Regional Trade in a Three Country Model

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This chapter develops a three country model of constant cost production and trade based on productivity and country size. A small country may produce too little to offer gains from trade to the other two, while at the other extreme a large country may not gain from trade. Trade may be limited to two of the countries assuming gains from trade are necessary for trade to take place due to costs of adjustments along the production frontier. Regional trade is observed if countries with similar productivities happen to be located closer together, a testable hypothesis.

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Regional trade in the literature is based on various forms of imperfect competition. In contrast, trade may be limited to two of three countries in the present competitive model due to their productivity and size. Each country in the present model maximizes identical Cobb-Douglas utility subject to constant cost production and balanced trade. Gains from trade are necessary for trade assuming a cost of adjusting to specialization along the production frontier. A country that is too unproductive is not able to offer gains from trade to the other two. At the other extreme, a country may be too productive to gain from trade. Regional trade is observed if countries with similar productivities happen to be located closer together.

Regional trade in the theoretical literature arises due to various forms of market imperfections including the differential tariffs and trade diversion of Viner (1950); game theoretic optimal tariffs of Johnson (1953); policy credibility of Staiger and Taellini (1987), Whalley (1996), Hamilton and Whalley (2000), and Keenan and Riezman (1990); increasing returns of Krugman (1991); insurance against trade wars of Peronni and Whaley (1994); border effects of Engel and Rogers (1996), Helliwell (1998), and Anderson and van Wincoop (2003); various nontraditional issues of Fernández and Portes (1998); geographic barriers of Eaton and Kortum (2002); and production externalities of Rossi-Hansberg (2005). In contrast the present model is based on the competitive Torrens-Ricardo-Mill trade model developed by McKenzie (1954), Chipman (1965), and Eaton and Kortum (2012).

The first section presents the classical constant cost trade model with two countries and two goods, followed by a section adding the third country. The third section extends the model to more goods and more countries.

1. Trade in the 2x2 model

Countries are represented by k = A, B and goods by j = 1, 2. Unit input coefficients a_{jk} imply the constant cost production frontier $E_k = \Sigma_j a_{jk}x_{jk}$ where E_k is the factor endowment and x_{jk} the output of good j. Complete specialization in good j occurs at E_k/a_{jk}.

Each country maximizes utility subject to its production frontier in autarky with consumption c_{jk} of good j equal to output x_{jk}. Assume the utility functions $u_k = c_{1k}c_{2k}$ implying marginal utilities $u_{1k} = c_{2k}$ and $u_{2k} = c_{1k}$. The autarky relative price of good 1 is a_{1k}/a_{2k}. Utility maximization implies equal consumption shares, $a_{1k}c_{1k} = a_{2k}c_{2k}$ with half the factor endowment employed producing each good, $E_k/2a_{jk} = c_{jk} = x_{jk}$.

Assuming country A has the comparative advantage in good 1,

$$a_{1B}/a_{2B} > a_{1A}/a_{2A}. \qquad (1)$$

it would specialize and export good 1, and country B good 2, if

$$a_{1B}/a_{2B} > p > a_{1A}/a_{2A}. \qquad (2)$$

where $p \equiv p_1/p_2$ is the terms of trade. Prices are determined in the producing country, $p_1 = a_{1A}w_A$ and $p_2 = a_{2B}w_B$ where w_k represents the factor price. It follows that $p = (a_{1A}/a_{2B})(w_A/w_B)$ limiting relative factor prices from (2) according to $a_{1B}/a_{1A} > w_A/w_B > a_{2B}/a_{2A}$.

Total consumption with trade equals specialized production,

$$c_{1A} + c_{1B} = E_A/a_{1A} \qquad (3)$$
$$c_{2A} + c_{2B} = E_B/a_{2B}.$$

Each country consumes the same amount of each good $c_{jA} = c_{jB}$ equal to half the specialized output. Trade is balanced with export revenue equal to import spending, $(E_A/a_{1A}) - c_{1A} = c_{2A}/p$ and $(E_B/a_{2B}) - c_{2B} = pc_{1B}$ implying $p = c_{2k}/c_{1k}$.

Figure 1 pictures production frontiers and autarky consumption at U_A and U_B. Consumption with trade is T_A and T_B with increased consumption of the import but consumption of the export remaining at the autarky level. The terms of trade depend on productivity and country size from (3) according to $p = (a_{1A}/a_{2B})(E_B/E_A)$.

*Figure 1 *

If a country is small, competitive trade would occur at the large country autarky prices. The large country is forced to partially specialize by low price imports, trading back to its autarky consumption. The small country enjoys all the gains from trade, a known property of trade theory. To avoid such small country trade without gains, assume an arbitrarily small cost of adjusting output along the production frontier. Gains from trade are then necessary to offset this arbitrarily small cost of specialization. Partial specialization and trade with a small country at domestic autarky prices is ruled out.

The condition for gains from trade is that the other country would export at least as much as would be consumed in autarky,

$$A_1 > B_1 \qquad (4)$$
$$B_2 > A_2,$$

where $A_j \equiv E_A/a_{jA}$ and $B_j \equiv E_B/a_{jB}$. Specialized production must be larger in a different good for each country. The production conditions in (4) imply the weaker comparative advantage in (1). The productivity and size restrictions for gains from trade from (4) are

$$a_{2A}/a_{2B} > E_A/E_B > a_{1A}/a_{2B}. \qquad (5)$$

Similar restrictions in the following three country model lead to the possibility that trade may be limited to two countries.

2. Trade in the 2x3 model

Assume the third country C has similar constant cost production $E_C = \Sigma_j a_{jC} x_{jC}$ and the same utility function. Its autarky production x_{jC} and consumption c_{jC} equal $E_C/2a_{jC} = ½C_j$. Assume it has the comparative advantage in good 2 with country B in the middle,

$$a_{1C}/a_{2C} > a_{1B}/a_{2B} > a_{1A}/a_{2A}. \qquad (6)$$

Limits to the terms of trade similar to (2) are $a_{1C}/a_{2C} > p > a_{1A}/a_{2A}$ with country A exporting good 1, country C good 2, and middle country B either good.

Production conditions extend (4) to the third country. One possibility is the mirror image condition

$$A_1 > B_1 > C_1 \qquad (7)$$
$$C_2 > B_2 > A_2,$$

implying

$$a_{1B}/a_{1A} > E_B/E_A > a_{2B}/a_{2A} \qquad (8)$$
$$a_{1C}/a_{1B} > E_C/E_B > a_{2C}/a_{2B},$$

The conditions in (8) imply $a_{1C}/a_{1A} > E_C/E_A > a_{2C}/a_{2A}$ and the comparative advantage in (6) but include restrictions on relative country sizes similar to (5). The potential competition in an export market may lead to losses from trade.

Country A exports and consumes $a_1 \equiv ½A_1$ in (7) and similarly $c_2 \equiv ½C_2$ for country C. Country B specializing in good 1 would compete with country A for c_2 earning its share $s_{B1}c_2$ where $s_{B1} \equiv B_1/(A_1+B_1)$ is its portion of the good 1 market. The utility of B would then be $u_{B1} = s_{B1}b_1c_2$

while utility specializing in good 2 would be $u_{B2} = s_{B2}a_1b_2$ where $b_2 \equiv \frac{1}{2}B_2$ and $s_{B2} \equiv B_2/(B_2 + C_2)$. Assume $u_{B1} > u_{B2}$ with country B specializing in good 1.

Table 1 reports consumption levels for autarky K and global specialization G as well as trade limited to countries k and h in the three R_{kh}. Utility is the product of consumption levels. Country C ranks global trade highest $G > R_{AC} > R_{BC} > K = R_{AB}$. The terms of trade for C are best in G as the other two specialize in its imported good 1. Country A ranks $R_{AC} > G$ consuming c_2 in R_{AC} but only its share $s_{A1} = 1 - s_{B1}$ in G. Country A also ranks $R_{AC} > R_{AB} > K = R_{BC}$.

* Table 1 *

Country B would export good 1 to country C in R_{BC} that it ranks ahead of autarky, $R_{BC} > K$. Country B also ranks R_{BC} ahead of G as it avoids competing in the good 1 export market. Its ranking of G and K are ambiguous. Countries A and B both prefer trading with only C while it prefers global trade.

As an example Figure 2 pictures production for $A_1 = 20$, $B_1 = 16$, $C_1 = 2$, $A_2 = 2$, $B_2 = 14$, and $C_2 = 30$ with production condition (7). Country A ranks $R_{AC} > G > R_{AB}$ while C ranks $R_{AC} > R_{BC}$. Country B ranks $K > G$ due to global good 1 competition with country A ruling out global trade. Countries A and C would trade with each other in R_{AC}.

* Figure 2 *

Production conditions other than (7) lead to different trade patterns. For instance $A_2 > C_2 > B_2$ replacing the second condition in (7) implies country A would not gain from trade since it produces more of both goods than either of the other countries can offer. Country A is too large to trade as seen in the implied conditions $a_{1B}/a_{1A} > a_{2B}/a_{2A} > E_B/E_A$ and $a_{1C}/a_{1A} > a_{2C}/a_{2A} > E_C/E_A$. There are six similar conditions with a country too large to gain from trade.

At the other extreme $B_2 > A_2 > C_2$ as the second condition in (7) implies country C is too small to offer gains from trade to the other two. There are six such rankings with a small economy excluded from trade. Global autarky would result with $A_2 > B_2 > C_2$ as the second condition in (7).

A third good allows each country to have the highest production potential in its own particular good. Nevertheless, under some conditions trade is limited to two countries.

3. Trade with more countries and goods

Gains from trade with three goods depend on production conditions extending (7) to the third good. Thompson (2001) identifies the general trade patterns in the 3x3 model. Utility maximization implies each country in autarky produces and consumes a third of each output, $a_h \equiv A_h/3$ for h = 1, 2, 3 and similarly for b_h and c_h. Each country can export one third of its output of up to two goods in exchange for one third of the outputs of other goods.

Each country has a unique advantage in the production conditions

$$\begin{aligned} &A_1 > B_1 > C_1 \\ &B_2 > C_2 > A_2 \\ &C_3 > A_3 > B_3. \end{aligned} \qquad (9)$$

Each country also has a unique disadvantage in (9). These conditions are consistent with the weaker assignment of Jones (1961) namely $a_{1A}/a_{2A} < a_{1B}/a_{2B}$, $a_{1A}/a_{3A} < a_{1C}/a_{3C}$, and $a_{2B}/a_{3B} < a_{2A}/a_{3A}$. This general condition with country A specializing in good 1, country B good 2, and country C good 3 can always be attained by relabeling countries and goods if necessary. Utility $a_1b_2c_3$ of each country with global trade is illustrated in Figure 3a by the dashed terms of trade plane beyond the three production frontiers.

* Figure 3 *

A country ranking last in production potential for every good would be excluded from trade. An example is country B in Figure 3b facing R_{AC} and the dashed terms of trade between goods 1 and 3. If one country has the highest production potential for every good, it will remain in autarky.

Another possibility is that one country does not rank highest for any good as is the case for country B in

$$\begin{aligned} &A_1 > B_1 > C_1 \\ &A_2 > C_2 > B_2 \\ &C_3 > B_3 > A_3. \end{aligned} \tag{10}$$

This production potential is consistent with the Jones assignment. Table 2 reports the outcomes. The rankings for country A are $R_{AC} > G$ and $R_{AC} > R_{AB} > R_{BC} = K$. Similarly country C ranks $R_{AC} > G$ and $R_{AC} > R_{BC} > R_{AB} = K$. Country B ranks $G > R_{BC}$ and $R_{AB} > R_{AC} = K$ but is isolated by R_{AC} as shown in Figure 3c.

* Table 2 *

The model extends to more countries and goods. With the same number of countries and goods each country could rank highest for a unique good resulting in global trade. Countries that do not rank highest for any good, however, would be excluded from trade. A country that ranks highest for all goods would not gain from trade.

Graham (1948) argues trade may be limited to a subset of countries when there are more countries than goods as in the present 2x3 model. With more goods than countries, each country may have the highest production potential for at least one good limited trade is possible as well. This principle extends to the continuum goods model of Dornbusch, Fischer, and Samuelson (1977).

4. Conclusion

The present competitive model offers an alternative motivation for regional trade, namely the geographical distribution of productivities and country sizes. Trade may be limited to a subset of countries in the present model. If the trading countries happen to be located closer together, regional trade is observed. The extent to which observed regional trade patterns are explained by the distribution of productivity and country size becomes an empirical issue.

Regarding policy implications, the various assumptions of imperfect competition in the regional trade literature lead to second best policy that would ease symptoms of the market imperfections. In the present competitive model, policy focus shifts to productivity and production potential.

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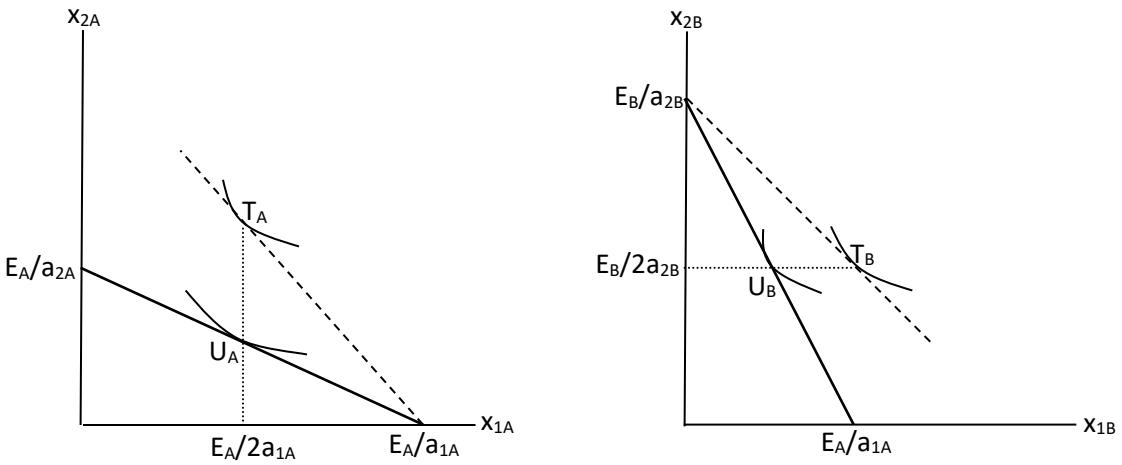


Figure 1. Gains from trade in the 2x2 Model

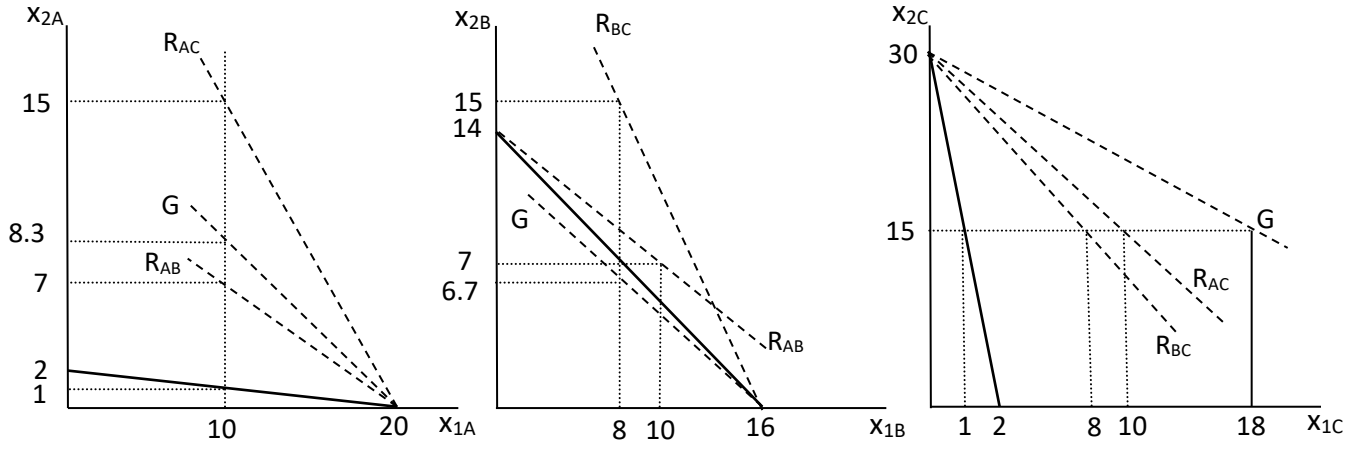
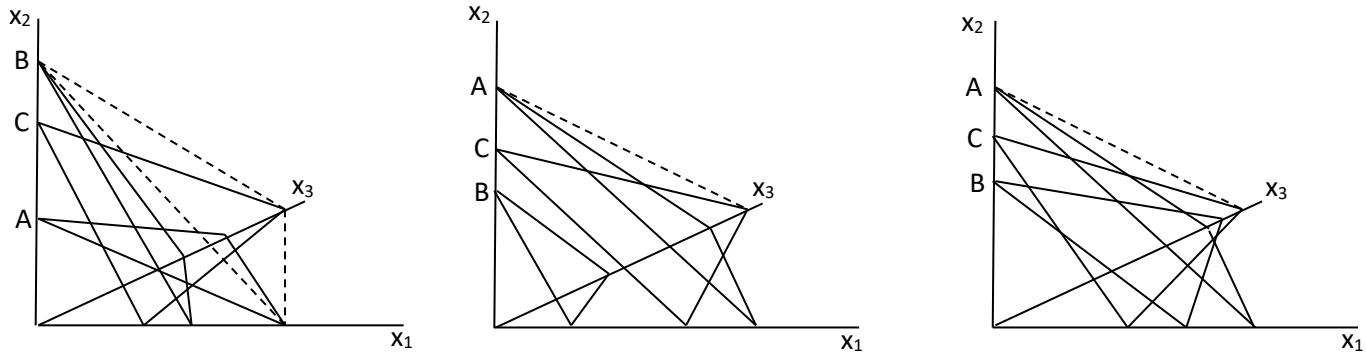


Figure 2. Trade in the 2x3 Model



3a. Global trade in (7) *3b. Small unproductive B* *3c. R_{AC} in (8)*

Figure 3. Trade in the 3x3 Model

Table 1. Consumption in the 2x3 Model

	A		B		C	
	1	2	1	2	1	2
K	a_1	a_2	b_1	b_2	c_1	c_2
R_{AB}	a_1	b_2	a_1	b_2	c_1	c_2
R_{AC}	a_1	c_2	b_1	b_2	a_1	c_2
R_{BC}	a_1	a_2	b_1	c_2	b_1	c_2
G	a_1	$s_{A1}c_2$	b_1	$s_{B1}c_2$	a_1+b_1	c_2

Table 2. Consumption in the 3x3 model

	A			B			C		
	1	2	3	1	2	3	1	2	3
K	a_1	a_2	a_3	b_1	b_2	b_3	c_1	c_2	c_3
R_{AB}	a_1	a_2	b_3	a_1	b_2	b_3	c_1	c_2	c_3
R_{AC}	a_1	a_2	c_3	b_1	b_2	b_3	a_1	c_2	c_3
R_{BC}	a_1	a_2	a_3	b_1	b_2	c_3	b_1	c_2	c_3
G	a_1	b_2	c_3	a_1	b_2	c_3	a_1	b_2	c_3