Factor Endowments and the Heckscher-Olin Model

EE451

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Outline

- Assumptions
- Autarky equilibrium
- The Heckscher-Ohlin Theorem
- Factor-Price-Equalization Theorem
- The Stolper-Samuelson Theorem
- The Rybczynski Theorem
- Testing the Heckscher-Ohlin Model
- Specific-Factor model

Assumptions

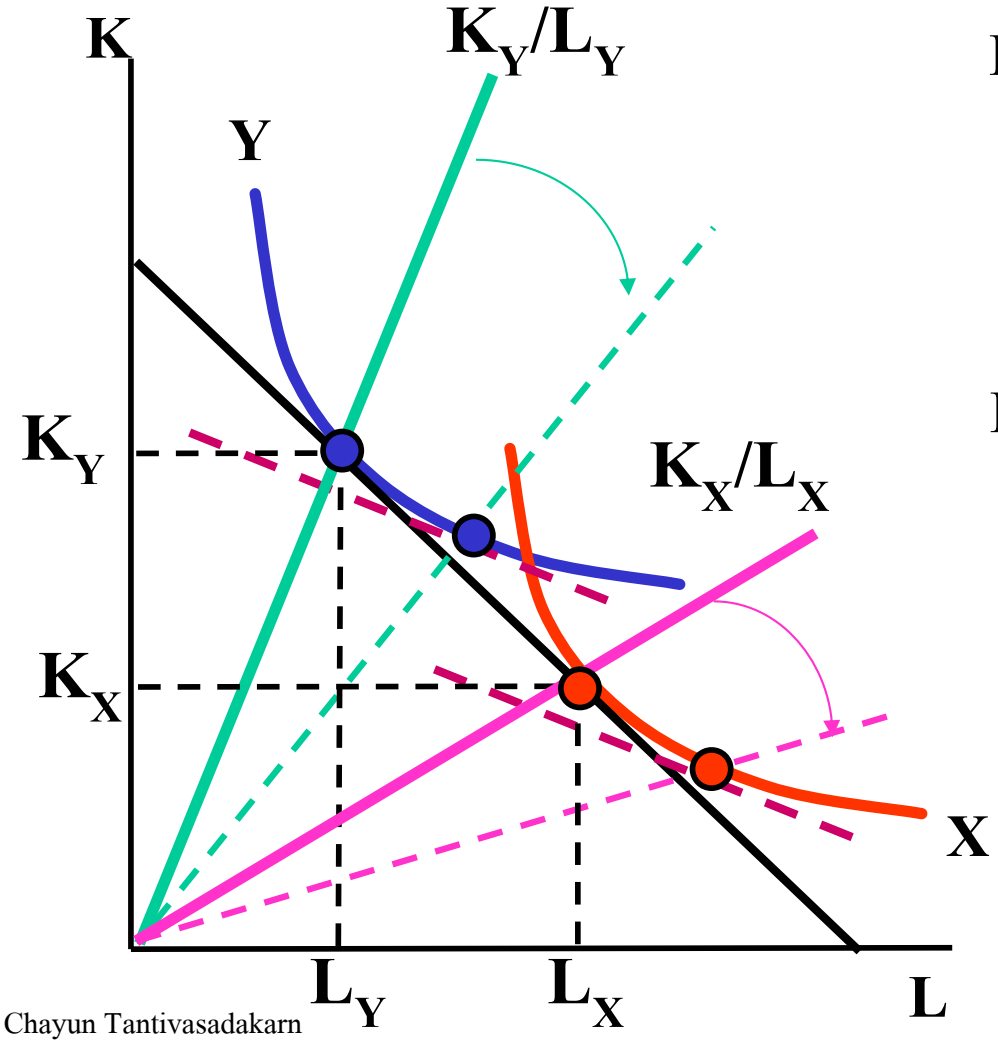
- 2 countries, Home and Foreign
- 2 homogenous goods, rice (X) and airplanes (Y)
- 2 homogenous factors, labor (L) and capital (K)
- CRTS and identical technology across countries
- Each good has different factor intensities and no factor intensity reversal
- Capital markets: $K = K_X + K_Y$ and $K^* = K^*_X + K^*_Y$
- Labor markets: $L = L_X + L_Y$ and $L^* = L^*_X + L^*_Y$
- Countries have different factor abundance
- Perfect competition in all markets

Assumptions

- Perfectly mobile factors within each country
  - Same wage rate earned in both industries of each country
  - Same rental rate earned in both industries of each country
- Identical and homothetic preferences across countries
  - A poorer country will buy less of both rice and airplane, but in the same ratio as a richer country facing the same prices
  - Not a realistic assumption, but it allows us to focus attention on the differences in resources as the sole reason for trade
- No transportation costs, no market distortions, no government interventions

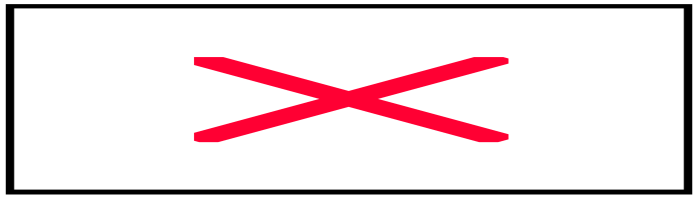
No factor intensity reversal

- Factor intensity is the relative capital-labor ratio. It refers to the demand for factors of the goods.

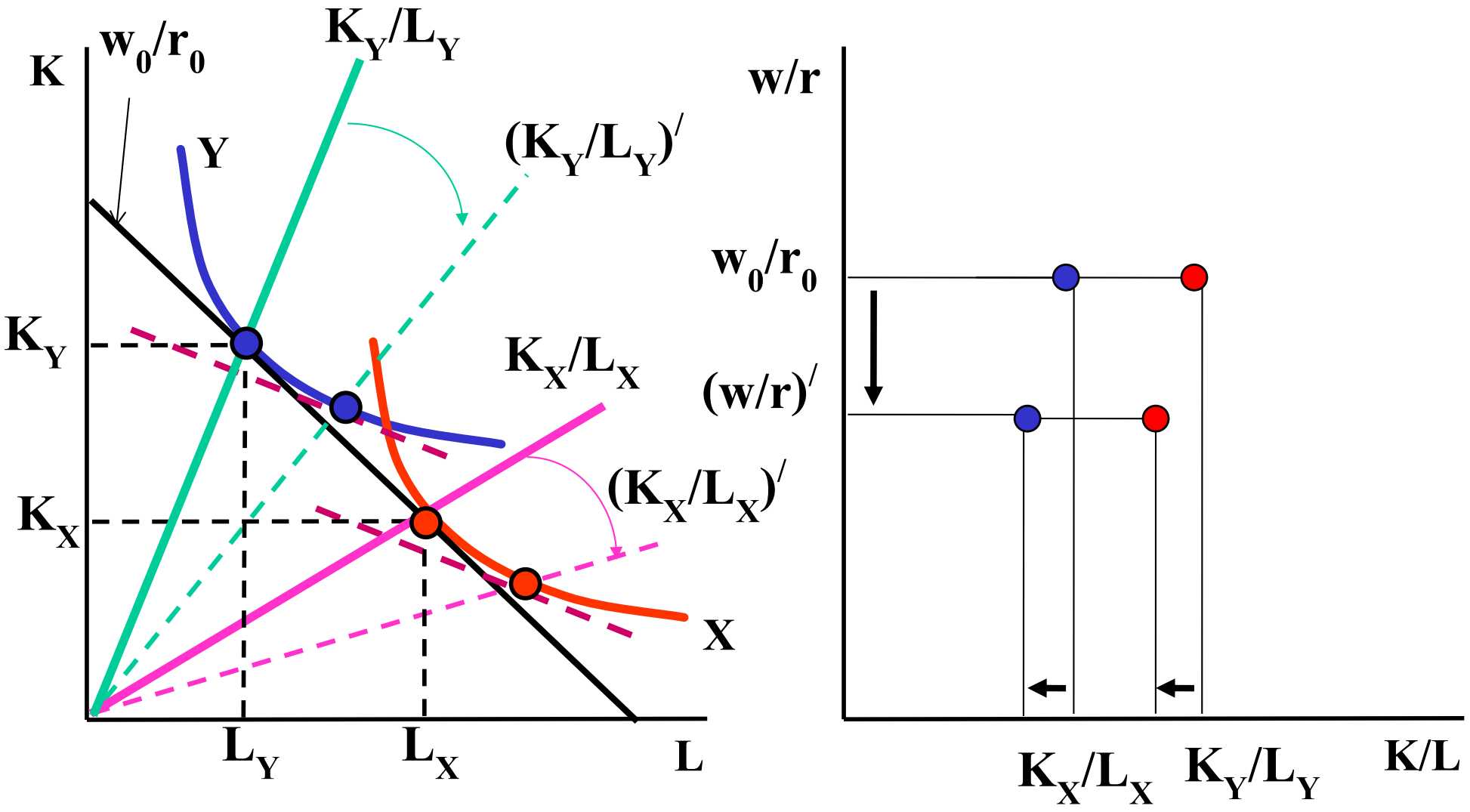


Regardless of the changes in w/r, the factor intensity of one good relative to that of other goods does not change.

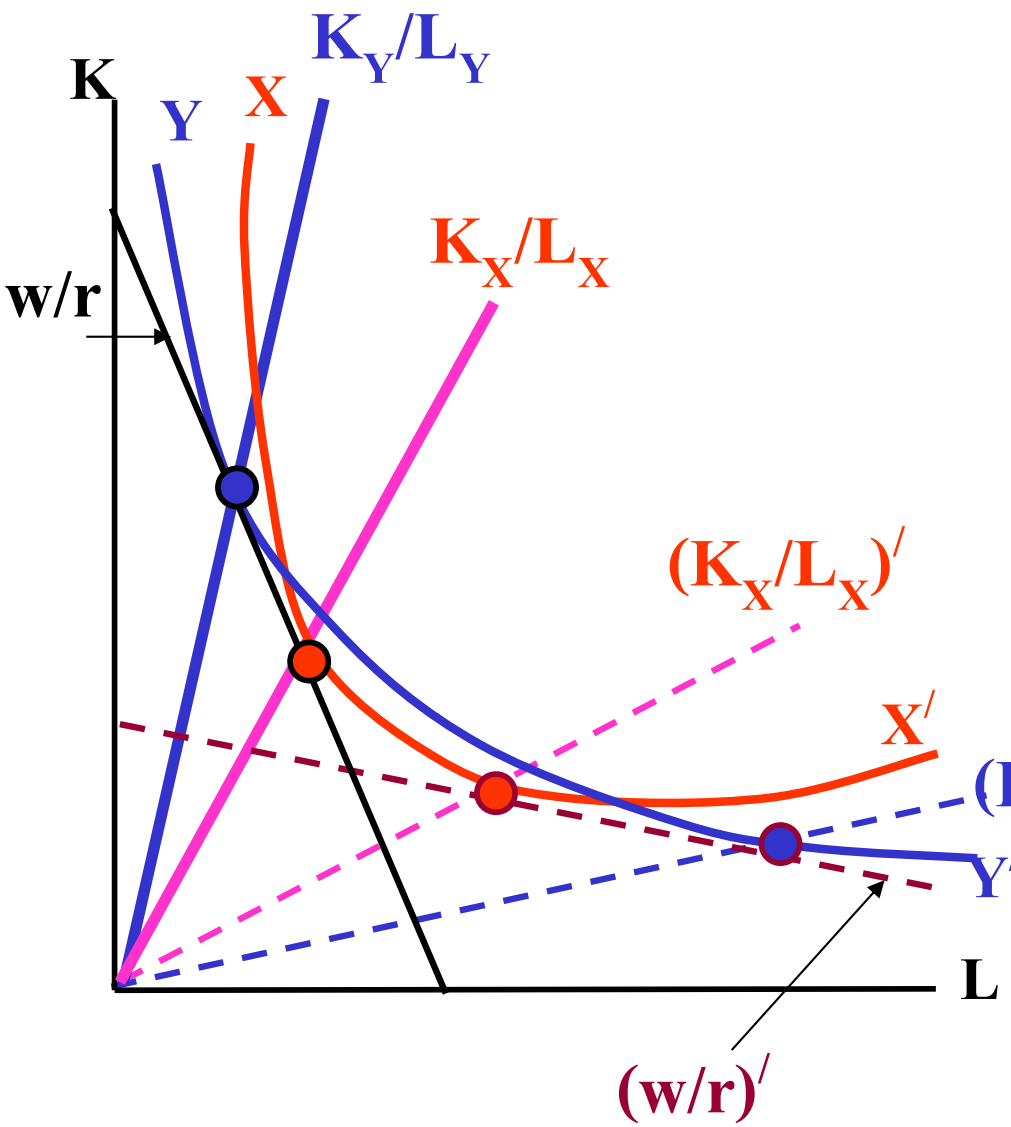
It is assumed here that Y is always capital intensive while X is labor intensive or the capital to labor demand of Y is always greater than those of X.



Factor intensity and capital-labor ratio



Factor intensity reversal (FIR)

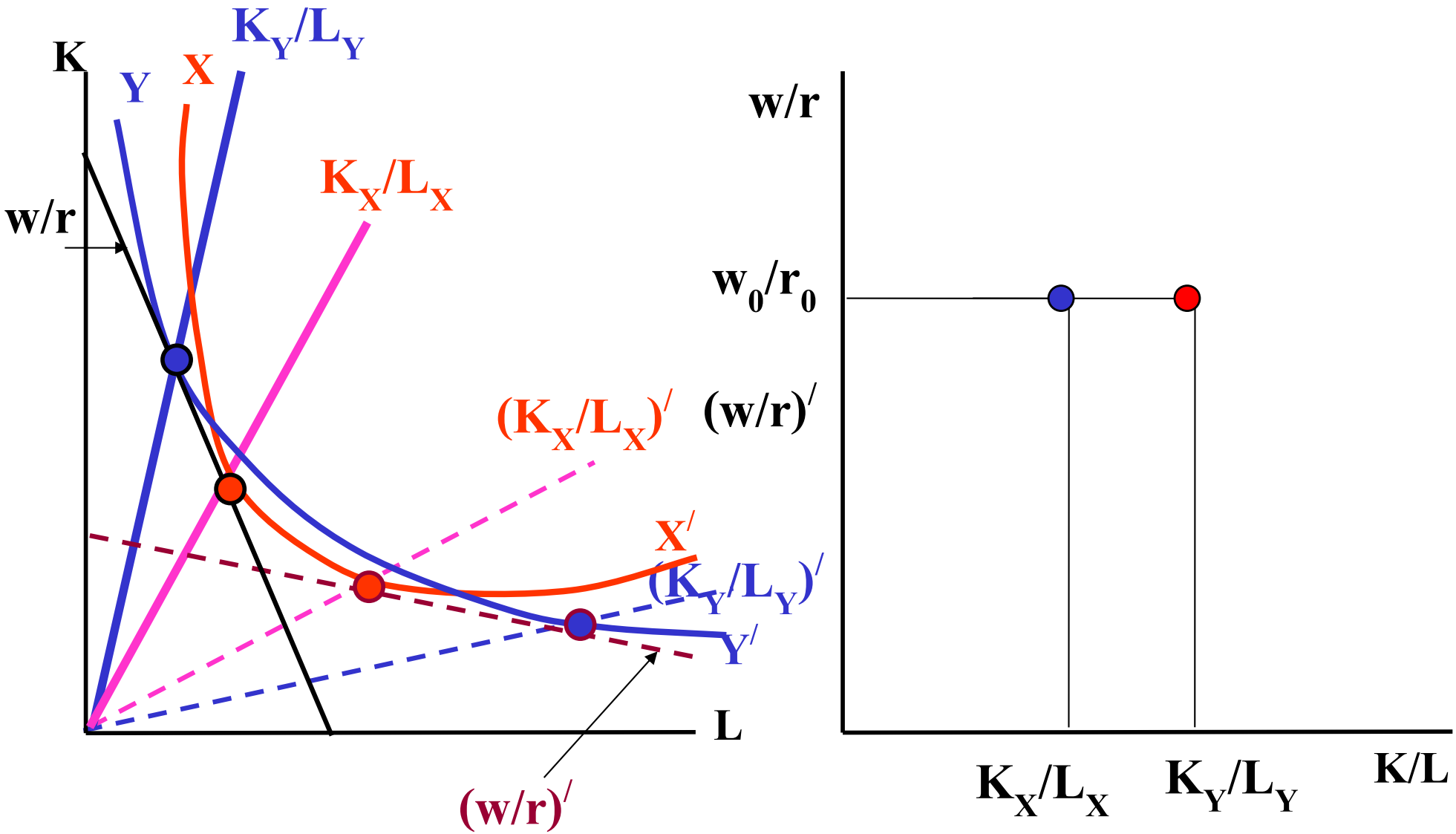


Factor intensity reversal means that the relative K-L ratio of the good may reverse when w/r is changed enough.

This happens when isoquants of the 2 goods cross more than once.

Y is K-intensive at w/r but turns L-intensive at $(w/r)'$.

Factor intensity and capital-labor ratio

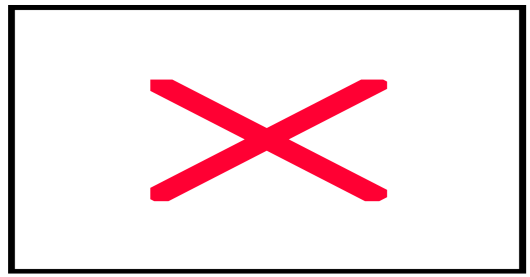


Factor intensity reversal (FIR): Example

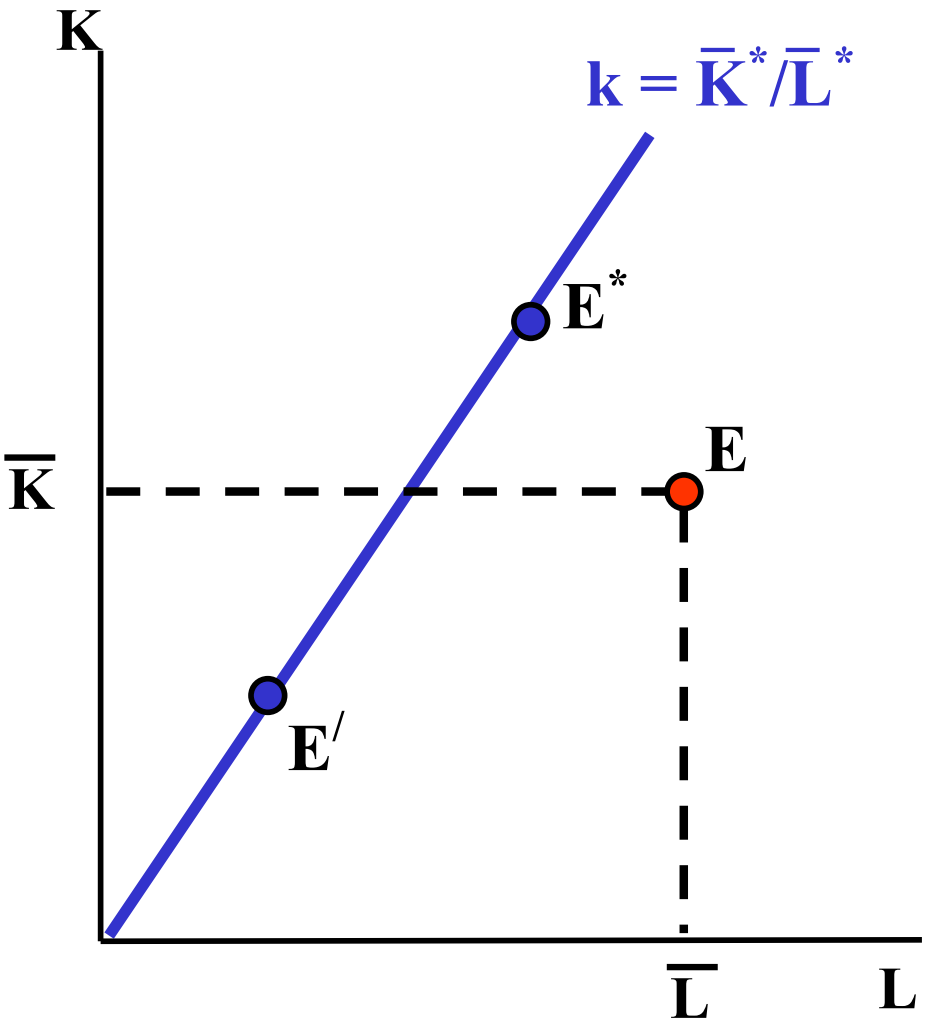
- Although all countries may have access to the same technologies, the machines used in the U.S. are different from those used in Asia and elsewhere
- Shoe production in US uses automated manufacturing machine, while the same production in India uses individual sewing machine
- In call centers, technologies are virturally identical and therefore factor intensities are similar across countries
- So, shoes in India are labor intensive compared to the call center—the opposite of the U.S.

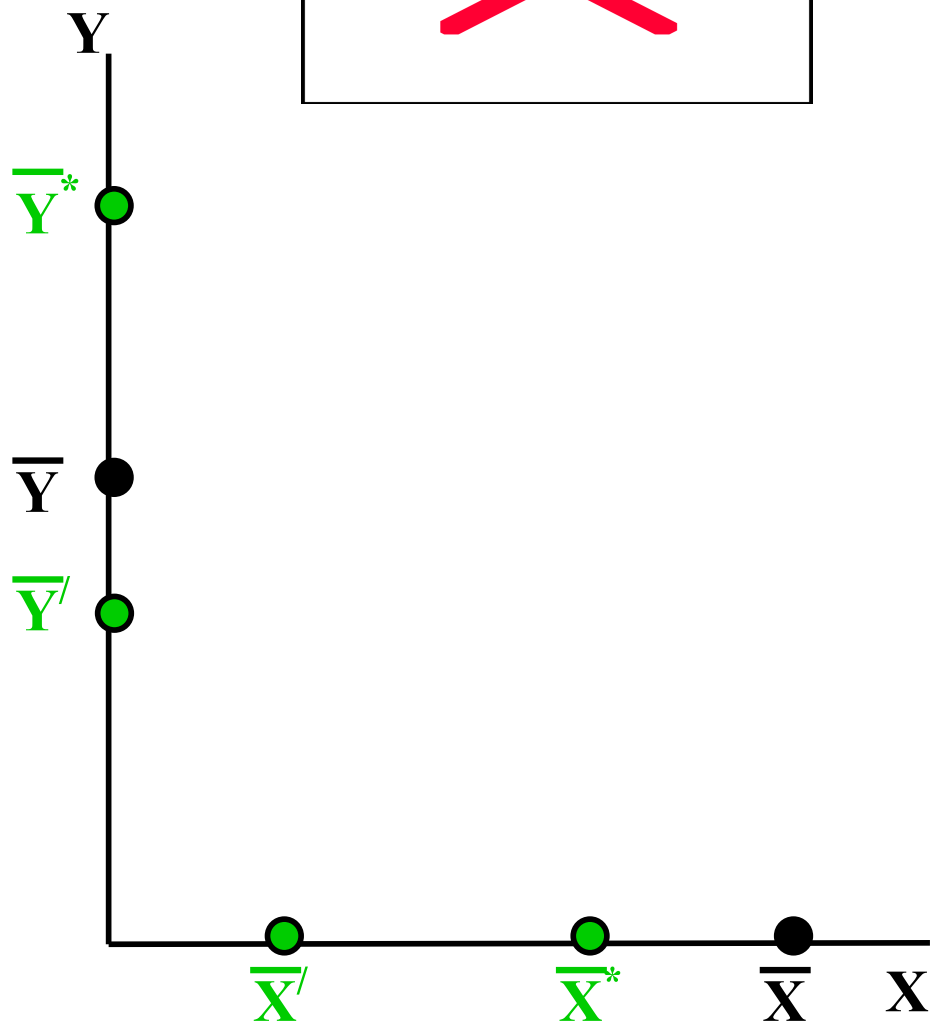
Factor Abundance

- The two nations are identical in every way except its factor abundance or the ratio between the capital stock and labor force that each country has.
- Factor abundance refers to supply of factors of countries
- It is assumed here that the supply of factors are fixed and Home is relatively labor abundant and Foreign is relatively capital abundant or the capital to labor supply in F is higher than those in H or



Factor Abundance and PPCs



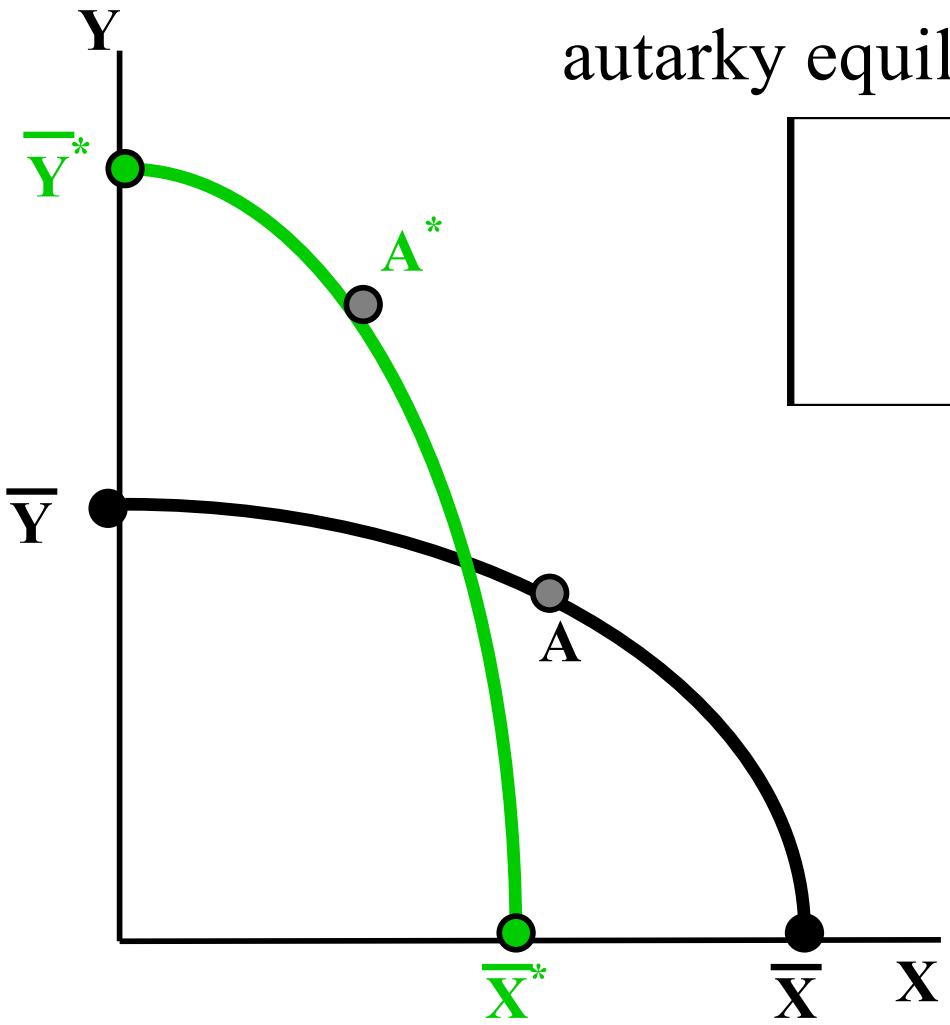


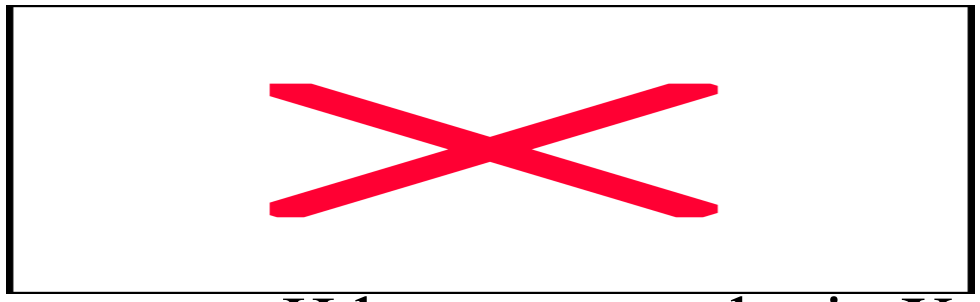
Factor Abundance and PPCs

- Home is L-abundant; its PPC is biased toward the X axis.
- Foreign is K-abundant; its PPC is biased toward the Y axis.
- This result holds, regardless of the sizes of the two economies as long as the factor proportions are the same.
  - Endowment point E^* and E' lie on the same ray k along with which relative endowments are the same.
  - Because of CRTS, isoquants for X and Y are both homogeneous of degree one.
  - PPC shrinks in or grows out in a parallel fashion.

Autarky equilibrium

- Given identical homothetic preferences, H's autarky equilibrium is at A while F's is at A^*.





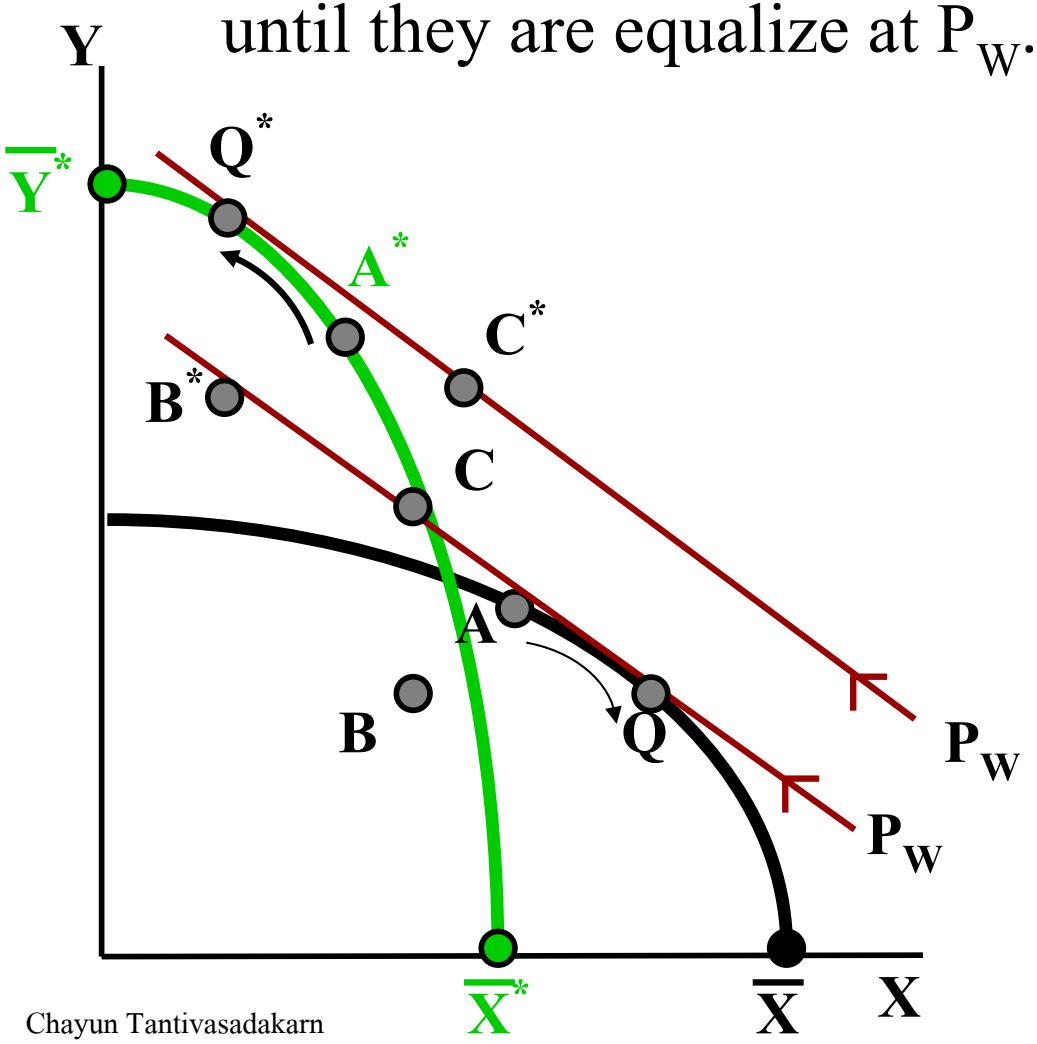
H has comp. adv. in X and F has comp. adv. in Y.

Note this result hold even with the smaller size economy with $\overline{Y}/\overline{X}$.

What if preferences are sufficiently biased toward X?

The Heckscher-Ohlin Theorem

- Since $P^*_A > P_A$, X from H is cheaper and Y from F is cheaper.
- D_X in H rises and P_X/P_Y rises. D_Y in F rises and P^*_X/P^*_Y falls until they are equalize at P_W.



H's production point moves to Q and consumes at C.

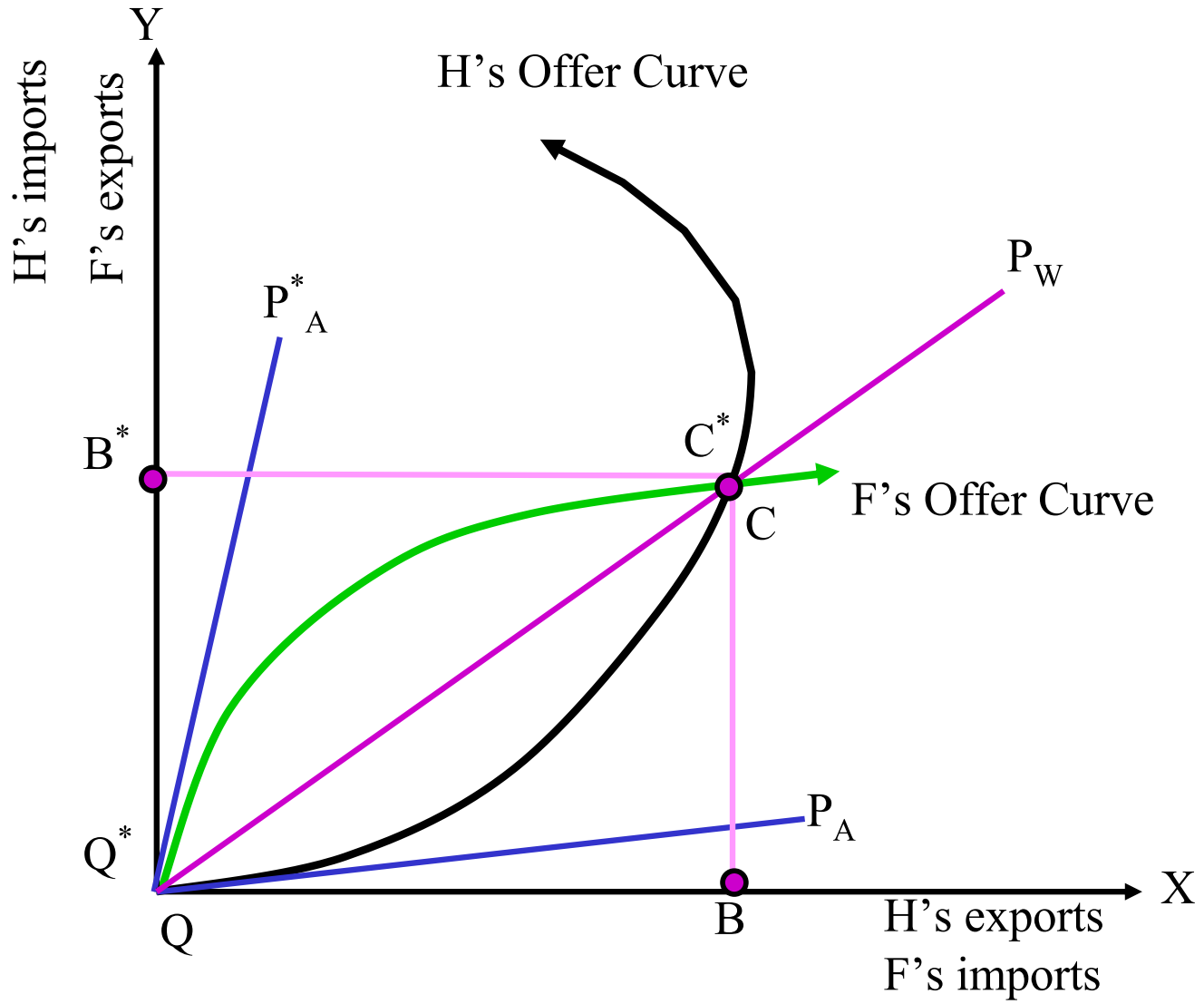
F's production point moves to Q^* and consumes at C^*.

F exports B^*Q^* and imports B^*C^*.

H exports $BQ = B^*C^*$ and imports $BC = B^*Q^*$.

Both countries gain from trade

Equilibrium relative price: Offer curves



The Heckscher-Ohlin Theorem

- The Heckscher-Ohlin Theorem: Given the assumptions of the model, a country will export the commodity that intensively uses its relatively abundant factor.
- It is also referred to as the Factor-Proportions Theory
- H is L-abundant, so the relative wage rate is lower and suitable to produce X which is L-intensive.
- F is K-abundant, so the relative interest rate is lower and suitable to produce Y which is K-intensive.
- H exports the L service which is its abundant factor and imports the K service which is its scarce factor.

Top 10 Exports

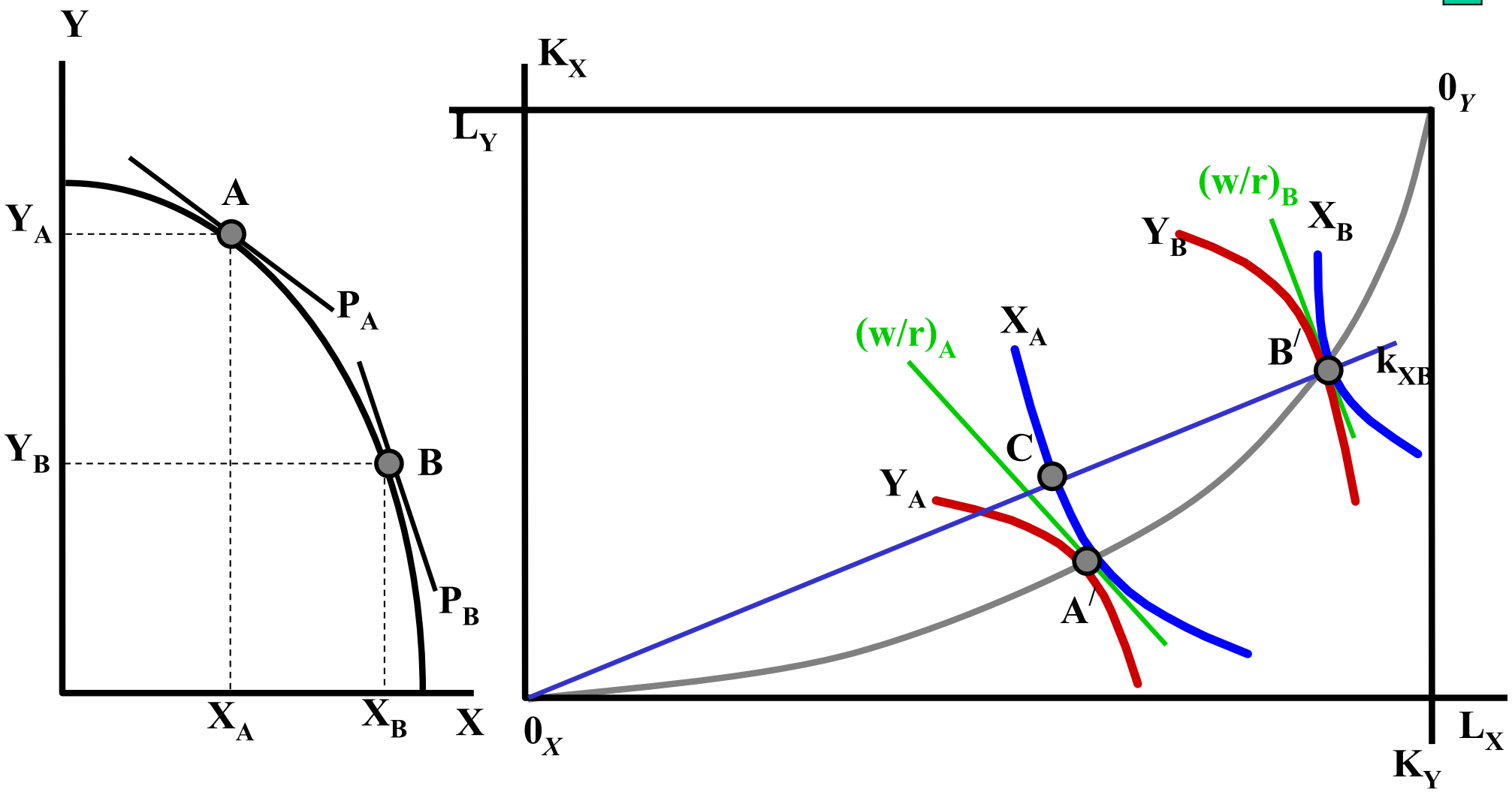
Rank	1999	2000	2001	2002	2003
1	Computers & Parts (307.3 ฿Bn.)	Computers & Parts (348.1 ฿Bn.)	Computers & Parts (351.8 ฿Bn.)	Computers & Parts (320.6 ฿Bn.)	Computers & Parts (340.1 ฿Bn.)
2	I.C. (111.8 ฿Bn.)	I.C. (179.3 ฿Bn.)	I.C. (154.9 ฿Bn.)	I.C. (148.1 ฿Bn.)	I.C. (191.6 ฿Bn.)
3	Garments (110.3 ฿Bn.)	Garments (124.2 ฿Bn.)	Garments (129.1 ฿Bn.)	Automobiles & Parts (125.3 ฿Bn.)	Automobiles & Parts (165.1 ฿Bn.)
4	Canned Seafood (76.4 ฿Bn.)	Automobiles & Parts (96.5 ฿Bn.)	Automobiles & Parts (117.6 ฿Bn.)	Garments (116.6 ฿Bn.)	Rubber (115.8 ฿Bn.)
5	Rice (73.8 ฿Bn.)	Canned Seafood (82.8 ฿Bn.)	Canned Seafood (89.4 ฿Bn.)	Gems & Jewelry (93.1 ฿Bn.)	Garments (114.9 ฿Bn.)
6	Automobiles & Parts (72.0 ฿Bn.)	Radios, T.V. (78.0 ฿Bn.)	Gems & Jewelry (81.3 ฿Bn.)	Radios, T.V. (90.1 ฿Bn.)	Gems & Jewelry (104.5 ฿Bn.)
7	Gems & Jewelry (67.5 ฿Bn.)	Plastic Pellets (74.0 ฿Bn.)	Radios, T.V. (74.9 ฿Bn.)	Canned Seafood (86.5 ฿Bn.)	Radios, T.V. (103.8 ฿Bn.)
8	Radios, T.V. (51.2 ฿Bn.)	Gems & Jewelry (69.4 ฿Bn.)	Plastic Pellets (71.4 ฿Bn.)	Plastic Pellets (77.1 ฿Bn.)	Plastic Pellets (89.3 ฿Bn.)
9	Frozen Shrimps (48.3 ฿Bn.)	Rice (65.6 ฿Bn.)	Rice (70.1 ฿Bn.)	Rubber (74.6 ฿Bn.)	Canned Seafood (88.9 ฿Bn.)
10	Plastic Pellets (46.0 ฿Bn.)	Rubber (60.7 ฿Bn.)	Rubber (58.7 ฿Bn.)	Rice (70.0 ฿Bn.)	Rice (76.7 ฿Bn.)

Source : Department of Trade Negotiations, Ministry of Commerce

Factor-Price-Equalization Theorem (FPE)

- The Heckscher-Ohlin Theorem shows that the differences in endowments lead to different factor prices, different pattern of comparative advantage and trade.
- But international trade eventually equalizes the commodity prices and change the production. What impact international trade should have on the factor prices of the trade partners?
- FPE Theorem predicts that international trade will equalize the relative factor prices.
- To show this we need to find the relationship between the commodity prices and the factor prices.

Commodity prices and factor prices

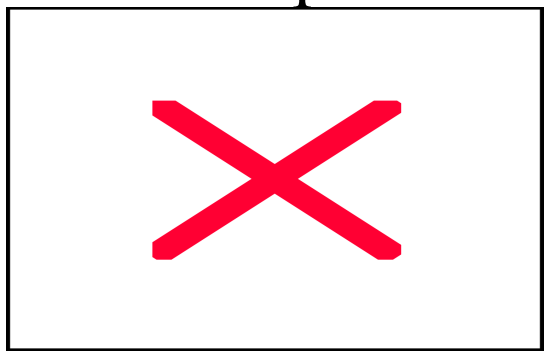


Commodity prices and factor prices

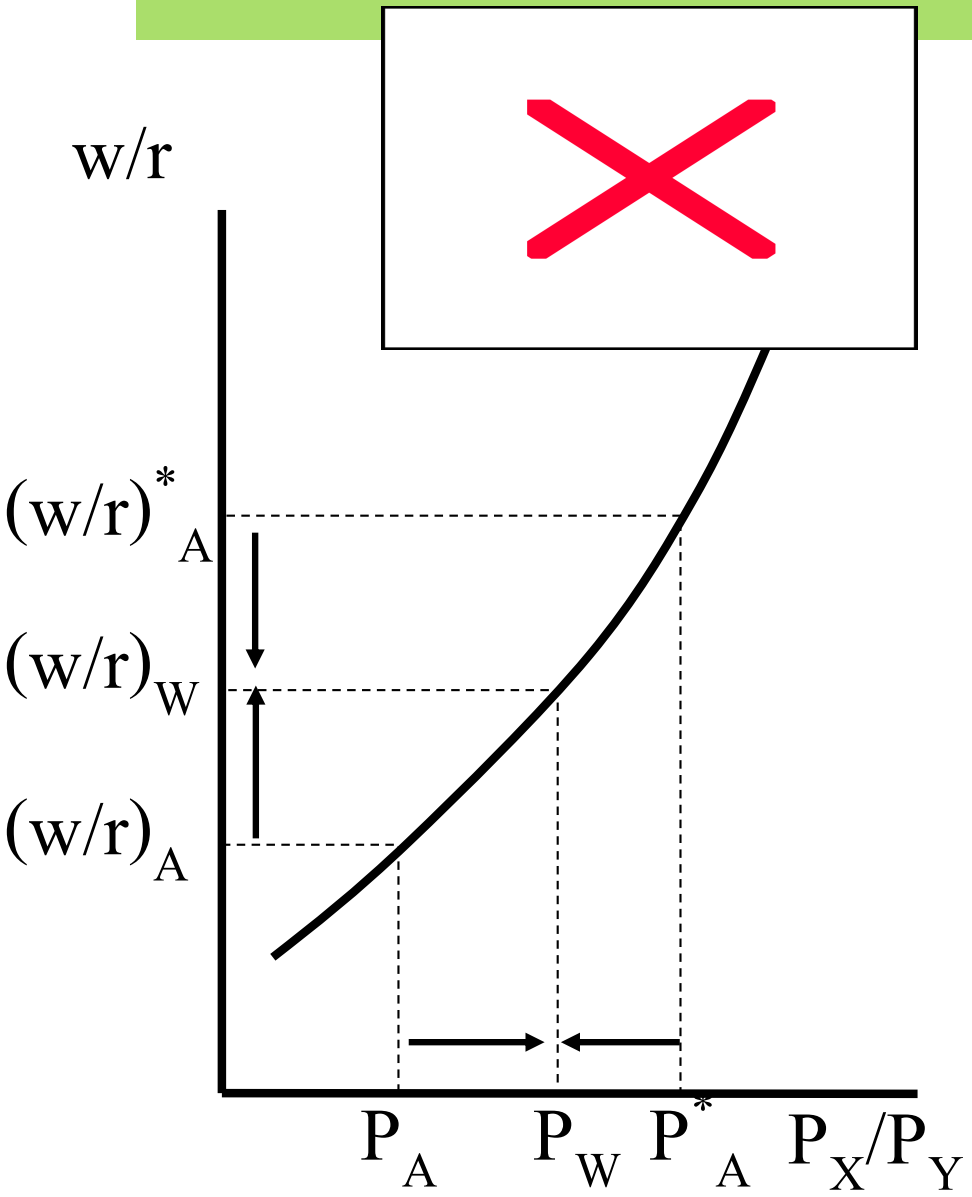
- At an initial price ratio P_A, the equilibrium on the PPC is at point A.
- This point corresponds to point A' in the Edgeworth box diagram
- Point A is the tangency point between the X_A and Y_A isoquants on the contact curve, the equilibrium factor price ratio is $(w/r)_A$.
- Suppose the relative price increases to P_B, the equilibrium on the PPC moves to point B. Outputs of X will rise and Y will fall.

Commodity prices and factor prices

- This point corresponds to point B' in the Edgeworth box diagram and the equilibrium factor price ratio is $(w/r)_B$.
- Given CRTS technology, the slope of X_B at point B' must be the same as the slope of X_A at point C which is higher than the slope of X_A at point A or $(w/r)_B > (w/r)_A$.
- This implies that as the relative commodity prices increases, the relative factor prices also increase.



Commodity prices and factor prices



- There is a unique relationship between relative commodity prices and the relative factor prices as long as both goods are produced.
- Reason: Since X is labor intensive, as P_X/P_Y increases, production of X increases. This demands more labor and increases the wage rate.

Factor-Price-Equalization Theorem (FPE)

- Note that this function is the same for both countries by CRTS and identical technology.
- Since free trade causing the relative commodity prices to equalize, the relative factor prices must also equalize.
- The Factor-Price-Equalization Theorem: Under identical CRTS, free trade in commodities will equalize relative factor prices through the equalization of relative commodity prices, so long as both countries produce both goods.

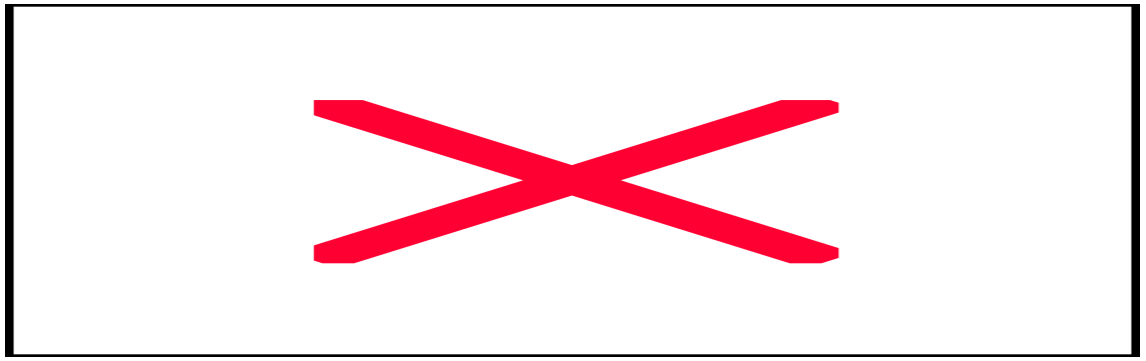
Why don't we observe FPE?

- Significant transportation costs.
- Trade restrictions: tariffs and quotas.
- Market distortions: monopolies, labor union
- Non CRTS technology
- Not identical technology
- Factor-intensity reversal
- Heterogeneous factor

Even though FPE is unlikely, trade can result in strong tendencies in that direction.

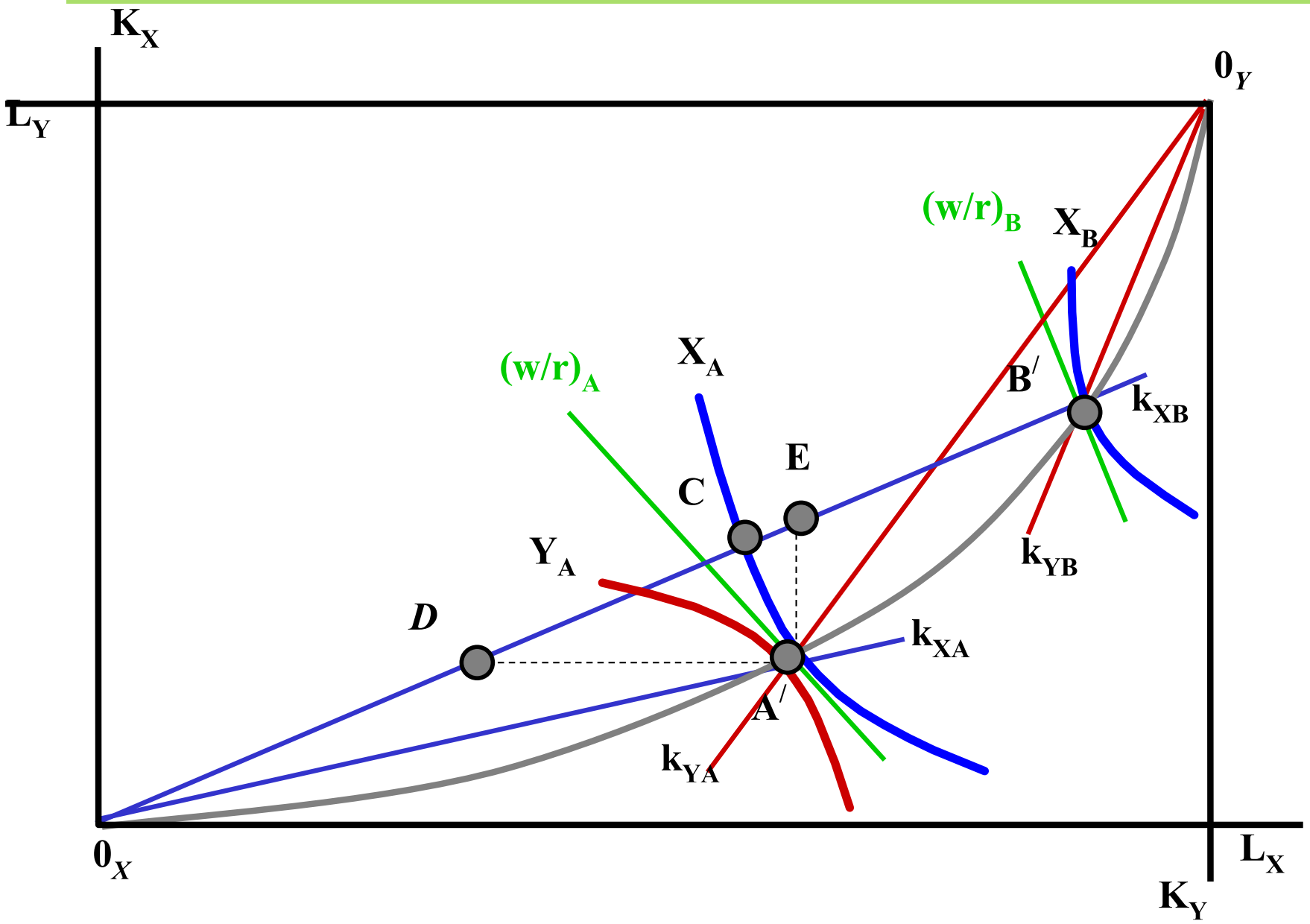
The Stolper-Samuelson Theorem

- The theorem intends to show that the change in commodity prices change the distribution of real incomes between capital and labor.
- From profit maximization conditions: VMP = factor price,



If the marginal products change, the real returns will change.

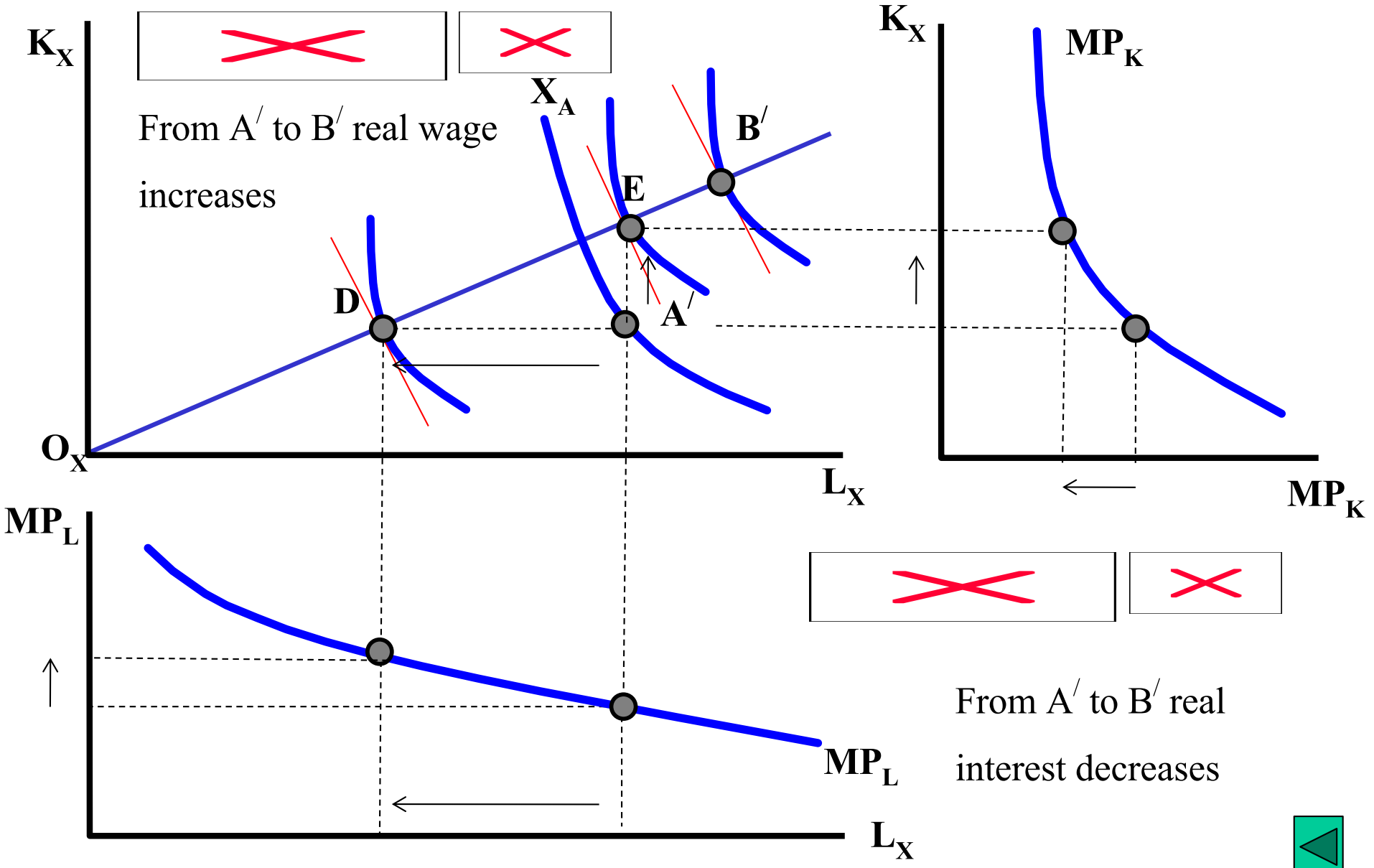
The Stolper-Samuelson Theorem



The Stolper-Samuelson Theorem

- Movement from $A^{/}$ to D reduces L keeping K constant. Law of Diminishing Returns implies further that MP_L at D is higher than that at $A^{/}$.
- By CRTS, the MP_L is constant along the ray $O_X DCB^{/}$. So MP_L at point D and $B^{/}$ are the same.
- MP_L at point $B^{/}$ is higher than MP_L at point $A^{/}$ and w/P_X is higher.
- Hence, the increase in commodity prices, movement from $A^{/}$ to $B^{/}$, has increased MP_L and w/P_X.

The Stolper-Samuelson Theorem

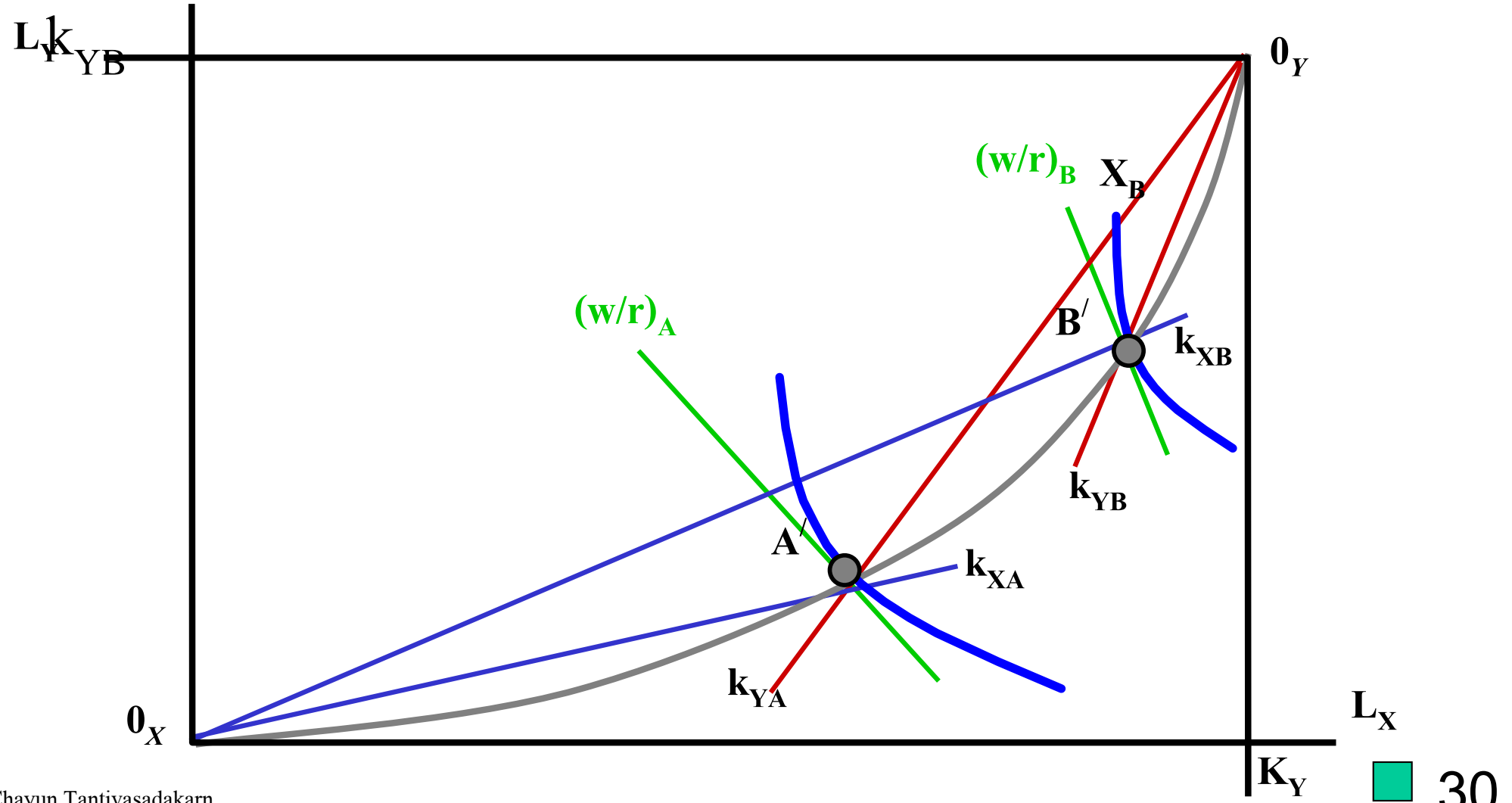


The Stolper-Samuelson Theorem

- Movement from $A^{/}$ to E raises K keeping L constant. Law of Diminishing Returns implies further that MP_K at E is lower than that at $A^{/}$.
- By CRTS, the MP_K is constant along the ray $O_XCB^{/}$. So MP_K at point E and $B^{/}$ are the same.
- MP_K at point $B^{/}$ is lower than MP_K at point $A^{/}$ and r/P_X is lower.
- Hence, these prove that the increase in commodity prices, movement from A to B, has decreased MP_K and r/P_X.

The Stolper-Samuelson Theorem

- Note that the K-L ratios in X at point $A^{/}$ is lower than those at point $B^{/}$ because $(w/r)_A < (w/r)_B$ or $k_{XA} < k_{XB}$ and $k_{YA} <$



The Stolper-Samuelson Theorem

- Movement from A' to B' increases X but decreases Y --> increases demand for L but decreases demand for K --> increase w/r, causing K/L to rise for both goods.
- This implies that any increase in K-L ratios will increase the real wage of L and lower the real returns to K.
- Since the movement from point A' to B' also increases the K-L ratios in Y, this will also increase the real wage of L and lower the real returns to K in industry Y.
- These results hold as long as the economy remains incompletely specialized.

The Stolper-Samuelson Theorem

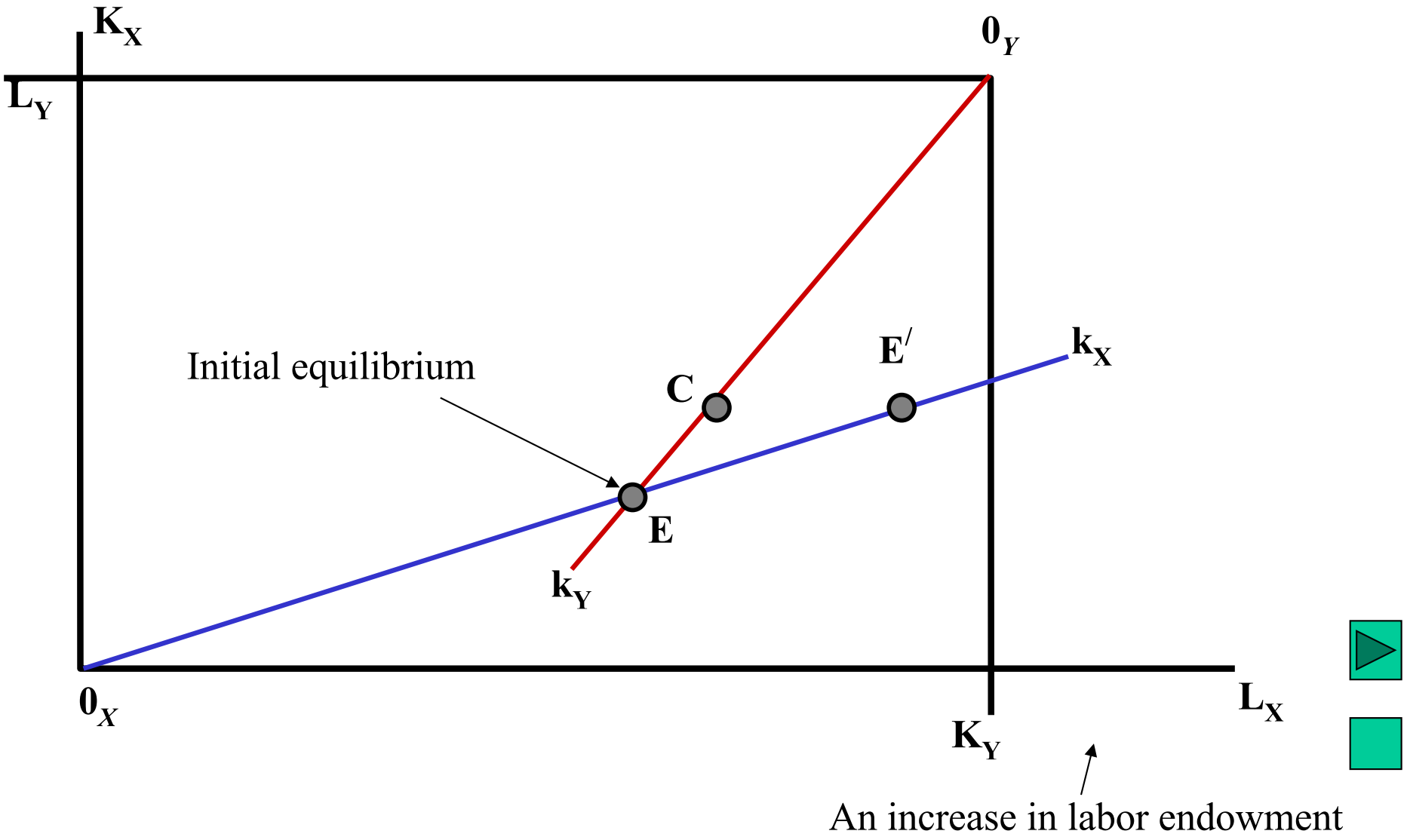
The Stolper-Samuelson Theorem: If there are CRTS and if both goods continue to be produced, a relative increase in the price of a commodity will increase the real return to the factor used intensively in that industry and reduce the real return to the other factor.

- A labor abundant country enters free trade. This will increase the relative price of labor intensive goods, make the workers better off and capitalists worse off.
  - Workers will support free trade while capitalists will oppose it.
  - Not only workers in labor intensive sectors will be better off, but also workers in capital intensive sectors

The Rybczynski Theorem

- The theorem show the relationship between changes in factor endowments and changes in the outputs of the two commodities when their prices are assumed to be constant.
- For instance, a country gains labor endowment through labor immigration.

The Rybczynski Theorem



The Rybczynski Theorem

- At the initial equilibrium point E on the contract curve where the isoquants of X and Y tangent, the K-L ratio for X and Y are k_X and k_Y, respectively.
- Suppose L is increased by ΔL, the origin for Y is shifted from O_Y to O'_Y.
- Recall that there is a one-to-one relationship between P_X/P_Y and w/r. Since P_X/P_Y is constant, so is w/r. Therefore, the K-L ratios in both goods are not affected.

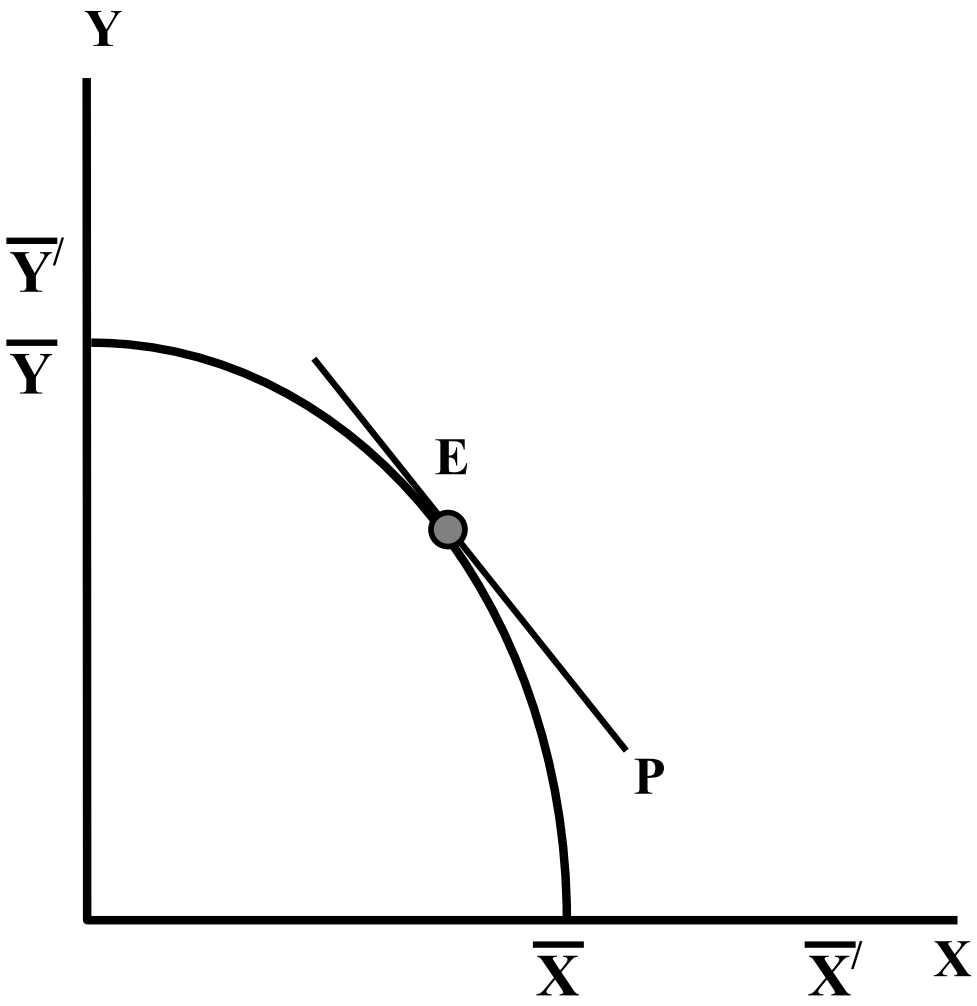
The Rybczynski Theorem

- Even though the endowment L has increased, the ray k_X and k_Y are not affected.
- Hence, the K-L ratio for Y is shifted parallel from k_Y to k'_Y and point E' must be the new equilibrium.
- Since point E' is farther from origin O_X than is point E, output of X must increase.
- Output of Y must decrease since O'_YE' is shorter than O_YE (O'_YE' is equal to $O_YC < O_YE$).

The Rybczynski Theorem

- The Rybczynski Theorem: If relative commodity prices are constant and if both commodities continue to be produced, an increase in the supply of a factor will lead to an increase in the output of the commodities using that factor intensively and a decrease in the output of the other commodities.
- Reason: The increase in L-intensive good, X, draws both L and K from K-intensive good, Y, causing Y to contract.

The Rybczynski Theorem



- An increase in L endowment will shift the PPC biased toward the X (L-intensive good) axis from $\overline{X}\overline{Y}$ to $\overline{X}'\overline{Y}'$.

Since P is constant, the equilibrium moves from E to E′.

The line joining them is called the Rybczynski line.

Note that X increases while Y decreases.

Testing the Heckscher-Ohlin Model

- **Tests on U.S. Data**
  - **Leontief paradox:** Leontief found that U.S. exports were less capital-intensive than U.S. imports, even though the U.S. is the most capital-abundant country in the world.

Factor Content of U.S. Exports and Imports for 1962

	Imports	Exports
Capital per million dollars	$2,132,000	$1,876,000
Labor (person-years) per million dollars	119	131
Capital-labor ratio (dollars per worker)	$17,916	$14,321
Average years of education per worker	9.9	10.1
Proportion of engineers and scientists in work force	0.0189	0.0255

Source: Robert Baldwin, "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review* 61 (March 1971), pp. 126–145.

Testing the Heckscher-Ohlin Model

- Leontief used labor and capital used directly in the production of final good exports in each industry.
- He also measured the labor and capital used indirectly in the industries that produced the intermediate inputs used in making exports.
- The capital is high because we are measuring the whole capital stock—not the part actually used to produce exports.
- The capital/labor ratio was $14,000: each person employed was working with $14,000 worth of capital.

Testing the Heckscher-Ohlin Model

- It was impossible for Leontief to get information on the amount of labor and capital used to produce imports.
- He used data on U.S. technology to calculate estimated amounts of labor and capital used in imports from abroad.
  - Remember the HO model assume technologies are the same across countries.
- This gave a capital/labor ratio of $18,200 per worker.
  - This exceeds the ratio for exports.

Heckscher-Ohlin Model

- Leontief assumed correctly that in 1947 the U.S. was capital abundant relative to the rest of the world.
  - From the HO model, Leontief expected that the U.S. would export capital intensive goods and import labor intensive goods.
- Leontief, however, found the opposite.
  - The capital labor ratio for U.S. imports was higher than for exports.
- This contradiction came to be called **Leontief's paradox.**

Testing the Heckscher-Ohlin Model

- **Tests on Global Data:** A study by Bowen, Leamer, and Sveikauskas tested the Heckscher-Ohlin model using data for a large number of countries.
  - This study confirms the Leontief paradox on a broader level.
- **Tests on North-South Trade**
  - North-South trade in manufactures seems to fit the Heckscher-Ohlin theory much better than the overall pattern of international trade.

Testing the Heckscher-Ohlin Model

- **A study by Trefler in 1995 showed that technological differences across a sample of countries are very large.**

Estimated Technological Efficiency, 1983 (United States = 1)

Country	
Bangladesh	0.03
Thailand	0.17
Hong Kong	0.40
Japan	0.70
West Germany	0.78

Source: Trefler, *American Economic Review,* (December 1995), p. 1037.

Possible explanations for the Leontief paradox

- Assumptions of H-O model are too restrictive:
  - land and natural resources
  - skilled and unskilled labor
- Demand biases for goods in which it normally has comparative advantage.
- Non-identical technologies.
- Factor intensity reversal.

Summary

- The Heckscher-Ohlin model, in which two goods are produced using two factors of production, emphasizes the role of resources in trade.
- The Heckscher-Ohlin theorem predicts that a country will export the commodity which uses *intensively* its *abundant* factor and import the commodity which uses *intensively* its *scarce* factor.
- International trade tends to equalize factor prices. Complete FPE is not observed due to transportation costs, barriers to trade, distortions, differences in technology and inputs.

Summary

- A rise in the relative price of the labor-intensive good will shift the distribution of income in favor of labor:
  - The real wage of labor will rise in terms of both goods, while the real income of capitalists will fall in terms of both goods.
- For any given commodity prices, an increase in a factor of production increases the supply of the good that uses this factor intensively and reduces the supply of the other good.

Summary

- The owners of a country's abundant factors gain from trade, but the owners of scarce factors lose.
- Empirical evidence is mixed on the Heckscher-Ohlin model.
  - Most researchers do not believe that differences in resources alone can explain the pattern of world trade or world factor prices.

The Specific-Factor Model

- H-O model assume free mobility of factors between sectors which can only happen in the long run.
- In the short run, some factors, such as capital take a long time to be converted from one industry to others.
- This model assume that capital is fixed and specific to each sector but labor still freely mobile.
- It is a short run version of H-O model.

The Specific-Factor Model: Assumptions

- 2 countries, 2 homogenous goods: X and Y
- Perfect competition in all markets. PX and PY are given.
- 3 factors: mobile Labor (L), specific capital for X (KX), specific capital for Y (KY).

$$X = F(KX,LX)$$

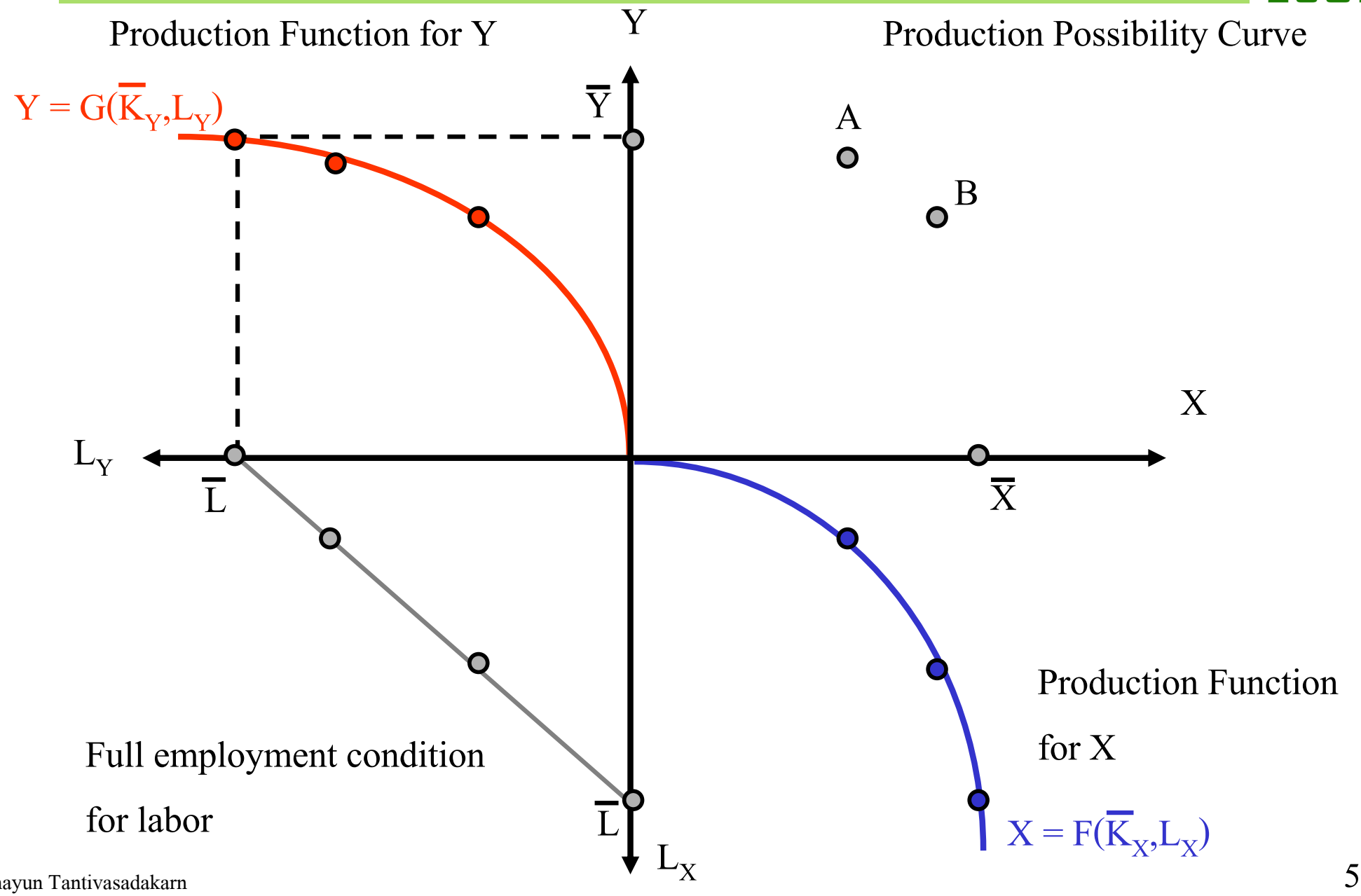
$$Y = G(KY,LY)$$

- Full employment conditions

$$K_X = \bar{K}_X, \quad K_Y = \bar{K}_Y,$$

$$L_X + L_Y = \bar{L}$$

The Specific-Factor Model: PPC



The Specific-Factor Model: labor allocation

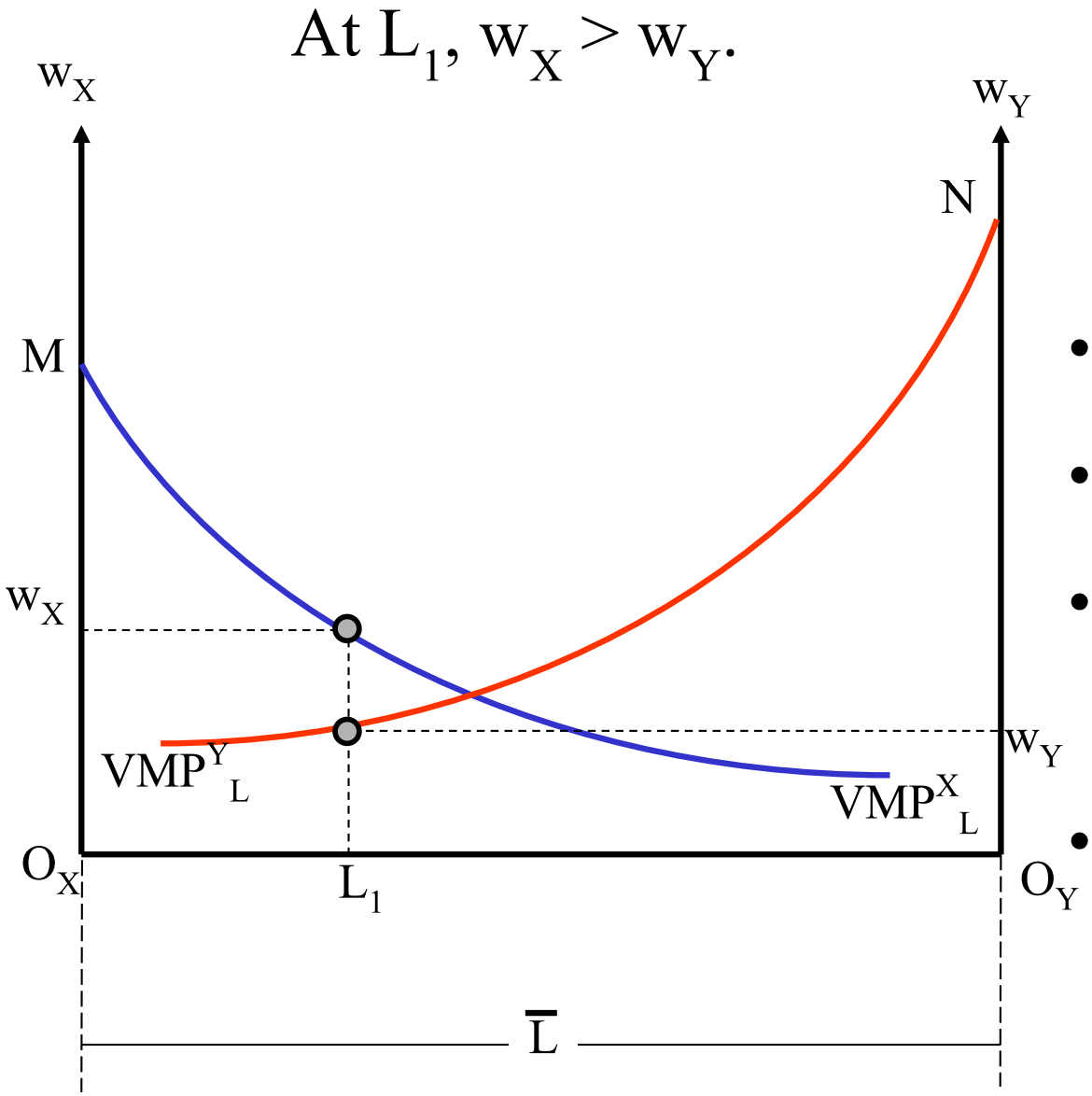
- Profit maximization requires that

$$VMP^X_L = P_X MP^X_L = w$$

$$VMP^Y_L = P_Y MP^Y_L = w$$

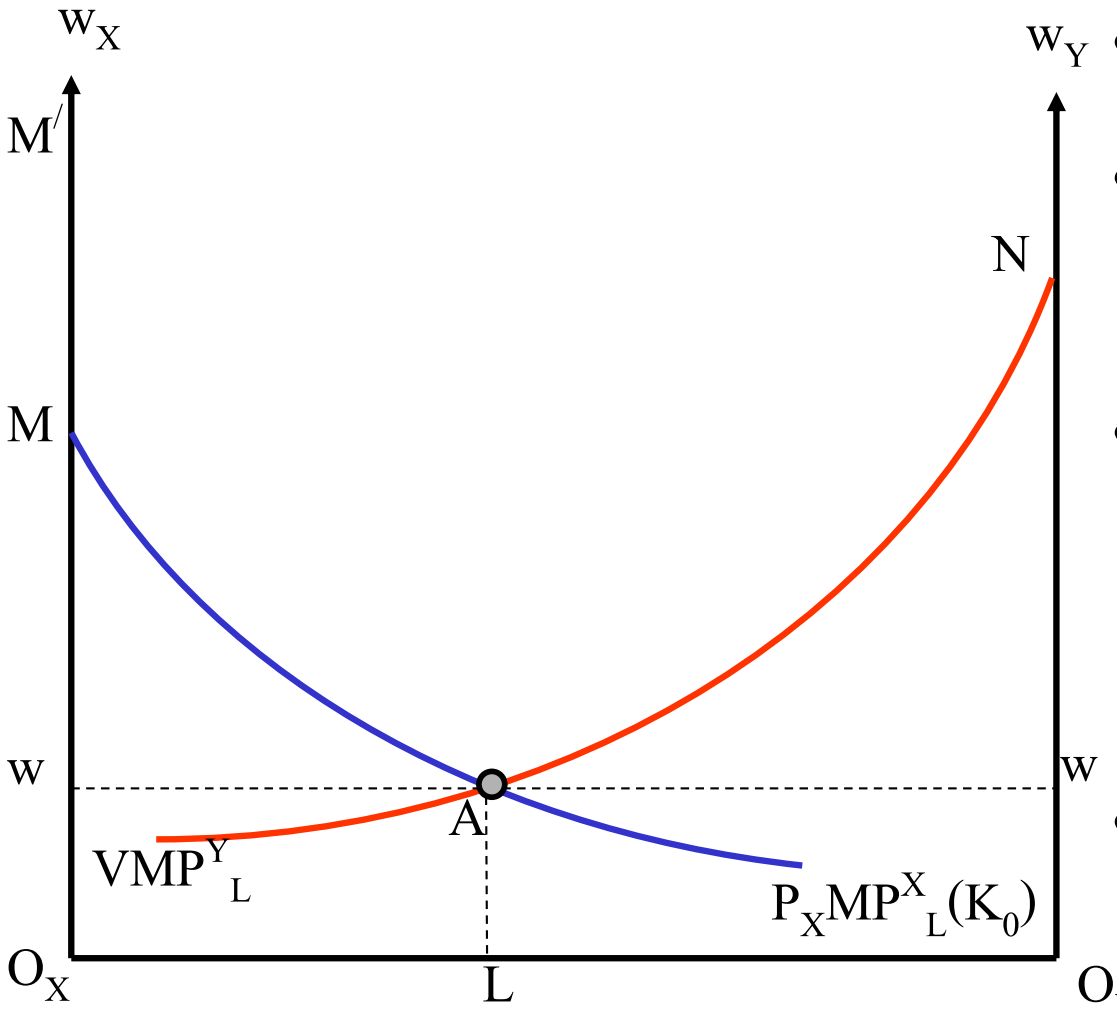
- Since labor is freely mobile, there must be only one wage rate. Hence, labor will move across industries until $VMP^X_L = VMP^Y_L$.
- VMP^X_L is plotted from left to right while VMP^Y_L is plotted from right to left.
- The length of the horizontal axis represents the labor supply: $\bar{L} = L_X + L_Y$

The Specific-Factor Model: labor allocation



- Labor will move from Y to X until wages are equalized at w.
- Employment in X = L_X.
- Employment in Y = L_Y.
- Labor income = area wO_XO_Yw.
- Capitalist return in X = AwM. Capitalist return in Y = AwN.

The Specific-Factor Model: increase in $\overline{K}_X$



- MP^X_L and VMP^X_L move up.
- This increases w, L_X, X and decreases L_Y and Y.
- r_X must fall since $\overline{K}_X$ increases. r_Y must also fall since output Y fall.
- Since good prices are fixed, real wage increases and real returns on both specific factor decreases.

The Specific-Factor Model: increase in K_X

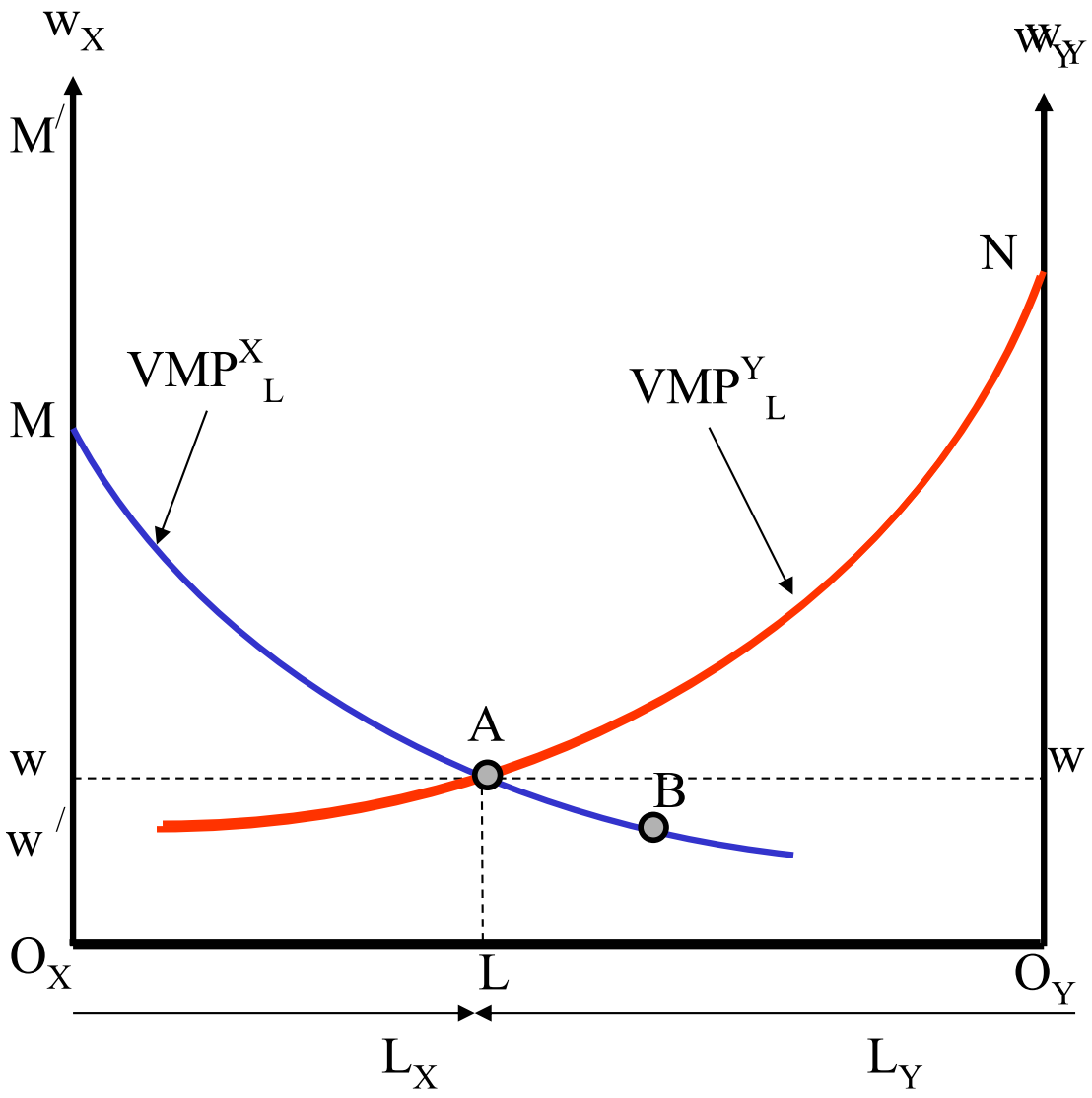
- If technology is constant returns to scale, the marginal product depends on K-L ratio. For instance,

  $X = L^{\alpha} K^{1-\alpha}$,

$$MP_L^X = \alpha\left[K/L\right]^{1-\alpha}, \quad MP_K^X = (1-\alpha)\left[L/K\right]^{\alpha}$$

- From $P_X MP^X_L = w$ and $P_X MP^X_K = r_x$, we know that $w/P_X = MP^X_L$ and $r_x/P_X = MP^X_K$.
- When K/L increases, MP^X_L and w/P_X increase; at the same time MP^X_K and r_x/P_X decrease

The Specific-Factor Model: increase in L



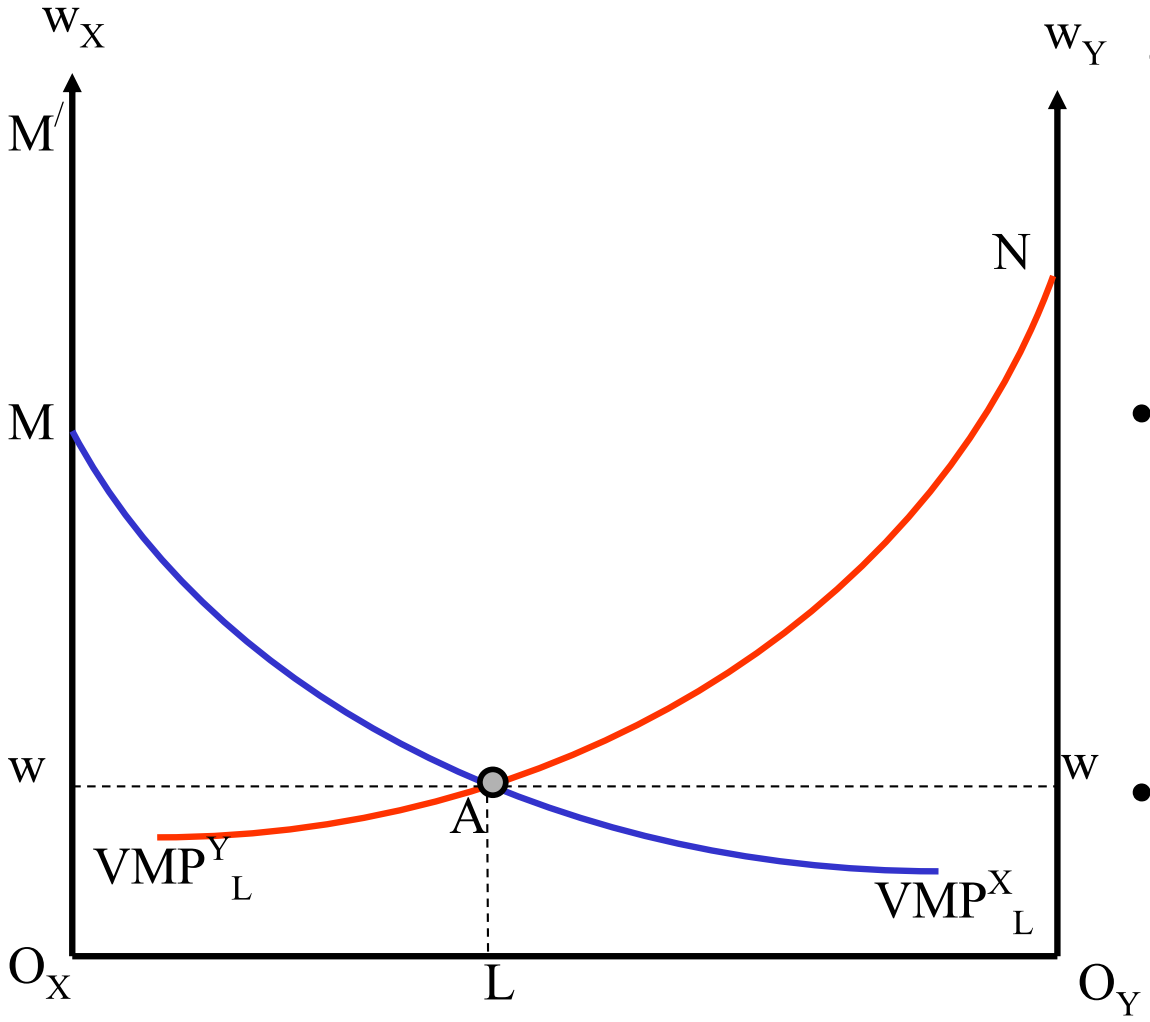
The Specific-Factor Model: increase in L

- The increase in L, will increase the length of the labor axis and carry the VMP^{Y}_{L} with it.
- Nominal wage falls due to the increase in labor supply.
- Both X and Y increase.
- Nominal r_X and r_Y rise because the increase in outputs increase the demand for their specific factors.
- Since good prices are constant, real wage falls, real r_X and r_Y both rise.

The Specific-Factor Model: increase in endowment

- At constant commodity prices, any increase in the endowment of a specific factor will increase the real returns to the mobile factor and lower the real returns to both specific factors.
- An increase in the endowment of the mobile factor will reduce its own real income and increase the real income of both specific factors.

The Specific-Factor Model: change in a price



- If P_X increases by free trade, VMP^X_L shifts upward.
- The $w_X > w_Y$, labor will move from Y to X until wages are equalized at $w^/$.
- Note that $w^/$ increases less than the increase in P_X.

The Specific-Factor Model: change in a price

- Employment in X, L_X increases. Employment in Y, L_Y decreases.
- Nominal labor income increases. w/P_Y increases while w/P_X decreases since w increases less than P_X.
- Capitalists nominal return in X increases to area $Bw^{/}M^{/}$. r_X/P_Y increases. r_X/P_X increases since MP^X_K increases by more L_X.
- Capitalists nominal return in Y decreases to area $Bw^{/}N$. Both r_Y/P_Y and r_Y/P_X decreases.

The Specific-Factor Model: change in a price

- A relative price increase of a good increases the real return of the specific factor used in that industry, reduces the real return of the other specific factor, and has an ambiguous effect on the mobile factor.
- Free trade affects the real returns in the short run differently from the long run.
- Different groups of capitalists may support free trade differently in the short run.