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Abstract

Ronald W. Jones (2000) celebrated book has inspired a generation of work that has been devoted to understanding the causes and consequences of outsourcing. While much of this work has focused on the outsourcing versus domestic production decision of the firm with labor cost-saving as the key driver for outsourcing, we further explore how preference-based outsourcing may arise in a dynamic world equilibrium. We address this problem in a North-South model in which the outsourcing decision depends not only on labor costs but also on information about local preferences that arise with outsourcing. As the South develops, demand for manufactured goods becomes more important, so identifying specific tastes of South consumers matters more. As a result, preference-based outsourcing displaces cost-saving outsourcing. Our quantitative analysis indicates that, as both agricultural and manufacturing technologies grow over time, the dynamic world equilibrium switches from the export regime to the cost-saving outsourcing regime, and eventually to the preference-based outsourcing regime.

JEL-Codes: F210, F230, F430, O190.

Keywords: dynamic outsourcing, learning and taste-matching, organizational choice.

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We would like to dedicate this paper to Ronald Jones whose pivotal contribution in general equilibrium trade theory has inspired all of us and whose comments and suggestions on earlier work by Riezman and Wang (2009) have led to the birth of this paper. We are also grateful for comments and suggestions by Eric Bond and Murray Kemp at various stages. Needless to say, the usual disclaimer applies.

1 Introduction

The important book by Ronald W. Jones (2000) has inspired a great deal of interesting research devoted to understanding the causes and consequences of outsourcing.[1] Outsourcing has played an increasingly important role in the international fragmentation of production and services. Not only has it been adopted globally in many industries, but it also comes in different organizational forms. In this paper, we explore the rise of two forms of outsourcing, namely, cost-saving outsourcing and preference-based outsourcing.

A great deal of the outsourcing literature focuses on the decision of a developed country (North) firm whether to export to a less developed country (South) or to outsource production to the South. This decision is typically driven by cheap Southern labor. We call this cost-saving outsourcing. In Riezman and Wang (2009), a preference-based theory of outsourcing is developed that focuses on outsourcing as a way for the North firm to learn about local tastes for the outsourced product. Our paper contributes to the literature by developing a unified theory devoted to understanding the North firm's decision whether to export, engage in cost-saving outsourcing or preference-based outsourcing.

We analyze this problem with a North-South model in which the outsourcing decisions depend not only on labor costs but also on local preference information advantages that arise with outsourcing. Southern consumers have heterogeneous preferences for horizontally differentiated manufactured goods. With land as a specific factor, outsourcing induced reallocation of labor from agricultural to manufactured sectors causes the wage in the South to rise. Thus, cheap-labor driven cost-saving outsourcing becomes less profitable. Because manufactured goods have a higher income elasticity than agricultural goods, as wages and hence incomes rise in the South the demand for manufactured goods becomes more important and knowledge regarding specific tastes matter more, and therefore preference-based outsourcing replaces cheap-labor driven outsourcing.

We establish two boundaries in North firms' organizational choice: (i) one pins down the switch from exporting manufactured goods to cost-saving outsourcing to take advantage of cheap labor in the South, and (ii) another from cost-saving outsourcing to preference-based outsourcing. In particular, we examine the effects of two key drivers, production technologies and taste specificity, on labor allocation, wages, relative price, outsourcing rent, and hence the organizational choice by North firms. We then study quantitatively under what circumstances these three alternative organizational forms may arise in a dynamic world equilibrium.

We find that, as agricultural and manufacturing technologies grow over time, the dynamic world equilibrium switches from the export regime to the cost-saving outsourcing regime, and

[1] See, for example, Grossman and Helpman (2002, 2005) and Antras (2005), to name but a few.

eventually to the preference-based outsourcing regime. Four key channels underlying our results are (i) the relative price of the manufactured good, (ii) the importance of taste specificity in South preferences (iii) relative wage between North and South, and finally, (iv) value of North labor in R&D investment compared to production and market research. Technology growth in the North and South will play a key role in affecting these channels.

Under the benchmark parameterization, the dynamic world equilibrium configuration switches from the export regime to the cost-saving outsourcing regime in 21 years, and then to the preference-based outsourcing regime after another 22 years. Moreover, we find that when the degree of taste-specificity rises, the preference-based outsourcing regime becomes more appealing and arises faster. Furthermore, when manufacturing technology improves faster, cost-saving outsourcing become more rewarding but preference-based outsourcing become less attractive. As a consequence, the dynamic world equilibrium transits into the cost-saving outsourcing regime earlier but the arrival of the preference-based outsourcing regime is later.

2 The Model

Time is discrete. Consider a simple North-South model with heterogenous tastes for horizontally differentiated varieties of manufactured goods. In each country, there is a continuum of consumers of mass one. There is a continuum of countries in the South, each identified by an ideal taste for the manufactured good of type i. The North (source country) using high-skilled labor H as the only input is capable of producing the entire spectrum of consumable manufactured good varieties for all countries in the South defined over a unit circle of circumference J, denoted $\{y^j\}_{j \in J}$. In the absence of outsourcing, the South can only produce the single agricultural good c, with land Z (exogenously supplied and normalized to one) and low-skilled labor L. With outsourcing, the South is authorized to use the North technology to produce North assigned varieties of manufactured goods at given contract prices.[2] While food is a necessity, manufactured goods are not. Because manufactured goods are only horizontally differentiated, their valuations do not depend on quality but simply specific tastes by consumers. We assume that North producers do not know South taste parameters. Moreover, we assume that only through outsourcing can North firms learn South consumers' specific taste. In addition, we assume that in the South, the agricultural technology A grows at an exogenous rate γ_A: $A_{t+1} = (1 + \gamma_A)A_t$ while in the North, the manufacturing technology $B > A$ grows at an endogenous rate γ_B: $B_{t+1} = (1 + \gamma_B)B_t$ (which depends on R&D labor R in the North.)

[2] That is, we assume that the manufactured good can only be produced in the South if it is outsourced and that the South firms cannot purchase the blueprint from the North directly. Those interested in looking at the latter issue are referred to Spulber (2008).

2.1 The South

The lifetime utility is time-additive with a time preference rate given by $\rho > 0$. In the South, each country is populated with identical consumers with an ideal taste type i. Each country purchases a different variety. The representative consumer's taste-specific periodic utility from purchasing a manufactured good of variety j and the local agricultural good is:

$$U^i(c_t, y_t^j) = \ln(c_t) + \ln(\theta + \Gamma^j y_t^j) \tag{1}$$

where $\theta > 0$ indicates that the manufactured good is not a necessity and $\Gamma^j \leq 1$ is a taste-specific discount factor capturing utility loss due to distance of the purchased variety from the ideal variety. With $\theta > 0$, income effect will play an important role – as income rises, demand for the manufactured good rises. Also, $\Gamma^i = 1$ when an ideal variety is purchased. In the absence of an ideal match (i.e., $j \neq i$), the discount factor is:

$$\Gamma^j = \frac{1}{1 + \psi(j - i)^2} \tag{2}$$

where $\psi > 0$ captures the importance of taste-specifics – a higher value of ψ implies tastes matter more for South consumers. Since varieties are defined over the unit circumference, $1/(1 + \psi)$ measures the maximum discount rate (when $j - i = 1$).

The production of the single agricultural good c by a continuum of perfectly competitive farms of mass one takes a simple Cobb-Douglas form:

$$c_t = A_t L_t^\alpha Z_t^{1-\alpha} \tag{3}$$

where $\alpha \in (0, 1)$ and the agricultural technology evolves at an exogenous growth rate γ_A:

$$A_{t+1} = (1 + \gamma_A) A_t. \tag{4}$$

Under perfectly competitive factor markets, wage w and land rent q must equal their marginal products:

$$w_t = \alpha A_t L_t^{\alpha-1} Z_t^{1-\alpha}, \tag{5}$$

$$q_t = (1 - \alpha) A L_t^\alpha Z_t^{-\alpha}. \tag{6}$$

In the absence of outsourcing, $L_t = 1$, so the factor prices become $w_t = \alpha A_t Z_t^{1-\alpha}$ and $q_t = (1 - \alpha) A_t Z_t^{-\alpha}$.

Outsourcing requires close long term local relationships to insure consistent high quality local production. With outsourcing at contract price p_t^k for any assigned variety k (recall that manufactured goods are only horizontally differentiated), there will be a continuum of contracted manufacturers of mass one formed producing the given variety using a decreasing-returns-to-scale technology authorized by the North:

$$y_t^{ko} = B_t N_t^{\beta} \tag{7}$$

where the superscript o indicates outsourced production and

$$N_t + L_t = 1.$$

Then the wage in the South is

$$w_t = \beta p_t^k B_t N_t^{\beta-1} \tag{8}$$

and the rent

$$\phi_t^k = p_t^k y_t^{ko} - w_t N_t = (1-\beta) p_t^k B_t N_t^{\beta} \tag{9}$$

is paid to the North.

Denote South consumer's asset holding as a and assume perfect borrowing-lending at world interest rate r. For simplicity we assume all South consumers have identical asset holdings. Let the agricultural good be the numeraire. Given the manufactured price p^j, the intertemporal budget constraint is then given by

$$a_{t+1} = w_t + (1+r_t)a_t - c_t - p_t^j y_t^j. \tag{10}$$

The intertemporal optimization is therefore given by

$$V^i(a_t) = \max_{c_t, y_t^j, a_{t+1}} \left[\ln(c_t) + \ln(\theta + \Gamma^j y_t^j) \right] + \frac{1}{1+\rho} V^i(a_{t+1}) \quad \text{s.t. (10)}.$$

The first-order conditions are:

$$\begin{aligned} \frac{1}{c_t} &= \frac{1}{1+\rho} V_{a_{t+1}}^i \\ \frac{\Gamma^j}{\theta + \Gamma^j y_t^j} &= \frac{p_t^j}{1+\rho} V_{a_{t+1}}^i \end{aligned}$$

which can be combined to yield the marginal rate of substitution of manufactured good to agricultural good,

$$MRS_{yc} = \frac{\Gamma^j c_t}{\theta + \Gamma^j y_t^j} = p_t^j. \tag{11}$$

It is straightforward that $\frac{\partial p_t^j}{\partial \psi} < 0$ ($\frac{\partial p_t^j}{\partial \Gamma^j} > 0$), $\frac{\partial p_t^j}{\partial c_t} > 0$ and $\frac{\partial p_t^j}{\partial y_t} < 0$. Moreover, $\frac{\partial^2 p_t^j}{\partial \psi \partial c_t} < 0$ and $\frac{\partial^2 p_t^j}{\partial \psi \partial y_t} > 0$. Using these results we have the following proposition.

Proposition 1: (Manufactured Good Pricing) *For a given South country i, consumers' willingness to pay for the manufactured good of variety j is decreasing in their degree of taste-specificity ψ.*

Moreover, in the absence of an ideal match ($\Gamma^j < 1$), the effect of the taste-specific discount on willingness to pay p_t^j is higher if there is more consumption on the manufactured good or less consumption on the agricultural good.

The implication is that the lack of knowledge of South consumers' ideal preference affects North firms more when the consumption of manufactured goods in the South is higher. Finally, the expenditure function is

$$e_t = c_t + p_t^j y_t^j = p_t^j \left(\frac{\theta}{\Gamma^j} + y_t^j \right) + p_t^j y_t^j = p_t^j \left(\frac{\theta}{\Gamma^j} + 2y_t^j \right)$$

and the expenditure share on the manufactured good is thus

$$\frac{p_t^j y_t^j}{e_t} = \left(\frac{\theta}{\Gamma^j y_t^j} + 2 \right)^{-1}. \tag{12}$$

As can be seen from (12), the income effect plays an important role with $\theta > 0$: as income rises (and hence consumption of the manufactured good y), the expenditure share of the manufactured good increases if $\theta > 0$. South consumers' demand for the manufactured good increases as their income level increases. However, the absence of an ideal match ($\Gamma^j < 1$) has a negative effect on South consumers' demand for the manufactured good, and its expenditure share is lower if the degree of South consumers' taste-specificity is higher (larger ψ and smaller Γ^j). Accordingly, the knowledge of South consumers' ideal preference becomes more valuable to North firms as South consumers' income level grows.

2.2 The North

There is a continuum of representative firms of mass one. Each firm owns a continuum of factories, with each factory producing a particular variety $j \in J$:

$$y_t^{js} = B_t \cdot (H_t^j)^\beta \tag{13}$$

where the superscript s indicates production in the source country and

$$H_t = \int_{j \in J} H_t^j dj.$$

In the North, labor is divided into manufacturing labor (H_t) and research labor (R_t):

$$R_t + H_t = 1.$$

Each firm will decide whether to outsource a particular variety to the South. By outsourcing, the firm can take advantage of cheap labor in the South as well as save their high-skilled labor for

R&D to advance its production technology.[3] In the R&D sector,

$$\gamma_B = \frac{B_{t+1} - B_t}{B_t} = \overline{B} R_t^{\mu}$$

and the manufacturing technology grows at an endogenous rate

$$B_{t+1} = (1 + \overline{B} R_t^{\mu}) B_t$$

or

$$B_{t+1} = B_t \left[1 + \overline{B} \left(1 - \textstyle\int_{j \in J} H_t^j dj \right)^{\mu} \right]. \tag{14}$$

Manufacturing technology rises with R&D but is subject to a maximal manufacturing technology growth rate $\overline{B} > 0$ which occurs when all North labor is committed to R&D.

3 Dynamic World Equilibrium

We solve the dynamic world equilibrium of the North-South model, taking the export regime as the initial stage. We next examine under what circumstances cost-saving outsourcing would supplant exporting in equilibrium. We then consider at what point preference-based outsourcing would replace cost-saving outsourcing. While learning is possible through exporting, especially via local distributors, we assume that more is learned by outsourcing than by exporting. To keep the model as simple as possible we assume that there is no learning by exporting. Theoretically, we don't lose anything since the relative payoff between exporting and outsourcing depends only on the learning advantage to outsourcing. The analysis is greatly simplified as we do not have to keep track of the export history. In addition, in practice exporting is not typically tailored to a particular country and doing market research to fit country-specific tastes will not be profitable unless the market is large.

3.1 The Export Regime

In the initial stage, firms in the North export the manufactured good to the South, referred to as the *export regime*. Given the wage paid for the high-skill labor, v_t, North firms' optimization problem in the export regime is described by

$$\begin{aligned} \Omega^E(A_t, B_t) \quad &= \quad \max_{\{H_t^j\}_{j \in J}} \mathbf{E} \int_{j \in J} \left[p_t^j B_t \cdot (H_t^j)^{\beta} - v_t H_t^j \right] dj - v_t \left(1 - \textstyle\int_{j \in J} H_t^j dj \right) \\ &\quad + \frac{1}{1+\rho} \Omega^E(A_{t+1}, B_{t+1}) \quad \text{s.t. } (4), (14). \end{aligned} \tag{15}$$

[3] It is possible for a firm to be indifferent between outsourcing a particular variety or not, but this knife-edge case cannot persist for more than a period and is hence omitted in our study.

Substituting in the law of motion of technologies, the value function becomes

$$\Omega^E(A_t, B_t) = \max_{\{H_t^j\}_{j\in J}} \mathbf{E}\int_{j\in J} p_t^j B_t \cdot (H_t^j)^\beta dj - v_t + \frac{1}{1+\rho}\Omega^E\left\{A_t(1+\gamma_A), B_t\left[1+\overline{B}\left(1-\textstyle\int_{j\in J} H_t^j dj\right)^\mu\right]\right\}$$

and the first-order condition is

$$\mathbf{E}[p_t^j] B_t \beta (H_t^j)^{\beta-1} = \frac{\mu\overline{B}}{1+\rho} B_t \left(1-\textstyle\int_{j\in J} H_t^j dj\right)^{\mu-1} \frac{\partial}{\partial B}\Omega^E(A_{t+1}, B_{t+1}).$$

Since the true marginal rate of substitution in the South and thus p_t^j are unknown by the North, firms can only form expectations on p_t^j when making decisions. Accordingly, the above condition implies the North firms' labor demand is symmetric for all varieties: $H_t^j = H_t$ for all j. By manipulation (see the Appendix), we obtain the first-order condition for H_t:

$$(1+\rho)\frac{\mathbf{E}[p_t^j]}{\mathbf{E}[p_{t+1}^j]}\frac{(1-H_t)^{1-\mu}}{H_t^{1-\beta}} = \frac{\mu\overline{B}}{\beta}H_{t+1}^\beta + [1+\overline{B}(1-H_{t+1})^\mu]\frac{(1-H_{t+1})^{1-\mu}}{H_{t+1}^{1-\beta}}. \quad (16)$$

Without knowledge of the South consumers' true preference, firms in the North export a randomly chosen variety j to South country i, with the amount of exporting equal to $y_t^j = B_t H_t^\beta$ for all j. The agriculture good produced in the South is $c_t = A_t$. Therefore, in equilibrium, the willingness to pay for the variety j by consumers in the South country i is

$$p_t^j = MRS_{yc} = \frac{\Gamma^j A_t}{\theta + \Gamma^j B_t H_t^\beta} = \frac{A_t}{\theta + \theta\psi(j-i)^2 + B_t H_t^\beta} \quad (17)$$

and North firms' expected price for variety j is thus

$$\mathbf{E}[p_t^j] = A_t \int_0^1 \frac{1}{\theta + \theta\psi\tilde{j}^2 + B_t H_t^\beta} d\tilde{j}, \quad \text{where } \tilde{j} = (j-i). \quad (18)$$

We focus on the stationary equilibrium where $H_t = H_{t+1}$, so (16) can be rewritten as

$$\begin{aligned} \frac{(1+\rho)}{(1+\gamma_A)}\frac{\tilde{p}(H_t; B_t)}{\tilde{p}(H_t; [1+\overline{B}(1-H_t)^\mu]B_t)} - 1 &= \frac{\mu\overline{B}}{\beta}\frac{H_t}{(1-H_t)^{1-\mu}} + \overline{B}(1-H_t)^\mu \\ \text{where } \tilde{p}(H_t; B_t) &= \int_0^1 \frac{1}{\theta + \theta\psi\tilde{j}^2 + B_t H_t^\beta} d\tilde{j}. \end{aligned} \quad (19)$$

The right-hand side of (19) is increasing in H_t while the left-hand side is hump shaped in H_t, and the slope of the former is greater than the later within reasonable values of H_t. Also, the left-hand side is increasing in B_t. Therefore, (19) yields a unique solution of H_t (see the Appendix for details), denoted as $H_t(B_t)$, and it is increasing in B_t. With $H_t = H_t(B_t)$, the relative price of manufactured good (17) can be thus expressed as $p_t^j(A_t, B_t)$ and is clearly increasing in A_t but decreasing in B_t. Moreover, if consumers in the South are more taste specific (larger ψ and smaller Γ^j), the price would increase in A_t and decrease in B_t but by less.[4]

[4] Note that $\frac{d\mathbf{E}p_t^j(A_t,B_t)}{dA_t} > 0$, $\frac{d\mathbf{E}p_t^j(A_t,B_t)}{dB_t} < 0$; $\frac{d^2\mathbf{E}p_t^j(A_t,B_t)}{dA_t d\Gamma^j} > 0$, $\frac{d^2\mathbf{E}p_t^j(A_t,B_t)}{dB_t d\Gamma^j} < 0$.

High-skilled labor is paid the expected marginal product, and given a perfectly competitive labor market in the North, wages are equalized between manufacturing and R&D sectors:

$$v_t(A_t, B_t) = \beta B_t [H_t(B_t)]^{\beta-1} \mathbf{E}[p_t^j(A_t, B_t)]$$

which is increasing in both A_t and B_t (see the Appendix). We summarize these results in the following proposition.

Proposition 2: (The Export Regime) *In the export regime,*

(i) *the North labor in the manufacturing sector $H_t(B_t)$ is increasing in the manufacturing technology B_t while the wage of North labor $v_t(A_t, B_t)$ is increasing in both A_t and B_t;*

(ii) *the relative price of the manufactured good $p_t^j(A_t, B_t)$ is increasing in A_t but decreasing in B_t;*

(iii) *the absolute elasticity of the manufactured price $p_t^j(A_t, B_t)$ with respect to technology A_t or B_t is smaller if South consumers' taste-specificity is higher (larger ψ and smaller Γ^j).*

Note that the manufacturing technology B_t is endogenous as it depends on North R&D. Thus, the properties derived above with respect to B_t should be viewed as the response of each endogenous variable to an exogenous shift in the maximal manufacturing technology growth rate, $\overline{B}$. For brevity, we do not repeat this argument that applies to the propositions that follow.

According to the above, the value function of North firms in the export regime is represented as:

$$\begin{aligned} \Omega^E(A_t, B_t) \quad = \quad & B_t[H_t(B_t)]^{\beta} \mathbf{E}[p_t^j(A_t, B_t)] - \beta B_t [H_t(B_t)]^{\beta-1} \mathbf{E}[p_t^j(A_t, B_t)] \\ & + \frac{1}{1+\rho} \Omega^E\{A_t(1+\gamma_A), B_t[1+\overline{B}[1-H_t(B_t)]^{\mu}\}. \end{aligned} \tag{20}$$

3.2 The Cost-Saving Outsourcing Regime

We next turn to the outsourcing possibility. For each variety j of the manufactured good, firms in the North determine whether to outsource the production to the South or to produce it domestically. Let ϕ_t^j denote the rent the firm will receive when outsourcing variety j, and we define the set of outsourced varieties as K, so the set of domestically produced varieties becomes $J \setminus K$. The optimization problem for North firms in the *cost-saving outsourcing regime* can be represented as

$$\begin{aligned} \Omega^O(A_t, B_t) \quad = \quad & \max_{K, \{N_t^j, H_t^j\}_{j \in J}} \mathbf{E} \int_{j \in K} \phi_t^j dj + \int_{j \in J \setminus K} [p_t^j B_t \cdot (H_t^j)^{\beta} - v_t H_t^j] dj - v_t \left(1 - \textstyle\int_{j \in J} H_t^j dj\right) \\ & + \frac{1}{1+\rho} \Omega^O(A_{t+1}, B_{t+1}) \quad \text{s.t.} \;\; (4), (14). \end{aligned} \tag{21}$$

When outsourcing, firms in the North authorize the manufacturing technology to be used in the South. Given the wage of unskilled labor w_t in the South, the rent earned by the North firm from outsourcing variety j is thus

$$\phi_t^j = p_t^j B_t \cdot (N_t^j)^\beta - w_t N_t^j$$

where N_t^j is the local labor demand in the South country where the variety j is outsourced to. With symmetry, we know $K = J$ as long as K is not an empty set, thus leading to a corner solution of $H_t^j = 0$ for all j (i.e. $R_t = 1$) and the optimization problem becomes:

$$\Omega^O(A_t, B_t) = \max_{\{N_t^j\}_{j\in J}} \mathbf{E} \int_{j\in J} p_t^j B_t \cdot (N_t^j)^\beta - w_t N_t^j dj - v_t + \frac{1}{1+\rho}\Omega^O(A_{t+1}, B_{t+1}) \quad \text{s.t.} \quad (4), (14).$$

If the production of variety j is outsourced at contract price p_t^j, perfect competition of the labor market in the South yields

$$w_t = \alpha A_t L_t^{\alpha-1} Z_t^{1-\alpha} = \beta p_t^j B_t N_t^{\beta-1}.$$

Without vacant land, $Z_t = 1$. Thus, with labor market clearing condition $N_t + L_t = 1$, the wage equalization condition implies

$$\frac{1 - N_t}{N_t^{\frac{1-\beta}{1-\alpha}}} = \left(\frac{\alpha A_t}{\beta p_t^j B_t}\right)^{\frac{1}{1-\alpha}}. \tag{22}$$

The left-hand side is decreasing in N_t whereas the right-hand side is exogenous to the South, thereby leading to a unique solution of local labor demand:

$$N_t^j = \tilde{N}_t(p_t^j; A_t, B_t)$$

which is increasing in p_t^j and B_t but decreasing in A_t. We can then obtain the rent paid to the North as:

$$\phi_t^j = (1-\beta) p_t^j B_t [\tilde{N}_t(p_t^j; A_t, B_t)]^\beta$$

which is also increasing in p_t^j and B_t but decreasing in A_t. In equilibrium, we can solve South consumers' willingness to pay of the manufactured good as:

$$p_t^j = \frac{\Gamma^j A_t L_t^\alpha Z_t^{1-\alpha}}{\theta + \Gamma^j B_t N_t^\beta} = \frac{\Gamma^j A_t [1 - \tilde{N}_t(p_t^j; A_t, B_t)]^\alpha}{\theta + \Gamma^j B_t [\tilde{N}_t(p_t^j; A_t, B_t)]^\beta} \quad \text{(with } Z_t = 1\text{)}$$

where the left-hand side is p_t^j while the right-hand side decreases in p_t^j, thus yielding a unique solution p_t^j, denoted as $p_t^j(A_t, B_t)$. Notice that $p_t^j(A_t, B_t)$ increases in A_t but decreases in B_t, and its response to A_t or B_t is smaller if South consumers are more taste specific (ψ larger, Γ^j smaller).[5]

The outsourcing contract is signed before knowing the market clearing price therefore, the North firms' demand for South labor N_t^j is determined based on expected price $\mathbf{E}[p_t^j(A_t, B_t)]$ and the wage

[5] Note that $\frac{d\text{RHS}}{dA_t} > 0$, $\frac{d\text{RHS}}{dB_t} < 0$; $\frac{d^2\text{RHS}}{dA_t d\Gamma^j} > 0$, $\frac{d^2\text{RHS}}{dB_t d\Gamma^j} < 0$.

which is the expected marginal product of labor. Therefore, the labor demand in the South will be the same regardless which variety is outsourced there. That is, $N_t^j = N_t$ for all j and is derived as

$$N_t = N_t(B_t) = \tilde{N}_t(\mathbf{E}[p_t^j(A_t, B_t)]; A_t, B_t)$$

and it is increasing in B_t.[6] The wage of the low-skilled labor in the South is thus

$$w_t = w_t(A_t, B_t) = \beta B_t[N_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t, B_t)],$$

which is increasing in both A_t and B_t (see the Appendix). Note that the wage in the South rises with technology advancement in the North. This represents a *trickle-down effect* similar to Matsuyama (1992). The expected rent paid to the North firms is given by

$$\mathbf{E}[\phi_t^j(A_t, B_t)] = (1-\beta)B_t[N_t(B_t)]^{\beta}\mathbf{E}[p_t^j(A_t, B_t)],$$

which is increasing in both A_t and B_t (see the Appendix). This represents a *trickle-up effect* in the sense that technological progress in the South would benefit entrepreneurs in the North. We summarize the above results in the following proposition.

Proposition 3: (The Cost-Saving Outsourcing Regime) *In the cost-saving outsourcing regime,*

(i) *South labor in the manufacturing sector $N_t(B_t)$ is increasing in the manufacturing technology B_t, while the South wage $w_t(A_t, B_t)$ is increasing in the agricultural technology A_t;*

(ii) *The relative price of the manufactured good $p_t^j(A_t, B_t)$ is increasing in A_t but decreasing in B_t, whereas the absolute value of the elasticity of the manufactured price $p_t^j(A_t, B_t)$ with respect to technology A_t or B_t is smaller if South consumers' taste-specificity is higher (larger ψ and smaller Γ^j);*

(iii) *North firms' expected outsourcing rent $E[\phi_t^j(A_t, B_t)]$ is increasing in both A_t and B_t;*

(iv) (Trickle-Down and Trickle-Up) *Better manufacturing technology in the North increases the South wage, while better agricultural technology in the South increases North firms' expected outsourcing rent.*

The value function in the cost-saving outsourcing regime is represented as

$$\Omega^O(A_t, B_t) = (1-\beta)B_t[N_t(B_t)]^{\beta}\mathbf{E}[p_t^j(A_t, B_t)] - v_t + \frac{1}{1+\rho}\Omega^O\{A_t(1+\gamma_A), B_t(1+\overline{B})\} \tag{23}$$

where the implicit wage of the high-skilled R&D labor in the North is derived as

$$v_t = \frac{1}{1+\rho}\frac{\partial \mathbf{E}[\phi_{t+1}^j(A_{t+1}, B_{t+1})]}{\partial B}\left.\frac{\partial B_{t+1}}{\partial R_t}\right|_{R_t=1}. \tag{24}$$

[6]It is noted that the labor demand will only depend on B_t as A_t cancels out after plugging $\mathbf{E}[p_t^j(A_t, B_t)]$ into (22).

3.3 The Preference-Based Outsourcing Regime

We assume that when North firms outsource they can choose to invest in market research to learn South consumers' most preferred varieties. This assumption is motivated by Eaton, Eslava, Jinkins, Krizan, and Tybout (2014) who show that, "[s]uccess in selling to a buyer reveals information to the seller about the appeal of her product in the market, ..." though their paper focuses on learning about forming business relationships with potential unrelated trade partners whereas we are examining closer and longer term outsourcing relationships. Eaton, Eslava, Jinkins, Krizan, and Tybout (2014) also find that "[m]ost buyer-seller matches are short-lived, lasting less than two years, on average." We therefore assume that the information about most preferred varieties only lasts one period. Our assumption can be justified by interpreting the firms as introducing new products each period so that the tastes for those products might vary from period to period.

Specifically, market research requires flow cost in η units of labor and fixed cost in χ units of goods to identify specific tastes of South consumers. That is, the R&D labor in the North becomes $(1-\eta)(1-H_t)$ and hence manufacturing technology evolves according to

$$B_{t+1} = \{1 + \overline{B}\,[(1-\eta)(1-H_t)]^{\mu}\}B_t = \{1 + \overline{B}(1-\eta)^{\mu}\}B_t$$

where the second equality follows because $H_t = 0$ under any type of outsourcing regime. Upon learning South customers' taste, $j = i$, Γ^j becomes 1, so the relative price of the manufactured good becomes

$$p_t^j = p_t = \frac{A_t(1-N_t)^{\alpha}}{\theta + B_t N_t^{\beta}},$$

where $N_t^j = N_t$ for all j (the ideal taste is matched.) The optimization problem in the preference-based outsourcing regime is thereby specified as

$$\Omega^P(A_t, B_t) = \max_{N_t} p_t B_t N_t^{\beta} - w_t N_t - v_t - \chi + \frac{1}{1+\rho}\Omega^P(A_{t+1}, B_{t+1}) \tag{25}$$
$$\text{s.t.} \quad (4) \text{ and } B_{t+1} = \{1 + \overline{B}\,[(1-\eta)]^{\mu}\}B_t$$

The presence of a fixed cost of market research (χ) together with the income effect for the manufactured good in the South suggests that doing market research to fit country-specific tastes is profitable only when its market size is large. This becomes more likely as incomes and the demand for the manufactured good in the South increases over time.

Labor allocation in the South becomes

$$\frac{1-N_t}{N_t^{\frac{1-\beta}{1-\alpha}}} = \left(\frac{\alpha A_t}{\beta p_t B_t}\right)^{\frac{1}{1-\alpha}} = \left(\frac{\alpha}{\beta}\,\frac{\theta + B_t N_t^{\beta}}{B_t(1-N_t)^{\alpha}}\right)^{\frac{1}{1-\alpha}}$$

which yields $N_t = N_t(B_t)$, which is increasing in B_t, and thus $p_t = p_t(A_t, B_t)$, which is increasing in A_t but decreasing in B_t. It is worth noting that, the difference between $p_t(A_t, B_t)$ in the preference-based outsourcing regime and $\mathbf{E}[p_t^j(A_t, B_t)]$ in the cost-saving outsourcing regime is higher when ψ is higher. The wage in the South is specified as

$$w_t = w_t(A_t, B_t) = \beta B_t [N_t(B_t)]^{\beta-1} p_t(A_t, B_t)$$

which is increasing in both A_t and B_t. The rent received by the North firms becomes

$$\phi_t(A_t, B_t) = (1-\beta) p_t(A_t, B_t) B_t [N_t(B_t)]^{\beta}$$

which is increasing in both A_t and B_t. The above properties are similar to that in the cost-saving outsourcing regime, and we summarize them as follows.

Proposition 4: (*Preference-Based Outsourcing Regime*) *In the preference-based outsourcing regime,*

(i) *the South labor in the manufacturing sector $N_t(B_t)$ is increasing in the manufacturing technology B_t, and the wage of South labor $w_t(A_t, B_t)$ is increasing in both technologies A_t and B_t;*

(ii) *the relative price of the manufactured good $p_t(A_t, B_t)$ is increasing in A_t but decreasing in B_t;*

(iii) *North firms' outsourcing rent $\phi_t(A_t, B_t)$ is increasing in both A_t and B_t.*

Thus, one can see again the presence of a trickle-down and a trickle-up effect via preference-based outsourcing.

The value function in the preference-based outsourcing regime is thereby specified as

$$\Omega^P(A_t, B_t) = (1-\beta) p_t(A_t, B_t) B_t [N_t(B_t)]^{\beta} - v_t - \chi + \frac{1}{1+\rho} \Omega^P \{A_t(1+\gamma_A), B_t[1+\overline{B}(1-\eta)^{\mu}]\} \quad (26)$$

where the implicit wage of the high-skilled R&D labor in the North is given by

$$v_t = \frac{1}{1+\rho} \frac{\partial \phi_{t+1}(A_{t+1}, B_{t+1})}{\partial B} \left. \frac{\partial B_{t+1}}{\partial R_t} \right|_{R_t=1} \quad (27)$$

4 Equilibrium Configuration

We now establish the conditions under which the export regime, the cost-saving outsourcing regime, or the preference-based outsourcing regime arises as an equilibrium. We focus on two key drivers, production technologies and taste specificity, via their effects on labor allocation, wages, relative price, and outsourcing rent. Note that under preference-based outsourcing, cost-saving may still play a role, though there are additional incentives for North firms to invest in market research.

Upon substituting out implicit wages of the R&D labor, the value incurred by the North firms under the three respective regimes ((20), (23), and (26)) can be written as:

$$
\begin{aligned}
\Omega^E(A_t, B_t) &= B_t[H_t(B_t)]^\beta \mathbf{E}[p_t^j(A_t, B_t)] - \beta B_t[H_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t, B_t)] \\
&\quad + \frac{1}{1+\rho}\Omega^E\{A_t(1+\gamma_A), B_t[1+\overline{B}[1-H_t(B_t)]^\mu\}; \\
\Omega^O(A_t, B_t) &= (1-\beta)B_t[N_t(B_t)]^\beta \mathbf{E}[p_t^j(A_t, B_t)] - \frac{\mu\overline{B}}{1+\rho}B_t\frac{\partial \mathbf{E}[\phi_t^j(A_{t+1}, B_{t+1})]}{\partial B} \\
&\quad + \frac{1}{1+\rho}\Omega^O\{A_t(1+\gamma_A), B_t(1+\overline{B})\}; \\
\Omega^P(A_t, B_t) &= (1-\beta)B_t[N_t(B_t)]^\beta p_t(A_t, B_t) - \frac{\mu\overline{B}(1-\eta)^{\mu-1}}{1+\rho}B_t\frac{\partial \phi_t(A_{t+1}, B_{t+1})}{\partial B} - \chi \\
&\quad + \frac{1}{1+\rho}\Omega^P\{A_t(1+\gamma_A), B_t[1+\overline{B}(1-\eta)^\mu]\}
\end{aligned}
$$

where it is noted that $p_t^j(A_t, B_t)$ and $N_t(B_t)$ are different in different regimes, but for brevity the same notation is used.

Due to high-dimensional nonlinearity, we are unable to solve for the explicit form of the value function under each regime. We now turn to numerical analysis to get insight into what determines when each regime is chosen.

4.1 Parameterization

For our baseline quantitative exercise, we set the manufacturing labor intensity and R&D labor intensity in the North as $\beta = 0.4$ and $\mu = 0.2$ respectively, while the agriculture labor intensity in the South as $\alpha = 0.6$. We normalize $\theta = 1$ so that South consumers obtain positive utility from manufactured goods only when its consumption is positive. We interpret the model period as one year and thus assign the market discount rate $\rho = 0.05$. Following Hansen and Prescott (2002), we set the agricultural technology growth rate γ_A as 0.09% and the maximal manufacturing technology growth rate $\overline{B}$ as 1.2%.[7] In the model the population is normalized to one both in the North and South. In the quantitative exercise we consult the World Bank employment data and set the population in the South as 1.19 times as that in the North.[8] Furthermore, we assume the degree of taste-specifics $\psi = 0.5$, yielding the taste-specific discount factor Γ^j ranging from 1/3 to 1 (i.e., two-thirds discounting to no discounting). Regarding the market research cost, we assume that $\eta = 0.18$ and $\chi = 0.18 \cdot \phi_0(A_0, B_0)$, indicating that learning South consumers' true preference involves labor cost and pecuniary cost, with the former around one-fifth of R&D workers and

[7] In Hansen and Prescott (2002), the model period is set as 35 years and the respective growth rates are set as 1.032 and 1.518.

[8] The population in the North is set as 2 to ensure interior solutions.

the later around one-fifth of the initial outsourcing rent. In this parameterized economy, the total market research cost relative to gross manufacturing income (computed by the sum of profits earned by entrepreneurs and wages earned by workers in the North) in the preference-based outsourcing regime is 11.3% on average.[9]

4.2 Quantitative Results

Under the parameterization provided above, we can now delineate the transition from the export regime, to the cost-saving outsourcing regime, and then to the preference-based outsourcing regime.

Specifically, we depict such transition in (A_t, B_t) space, as shown in Figure 1. We see that as manufacturing technology (B_t) rises, the value of marginal product of labor in producing outsourced manufactured good is higher whereas the rent received by North firms also increases. As a result, the dynamic world equilibrium is shifted from the export regime (E) to the cost-saving outsourcing regime (O). We now consider an ongoing agricultural technical progress (A_t), which enhances agriculture labor productivity to fulfill the necessity of agriculture consumption, thus enabling the South to shift resources toward producing the outsourced manufactured good (O). The improving agricultural technology would however raise the wage level in the South. As the two forces cancel out, the indifference boundary between E and O is flat.

We now turn to the transition between the two outsourcing regimes. On the one hand, there is a preference effect. As implied by Proposition 1, the price benefit of identifying the ideal taste is increasing in the amount of agriculture good consumption and decreasing in the manufactured good consumption. That is, as A_t rises or B_t falls, the difference of $p(A_t, B_t)$ in the preference-based outsourcing regime and $\mathbf{E}[p_t^j(A_t, B_t)]$ in the cost-saving outsourcing regime increases. This increases the incentive for North firms to invest in learning the ideal preference in the South. On the other hand, there is a diminishing cheap labor effect due to rising wage in the South as result of both agricultural and manufacturing technical progress. That is, as both A_t and B_t rise, it becomes more appealing to shift to preference-based outsourcing. Under our parameterization, the diminishing cheap labor effect of B_t dominates its preference effect, so the net effect of a higher manufacturing technology is to make the preference-based outsourcing regime more advantageous. Thus, the indifference boundary between the two outsourcing regimes (O and P) is downward sloping.

We next ask should both technologies grow over time at the respective rates given above (A_t grows at a constant rate of 0.09% and the maximal growth rate $\overline{B}$ is 1.2%), at what stage of economic development the dynamic world equilibrium configuration switches from one regime to another. We

[9] Gross manufacturing income = entrepreneur profit + R&D wage + marketing wage = outsourcing rent (ϕ) − sunk cost (c). The market survey cost share in period t is computed by $\frac{\eta v_t + c}{\phi_t - c}$.

consider the initial period of the model economy as year 1960 and run simulations for 60 periods to year 2020. The dynamic world equilibrium configuration switches from the export regime to the cost-saving outsourcing regime in 21 years (in early 1980s). After another 22 years (in early 2000s), the preference-based outsourcing regime arises in equilibrium. However, if the agricultural technology in the South ceases to grow in early 1980s (while the manufacturing technology continues to grow), it would take 13 years longer than the benchmark case for the emergence of the preference-based outsourcing regime in equilibrium. Thus, not only technical progress in the North but also that in the South plays a critical role in promoting preference-based outsourcing.

An interesting implication from our quantitative exercises is the presence of long delays of transition. There is some evidence to support such delays. Regarding the first transition, Piscitello and Santangelo (2011) point out that, despite rapid increase in international trade since 1960s, global sourcing of manufacturing activities only started in the 1980s. This suggests a delay over two decades. We also note that information technology (IT) has grown to become a key industry since 1970s and 1980s, but global sourcing faced a long delay. While India has been one of the largest destinations, even by 1999 software outsourcing to India only amounted to US$4 billion and it wasn't until 2009 that global IT outsourcing to India rose to US$56 billion (cf. Palugod and Palugod, 2011). That is, the transition from IT exporting to outsourcing took over 3 decades. We next turn to the second transition. Lewin and Peeters (2006) conducted a survey of 90 U.S. Forbes Global 2000 companies and found that 93% of respondents cited cost as the strategic driver of global sourcing whereas only about 1/3 cited business redesign and access to new markets that are related to preference-based outsourcing. One well known case study is Mattel outsourcing Barbie dolls to China. They began producing Barbie dolls in China in 2002, but it was not until 2013 that dolls were made for the Chinese market. Even then, production tailored for the Chinese market only became significant in 2017 after striking deals with Alibaba. This suggests a delay of about 15 years in transition from cost- to preference-based outsourcing.

One may wonder how the equilibrium configuration changes in response to shifts in other parameters. We are particularly interested in the degree of taste-specificity ψ and the maximal manufacturing technology growth rate $\overline{B}$. When the degree of taste-specificity increases by 10% from 0.5 to 0.55, the indifference boundary between the export and the cost-saving outsourcing regimes slightly shifts upward whereas the preference-based outsourcing regime becomes more attractive and it arises much faster, as seen in Figure 2. In this higher taste-specificity case, the dynamic world equilibrium stays only one year in the cost-saving outsourcing regime before switching into the preference-based outsourcing regime. While the transition from the export to the cost-saving outsourcing regime is only 1 year delayed compared to the benchmark case, the preference-based outsourcing regime arrives 20 years earlier.

When the maximal manufacturing technology growth rate increases by 10% from 1.2% to 1.32%, the efficacy of R&D investment rises, thereby encouraging labor allocation from production to R&D. This makes outsourcing more rewarding, so the indifference boundary between the export and the cost-saving outsourcing regimes shifts inward, as seen in Figure 3. However, for the same reason mentioned above, labor is also reallocated from market research to R&D, which causes the indifference boundary between the two outsourcing regimes to shift outward. though only marginally. Therefore, while the transition from the export to the cost-saving outsourcing regime arrives faster, the transition into the preference-based outsourcing regime may be slightly delayed. In this faster manufacturing technology growth case, the cost-saving outsourcing regime appears 3 years earlier than the benchmark case, while the arrival of the preference-based outsourcing is in the same year as the benchmark case.

5 Concluding Remarks

In this paper, we have established conditions under which the dynamic world equilibrium switches from exporting manufactured goods to cost-saving outsourcing, and eventually to preference-based outsourcing. We find that, as Southern and Northern technologies improve over time, the dynamic world equilibrium switches from the export regime to the cost-saving outsourcing regime, and eventually to the preference-based outsourcing regime. Interestingly, we find trickle down and trickle up effects of technology change. Better Northern technology increases the demand for Southern labor and leads to higher Southern wages. Better technology in the South increases the demand for the manufactured goods and increases expected rent from Northern outsourcing.

While this paper has provided a theoretical framework toward understanding two key drivers of outsourcing, production technologies and taste specificity, it may be of interest to empirically implement the model using microdata to understand the relative importance of the underlying forces. Moreover, in this paper, we contrast the two outsourcing regimes with the export regime, in which labor allocation is the main player so that we are abstracting from international capital flows. Should one extend the model to incorporate capital, one may then contrast outsourcing regimes with FDI or joint venture regimes. Both of the aforementioned are potentially rewarding but beyond the scope of the current paper. We leave them to future research.

Figure 1: Equilibrium Configuration

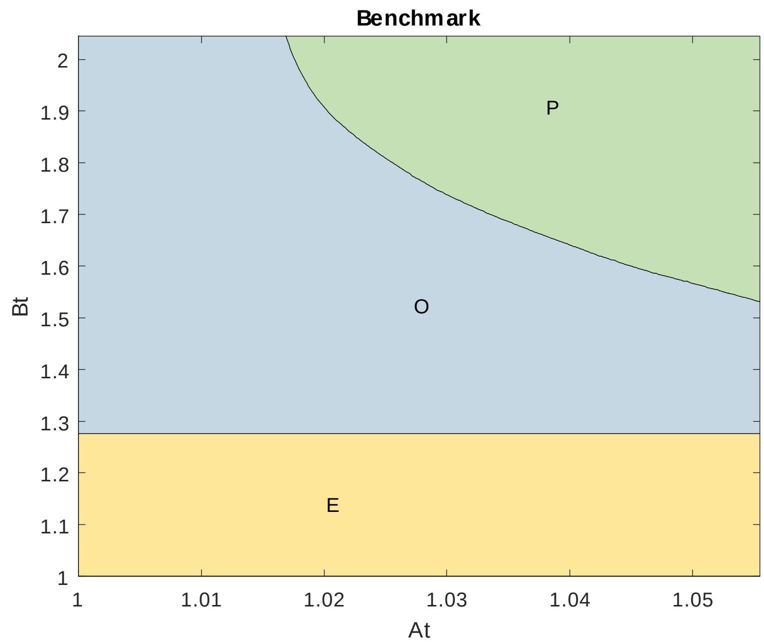


Figure 2: Equilibrium Configuration (ψ)

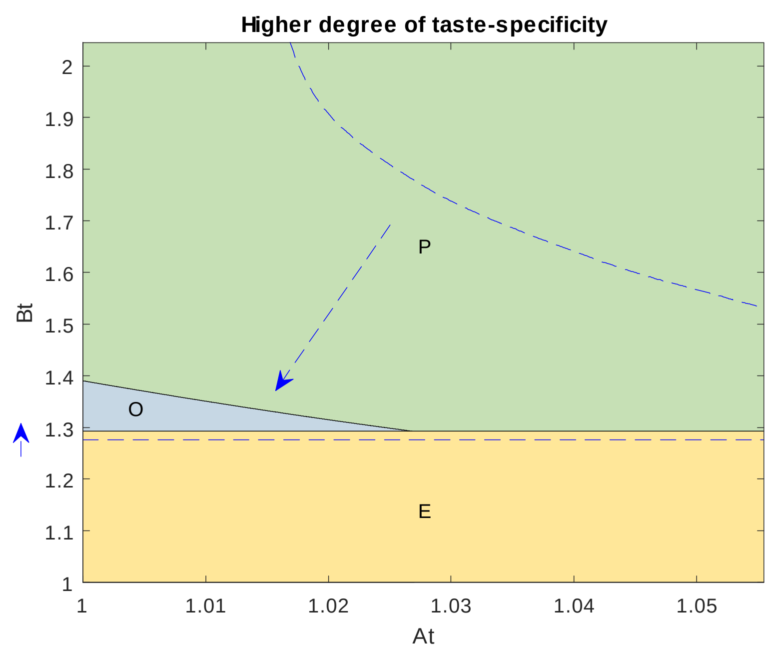
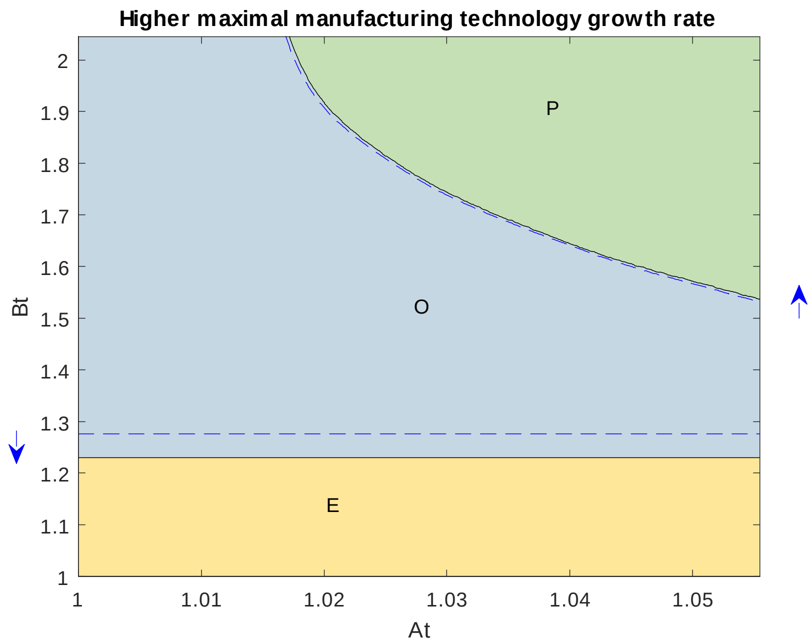


Figure 3: Equilibrium Configuration ($\overline{B}$)



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Appendix

In the Export Regime (E):

<u>*Optimization problem*</u>:

Since $H_t^j = H_t$ for all j, we can rewrite the Bellman equation and the first-order condition as follows:

$$\Omega^E(A_t, B_t) = \max_{H_t} \mathbf{E}[p_t^j] B_t H_t^\beta - v_t + \frac{1}{1+\rho}\Omega^E\{A_{t+1}, B_t[1+\overline{B}(1-H_t)^\mu]\},$$

$$\mathbf{E}[p_t^j] B_t \beta H_t^{\beta-1} = \frac{\mu\overline{B}}{1+\rho} B_t (1-H_t)^{\mu-1} \frac{\partial}{\partial B}\Omega^E(A_{t+1}, B_{t+1}).$$

The Benveniste-Scheinkman condition with respect to B_t is given by

$$\begin{aligned}\frac{\partial}{\partial B}\Omega^E(A_t, B_t) &= \mathbf{E}[p_t^j] H_t^\beta + \mathbf{E}[p_t^j] B_t \beta H_t^{\beta-1} \frac{\partial H_t}{\partial B_t} \\ &\quad + \frac{1}{1+\rho}\left\{[1+\overline{B}(1-H_t)^\mu] - B_t\overline{B}\mu(1-H_t)^{\mu-1}\frac{\partial H_t}{\partial B_t}\right\} \times \frac{\partial}{\partial B}\Omega^E(A_{t+1}, B_{t+1}).\end{aligned}$$

Note that the first-order condition implies

$$\frac{\partial}{\partial B}\Omega^E(A_{t+1}, B_{t+1}) = \frac{1+\rho}{\mu\overline{B}} \mathbf{E}[p_t^j] \beta H_t^{\beta-1}(1-H_t)^{1-\mu},$$

and plug it into the above Benveniste-Scheinkman condition, we derive the following:

$$\begin{aligned}\frac{\partial}{\partial B}\Omega^E(A_t, B_t) &= \mathbf{E}[p_t^j] H_t^\beta + \mathbf{E}[p_t^j] B_t \beta H_t^{\beta-1} \frac{\partial H_t}{\partial B_t} \\ &\quad + \frac{1}{1+\rho}\left\{[1+\overline{B}(1-H_t)^\mu] - B_t\overline{B}\mu(1-H_t)^{\mu-1}\frac{\partial H_t}{\partial B_t}\right\} \times \frac{1+\rho}{\mu\overline{B}} \mathbf{E}[p_t^j] \beta H_t^{\beta-1}(1-H_t)^{1-\mu} \\ &= \mathbf{E}[p_t^j] H_t^\beta + \frac{1}{\mu\overline{B}} \mathbf{E}[p_t^j] \beta H_t^{\beta-1}(1-H_t)^{1-\mu}[1+\overline{B}(1-H_t)^\mu].\end{aligned}$$

Updating the above condition to $t+1$, we can rewrite the first-order condition as:

$$\mathbf{E}[p_t^j] B_t \beta H_t^{\beta-1} = \frac{\mu\overline{B}}{1+\rho} B_t (1-H_t)^{\mu-1}\left\{\mathbf{E}[p_{t+1}^j] H_{t+1}^\beta + \frac{1}{\mu\overline{B}}\mathbf{E}[p_{t+1}^j]\beta H_{t+1}^{\beta-1}(1-H_{t+1})^{1-\mu}[1+\overline{B}(1-H_{t+1})^\mu]\right\}.$$

By manipulation, we obtain

$$(1+\rho)\frac{\mathbf{E}[p_t^j]}{\mathbf{E}[p_{t+1}^j]}\frac{(1-H_t)^{1-\mu}}{H_t^{1-\beta}} = \frac{\mu\overline{B}}{\beta} H_{t+1}^\beta + [1+\overline{B}(1-H_{t+1})^\mu]\frac{(1-H_{t+1})^{1-\mu}}{H_{t+1}^{1-\beta}}.$$

<u>*Manufacturing labor in the North*</u>:

The right-hand side of equation (19) is increasing in H_t:

$$\begin{aligned}
&\frac{\partial}{H_t}\left[\frac{\mu\overline{B}}{\beta}\frac{H_t}{(1-H_t)^{1-\mu}}+\overline{B}(1-H_t)^{\mu}\right]\\
=\ &\frac{\mu\overline{B}}{\beta}\frac{(1-H_t)^{1-\mu}+(1-\mu)H_t(1-H_t)^{-\mu}}{(1-H_t)^{2(1-\mu)}}-\mu\overline{B}(1-H_t)^{\mu-1}\\
\propto\ &\left[\frac{(1-H_t)^{1-\mu}+(1-\mu)H_t(1-H_t)^{-\mu}}{(1-H_t)^{1-\mu}}\right]-\beta=(1-\beta)+(1-\mu)\frac{H_t}{1-H_t}>0
\end{aligned}$$

The left-hand side of equation (19) is hump shaped in H_t:

$$\begin{aligned}
&\frac{\partial}{\partial H_t}\frac{\rho(H_t;B_t)}{\rho(H_t;\left[1+\overline{B}(1-H_t)^{\mu}\right]B_t)}\\
\propto\ &\frac{\partial\rho(H_t;B_t)}{\partial H_t}\rho(H_t;[1+\overline{B}\,(1-H_t)^{\mu}]B_t)-\frac{\partial\rho(H_t;[1+\overline{B}\,(1-H_t)^{\mu}]B_t)}{\partial H_t}\rho(H_t;B_t)\\
=\ &-\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+\left[1+\overline{B}\,(1-H_t)^{\mu}\right]B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{\beta B_t\frac{1}{H_t^{1-\beta}}}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})^2}d\tilde{j}\\
&+\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{B_t\left(\beta\frac{1}{H_t^{1-\beta}}+\beta\overline{B}\frac{(1-H_t)^{\mu}}{H_t^{1-\beta}}-\mu\overline{B}\frac{H_t^{\beta}}{(1-H_t)^{1-\mu}}\right)}{(\theta+\theta\psi\tilde{j}^2+\left[1+\overline{B}\,(1-H_t)^{\mu}\right]B_tH_t^{\beta})^2}d\tilde{j}
\end{aligned}$$

which approaches ∞ when $H_t\to 0$ and $-\infty$ when $H_t\to 1$. Therefore, the left-hand side of (19) is hump shaped in H_t, thus implying within reasonable ranges of H_t the slope of the right-hand side of (19) is greater than the left-hand side. Finally, when $H_t=0$, the left-hand side equals $\frac{\rho-\gamma_A}{(1+\gamma_A)}$ while the right-hand side equals $\overline{B}$. Since $\frac{\rho-\gamma_A}{(1+\gamma_A)}-\overline{B}=\frac{\rho-\overline{B}-\gamma_A-\overline{B}\gamma_A}{(1+\gamma_A)}>0$ under the parameter values taken from the literature, we can conclude that equation (19) yields a unique interior solution of H_t which is a function of B_t, denoted as $H_t(B_t)$. Moreover, the left-hand side is increasing in B_t:

$$\begin{aligned}
&\frac{\partial}{\partial B_t}\frac{\rho(H_t;B_t)}{\rho(H_t;[1+\overline{B}\,(1-H_t)^{\mu}]B_t)}\\
\propto\ &\frac{\partial\rho(H_t;B_t)}{\partial B_t}\rho(H_t;[1+\overline{B}\,(1-H_t)^{\mu}]B_t)-\frac{\rho(H_t;[1+\overline{B}\,(1-H_t)^{\mu}]B_t)}{\partial B_t}\rho(H_t;B_t)\\
=\ &-\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+[1+\overline{B}\,(1-H_t)^{\mu}]B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{H_t^{\beta}}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})^2}d\tilde{j}\\
&+\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{[1+\overline{B}\,(1-H_t)^{\mu}]H_t^{\beta}}{(\theta+\theta\psi\tilde{j}^2+\left[1+\overline{B}\,(1-H_t)^{\mu}\right]B_tH_t^{\beta})^2}d\tilde{j}\\
\propto\ &-\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+\left[1+\overline{B}\,(1-H_t)^{\mu}\right]B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})^2}d\tilde{j}\\
&+[1+\overline{B}\,(1-H_t)^{\mu}]\cdot\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+B_tH_t^{\beta})}d\tilde{j}\cdot\int_0^1\frac{1}{(\theta+\theta\psi\tilde{j}^2+\left[1+\overline{B}\,(1-H_t)^{\mu}\right]B_tH_t^{\beta})^2}d\tilde{j}\\
>\ &0
\end{aligned}$$

Therefore, the solution $H_t(B_t)$ is increasing in B_t.

Wage of high-skilled labor in the North:

$$\frac{\partial v_t(A_t,B_t)}{\partial A_t}=\beta B_t[H_t(B_t)]^{\beta-1}\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial A_t}>0$$

$$\begin{aligned}\frac{\partial v_t(A_t,B_t)}{\partial B_t} &= \beta[H_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t,B_t)]+\beta(\beta-1)B_t[H_t(B_t)]^{\beta-2}\frac{\partial H_t(B_t)}{\partial B_t}\mathbf{E}[p_t^j(A_t,B_t)] \\ &\quad +\beta B_t[H_t(B_t)]^{\beta-1}\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t} \\ &= \beta[H_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t,B_t)]\left\{1-(1-\beta)\frac{\partial H_t(B_t)}{\partial B_t}\frac{B_t}{H_t(B_t)}+\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t}\frac{B_t}{\mathbf{E}[p_t^j(A_t,B_t)]}\right\}\end{aligned}$$

which is positive under reasonable parameters as the absolute values of the labor demand elasticity to technology and the price elasticity to technology are expected to be sufficiently less than 1.

In the Cost-Saving Outsourcing Regime (O):

Wage of low-skilled labor:

$$\begin{aligned}\frac{\partial w_t(A_t,B_t)}{\partial B_t} &\propto [N_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t,B_t)]+B_t[N_t(B_t)]^{\beta-1}\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t} \\ &\quad +(\beta-1)B_t[N_t(B_t)]^{\beta-2}\mathbf{E}[p_t^j(A_t,B_t)]\frac{\partial N_t(B_t)}{\partial B_t} \\ &= [N_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t,B_t)]\left\{1-(1-\beta)\frac{\partial N_t(B_t)}{\partial B_t}\frac{B_t}{N_t(B_t)}+\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t}\frac{B_t}{\mathbf{E}[p_t^j(A_t,B_t)]}\right\}\end{aligned}$$

which is positive under reasonable parameters as the absolute values of the labor demand elasticity to technology and the price elasticity to technology are expected to be sufficiently less than 1.

Expected outsourcing rent:

$$\begin{aligned}\frac{\partial \mathbf{E}[\phi_t^j(A_t,B_t)]}{\partial B_t} &\propto [N_t(B_t)]^{\beta}\mathbf{E}[p_t^j(A_t,B_t)]+B_t[N_t(B_t)]^{\beta}\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t} \\ &\quad +\beta B_t[N_t(B_t)]^{\beta-1}\mathbf{E}[p_t^j(A_t,B_t)]\frac{\partial N_t(B_t)}{\partial B_t} \\ &= [N_t(B_t)]^{\beta}\mathbf{E}[p_t^j(A_t,B_t)]\left\{1+\beta\frac{\partial N_t(B_t)}{\partial B_t}\frac{B_t}{N_t(B_t)}+\frac{\partial \mathbf{E}[p_t^j(A_t,B_t)]}{\partial B_t}\frac{B_t}{\mathbf{E}[p_t^j(A_t,B_t)]}\right\}\end{aligned}$$

which is positive under reasonable parameters.