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DOMESTIC AND GLOBAL SOURCING

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ABSTRACT:

This paper develops a general equilibrium Ricardian model with transaction costs to investigate the determinants of the firm's sourcing decision. It derives conditions under which different sourcing choices and corresponding trade patterns occur in general equilibrium. These conditions suggest that, *inter alia*, the choice between vertical integration and specialisation depends on the relative internal transaction costs associated with vertical integration and external transaction costs associated with international outsourcing; and that the equilibrium sourcing structures and trade patterns are consistent with a refined theory of comparative advantage that incorporates the effects of transaction costs in international trade.

Key words: endogenous sourcing decisions, transaction costs, Ricardian model

JEL classification: L2, F19

DOMESTIC AND GLOBAL SOURCING

1. INTRODUCTION

In relation to sourcing an intermediate good, a final good producing firm makes two choices. First, it chooses an ownership structure, i.e., whether or not to vertically integrate into the production of the intermediate good. Second, it chooses the production location of the intermediate good, i.e., whether the intermediate good should be produced in the firm's home country or a foreign country or both. The combination of the two choices can result in 6 different decision outcomes:

(i) Domestic integration: the firm vertically integrates and produces the intermediate good in its home country.

(ii) Foreign direct investment (FDI): the firm vertically integrates, and makes the intermediate good in a foreign country through FDI.

(iii) Domestic integration and FDI combined: the firm vertically integrates and produces the intermediate good both in the home country and in the foreign country through FDI. This decision may in part be due to the fact that the foreign country is too small to meet all of the firm's demand for the intermediate good.

(iv) Domestic outsourcing: the firm does not vertically integrate, and buys the intermediate good from a specialised producer in the home country.

(v) Global outsourcing: the firm does not vertically integrate, and buys the intermediate good from a specialised producer in a foreign country.

(vi) Domestic and global outsourcing combined: the firm does not vertically integrate, and buys the intermediate good from both home country and foreign country. This decision may in part be due to the fact that the foreign country is too small to meet all of the firm's demand for the intermediate good.

There is substantial evidence that both domestic and global outsourcing (which involve the last three decision outcomes above) have become increasingly widespread in recent decades. For instance, Abraham and Taylor (1996) documented rising subcontracting in 13 US industries. Feenstra (1998) showed that by a variety of measures, global outsourcing has increased significantly since the 1970s in many OECD countries. Hummels, Ishii, and Yi (2001), reported that international trade has grown faster in components than in final goods. They also found that outsourcing accounted for 22% of US exports in 1997, and for 30% of the growth in the US export share of merchandise GDP between 1962 and 1997. In addition, citing data from the Bureau of Economic Analysis, Antràs and Helpman (2004) suggested that the growth of foreign outsourcing by US firms might have outpaced the growth of their foreign intra-firm sourcing.

What's driving the growth in out-sourcing? How does a firm make its sourcing decisions? What trade-offs are involved? How would firms' sourcing decisions interact with consumer choices and how would the interactions affect consumption, production and trade patterns in equilibrium? These questions have attracted some attention in the literature. For instance, following the seminal paper by Coase (1937), a large literature has emerged that studies a firm's make-or-buy decision, examples of this literature include Williamson (1975, 1985), Grossman and Hart (1986), Yang and Ng (1995), and Grossman and Helpman (2002). These studies focus on how asset specificity, transaction costs, and incomplete contracts may affect a firm's decision of whether to produce an input in-house or to purchase it from the market, but do not consider the production location of the input, therefore do not shed light on the impact of sourcing decisions on international trade. Another stream of literature, in contrast, takes a firm's decision to outsource as given and examines the firm's decision of where to outsource. For instance, Gross and Helpman (2005) studied the determinants of the location of outsourcing activities in a general equilibrium trade model. Still another stream of literature takes as given a firm's decision to outsource overseas, and examines how this may impact on trade patterns and factor prices. Some examples of this literature are Deardorff (2001) and Kohler (2001).

While the literature cited above provides insights into various aspects of outsourcing, it does not simultaneously endogenise a firm's decision to outsource and the location of sourcing. As a result, it does not capture the impact of firms' sourcing decisions and equilibrium patterns of production organization and trade flows. Recognising this gap, Antràs and Helpman (2004) proposed a framework in which firms make endogenous organisational decisions. Specifically, they developed a North-South model of international trade, in which firms decide whether to integrate into the production of intermediate inputs or outsource them, and from which country to source the inputs. Their model shows that in equilibrium firms with different productivity levels choose different ownership structure and locations of input production.

Similar to Antràs and Helpman (2004), we develop a model that endogenises both a final-good producer's decision whether to outsource and where to source its input. However our model differs from Antràs and Helpman (2004) in three significant ways.

Firstly, we adopt the familiar Ricardian model of comparative advantage whereas Antràs and Helpman develop a North-South model of trade with differentiated final product varieties.

Secondly, Antràs and Helpman assume that only the North knows how to produce the final good, therefore in their model, the existence of international trade is exogenously given -otherwise consumers in the South cannot consume the final good. Moreover, the pattern of trade flow is also

exogenously given - the North exports final products in exchange of intermediate goods, or produces intermediate goods in the South, pays wages to the South which are used to buy final products from the North. In contrast, our model endogenises both the existence and the pattern of trade or investment. Depending on values of parameters (such as transaction costs in international trade, degree of comparative advantage, and production technology), autarky or international trade may occur in equilibrium. Similarly different parameter values would lead to different patterns of trade between the two countries. Either country may produce the final product, and/or the intermediate good in equilibrium.

Thirdly, we emphasise different trade-offs in a firm's sourcing decision. In choosing between domestic and foreign production of input, our model assumes that a final-good producer trades off the benefit of low transport costs against the benefit from technical comparative advantage. In choosing between vertical integration and outsourcing, the final-good producer is assumed to trade off the benefit of lower transaction cost involved in hiring labour and internal control against economies from specialisation. In comparison, Antràs and Helpman's model focuses on the trade-off between benefits of lower variable costs in the South against the benefit of lower fixed costs in the North, and between the benefits of ownership advantage against better incentive for independent supplier.

We present our model in Section 2 and describe the equilibrium in Section 3. In Section 4, we discuss the conditions under which different patterns of production organization, and trade patterns occur in general equilibrium. We summarise the paper and discuss possible extension of the model in Section 5.

2. THE MODEL

Consider a world economy with two countries, country one (the home country) and country two (the foreign country). Country i has a labor force of M_i, (i = 1, 2). Migration between the two countries is assumed to be prohibitively expensive. There is a final consumption good Y which can be produced in either country and is produced using labor and an intermediate good X. The intermediate good X can be produced in either country and is produced using only labor.

2.1. Consumer decision

Consumers in both countries have the same preferences. A representative consumer is endowed with one unit of labor. The consumer receives a wage from employment and uses the wage to buy the consumption good Y. Good Y can be bought from either the domestic market or the foreign market. It is assumed that there is no transaction costs if the consumer buys domestically, but if

he/she chooses to buy imports, a transaction cost will be incurred. The decision problem for a representative consumer in country *i* is

$$\text{Max: } u_i = y_i + k_i y_{ji}$$
$$\text{s.t. } p_{iy} y_i + p_{jy} y_{ji} = w_i$$

where y_i is the quantities of the consumption good Y purchased from the domestic market; y_{ji} is the quantities of the good imported (from country *j* to country *i*); k_i is the transaction efficiency coefficient in country *i* for importing good Y, $k_i \in [0, 1]$; p_{iy} is the price of good Y bought domestically; p_{jy} is the price of good Y imported; w_i is the wage level in country *i*. The wage level in country 1 is assumed to be the numeraire, so that $w_1 = 1$ and $w_2 = w$.

The specification of transaction cost efficiency coefficient assumes iceberg transaction costs, that is, for each unit of good Y imported by country *i*, a fraction $1-k_i \in [0, 1]$ is assumed to have "melted" in transaction, only k_i is received by the consumer. Transaction costs are broadly specified to capture a variety of costs including transport costs, tariff regime and other institutional conditions affecting the cost of importing.

If the price of imported final good Y is lower after transaction costs are taken into account, the consumer will buy imports; otherwise he/she will buy domestically. The consumer's decision, the price relationships and trade structures consistent with the decisions are summarised in Table 1.

Table 1: Consumer decision

Decision criteria	**Conditions satisfying decision criteria**	**Structure of trade in final goods**
$p_{2y}/p_{1y} > k_1, p_{1y}/p_{2y} < k_2$	$p_{1y}/p_{2y} < k_2$	$y_1 > 0, y_{21} = 0, y_2 = 0, y_{12} > 0$
$p_{2y}/p_{1y} > k_1, p_{1y}/p_{2y} > k_2$	$k_2 < p_{1y}/p_{2y} < 1/k_1$	$y_1 > 0, y_{21} = 0, y_2 > 0, y_{12} = 0$
$p_{2y}/p_{1y} < k_1, p_{1y}/p_{2y} > k_2$	$p_{1y}/p_{2y} > 1/k_1$	$y_1 = 0, y_{21} > 0, y_2 > 0, y_{12} = 0$

To illustrate, the first row (below the headings) in Table 1 shows that if the price of imports including transaction costs is higher than domestic price in country 1 (i.e., $p_{2y}/p_{1y} > k_1$), and if the price of imports including transaction costs is lower than domestic price in country 2 (i.e., $p_{1y}/p_{2y} < k_2$), then the relative price would satisfy the condition that $p_{1y}/p_{2y} < k_2$. Under this condition, consumers in country 1 will buy domestically ($y_1 > 0$, $y_{21} = 0$), and consumers in country 2 will buy imports ($y_2 = 0$, $y_{12} > 0$).

Similarly the second row shows the situation where consumers in both countries choose to buy domestically, and the third row shows the situation where consumers in country 1 buy imports and those in country 2 buy domestically.

2.2. Firm decision

2.2.1 Production of the final good

A final-good producing firm makes two decisions: whether to vertically integrate into the production of intermediate good X, and where to source good X.

If the firm chooses to vertically integrate, it can produce the intermediate good X either in its home country or overseas, or both. If it chooses to produce overseas, an internal transaction cost will be incurred. The internal transaction cost includes the transport cost and other cost associated with intra-firm importation of intermediate goods. The production function of good Y for the representative vertically integrated firm in country *i* is:

$$y_i = a_{iy}(x_{iv}+t_{iv}x_{jiv})^{\beta} L_{iy}^{1-\beta}$$

where a_{iy} is the productivity coefficient in country *i* which captures the productivity difference in producing good Y between the two countries; x_{iv} is the quantity of intermediate good X produced domestically and x_{jiv} is that produced overseas by the vertically integrated firm in country *i*; t_{iv} (t_{iv} <1) is the internal transaction efficiency coefficient associated with foreign production by a vertically integrated firm in country *i*; and L_{iy} is the amount of labor used in the production of good Y in country *i*.

Similar to the transaction costs associated with importing final goods, the internal transaction costs are also assumed to take the iceberg form. That is, for each unit of good X produced overseas by the integrated firm in country *i*, only t_{iv} can be used in the final good production, the rest is lost in cross-boarder intra-firm transaction.

If the firm chooses not to vertically integrate, it will become a specialised final-good producing firm and buy the intermediate good X domestically or import, or both. If it chooses to import, an external transaction cost will be incurred. The external transaction cost includes, for instance, the cost of searching for a supplier, transport costs and other costs associated with importation of intermediate goods. The production function of Y for a specialised final-good producing firm in country *i* is:

$$y_i = a_{iy}(x_i +t_i x_{ji})^{\beta} L_{iy}^{1-\beta}$$

where x_i is the amount of the intermediate good X purchased domestically and x_{ji} is that imported by the specialised final-good producing firm in country *i*; and t_i is the external transaction efficiency coefficient for importing good X to country *i*.

2.2.2 Production of the intermediate good

The intermediate good X can be produced domestically or overseas by a vertically integrated firm, or it can be produced by a specialised X-producing firm. If X is produced domestically by a vertically integrated firm in country *i,* the production function is

$$x_{iv} = a_{ix}L_{ix}$$

where a_{ix} is the labor productivity coefficient for a vertically integrated firm in country *i* producing domestically; and L_{ix} is the amount of labor in country *i* used in the production of X.

If X is produced by a specialised X-producing firm in country *i*, the production function is

$$x_i = b_{ix}L_{ix}$$

where b_{ix} is the labor productivity coefficient for a specialised X-producing firm in country *i*.

If X is produced overseas by the vertically integrated firm, the production function is

$$x_{jiv} = b_{jx}L_{jx}$$

where b_{jx} is the labor productivity coefficient for a specialised firm in country *j*. This specification assumes that if a vertically integrated firm sets up an input plant overseas, the plant will have the same productivity as a local specialised X-producing firm.

Due to economies of specialisation, labor productivity in X production by a specialised firm is assumed to be higher than that in a vertically integrated firm, i.e., $a_{ix}<b_{ix}$.

In deciding whether to vertically integrate and where to source the intermediate good X, a Y-producing firm compares the unit costs of producing Y associated with different structural forms of production. If a Y-producing firm in country *i* vertically integrates and produces X domestically, the unit cost function for good Y can be obtained by solving the cost minimisation problem:

$$\min w_i(L_{ix} + L_{iy})$$

$$s.t.\ a_{iy}x_{iv}^{\beta}L_{iy}^{1-\beta} = 1,\ x_{iv} = a_{ix}L_{ix}$$

The resultant unit cost function is $c_i(w_i) = w_i a_{iy}^{-1} a_{ix}^{-\beta} \beta^{-\beta}(1-\beta)^{\beta-1}$.

Similarly we can obtain the unit cost functions for other structural forms of production. These are summarised in Table 2.

Table 2: Unit cost functions for different structures of production

Structures of production	Unit cost functions
$(Y_i X_i)_v$	$c_i(w_i) = w_i a_{iy}^{-1} a_{ix}^{-\beta} \beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_i)_v (X_j)_v$	$c_i(w_i, w_j) = w_i^{1-\beta} w_j^{\beta} a_{iy}^{-1} t_{iv}^{-\beta} b_{jx}^{-\beta} \beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_i X_i)_s$	$c_i(p_{ix}, w_i) = w_i^{1-\beta} p_{ix}^{\beta} a_{iy}^{-1} \beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_i)_s (X_j)_s$	$c_i(p_{jx}, w_i) = w_i^{1-\beta} p_{jx}^{\beta} a_{iy}^{-1} t_i^{-\beta} \beta^{-\beta}(1-\beta)^{\beta-1}$

In Table 2, $(Y_i X_i)_v$ and $(Y_i)_v (X_j)_v$ denote a vertically integrated firm in country *i* producing X domestically and overseas, respectively; $(Y_i X_i)_s$ and $(Y_i)_s (X_j)_s$ denote a specialized Y-producing firm in country *i* buying good X domestically and overseas, respectively.

A Y-producing firm will choose a structure of production that has the lowest unit cost. The Y-producing firms' decision on production structures are summarised in Table 3.

Compared to Table 2, Table 3 includes two additional production structures: structure $(Y_i X_i)_v (X_j)_v$ denotes a vertically integrated firm produces X both domestically and overseas, and structure $(Y_i X_i)_s (X_j)_s$ denotes a specialised firm buys X both domestically and overseas. The first structure is chosen when the costs of producing domestically and overseas are the same, and the second structure chosen when the costs of buying domestically and overseas are the same.

Table 3: Firm's decision on structures of production

Optimal production structure	Decision criteria	Conditions satisfying decision criteria
$(Y_i X_i)_v$	$c_i(w_i) < c_i(w_i, w_j)$, $c_i(w_i) < c_i(p_{ix}, w_i)$, $c_i(w_i) < c_i(p_{jx}, w_i)$	$\frac{w_i}{w_j} < \frac{a_{ix}}{t_{iv} b_{jx}}$, $\frac{p_{jx}}{w_i} > \frac{t_i}{a_{ix}}$, $\frac{p_{ix}}{w_i} > \frac{1}{a_{ix}}$
$(Y_i)_v (X_j)_v$	$c_i(w_i, w_j) < c_i(w_i)$, $c_i(w_i, w_j) < c_i(p_{ix}, w_i)$, $c_i(w_i, w_j) < c_i(p_{jx}, w_i)$	$\frac{w_i}{w_j} > \frac{a_{ix}}{t_{iv} b_{jx}}$, $\frac{p_{jx}}{w_j} > \frac{t_i}{t_{iv} b_{jx}}$, $\frac{p_{ix}}{w_j} > \frac{1}{t_{iv} b_{jx}}$
$(Y_i X_i)_v (X_j)_v$	$c_i(w_i, w_j) = c_i(w_i)$, $c_i(w_i, w_j) < c_i(p_{ix}, w_i)$, $c_i(w_i, w_j) < c_i(p_{jx}, w_i)$	$\frac{w_i}{w_j} = \frac{a_{ix}}{t_{iv} b_{jx}}$, $\frac{p_{jx}}{w_j} > \frac{t_i}{t_{iv} b_{jx}}$, $\frac{p_{ix}}{w_j} > \frac{1}{t_{iv} b_{jx}}$
$(Y_i X_i)_s$	$c_i(p_{ix}, w_i) < c_i(w_i)$, $c_i(p_{ix}, w_i) < c_i(w_i, w_j)$, $c_i(p_{ix}, w_i) < c_i(p_{jx}, w_i)$	$\frac{p_{ix}}{p_{jx}} < \frac{1}{t_i}$, $\frac{p_{ix}}{w_j} < \frac{1}{t_{iv} b_{jx}}$, $\frac{p_{ix}}{w_i} < \frac{1}{a_{ix}}$
$(Y_i)_s (X_j)_s$	$c_i(p_{jx}, w_i) < c_i(w_i)$, $c_i(p_{jx}, w_i) < c_i(w_i, w_j)$, $c_i(p_{jx}, w_i) < c_i(p_{ix}, w_i)$	$\frac{p_{jx}}{w_j} < \frac{t_i}{t_{iv} b_{jx}}$, $\frac{p_{jx}}{w_i} < \frac{t_i}{a_{ix}}$, $\frac{p_{jx}}{p_{ix}} < t_i$
$(Y_i X_i)_s (X_j)_s$	$c_i(p_{jx}, w_i) < c_i(w_i)$, $c_i(p_{jx}, w_i) < c_i(w_i, w_j)$, $c_i(p_{jx}, w_i) = c_i(p_{ix}, w_i)$	$\frac{p_{jx}}{w_j} < \frac{t_i}{t_{iv} b_{jx}}$, $\frac{p_{jx}}{w_i} < \frac{t_i}{a_{ix}}$, $\frac{p_{jx}}{p_{ix}} = t_i$

2.3. Possible trade structures

Combining consumer decisions and firm decisions in both countries (see Table 1 and Table 3 above), we can identify a set of trade structures that can occur in equilibrium and corresponding conditions that satisfy the optimisation of both consumer and firm decisions. These are summarised in Table 4.

Table 4: Trade structures and corresponding conditions

Conditions for optimal consumption pattern	Conditions for optimal production structure	Trade structure
$\frac{p_{1y}}{p_{2y}} < k_2$	$\frac{w_1}{w_2} > \frac{a_{1x}}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_2} > \frac{t_1}{t_{1v}b_{2x}}, \frac{p_{1x}}{w_2} > \frac{1}{t_{1v}b_{2x}}$	$(Y_1)_v(X_2)_v$
	$\frac{w_1}{w_2} = \frac{a_{1x}}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_2} > \frac{t_1}{t_{1v}b_{2x}}, \frac{p_{1x}}{w_2} > \frac{1}{t_{1v}b_{2x}}$	$(Y_1X_1)_v(X_2)_v$
	$\frac{p_{2x}}{w_2} < \frac{t_1}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_1} < \frac{t_1}{a_{1x}}, \frac{p_{2x}}{p_{1x}} < t_1$	$(Y_1)_s(X_2)_s$
	$\frac{p_{2x}}{w_2} < \frac{t_1}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_1} < \frac{t_1}{a_{1x}}, \frac{p_{2x}}{p_{1x}} = t_1$	$(Y_1X_1)_s(X_1)_s$
	$\frac{w_1}{w_2} < \frac{a_{1x}}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_1} > \frac{t_1}{a_{1x}}, \frac{p_{1x}}{w_1} > \frac{1}{a_{1x}}$ $\frac{w_2}{w_1} < \frac{a_{2x}}{t_{2v}b_{1x}}, \frac{p_{2x}}{w_2} > \frac{1}{a_{2x}}, \frac{p_{1x}}{w_2} > \frac{t_2}{a_{2x}}$	$(Y_1X_1)_v(Y_2X_2)_v$
$k_2 < \frac{p_{1y}}{p_{2y}} < \frac{1}{k_1}$	$\frac{w_1}{w_2} < \frac{a_{1x}}{t_{1v}b_{2x}}, \frac{p_{2x}}{w_1} > \frac{t_1}{a_{1x}}, \frac{p_{1x}}{w_1} > \frac{1}{a_{1x}}$ $\frac{p_{1x}}{p_{2x}} > t_2, \frac{p_{2x}}{w_2} < \frac{1}{a_{2x}}, \frac{p_{2x}}{w_1} < \frac{1}{t_{2v}b_{1x}}$	$(Y_1X_1)_v(Y_2X_2)_s$
	$\frac{p_{1x}}{p_{2x}} < t_1, \frac{p_{1x}}{w_2} < \frac{1}{t_{1v}b_{2x}}, \frac{p_{1x}}{w_1} < \frac{1}{a_{1x}}$ $\frac{w_2}{w_1} < \frac{a_{2x}}{t_{2v}b_{1x}}, \frac{p_{2x}}{w_2} > \frac{1}{a_{2x}}, \frac{p_{1x}}{w_2} > \frac{t_2}{a_{2x}}$	$(Y_1X_1)_s(Y_2X_2)_v$
	$\frac{p_{1x}}{p_{2x}} < \frac{1}{t_1}, \frac{p_{1x}}{w_2} < \frac{1}{t_{1v}b_{2x}}, \frac{p_{1x}}{w_1} < \frac{1}{a_{1x}}$ $\frac{p_{1x}}{p_{2x}} > t_2, \frac{p_{2x}}{w_2} < \frac{1}{a_{2x}}, \frac{p_{2x}}{w_1} < \frac{1}{t_{2v}b_{1x}}$	$(Y_1X_1)_s(Y_2X_2)_s$
$\frac{p_{1y}}{p_{2y}} > \frac{1}{k_1}$	$\frac{w_2}{w_1} > \frac{a_{2x}}{t_{2v}b_{1x}}, \frac{p_{2x}}{w_1} > \frac{1}{t_{2v}b_{1x}}, \frac{p_{1x}}{w_1} > \frac{t_2}{t_{2v}b_{1x}}$	$(X_1)_v(Y_2)_v$
	$\frac{w_2}{w_1} = \frac{a_{2x}}{t_{2v}b_{1x}}, \frac{p_{2x}}{w_1} > \frac{1}{t_{2v}b_{1x}}, \frac{p_{1x}}{w_1} > \frac{t_2}{t_{2v}b_{1x}}$	$(X_1)_v(Y_2X_2)_v$
	$\frac{p_{1x}}{w_2} < \frac{t_2}{a_{2x}}, \frac{p_{1x}}{w_1} < \frac{t_2}{t_{2v}b_{1x}}, \frac{p_{1x}}{p_{2x}} < t_2$	$(X_1)_s(Y_2)_s$
	$\frac{p_{1x}}{w_2} < \frac{t_2}{a_{2x}}, \frac{p_{1x}}{w_1} < \frac{t_2}{t_{2v}b_{1x}}, \frac{p_{1x}}{p_{2x}} = t_2$	$(X_1)_s(Y_2X_2)_s$

The notation for trade structures in Table 4 is as follows. The letters X_i, Y_i (i = 1,2) in each bracket denote goods produced in country i; subscribes s and v denote that production is characterised by specialisation and vertical integration, respectively.

3. EQUILIBRIUM

This section describes the general equilibrium of the model outlined in Section 2. The possible general equilibrium trade structures and corresponding conditions for consumer and firm optimisation problems are already presented in Table 4. However the conditions in Table 4 involve prices and wages, which are endogenous variables. To describe the general equilibrium, these endogenous variables need to be solved, and the equilibrium conditions need to be expressed in terms of exogenous parameters of the model. The solutions of these endogenous variables are obtained for each structure by taking the structure as given, and using the conventional general equilibrium analysis which comprises optimisation in consumer and firm decisions, and clearance of all markets.*

To illustrate, consider structure $(Y_1)_s(X_2)_s$. In this structure, firms in country 1 specialise in producing good Y, they import the intermediate good X from specialised X-producers in country 2, and export the final good Y.

First we look at consumer decision. Given this structure, a representative consumer in country 2 buys good Y domestically, i.e., y_{21} = 0, thus the consumer decision problem simplifies to

Max: $u_1 = y_1$

s.t. $p_{1y} y_1 = w_1$

Solving this problem gives us the demand function for good Y in country 1, which is

$$y_1^d = \frac{w_1}{p_{1y}}$$

* The two-stage method of solving for general equilibrium was proposed by Yang and Ng (1993) and refined by Sun (2003), Sun, Yang and Zhu (2004). It is sometimes referred to as "inframarginal analysis" as the method comprises an "infra-marginal" stage of identifying economic structures and corresponding conditions using the Kuhn-Tucker conditions of consumer and firm optimisation problems, as well as the standard stage of marginal analysis which solves for the equilibrium prices and quantities for each economic structure.

In contrast, a representative consumer in country 2 only buys imports, i.e., $y_2=0$, thus the consumer decision problem simplifies to

Max: $u_2 = k_2 y_{12}$

s.t. $p_{1y} y_{12} = w_2$

Solving this problems gives us the demand function for good Y in country 2, which is

$$y_{12}^d = \frac{w_2}{p_{1y}}$$

Now we consider firm decisions. Given this structure, the decision problem for the representative firm in country 1 is:

$$\underset{x_{21}, L_{1y}}{Max}\, \pi_{1y} = p_{1y} a_{1y} (t_1 x_{21})^{\beta} L_{1y}^{1-\beta} - p_{2x} x_{21} - w_1 L_{1y}.$$

The decision problem for the representative firm in country 2 is:

$$\max_{L_{2x}} \pi_{2x} = p_{2x} b_{2x} L_{2x} - w_2 L_{2x}$$

The market clearing conditions for good Y and good X are:

$$\frac{M_1 w_1}{p_{1y}} + \frac{M_2 w_2}{p_{1y}} = a_{1y} (t_1 x_{21})^{\beta} L_{1y}^{1-\beta}$$

$$x_{21} = b_{2x} M_2$$

Using the first-order conditions of the firms' decisions in both countries, and the market clearing condition, we obtain the equilibrium prices and wages in for structure $(Y_1)_s (X_2)_s$ as follows:

$$w_1 = 1,\ w_2 = \frac{\beta M_1}{(1-\beta) M_2},\ p_{2x} = \frac{w_2}{b_{2x}},\ p_{1y} = a_{1y}^{-1} b_{2x}^{-\beta} \beta^{-\beta} (1-\beta)^{\beta-1} t_1^{-\beta} w_2^{\beta}$$

Taking a similar approach, we can solve for equilibrium prices and wages for other structures. The results are summarised in Table 5.

Table 5: Equilibrium prices and wages for all economic structures

Structure	Equilibrium prices
$(Y_1X_1)_v(Y_2X_2)_v$	$w_i = 1,\ \ p_{iy} = a_{iy}^{-1}a_{ix}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_1X_1)_v(Y_2X_2)_s$	$w_i = 1,\ p_{2x} = b_{2x}^{-1},\ p_{1y} = a_{1y}^{-1}a_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1},\ p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_1X_1)_s(Y_2X_2)_v$	$w_i = 1,\ p_{1x} = b_{1x}^{-1},\ p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1},\ p_{2y} = a_{2y}^{-1}a_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_1X_1)_s(Y_2X_2)_s$	$w_i = 1,\ p_{ix} = b_{ix}^{-1},\ p_{iy} = a_{iy}^{-1}b_{ix}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$
$(Y_1X_1)_s(X_1)_s$	$w_1 = 1,\ w_2 = \frac{t_1 b_{2x}}{b_{1x}},\ p_{1x} = b_{1x}^{-1}, p_{2x} = \frac{w_2}{b_{2x}},\ p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1},$ $p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2$ (shadow price)
$(Y_1)_s(X_2)_s$	$w_1 = 1,\ w_2 = \frac{\beta M_1}{(1-\beta)M_2},\ \ p_{2x} = \frac{w_2}{b_{2x}},\ p_{1y} = a_{1y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}t_1^{-\beta}w_2^{\beta},$ $p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2$ (shadow price)
$(Y_1)_v(X_2)_v$	$w_1 = 1,,\ \ w_2 = \frac{\beta M_1}{(1-\beta)M_2},\ p_{1y} = a_{1y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}t_{1v}^{-\beta}w_2^{\beta},$ $p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2$ (shadow price)
$(Y_1X_1)_v(X_2)_v$	$w_1 = 1,\ w_2 = \frac{t_{1v}b_{2x}}{a_{1x}},\ \ p_{1y} = a_{1y}^{-1}a_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1},$ $p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2$ (shadow price)
$(X_1)_s(Y_2X_2)_s$	$w_1 = 1,\ w_2 = \frac{b_{2x}}{t_2 b_{1x}},\ p_{1x} = b_{1x}^{-1},\ p_{2x} = \frac{w_2}{b_{2x}},\ p_{2y} = a_{2y}^{-1}b_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2,$ $p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$ (shadow price)
$(X_1)_s(Y_2)_s$	$w_1 = 1,\ w_2 = \frac{(1-\beta)M_1}{\beta M_2},\ p_{1x} = a_{1x}^{-1},\ \ p_{2y} = a_{2y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}t_2^{-\beta}w_2^{1-\beta},$ $p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$ (shadow price)
$(X_1)_v(Y_2)_v$	$w_1 = 1,\ w_2 = \frac{(1-\beta)M_1}{\beta M_2},\ p_{2y} = a_{2y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}t_{2v}^{-\beta}w_2^{1-\beta},$ $p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$ (shadow price)
$(X_1)_v(Y_2X_2)_v$	$w_1 = 1,\ w_2 = \frac{a_{2x}}{t_{2v}b_{1x}},\ \ p_{2y} = a_{2y}^{-1}a_{2x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}w_2,$ $p_{1y} = a_{1y}^{-1}b_{1x}^{-\beta}\beta^{-\beta}(1-\beta)^{\beta-1}$ (shadow price)

In some of the structures where good Y is not produced domestically in one country, there is no actual domestic price for Y in that country. We have calculated a "shadow" domestic price of Y for that structure, which is the price that would be if Y were to be produced domestically.[†] The shadow prices are information required for consumer decisions as to whether to buy domestically or abroad (refer to Table 1).

4. CHARACTERISTICS OF CONDITIONS FOR GENERAL EQUILIBRIUM STRUCTURES

If we insert the equilibrium prices and wages in Table 5 into the conditions for consumer and firm optimisation problems set out in Table 4, we obtain the conditions under which each structure occurs in general equilibrium. These are summarised in Table 6.

Table 6: Inframarginal comparative statics of general equilibrium

Conditions of general equilibrium			**General equilibrium structure**
$t_{1v} < t_1$, $t_{2v} < t_2$	$\frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{b_{2x}})^{1-\beta} < k_2 t_1$	$\frac{\beta}{1-\beta}\frac{M_1}{M_2} > \frac{t_1 b_{2x}}{b_{1x}}$	$(Y_1X_1)_s(X_1)_s$
		$\frac{\beta}{1-\beta}\frac{M_1}{M_2} < \frac{t_1 b_{2x}}{b_{1x}}$	$(Y_1)_s(X_2)_s$
	$k_2 t_1 < \frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{b_{2x}})^{1-\beta} < k_1^{-1}t_2^{-1}$		$(Y_1X_1)_s(Y_2X_2)_s$
	$\frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{b_{2x}})^{1-\beta} > k_1^{-1}t_2^{-1}$	$\frac{1-\beta}{\beta}\frac{M_1}{M_2} > \frac{b_{2x}}{t_2 b_{1x}}$	$(X_1)_s(Y_2)_s$
		$\frac{1-\beta}{\beta}\frac{M_1}{M_2} < \frac{b_{2x}}{t_2 b_{1x}}$	$(X_1)_s(Y_2X_2)_s$
	$\frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} < k_2 t_{1v}$	$\frac{\beta}{1-\beta}\frac{M_1}{M_2} > \frac{t_{1v} b_{2x}}{a_{1x}}$	$(Y_1X_1)_v(X_2)_v$
		$\frac{\beta}{1-\beta}\frac{M_1}{M_2} < \frac{t_{1v} b_{2x}}{a_{1x}}$	$(Y_1)_v(X_2)_v$

[†] In calculation the shadow prices, we have assumed that if good Y were to be produced in that country, it would be produced by a specialised Y producer buying X domestically. We consider this assumption to be reasonable given that production in that country is characterised by specialised X production by either its own firms or plants set up by integrated firms in the other country.

$t_{1v} > t_1$, $t_{2v} > t_2$	$k_2 t_{1v} < \frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} < k_1^{-1} t_{2v}^{-1}$		$(Y_1X_1)_s(Y_2X_2)_s$
	$\frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} > k_1^{-1} t_{2v}^{-1}$	$\frac{1-\beta}{\beta}\frac{M_1}{M_2} < \frac{a_{2x}}{t_{2v} b_{1x}}$	$(X_1)_v(Y_2X_2)_v$
		$\frac{1-\beta}{\beta}\frac{M_1}{M_2} > \frac{a_{2x}}{t_{2v} b_{1x}}$	$(X_1)_v(Y_2)_v$
$t_{1v} < t_1$, $t_{2v} > t_2$	$\frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{a_{2x}})^{1-\beta} < k_2 t_1$	$\frac{\beta}{1-\beta}\frac{M_1}{M_2} > \frac{t_{21} b_{2x}}{t_1 b_{1x}}$	$(Y_1X_1)_s(X_2)_s$
		$\frac{\beta}{1-\beta}\frac{M_1}{M_2} < \frac{t_{21} b_{2x}}{t_1 b_{1x}}$	$(Y_1)_s(X_2)_s$
	$k_2 t_1 < \frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{a_{2x}})^{1-\beta} < k_1^{-1} t_{2v}^{-1}$		$(Y_1X_1)_s(Y_2X_2)_s$
	$\frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{a_{2x}})^{1-\beta} > k_1^{-1} t_{2v}^{-1}$	$\frac{1-\beta}{\beta}\frac{M_1}{M_2} < \frac{a_{2x}}{t_{2v} b_{1x}}$	$(X_1)_v(Y_2X_2)_v$
		$\frac{1-\beta}{\beta}\frac{M_1}{M_2} > \frac{a_{2x}}{t_{2v} b_{1x}}$	$(X_1)_v(Y_2)_v$
$t_{1v} > t_1$, $t_{2v} < t_2$	$\frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} < k_2 t_{1v}$	$\frac{\beta}{1-\beta}\frac{M_1}{M_2} > \frac{t_{1v} b_{2x}}{a_{1x}}$	$(Y_1X_1)_v(X_2)_v$
		$\frac{\beta}{1-\beta}\frac{M_1}{M_2} < \frac{t_{1v} b_{2x}}{a_{1x}}$	$(Y_1)_s(X_2)_s$
	$k_2 t_{1v} < \frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} < k_1^{-1} t_2^{-1}$		$(Y_1X_1)_s(Y_2X_2)_s$
	$\frac{a_{2y}}{a_{1y}}(\frac{a_{1x}}{b_{2x}})^{1-\beta} > k_1^{-1} t_2^{-1}$	$\frac{1-\beta}{\beta}\frac{M_1}{M_2} > \frac{t_2 b_{2x}}{t_{12} b_{1x}}$	$(X_1)_s(Y_2)_s$
		$\frac{1-\beta}{\beta}\frac{M_1}{M_2} < \frac{t_2 b_{2x}}{t_{12} b_{1x}}$	$(X_1)_s(Y_2X_2)_s$

Note that the conditions of general equilibrium in effect partition the fifteenth dimension parameter space (a_{ix}, a_{iy}, b_{ix} M_1, M_2, β, t_1, t_2, t_{1v}, t_{2v}, k_1, k_2) into subsets. Within each parameter subset, a specific economic structure emerges as the general equilibrium structure. For instance, the first row of Table 6 means that within the subset defined by $t_{1v} < t_1$, $t_{2v} < t_2$, $\frac{a_{2y}}{a_{1y}}(\frac{b_{1x}}{b_{2x}})^{1-\beta} < k_2 t_1$ and $\frac{\beta}{1-\beta}\frac{M_1}{M_2} > \frac{t_1 b_{2x}}{b_{1x}}$, the structure $(Y_1X_1)_s(X_1)_s$ will emerge as the general equilibrium structure.

It can be seen from Table 6 that 9 different economic structures each with different consumption, production and trade patterns can emerge in general equilibrium, these structures are:

(1) the autarky structure $(Y_1X_1)_s(Y_2X_2)_s$, in which both countries produce both good X and good Y in specialised firms; there is no international trade. Note that vertical integration cannot be a general equilibrium autarky structure because we assume the productivity of X in a specialised firm is higher than an integrated firm, and that there is zero domestic transaction cost in trading good X in the domestic market or internal control cost in producing X domestically. In other words, there is no trade-off between economies of specialisation and low transaction costs, thus specialisation will be the dominant choice that occurs in equilibrium with no international trade.

(2) The global outsourcing structures $(Y_1)_s(X_2)_s$ and $(X_1)_s(Y_2)_s$, in which firms in country 1 and country 2, respectively, specialise in producing Y and outsource the intermediate good X globally.

(3) The FDI structures $(Y_1)_v(X_2)_v$ and $(X_1)_v(Y_2)_v$, in which firms in country 1 and country, respectively, vertically integrate into X production and set up overseas plants to produce good X.

(4) The mixed specialised structures $(Y_1X_1)_s(X_1)_s$ and $(X_1)_s(Y_2X_2)_s$, in which firms in country 1 and country 2, respectively, specialise in producing Y and outsource good X both domestically and globally.

(5) The missed vertical structures $(Y_1X_1)_v(X_2)_v$ and $(X_1)_v(Y_2X_2)_v$, in which firms in country 1 and country 2, respectively, vertically integrate into X production and produce good X both domestically and overseas.

Which structure will occur in general equilibrium depends on which subsets the parameters fall into. Each parameter subset is defined in terms of technological comparative advantage in producing goods Y and X between the two countries ($\frac{a_{2y}}{a_{1y}}, \frac{b_{1x}}{b_{2x}}, \frac{a_{1x}}{b_{2x}}, \frac{b_{1x}}{a_{2x}}$), intensity of intermediate good X used in the production of good (β), transaction efficiency associated with international trade in good Y (k_1, k_2), internal transaction efficiency associated with producing X overseas by a vertically integrated firm (t_{1v}, t_{2v}), external transaction efficiency associated with importing good X (t_1, t_2), and relative population size ($\frac{M_1}{M_2}$).

The interactions of the parameters are complex, however, some general conclusions can be drawn from the results presented in Table 6. The first conclusion is the general statement that the general equilibrium structure is determined by the interaction of parameters, specifically, we have

Proposition 1 *Depending on the values of parameters, different economic structures can occur in general equilibrium. The general equilibrium structure may involve autarky where there is international trade in neither final goods nor intermediate goods; or specialised final good producers engaging in global outsourcing or both domestic and global outsourcing of intermediate good; or vertically integrated producers engaging in global production (through FDI) or both of domestic and global production of intermediate good.*

Note that in Table 6 the first column compares the internal transaction efficiency of a vertically integrated firm and the external transaction efficiency of a specialised firm. It is clear from Table 6 that when internal transaction efficiency is lower than external transaction efficiency in a country ($t_{iv}<t_i$), firms in that country do not choose vertical integration in general equilibrium. For instance, the first block of 5 structures in Table 6 are all characterised by firms in country 1 being specialised producers of X and or Y. Thus we have

Proposition 2 *The choice between vertical integration and specialised production of final goods depends on the relative size of the internal transaction efficiency associated with vertical integration and external transaction efficiency associated with specialised production. Ceteris paribus, an increase in external transaction efficiency increases the likelihood that specialised production of final goods occurs in general equilibrium.*

It should be noted that our model assumes zero transaction costs in domestic trading, that is the domestic transactions efficiency of good X is one. Thus the trade-off between vertical integration and specialisation characterised in proposition 2 is more precisely the trade-off between vertically integration with production of good X overseas, and the specialisation with good X imported.[‡] Nevertheless, Proposition 2 still captures the idea put forward by Cheung (1983) that the boundary of the firm is determined by the relative transaction efficiency in trading intermediate goods (external transaction efficiency in our model) and the transaction cost of hiring labor to produce the intermediate goods internally (internal transaction efficiency in our model).

[‡] If we introduce transaction costs in domestic trade and production in both countries, the definition of parameter subsets will be more complex as there will be four additional parameters. However the general conclusions of the model will be the same except that 3 additional autarky structures may emerge which are characterised by at least one country vertically integrating into X production.

The second column of Table 6 describes each country's comparative advantage in relation to the two goods X and Y, taking into account different types of transaction costs. Notice that due to positive transaction costs, international trade does not always occur in equilibrium. However if international trade does occur in equilibrium, the direction of trade flow in our model is consistent with Ricardo's theory of comparative advantage, which predicts that a country will export the good it has comparative advantage in producing. For instance, the first cell of column 2 indicates that country 2 has comparative advantage in good X, the corresponding equilibrium structures are characterised by country 2 exporting good X. Thus we have

Proposition 3 *If the extent of comparative advantage is not sufficient to outweigh the transaction costs associated with international trade, the general equilibrium structure will be autarky. If comparative advantage is sufficiently large such that international trade occurs in equilibrium, then the direction of trade flow will be such that each trading country exports the good that it has a comparative advantage in producing.*

Proposition 3 highlights a distinct feature of our model, which is its ability to endogenize the emergence of international trade as well as the consumption and trade pattern and production organisations.

Finally, the third column of Table 6 is a measure of the relative production capacity of the intermediate good between the two countries. The relative production capacity is determined by the relative size of the labor force, relative productivity in X production and the intensity of X used in the production of Y. From the results in Table 6, we get

Proposition 4 *If the production capacities of the intermediate good in the two countries are balanced, complete international specialisation (i.e., each country producing only one good) may occur in equilibrium. If the production capacities are out of balance, the country with a larger capacity will produce both goods in equilibrium and the equilibrium structure will involve the larger country either outsourcing both domestically and abroad, or producing the intermediate good both domestically and overseas.*

5. CONCLUSION

In this paper we have developed a general equilibrium model of domestic and global sourcing. The model adapts the traditional Ricardian model of international trade to analyse production and trade in intermediate goods, and introduces three types of transaction costs to the model: the transaction costs associated with international trade in final goods, the external transaction costs associated with international outsourcing of intermediate goods, and the internal transaction costs

associated with overseas production of intermediate goods by vertically integrated firms. Our model endogenises the decision as to whether or not to vertically integrate and the location of intermediate good production. It also endogenises the emergence of international trade in equilibrium.

The main conclusions of our model are summarised in four propositions. In summary form, our model suggests that (1) depending on parameter values, different equilibrium structures may occur in general equilibrium; (2) the choice between vertical integration and specialisation depends on the comparison or relative sizes of external transaction costs of outsourcing and internal transaction costs of production; (3) international trade will occur in equilibrium if the extent of comparative advantage outweighs the transaction costs of international trade. The direction of trade flow will be such that each country exports the good it has comparative advantage in; and (4) complete international specialisation is possible if the production capacities of the trading countries are balanced; otherwise the country with a larger capacity will produce both goods domestically.

Despite the relative simplicity in the logical structure of our model, the model is able to derive a rich set of conclusions. This suggests to us that the underlying structure of the traditional Ricardian model is a powerful tool for analyzing a wide range of issues in international trade. For instance, our model can be extended to include different types of labor to analyze the impact of international outsourcing on wage dispersion between skilled and unskilled labor. A further extension is to introduce the difference in labor market institutions to the model and investigate how labor market institutions interact with international trade to affect wages for skilled and unskilled labor.

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