14.581 International Trade
— Lecture 7: Factor Proportion Theory —

Today's Plan

1. Factor Proportion Theory
2. Ricardo-Viner model
    1. Basic environment
    2. Comparative statics
3. Heckscher-Ohlin model
    1. Basic environment
    2. Classical results
    3. High-dimensional issues
    4. Quantitative issues

Factor Proportion Theory

- The law of comparative advantage establishes the relationship between relative autarky prices and trade flows
  - But where do relative autarky prices come from?
- Factor proportion theory emphasizes **factor endowment differences**
- **Key elements:**
  1. Countries differ in terms of factor abundance [i.e *relative* factor supply]
  2. Goods differ in terms of factor intensity [i.e *relative* factor demand]
- Interaction between 1 and 2 will determine differences in relative autarky prices, and in turn, the pattern of trade

Factor Proportion Theory

- In order to shed light on factor endowments as a source of CA, we will assume that:
  1. Production functions are identical around the world
  2. Households have identical homothetic preferences around the world
- We will first focus on two special models:
  - **Ricardo-Viner** with 2 goods, 1 "mobile" factor (labor) and 2 "immobile" factors (sector-specific capital)
  - **Heckscher-Ohlin** with 2 goods and 2 "mobile" factors (labor and capital)
- The second model is often thought of as a long-run version of the first (Neary 1978)
  - In the case of Heckscher-Ohlin, what it is the time horizon such that one can think of total capital as fixed in each country, though freely mobile across sectors?

- Consider an economy with:
  - Two goods, $g = 1, 2$
  - Three factors with endowments l, k_1, and k_2
- Output of good g is given by

$$y_g = f^g(l_g, k_g),$$

where:

  - l_g is the (endogenous) amount of labor in sector g
  - f^g is homogeneous of degree 1 in (l_g, k_g)
- **Comments:**
  - l is a "mobile" factor in the sense that it can be employed in all sectors
  - k_1 and k_2 are "immobile" factors in the sense that they can only be employed in one of them
  - Model is isomorphic to DRS model: $y_g = f^g(l_g)$ with $f_{ll}^g < 0$
  - Payments to specific factors under CRS $\equiv$ profits under DRS

- We denote by:
  - p_1 and p_2 the prices of goods 1 and 2
  - w, r_1, and r_2 the prices of l, k_1, and k_2
- For now, (p_1, p_2) is exogenously given: **"small open economy"**
  - So no need to look at good market clearing
- **Profit maximization:**

$$p_g f_l^g (l_g, k_g) = w \quad (1)$$

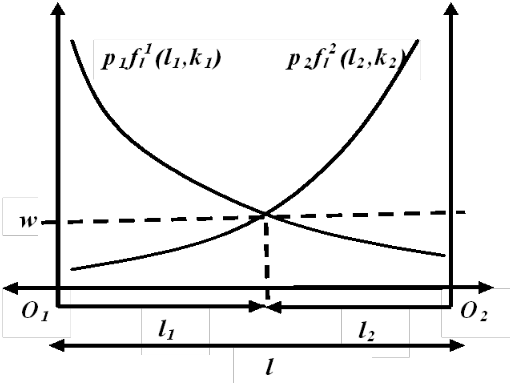
$$p_g f_k^g (l_g, k_g) = r_g \quad (2)$$

- **Labor market clearing:**

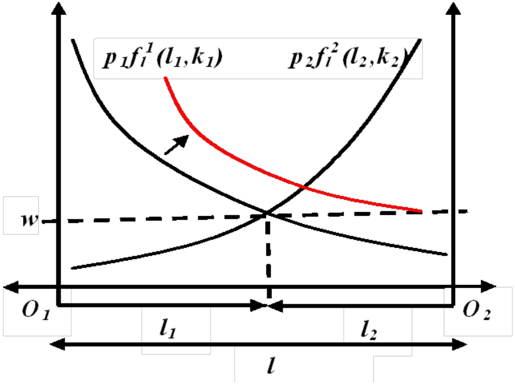
$$l = l_1 + l_2 \quad (3)$$

Ricardo-Viner Model

Graphical analysis



- Equations (1) and (3) jointly determine labor allocation and wage
- How do we recover payments to the specific factor from this graph?



- Consider a TOT shock such that p_1 increases:
  - $w \nearrow$, $l_1 \nearrow$, and $l_2 \searrow$
  - Condition (2) $\Rightarrow r_1/p_1 \nearrow$ whereas r_2 (and a fortiori r_2/p_1) $\searrow$

Ricardo-Viner Model
Comparative statics

- One can use the same type of arguments to analyze consequences of:
  - Productivity shocks
  - Changes in factor endowments
- In all cases, results are intuitive:
  - "Dutch disease" (Boom in export sectors, Bids up wages, which leads to a contraction in the other sectors)
  - Useful political-economy applications (Grossman and Helpman 1994)
- Easy to extend the analysis to more than 2 sectors:
  - Plot labor demand in one sector vs. rest of the economy
  - Convenient for empirical work (Kovak 2013)

Ricardo-Viner Model

Equilibrium (II): two-country world

- Predictions on the pattern of trade in a two-country world depend on whether differences in factor endowments come from:
  - Differences in the relative supply of specific factors
  - Differences in the relative supply of mobile factors
- Accordingly, any change in factor prices is possible as we move from autarky to free trade (see Feenstra Problem 3.1 p. 98)

Two-by-Two Heckscher-Ohlin Model

Basic environment

- Consider an economy with:
  - Two goods, $g = 1, 2$,
  - Two factors with endowments l and k
- Output of good g is given by

$$y_g = f^g\left(l_g, k_g\right),$$

where:

  - l_g, k_g are the (endogenous) amounts of labor and capital in sector g
  - f^g is homogeneous of degree 1 in $\left(l_g, k_g\right)$

- $c_g(w,r) \equiv$ unit cost function in sector g

$$c_g(w,r) = \min_{l,k} \{wl + rk | f^g(l,k) \geq 1\},$$

  where w and r the price of labor and capital

- $a_{fg}(w,r) \equiv$ unit demand for factor f in the production of good g
- Using the Envelope Theorem, it is easy to check that:

$$a_{lg}(w,r) = \frac{dc_g(w,r)}{dw} \text{ and } a_{kg}(w,r) = \frac{dc_g(w,r)}{dr}$$

- $A(w,r) \equiv [a_{fg}(w,r)]$ denotes the matrix of total factor requirements

- Like in RV model, we first look at the case of a **"small open economy"**
  - So no need to look at good market clearing
- **Profit-maximization:**

$$p_g \leq wa_{lg}(w,r) + ra_{kg}(w,r) \text{ for all } g = 1,2 \quad (4)$$
$$p_g = wa_{lg}(w,r) + ra_{kg}(w,r) \text{ if } g \text{ is produced in equilibrium} \quad (5)$$

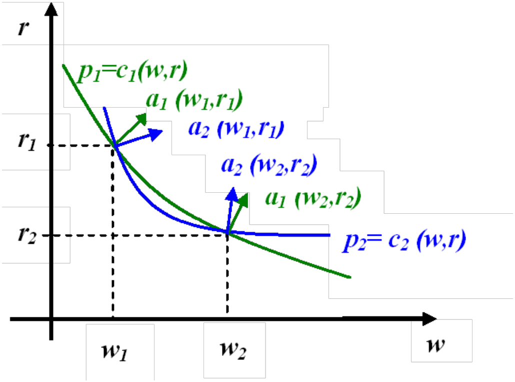
- **Factor market-clearing**:

$$l = y_1 a_{l1}(w,r) + y_2 a_{l2}(w,r) \quad (6)$$
$$k = y_1 a_{k1}(w,r) + y_2 a_{k2}(w,r) \quad (7)$$

- **Question:**
  Can trade in goods be a (perfect) substitute for trade in factors?
- First classical result from the HO literature answers by the affirmative
- To establish this result formally, we'll need the following definition:
- **Definition**. *Factor Intensity Reversal (FIR) does not occur if:* (i) $a_{l1}(w,r)/a_{k1}(w,r) > a_{l2}(w,r)/a_{k2}(w,r)$ *for all* (w,r)*; or* (ii) $a_{l1}(w,r)/a_{k1}(w,r) < a_{l2}(w,r)/a_{k2}(w,r)$ *for all* (w,r).

- **Lemma** *If both goods are produced in equilibrium and FIR does not occur, then factor prices* $\omega \equiv (w, r)$ *are uniquely determined by good prices* $p \equiv (p_1, p_2)$
- **Proof:** If both goods are produced in equilibrium, then $p = A'(\omega)\omega$. By Gale and Nikaido (1965), this equation admits a unique solution if $a_{fg}(\omega) > 0$ for all f, g and $\det[A(\omega)] \neq 0$ for all ω, which is guaranteed by no FIR.
- **Comments:**
  - Good prices rather than factor endowments determine factor prices
  - In a closed economy, good prices and factor endowments are, of course, related, but not for a small open economy
  - All economic intuition can be gained by simply looking at Leontieff case
  - Proof already suggests that "dimensionality" will be an issue for FIR

- Link between no FIR and FPI can be seen graphically:



- If iso-cost curves cross more than once, then FIR must occur

- The previous lemma directly implies (Samuelson 1949) that:
- **FPE Theorem** *If two countries produce both goods under free trade with the same technology and FIR does not occur, then they must have the same factor prices*
- **Comments:**
  - Trade in goods can be a "perfect substitute" for trade in factors
  - Countries with different factor endowments can sustain same factor prices through different allocation of factors across sectors
  - Assumptions for FPE are stronger than for FPI: we need free trade and same technology in the two countries...
  - For next results, we'll maintain assumption that both goods are produced in equilibrium, but won't need free trade and same technology

- **Stolper-Samuelson Theorem** *An increase in the relative price of a good will increase the real return to the factor used intensively in that good, and reduced the real return to the other factor*
- **Proof:** W.l.o.g. suppose that (i) $a_{l1}(\omega)/a_{k1}(\omega) > a_{l2}(\omega)/a_{k2}(\omega)$ and (ii) $\widehat{p}_2 > \widehat{p}_1$. Differentiating the zero-profit condition (5), we get

$$\widehat{p}_g = \theta_{lg}\widehat{w} + (1 - \theta_{lg})\widehat{r}, \tag{8}$$

where $\widehat{x} = d\ln x$ and $\theta_{lg} \equiv wa_{lg}(\omega)/c_g(\omega)$. Equation (8) + (ii) imply

$$\widehat{w} > \widehat{p}_2 > \widehat{p}_1 > \widehat{r} \text{ or } \widehat{r} > \widehat{p}_2 > \widehat{p}_1 > \widehat{w}$$

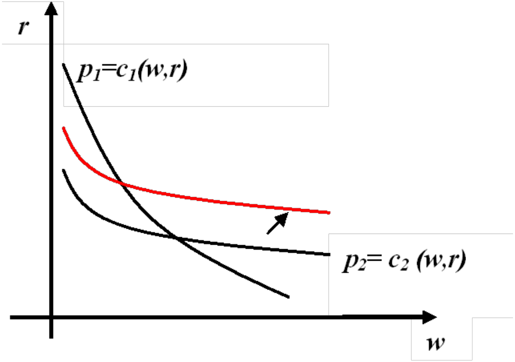
By (i), $\theta_{l2} < \theta_{l1}$. So (ii) further requires $\widehat{r} > \widehat{w}$. Combining the previous inequalities, we get

$$\widehat{r} > \widehat{p}_2 > \widehat{p}_1 > \widehat{w}$$

- **Comments:**
  - Previous "hat" algebra is often referred to "Jones' (1965) algebra"
  - The chain of inequalities $\widehat{r} > \widehat{p}_2 > \widehat{p}_1 > \widehat{w}$ is referred as a "magnification effect"
  - SS predict both winners and losers from change in relative prices
  - Like FPI and FPE, SS entirely comes from zero-profit condition (+ no joint production)
  - Like FPI and FPE, sharpness of the result hinges on "dimensionality"
  - In the empirical literature, people often talk about "Stolper-Samuelson effects" whenever looking at changes in relative factor prices (though changes in relative good prices are rarely observed)

Heckscher-Ohlin Model

Stolper-Samuelson (1941) Theorem: graphical analysis



- Like for FPI and FPE, all economic intuition could be gained by looking at the simpler Leontieff case:
  - In the general case, iso-cost curves are not straight lines, but under no FIR, same logic applies

- Previous results have focused on the implication of *zero profit condition*, Equation (5), for *factor prices*
- We now turn our attention to the implication of *factor market clearing*, Equations (6) and (7), for *factor allocation*
- **Rybczynski Theorem** *An increase in factor endowment will increase the output of the industry using it intensively, and decrease the output of the other industry*

- **Proof:** W.l.o.g. suppose that (i) $a_{l1}(\omega)/a_{k1}(\omega) > a_{l2}(\omega)/a_{k2}(\omega)$ and (ii) $\widehat{k} > \widehat{l}$. Differentiating factor market clearing conditions (6) and (7), we get

$$\widehat{l} = \lambda_{l1}\widehat{y}_1 + (1 - \lambda_{l1})\widehat{y}_2 \quad (9)$$

$$\widehat{k} = \lambda_{k1}\widehat{y}_1 + (1 - \lambda_{k1})\widehat{y}_2 \quad (10)$$

where $\lambda_{l1} \equiv a_{l1}(\omega) y_1/l$ and $\lambda_{k1} \equiv a_{k1}(\omega) y_1/k$. Equation (8) + (ii) imply

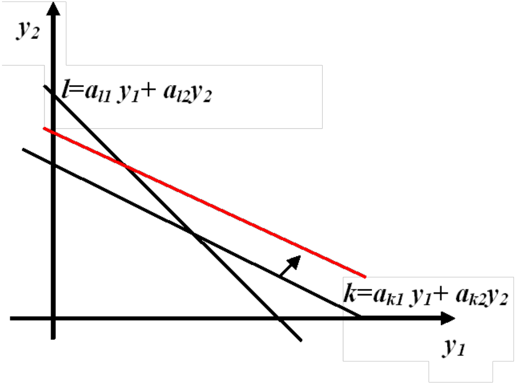
$$\widehat{y}_1 > \widehat{k} > \widehat{l} > \widehat{y}_2 \text{ or } \widehat{y}_2 > \widehat{k} > \widehat{l} > \widehat{y}_1$$

By (i), $\lambda_{k1} < \lambda_{l1}$. So (ii) further requires $\widehat{y}_2 > \widehat{y}_1$. Combining the previous inequalities, we get

$$\widehat{y}_2 > \widehat{k} > \widehat{l} > \widehat{y}_1$$

- Like for FPI and FPE Theorems:
  - (p_1, p_2) is exogenously given $\Rightarrow$ factor prices and factor requirements are not affected by changes factor endowments
  - Empirically, Rybczynski Theorem suggests that impact of immigration may be very different in closed vs. open economy
- Like for SS Theorem, we have a "magnification effect"
- Like for FPI, FPE, and SS Theorems, sharpness of the result hinges on "dimensionality"

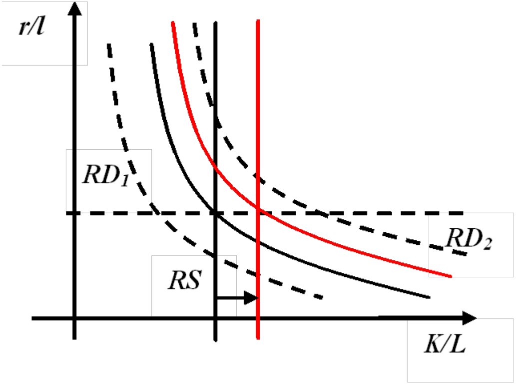
- Since good prices are fixed, it is as if we were in Leontieff case



Two-by-Two Heckscher-Ohlin Model

Rybczynski (1965) Theorem: graphical analysis (II)

- Rybczynski effect can also be illustrated using relative factor supply and relative factor demand:



- *Cross-sectoral reallocations* are at the core of HO predictions:
  - For relative factor prices to remain constant, *aggregate* relative demand must go up, which requires expansion capital intensive sector

- Previous results hold for small open economies
  - relative good prices were taken as exogenously given
- We now turn world economy with two countries, North and South
- We maintain the two-by-two HO assumptions:
  - there are two goods, $g = 1{,}2$, and two factors, k and l
  - identical technology around the world, $y_g = f_g(k_g, l_g)$
  - identical homothetic preferences around the world, $d_g^c = \alpha_g(p) I^c$
- **Question**
  What is the pattern of trade in this environment?

- Start from **Integrated Equilibrium** $\equiv$ competitive equilibrium that would prevail if *both* goods and factors were freely traded
- Consider **Free Trade Equilibrium** $\equiv$ competitive equilibrium that prevails if goods are freely traded, but factors are not
- Ask: Can free trade equilibrium reproduce integrated equilibrium?
- *If factor prices are equalized through trade*, the answer is yes
- In this situation, one can then use homotheticity to go from differences in factor endowments to pattern of trade

- **Integrated equilibrium** corresponds to (p, ω, y) such that:

$$
\begin{aligned}
(ZP) &: \quad p = A'(\omega)\,\omega & (11)\\
(GM) &: \quad y = \alpha(p)\,(\omega' v) & (12)\\
(FM) &: \quad v = A(\omega)\,y & (13)
\end{aligned}
$$

where:

- $p \equiv (p_1, p_2)$, $\omega \equiv (w, r)$, $A(\omega) \equiv [a_{fg}(\omega)]$, $y \equiv (y_1, y_2)$, $v \equiv (l, k)$, $\alpha(p) \equiv [\alpha_1(p), \alpha_2(p)]$
- $A(\omega)$ derives from cost-minimization
- $\alpha(p)$ derives from utility-maximization

- **Free trade equilibrium** corresponds to $(p^t, \omega^n, \omega^s, y^n, y^s)$ such that:

$$(ZP) \quad : \quad p^t \leq A'(\omega^c)\,\omega^c \text{ for } c = n, s \tag{14}$$

$$(GM) \quad : \quad y^n + y^s = \alpha\left(p^t\right)\left(\omega^{n\prime} v^n + \omega^{s\prime} v^s\right) \tag{15}$$

$$(FM) \quad : \quad v^c = A(\omega^c)\, y^c \text{ for } c = n, s \tag{16}$$

  where (14) holds with equality if good is produced in country c

- **Definition** *Free trade equilibrium replicates integrated equilibrium if* $\exists\ (y^n, y^s) \geq 0$ *such that* $(p, \omega, \omega, y^n, y^s)$ *satisfy conditions* (14)-(16)

- **Definition** (v^n, v^s) *are in the FPE set if* $\exists$ $(y^n, y^s) \geq 0$ *such that condition* (16) *holds for* $\omega^n = \omega^s = \omega$.
- **Lemma** *If* (v^n, v^s) *is in the FPE set, then free trade equilibrium replicates integrated equilibrium*
- **Proof:** By definition of the FPE set, $\exists$ $(y^n, y^s) \geq 0$ such that

$$v^c = A(\omega) y^c$$

So Condition (16) holds. Since $v = v^n + v^s$, this implies

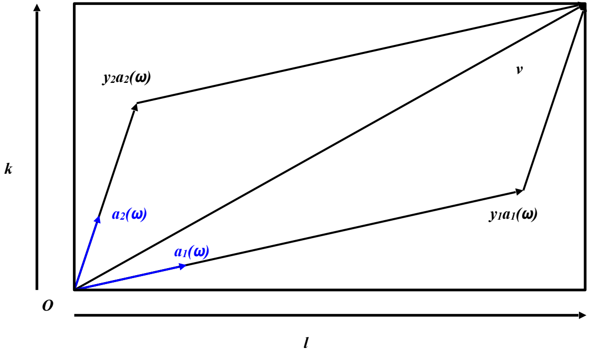
$$v = A(\omega)(y^n + y^s)$$

Combining this expression with condition (13), we obtain $y^n + y^s = y$. Since $\omega^{n\prime} v^n + \omega^{s\prime} v^s = \omega' v$, Condition (15) holds as well. Finally, Condition (11) directly implies (14) holds.

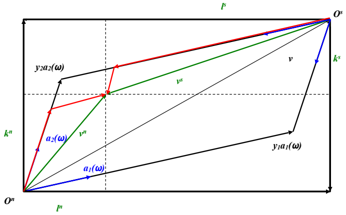
Two-by-Two-by-Two Heckscher-Ohlin Model

Integrated equilibrium: graphical analysis

- Factor market clearing in the integrated equilibrium:

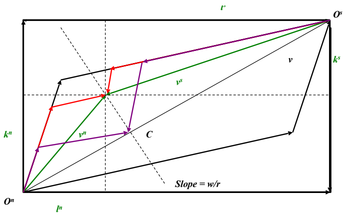


- **FPE set** $\equiv (v^n, v^s)$ inside the parallelogram



- When v^n and v^s are inside the parallelogram, we say that they belong to the same **diversification cone**
- This is a very different way of approaching FPE than FPE Theorem
  - Here, we have shown that there can be FPE iff factor endowments are not too dissimilar, whether or not there are no FIR
  - Instead of taking prices as given—whether or not they are consistent with integrated equilibrium—we take factor endowments as primitives

- Suppose that (v^n, v^s) is in the FPE set
- **HO Theorem** *In the free trade equilibrium, each country will export the good that uses its abundant factor intensively*



- Outside the FPE set, additional technological and demand considerations matter (e.g. FIR or no FIR)

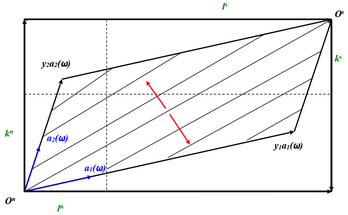
- HO Theorem can also be derived using Rybczynski effect:
  1. Rybczynski theorem $\Rightarrow y_2^n/y_1^n > y_2^s/y_1^s$ for any p
  2. Homotheticity $\Rightarrow c_2^n/c_1^n = c_2^s/c_1^s$ for any p
  3. This implies $p_2^n/p_1^n < p_2^s/p_1^s$ under autarky
  4. Law of comparative advantage $\Rightarrow$ HO Theorem

Two-by-Two-by-Two Heckscher-Ohlin Model

Trade and inequality

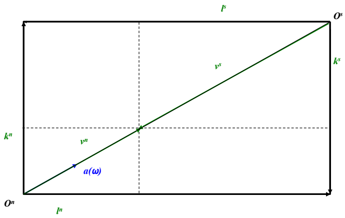
- Predictions of HO and SS Theorems are often combined:
  - HO Theorem $\Rightarrow p_2^n / p_1^n < p_2 / p_1 < p_2^s / p_1^s$
  - SS Theorem $\Rightarrow$ *Moving from autarky to free trade, real return of abundant factor increases, whereas real return of scarce factor decreases*
  - If North is skill-abundant relative to South, inequality increases in the North and decreases in the South
- So why may we observe a rise in inequality in the South in practice?
  - Southern countries are not moving from autarky to free trade
  - Technology is not identical around the world
  - Preferences are not homothetic and identical around the world
  - There are more than two goods and two countries in the world

- Let us define trade volumes as the sum of exports plus imports
- Inside FPE set, iso-volume lines are parallel to diagonal (HKa p.23)
    - the further away from the diagonal, the larger the trade volumes
    - factor abundance rather than country size determines trade volume

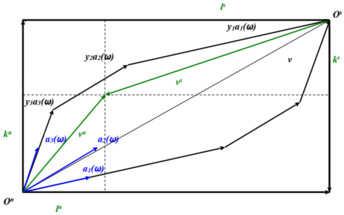


- If country size affects trade volumes in practice, what should we infer?

- Suppose now that there are F factors and G goods
- By definition, (v^n, v^s) is in the FPE set if $\exists\,(y^n, y^s) \geq 0$ s.t. $v^c = A(\omega)\,y^c$ for $c = n, s$
- If $F = G$ ("even case"), the situation is qualitatively similar
- If $F > G$, the FPE set will be "measure zero": $\{v | v = A(\omega)\,y^c \text{ for } y^c \geq 0\}$ is a G-dimensional cone in F-dimensional space
- **Example:** "Macro" model with 1 good and 2 factors



- If $F < G$, there will be indeterminacies in production, (y^n, y^s), and so, trade patterns, but FPE set will still have positive measure
- **Example:** 3 goods and 2 factors



- By the way, are there more goods than factors in the world?

High-Dimensional Predictions

Stolper-Samuelson-type results (I): "Friends and Enemies"

- SS Theorem was derived by differentiating zero-profit condition
- With an arbitrary number of goods and factors, we still have

$$\widehat{p}_g = \sum_f \theta_{fg} \widehat{w}_f \tag{17}$$

where w_f is the price of factor f and $\theta_{fg} \equiv w_f a_{fg}(\omega) / c_g(\omega)$

- Now suppose that $\widehat{p}_{g_0} > 0$, whereas $\widehat{p}_g = 0$ for all $g \neq g_0$
- Equation (17) immediately implies the existence of f_1 and f_2 s.t.

$$\begin{aligned} \widehat{w}_{f_1} &\geq \widehat{p}_{g_0} > \widehat{p}_g = 0 \text{ for all } g \neq g_0, \\ \widehat{w}_{f_2} &< \widehat{p}_g = 0 < \widehat{p}_{g_0} \text{ for all } g \neq g_0. \end{aligned}$$

- So every good is "friend" to some factor and "enemy" to some other (Jones and Scheinkman 1977)

- Ethier (1984) also provides the following variation of SS Theorem
- If good prices change from p^1 to p^2, then the associated change in factor prices, $\omega^2 - \omega^1$, must satisfy

$$\left(p^2 - p^1\right)' A'\left(\omega^0\right)\left(\omega^2 - \omega^1\right) > 0, \text{ for some } \omega^0 \text{ between } \omega^1 \text{ and } \omega^2$$

- **Proof:**
- Define $f(\omega) = \left(p^2 - p^1\right)' A'(\omega)\,\omega$. Mean value theorem implies

$$f\left(\omega^2\right) = f\left(\omega^1\right) + \left(p^2 - p^1\right)'\left[A'\left(\omega^0\right) + dA'\left(\omega^0\right)\omega^0\right]\left(\omega^2 - \omega^1\right)$$

for some ω^0 between ω^1 and ω^2. Cost-minimization at ω^0 requires

$$dA'\left(\omega^0\right)\omega^0 = 0$$

- **Proof (Cont.):**
  Combining the two previous expressions, we obtain
  $$f\left(\omega^2\right) - f\left(\omega^1\right) = \left(p^2 - p^1\right)' A'\left(\omega^0\right)\left(\omega^2 - \omega^1\right)$$
  From zero profit condition, we know that $p^1 = A'\left(\omega^1\right)\omega^1$ and $p^2 = A'\left(\omega^2\right)\omega^2$. Thus
  $$f\left(\omega^2\right) - f\left(\omega^1\right) = \left(p^2 - p^1\right)'\left(p^2 - p^1\right) > 0$$
  The last two expressions imply
  $$\left(p^2 - p^1\right)' A'\left(\omega^0\right)\left(\omega^2 - \omega^1\right) > 0$$
- **Interpretation:**
  Tendency for changes in good prices to be accompanied by raises in prices of factors used intensively in goods whose prices have gone up
- What is ω^0?

- Rybczynski Theorem was derived by differentiating the factor market clearing condition
- If $G = F > 2$, same logic implies that increase in endowment of one factor decreases output of one good and increases output of another (Jones and Scheinkman 1977)
- If $G < F$, increase in endowment of one factor may increase output of all goods (Ricardo-Viner)
- In this case, we still have the following correlation (Ethier 1984)

$$\left(v^2 - v^1\right)' A\left(\omega^0\right)\left(y^2 - y^1\right) = \left(v^2 - v^1\right)'\left(v^2 - v^1\right) > 0$$

- If $G > F$, indeterminacies in production imply that we cannot predict changes in output vectors

- Since HO Theorem derives from Rybczynski effect + homotheticity, problems of generalization in the case $G < F$ and $F > G$ carry over to the Heckscher-Ohlin Theorem
- If $G = F > 2$, we can invert the factor market clearing condition

$$y^c = A^{-1}(\omega) v^c$$

- By homotheticity, the vector of consumption in country c satisfies

$$d^c = s^c d$$

  where $s^c \equiv c$'s share of world income, and $d \equiv$ world consumption
- Good and factor market clearing requires

$$d = y = A^{-1}(\omega) v$$

- Combining the previous expressions, we get net exports

$$t^c \equiv y^c - d^c = A^{-1}(\omega)(v^c - s^c v)$$

- Without assuming that $G = F$, we can still derive sharp predictions if we focus on the *factor content of trade* rather than *commodity trade*
- We define the *net exports of factor f* by country c as

$$\tau_f^c = \sum_g a_{fg}(\omega) t_g^c$$

- In matrix terms, this can be rearranged as

$$\tau^c = A(\omega) t^c$$

- **HOV Theorem** *In any country c, net exports of factors satisfy*

$$\tau^c = v^c - s^c v$$

- So countries should export the factors in which they are abundant compared to the world: $v_f^c > s^c v_f$
- Assumptions of HOV Theorem are extremely strong: identical technology, FPE, homotheticity
  - One shouldn't be too surprised if it performs miserably in practice...

Quantitative Issues

Basic Idea

- Stolper-Samuelson offers sharp insights about distributional consequences of international trade, but...
  - Theoretical insights are only *qualitative*
  - Theoretical insights crucially rely on 2×2 assumptions
- Alternatively one may want to know the *quantitative* importance of international trade:
  - Given the amount of trade that we actually observe in the data, how large are the effects of international trade on the skill premium?
  - In a country like the United States, how much higher or smaller would the skill premium be in the absence of trade?

- Eaton and Kortum (2002)—as well as other gravity models—offer a simple starting point to think about these issues
- Consider multi-sector-multi-factor EK (e.g. Chor JIE 2010)
  - many varieties with different productivity levels $z(\omega)$ in each sector s
  - same factor intensity across varieties within sectors
  - different factor intensities across sectors
- Unit costs of production in country i and sector s are proportional to:

$$c_{i,s} = \left[\left(\mu_s^H \right)^{\rho} \left(w_i^H \right)^{1-\rho} + \left(\mu_s^L \right)^{\rho} \left(w_i^L \right)^{1-\rho} \right]^{1/(1-\rho)} \tag{18}$$

where:

- w_i^H, $w_i^L \equiv$ wages of skilled and unskilled workers.
- $\rho \equiv$ elasticity of substitution between skilled and unskilled

Quantitative Issues

Dekle, Eaton, and Kortum (2008) Revisited

- Suppose, like in EK, that productivity draws across varieties within sectors are independently drawn from a Fréchet
- Then one can show that the following gravity equation holds:

$$X_{ij,s} = \frac{T_i \left(\tau_{ij,s} c_{i,s}\right)^{-\theta_s}}{\sum_{l=1}^{n} T_l \left(\tau_{lj,s} c_{l,s}\right)^{-\theta_s}} E_{j,s}, \tag{19}$$

  where $E_{j,s} \equiv$ total expenditure on goods from sector s in country j
- Two key equations, (18) and (19), are CES:
  - One can use DEK's strategy to do welfare and counterfactual analysis
  - But one can also discuss the consequences of changes in variable trade costs, $\tau_{lj,s}$, or technology, T_i, on skill premium
  - How large are GT compared to distributional consequences?
  - Some preliminary answers in Costinot and Rodriguez-Clare (2014); more in Burstein and Vogel (2016), Galle, Rodriguez-Clare and Yi (2017)
  - See also Burstein, Hanson, Tian, and Vogel (2018) for immigration