors will be skilled-intensive in the South's product mix and unskilled-intensive in the North's product mix. In this case, an expansion of any sector in the South will have a positive effect on the skill demand in both countries. The expansion, however, will be accompanied by a shrinkage of the other sector, which will have a negative effect on the skill demand in both countries. The net effect is in general ambiguous.[8]

So far we have focused on sectoral FDI liberalization. What about across-the-board FDI liberalization? We define across-the-board FDI liberalization as a decrease in t_x and t_y by the same proportion, i.e., $d\tau \equiv dt_x/(1+t_x) = dt_y/(1+t_y)$. It is easy to verify that $d\tilde{x}/d\tau < 0$ and $d\tilde{y}/d\tau < 0$. That is, across-the-board FDI liberalization results in an expansion of outsourcing in both sectors. The effects of the liberalization on wage inequality can be derived from:

$$\frac{\partial h^d}{\partial \tau} = \underbrace{\frac{\partial h^d}{\partial \tilde{x}}}_{(-)} \underbrace{\frac{d\tilde{x}}{d\tau}}_{} + \underbrace{\frac{\partial h^d}{\partial \tilde{y}}}_{(-)} \frac{d\tilde{y}}{d\tau}, \qquad \frac{\partial h^{*d}}{\partial \tau} = \underbrace{\frac{\partial h^{*d}}{\partial \tilde{x}}}_{(-)} \frac{d\tilde{x}}{d\tau} + \underbrace{\frac{\partial h^{*d}}{\partial \tilde{y}}}_{(-)} \frac{d\tilde{y}}{d\tau}. \qquad (19)$$

We can use Lemma 3 to determine the partial derivatives of h^d and h^{*d} with respect to $\tilde{x}$ and $\tilde{y}$. As we know from our earlier analysis, these partial derivatives depend on the degree of sectoral differences in FDI barriers. Following the same procedure as in the derivation of Proposition 2, we establish:

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[8]We can determine the net effect in some special cases. For example, if $t_x = t_y$ initially and $\lambda = 0.5$, then sectoral FDI liberalization will lead to an increase in wage inequality in both countries.

Proposition 3. In the presence of sector-specific FDI barriers $(t_x \leq t_y)$,

(i) if $(t_y - t_x)$ is small enough that $h < h(\tilde{y}) \leq h(\tilde{x}) < h^*$, across-the-board FDI liberalization in the South will increase wage inequality in both the South and the North;

(ii) if $(t_y - t_x)$ is large enough that $h(\tilde{y}) < h$ or $h(\tilde{x}) > h^*$, across-the-board FDI liberalization in the South will have an ambiguous effect on wage inequality in the South and the North.

Proposition 3(i) generalizes the result of Feenstra and Hanson (1996). In their one-sector model, the borderline good is the most skilled-intensive in the South and the most unskilled-intensive in the North, and hence FDI liberalization, which is "across-the-board" by definition, will increase wage inequality in both countries. In our two-sector model, we find that the Feenstra-Hanson result holds when FDI liberalization applies to both sectors in the same proportion *and* the sectoral difference in FDI barriers is sufficiently small that both borderline goods are skilled-intensive in the South and unskilled-intensive in the North. Proposition 3(ii) indicates that the Feenstra-Hanson result may not hold under across-the-board FDI liberalization when the sectoral difference in FDI barriers is sufficiently large.

Now we can use Propositions 1-3 to determine the relationship between outsourcing and wage inequality. The results are summarized in:

Corollary 3. In the presence of sector-specific FDI barriers,

(i) if the sectoral difference in FDI barriers is sufficiently small and the FDI liberalization is across-the-board, outsourcing and wage inequality will be positively related in both countries;

(ii) if the sectoral difference in FDI barriers is sufficiently large and the FDI liberalization is sectoral, outsourcing and wage inequality will be positively (negatively) related in the South and negatively (positively) related in the North when the liberalization occurs in the low-barrier (high-barrier) sector;

(iii) if the sectoral difference in FDI barriers is sufficiently large (small) and the FDI liberalization is across-the-board (sectoral), outsourcing and wage inequality will in general be ambiguously related in both countries.

Corollary 3 conveys a central message of the paper: sectoral differences in FDI barriers and sector specificity of FDI liberalization play an important role in determining the relationship between outsourcing and wage inequality. The results in Corollary 3 provide a guide for empirical studies of the relationship. They might also be useful in understanding the observation that outsourcing and wage inequality are positively correlated in some cases (e.g. Mexico after 1985) but negatively correlated in some others (e.g. Singapore).

It is worth noting that we distinguish sectors by differences in FDI barriers, not by differences in *average* skill intensity. The differences in FDI barriers determine the *marginal* skill intensity of a sector, i.e., the skill intensity of the borderline good. For the relationship between outsourcing and wage inequality, what matters is the skill intensity of the borderline good relative to the country's skill abundance, which is endogenously determined by the sectoral difference in FDI barriers. It follows that the skill-intensity ranking of the two final goods does not matter for the relationship between outsourcing and wage inequality. Although for convenience we have assumed that both final goods are assembled from the same range of intermediate goods, we could assume that they use different ranges of intermediate goods.[9]

5   Conclusion

This paper investigates the relationship between international outsourcing and wage inequality in a North-South general equilibrium model. In contrast to the one-sector model of Feenstra and Hanson (1996), we considered two sectors each of which assembles a final good from a continuum of intermediate goods. With wages unequal between countries, the South specializes in intermediate goods that are less skill-intensive than those in the North. In response to a higher rate of return to capital in the South, multinational firms outsource a portion of intermediate-good production from the North to the South through FDI.

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[9]Note that the average skill intensity of a sector *in each country* is endogenously determined. If the borderline good $\tilde{y}$ is unskilled-intensive in the South, for example, then sector Y is unskilled-intensive in the South in terms of average skill intensity. We cannot conclude, however, that outsourcing in an unskilled-intensive sector will raise the South's wage inequality; it may not. For the South's wage inequality to rise, outsourcing must increase in the sector with an unskilled-intensive *borderline* good.

The main finding of the paper is that the sectoral dimension plays a key role in the outsourcing-wages relationship. We found that the relationship depends on the sectoral difference in FDI barriers and the sector specificity of FDI liberalization. The sectoral difference in FDI barriers determines the skill intensity of outsourcing activities relative to a country's skill abundance; the high-barrier sector in the South attracts outsourcing activities that are relatively unskilled-intensive, while the low-barrier sector attracts outsourcing activities that are relatively skilled-intensive. The sector specificity of FDI liberalization determines the *change* in the skill intensity of outsourcing activities; FDI liberalization causes an increase in the skill intensity of outsourcing activities in the sector where it occurs and a decrease in the skill intensity of outsourcing activities in the other sector. In the paper we derived the effects of outsourcing on wage inequality in various cases, with the FDI liberalization varying from sector-specific to across-the-board and the sectoral difference in FDI barriers varying from small to large. We showed that the Feenstra-Hanson (1996) result is a special case of our model.

Our analytical results provide some guidance for empirical investigations into the effects of international outsourcing on relative wages. In particular, they might help to explain the observation that foreign outsourcing and wage inequality are positively related in some countries but negatively related in others. Our analysis highlights the role of FDI policies in determining the outsourcing-wages relationship, which might be useful for policy makers concerned with the income-distribution implication of foreign outsourcing.

Appendix

Proof of Lemma 4

Totally differentiating $c_x \equiv [w_L + w_H h(\tilde{x})]^\alpha (1 + t_x)^{1-\alpha} = [w_L^* + w_H^* h(\tilde{x})]^\alpha \equiv c_x^*$ yields

$$(\frac{\partial \ln c_x}{\partial \tilde{x}} - \frac{\partial \ln c_x^*}{\partial \tilde{x}})d\tilde{x} + \alpha[(\tilde{\theta}_L \hat{w}_L + \tilde{\theta}_H \hat{w}_H) - (\tilde{\theta}_L^* \hat{w}_L^* + \tilde{\theta}_H^* \hat{w}_H^*)] = \frac{1-\alpha}{1+t_x}dt_x, \qquad (A.1)$$

where a hat over a variable denotes a logarithmic change, and $\tilde{\theta}_F$ denotes share of factor F in labor cost of the borderline good $\tilde{x}$. For example, $\tilde{\theta}_L \equiv w_L / (w_L + w_H h(\tilde{x}))$.

Define $I \equiv w_L L + w_H H + rK$. Given the Cobb-Douglas production functions of intermediate goods, $w_L L + w_H H = \alpha I$. From the two full-employment conditions we obtain $\lambda \alpha \tilde{x} + (1-\lambda)\alpha \tilde{y} = w_L L + w_H H = \alpha I$. Totally differentiating this equation yields

$$\theta_L \hat{w}_L + \theta_H \hat{w}_H = \frac{\lambda}{I}d\tilde{x} + \frac{1-\lambda}{I}d\tilde{y}, \qquad (A.2)$$

where θ_F denotes share of factor F in labor cost of the South. Using (A.2), $\theta_L + \theta_H = 1$, and $\tilde{\theta}_L + \tilde{\theta}_H = 1$, we have:

$$\begin{aligned}
\tilde{\theta}_L \hat{w}_L + \tilde{\theta}_H \hat{w}_H &= \theta_L \hat{w}_L + \theta_H \hat{w}_H + (\tilde{\theta}_H - \theta_H)(\hat{w}_H - \hat{w}_L) \\
&= \frac{\lambda}{I}d\tilde{x} + \frac{1-\lambda}{I}d\tilde{y} + (\tilde{\theta}_H - \theta_H)\frac{\partial \ln \omega}{\partial \tilde{x}}d\tilde{x}. \qquad (A.3)
\end{aligned}$$

Similarly we obtain for the North:

$$\tilde{\theta}_L^* \hat{w}_L^* + \tilde{\theta}_H^* \hat{w}_H^* = -\frac{\lambda}{I^*}d\tilde{x} - \frac{1-\lambda}{I^*}d\tilde{y} + (\tilde{\theta}_H^* - \theta_H^*)\frac{\partial \ln \omega^*}{\partial \tilde{x}}d\tilde{x}. \qquad (A.4)$$

Substituting (A.3) and (A.4) into (A.1) yields

$$[\Delta_x + \alpha\lambda(\frac{1}{I} + \frac{1}{I^*})]d\tilde{x} + \alpha(1-\lambda)(\frac{1}{I} + \frac{1}{I^*})d\tilde{y} = -\frac{1-\alpha}{1+t_x}dt_x. \qquad (A.5)$$

where $\Delta_x \equiv (\frac{\partial \ln c_x}{\partial \tilde{x}} - \frac{\partial \ln c_x^*}{\partial \tilde{x}}) + (\tilde{\theta}_H - \theta_H)\frac{\partial \ln \omega}{\partial \tilde{x}} + (\theta_H^* - \tilde{\theta}_H^*)\frac{\partial \ln \omega^*}{\partial \tilde{x}}$. The first term of Δ_x is the difference between the slopes of $C_x C_x$ and $C^* C^*$ at the point $\tilde{x}$ in Figure 1, which is positive. If $t_x < t_y$, the borderline good $\tilde{x}$ is the most skill-intensive in the South; hence $\tilde{\theta}_H > \theta_H$. According to Lemma 3, an increase in $\tilde{x}$ raises the relative demand for skilled labor in the South at fixed wages; hence $\frac{\partial \ln \omega}{\partial \tilde{x}} > 0$. It follows that the second term of Δ_x is positive. To determine the sign

of the third term, we find that if $h^* > h(\tilde{x})$, then $\theta_H^* > \tilde{\theta}_H^*$ and $\frac{\partial \ln \omega^*}{\partial \tilde{x}} > 0$; if $h^* < h(\tilde{x})$, then $\theta_H^* < \tilde{\theta}_H^*$ and $\frac{\partial \ln \omega^*}{\partial \tilde{x}} < 0$. It follows that the third term of Δ_x is positive. These results establish $\Delta_x > 0$ when $t_x < t_y$. Similarly we can show that $\Delta_x > 0$ holds when $t_x \geq t_y$.

Following the same procedure we obtain from $c_y = c_y^*$ and full-employment conditions:

$$[\Delta_y + \alpha(1-\lambda)(\frac{1}{I} + \frac{1}{I^*})]d\tilde{y} + \alpha\lambda(\frac{1}{I} + \frac{1}{I^*})d\tilde{x} = -\frac{1-\alpha}{1+t_y}dt_y. \tag{A.6}$$

where $\Delta_y \equiv (\frac{\partial \ln c_y}{\partial \tilde{y}} - \frac{\partial \ln c_y^*}{\partial \tilde{y}}) + (\tilde{\phi}_H - \theta_H)\frac{\partial \ln \omega}{\partial \tilde{y}} + (\theta_H^* - \tilde{\phi}_H^*)\frac{\partial \ln \omega^*}{\partial \tilde{y}}$. Here $\tilde{\phi}_F$ denotes share of factor F in labor cost of the borderline good indexed by $\tilde{y}$. The first term of Δ_y is the difference between the slopes of $C_y C_y$ and $C^* C^*$ at the point $\tilde{y}$ in Figure 1, which is positive. If $t_x < t_y$, the borderline good $\tilde{y}$ is the least skill-intensive in the North; hence $\theta_H^* > \tilde{\phi}_H^*$. According to Lemma 3, an increase in $\tilde{y}$ raises the relative demand for skilled labor in the North at fixed wages; hence $\frac{\partial \ln \omega^*}{\partial \tilde{y}} > 0$. It follows that the third term of Δ_y is positive. To determine the sign of the second term, we find that if $h(\tilde{y}) > h$, then $\tilde{\phi}_H > \theta_H$ and $\frac{\partial \ln \omega}{\partial \tilde{y}} > 0$; if $h(\tilde{y}) < h$, then $\tilde{\phi}_H < \theta_H$ and $\frac{\partial \ln \omega}{\partial \tilde{y}} < 0$. It follows that the second term of Δ_y is positive. Thus $\Delta_y > 0$ when $t_x < t_y$. Similarly we can show that $\Delta_y > 0$ holds when $t_x \geq t_y$.

From equations (A.5) and (A.6) we solve $d\tilde{x}$ and $d\tilde{y}$. The solutions are given by

$$d\tilde{x} = -\frac{[\Delta_y + \alpha(1-\lambda)(\frac{1}{I} + \frac{1}{I^*})]\frac{1-\alpha}{1+t_x}}{\Delta}dt_x + \frac{\alpha(1-\lambda)(\frac{1}{I} + \frac{1}{I^*})\frac{1-\alpha}{1+t_y}}{\Delta}dt_y, \tag{A.7}$$

$$d\tilde{y} = -\frac{[\Delta_x + \alpha\lambda(\frac{1}{I} + \frac{1}{I^*})]\frac{1-\alpha}{1+t_y}}{\Delta}dt_y + \frac{\alpha\lambda(\frac{1}{I} + \frac{1}{I^*})\frac{1-\alpha}{1+t_x}}{\Delta}dt_x, \tag{A.8}$$

where $\Delta \equiv \Delta_x \Delta_y + \alpha\lambda(\frac{1}{I} + \frac{1}{I^*})\Delta_y + \alpha(1-\lambda)(\frac{1}{I} + \frac{1}{I^*})\Delta_x > 0$. This establishes Lemma 4.

Proof of Lemma 5

Differentiating (12) with respect to t_x yields

$$\begin{aligned}\frac{d(FDI)}{dt_x} &= \frac{(1-\alpha)\lambda}{(1+t_x)r^*}\frac{d\tilde{x}}{dt_x} + \frac{(1-\alpha)(1-\lambda)}{(1+t_y)r^*}\frac{d\tilde{y}}{dt_x} \\ &= -\frac{(1-\alpha)\lambda}{(1+t_x)^2 r^*}[\tilde{x} + \frac{(1+t_x)\Delta_y}{\Delta}] < 0. \end{aligned} \tag{A.9}$$

The last expression is obtained by substituting $d\tilde{x}/dt_x$ and $d\tilde{y}/dt_x$ from (A.7) and (A.8). The proof of $d(FDI)/dt_y < 0$ is similar. Other results in Lemma 5 are obvious.

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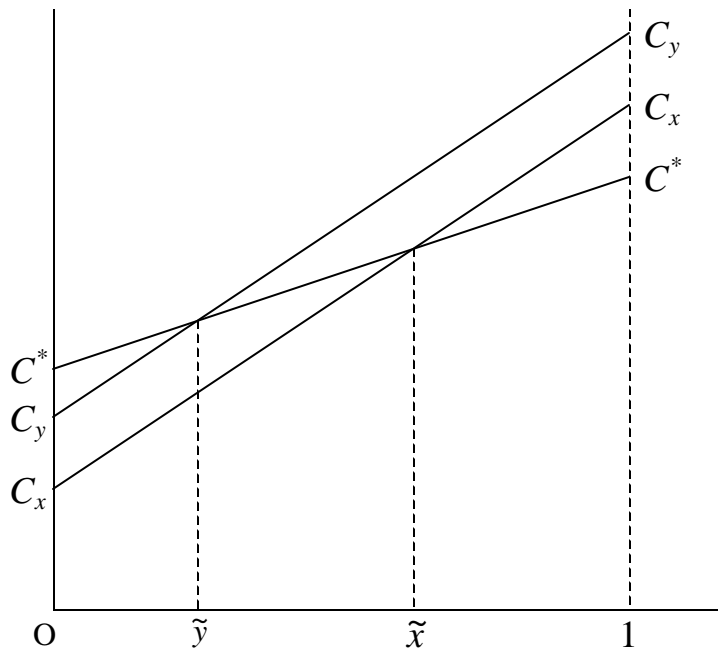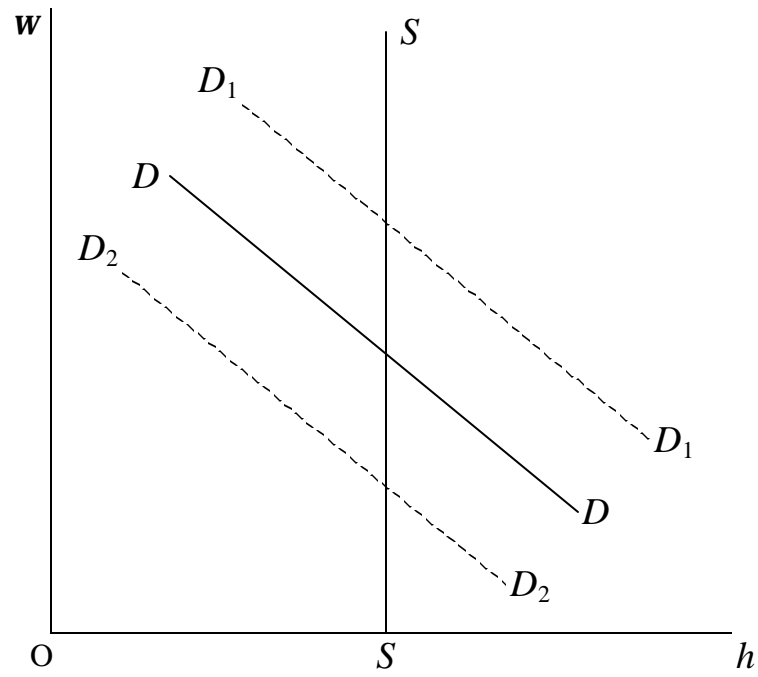
Figure 1. Determination of $\tilde{x}$ and $\tilde{y}$

Figure 2. Determination of $\boldsymbol{w}$