

Economic Integration and Factor Price Equalization

Project for ECON 567 Computer Modeling for Economic Policy Analysis

Jack Ke Jin

Xuanping Lim

Renyong Zhang

Contents

I.	Introduction.....	1
II.	Model	2
	A. Assumptions	2
	B. Variables	3
	C. Equations.....	4
III.	Simulation Results and analysis.....	5
	A. Stage 0, initial endowments.....	5
	B. Stage 1, autarky	5
	C. Stage 2, customs union	5
	D. Stage 3, currency union.....	6
	E. Stage 4, economic and monetary union.....	6
IV.	Conclusion	8

I. Introduction

Economic integration may occur over three main stages, namely the customs union, currency union then finally economic and monetary union. More successful cases include international entities like the European Union. Customs union implies removal of all trade barriers and tariffs to create free trade conditions between countries. Currency union implies that capital as a production factor is free to move between countries. Economic and monetary integration implies both capital and labor as factors of production are free to move between countries.

Factor price equalization is expected to take effect all three main stages, with no improvements in utility for from customs union or free trade, to currency union to economic and monetary union. All stages are expected to have the same utility level as each other. In figure 1, one country is labor abundant and the other is capital abundant, hence with the different initial endowments lines (K/L ratios). Both countries have the same budget constraint. Free trade occurs where the initial endowment lines intersects with the budget constraint and production curves.

Figure 1 Factor price equalization

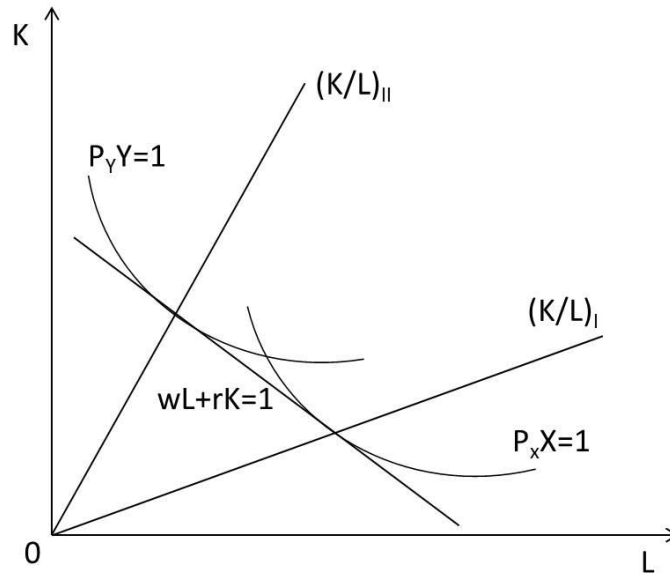
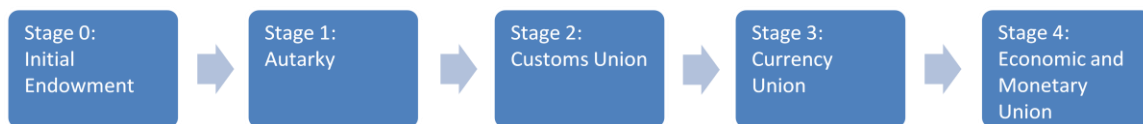


Figure 2 Simulation process of this case



II. Model

A. Assumptions

1) Economy structure

- Two countries: country I and country II.
- Two goods: good A and good B. Inferior goods are ruled out in this economy.
- Individuals in the population of each country have the same preference between good A and good B, i.e. the same utility function. Thus, the population in one country can behave collectively as a single entity.
- Initial production: country I produce 120.83 of A and 86.91 of B; country II produce 86.91 of A and 120.83 of B. Production values are optimized under condition of autarky.
- Initial endowment: country I has 30000 of L and 10000 of K; country II has 10000 of L and 30000 of K.
- Cobb-Douglas utility functions:

$$\text{Country I: } U_I = 2 \times A^{0.5} \times B^{0.5};$$

$$\text{Country II: } U_{II} = 2 \times A^{0.5} \times B^{0.5}.$$

- Both countries aim to maximize it utility.
- Both countries possess the same production technology level in each industry.
- There is no transaction cost in international trade.
- Initially, the two countries are in autarky and no trade exists between them.
- Production technology in two countries are the same, thus they have the same production functions in producing A and B

$$IA = IAL^{0.4} \times IAK^{0.1} \quad IB = IBL^{0.1} \times IBK^{0.4}$$

$$IIA = IIAL^{0.4} \times IIAK^{0.1} \quad IIB = IIBL^{0.1} \times IIBK^{0.4}$$

2) Price

- In this two-country, two-good economy, no currency is needed and good A is only exchanged for good B. Therefore, we use relative price in this barter economy and define relative price P as the quantity of A to be traded for one unit of B.

$$P = Ae / Be = PB / PA$$

3) Restrictions

- Trade balance

It is assumed that the countries in this economy seek a balance of trade, where total value of imports is equivalent to total value of exports.

$$P \times Be = Ae$$

- Material balance

The initial endowments for labor and capital in two countries are not the same. Country I is a labor abundant country and country II is a capital abundant country.

$$IAL + IBL = 30000 \quad IAK + IBK = 10000$$

$$IIAL + IIBL = 10000 \quad IIAK + IIBK = 30000$$

- Consumption ratio

At each equilibrium point, the marginal rate of substitution in each country equals to the inverse of relative price in that country.

$$MRS_{IAB} = \frac{MU_{IA}}{MU_{IB}} = \frac{dB_1}{dA_1} = \left(\frac{PA}{PB}\right)_I = 1 / P_I$$

and

$$MRS_{IIAB} = \frac{MU_{IIA}}{MU_{IIB}} = \frac{dB_2}{dA_2} = \left(\frac{PA}{PB}\right)_{II} = 1 / P_{II} ;$$

And these generate the following consumption ratio equations.

$$\text{Country I } A_1 = B_1 \times P_I \quad \text{and} \quad \text{Country II } P_{II} \times B_2 = A_2$$

B. Variables

In this model, 18 variables are to be used. All of variables listed below are endogenous variables all the time. But a few variables are not being used, depending on which stage the model is simulating.

Table 1 Variables definitions

	Variables	Type	Definition	Initial Endowment
1	<i>IA</i>	Endogenous	Initial production of A in Country I	109.73
2	<i>IB</i>	Endogenous	Initial production of B in Country I	78.92
3	<i>IIA</i>	Endogenous	Initial production of A in Country II	78.92
4	<i>IIB</i>	Endogenous	Initial production of B in Country II	109.73
5	<i>Ae</i>	Endogenous	Initial trade of A between I and II	0
6	<i>Be</i>	Endogenous	Initial trade of B between I and II	0
7	<i>P</i>	Endogenous	World Initial relative price	1
8	<i>IAL</i>	Endogenous	Initial labor in sector A in Country I	15000
9	<i>IBL</i>	Endogenous	Initial labor in sector B in Country I	15000
10	<i>IAK</i>	Endogenous	Initial capital in sector A in Country I	5000
11	<i>IBK</i>	Endogenous	Initial capital in sector B in Country I	5000
12	<i>IIAL</i>	Endogenous	Initial labor in sector A in Country II	5000
13	<i>IIBL</i>	Endogenous	Initial labor in sector B in Country II	5000
14	<i>IIAK</i>	Endogenous	Initial capital in sector A in Country II	15000
15	<i>IIBK</i>	Endogenous	Initial capital in sector B in Country II	15000
16	<i>UI</i>	Endogenous	Initial utility for Country I	186.12
17	<i>UII</i>	Endogenous	Initial utility for Country II	186.12
18	<i>TUtility</i>	Endogenous	Initial total utility for country I and II	372.24

C. Equations

There are 15 equations in the model. Equations 1, 2, 3 and 4 are used in customs union/free trade, equation 5 replaces equation 2 and 4 in currency union and equation 6 replaces equations 1 and 3 in economic and monetary union. After the customs union stage, consumption ratios in equations 14 and 15 are removed from the model.

Table 2 Equations definitions

	Equations	Definition
1	$MbLI = IAL + IBL$	Material balance country I labor
2	$MbKI = IAK + IBK$	Material balance of country II capital
3	$MbLII = IIAL + IIBL$	Material balance country I labor
4	$MbKII = IIAK + IIBK$	Material balance of country II capital
5	$MbK = IAK + IBK + IIAK + IIBK$	Material balance of labor
6	$MbL = IAL + IBL + IIAL + IIBL$	Material balance of capital
7	$IA = IAL^{0.4} \times IAK^{0.1}$	Production of A in country I
8	$IB = IBL^{0.1} \times IBK^{0.4}$	Production of B in country I
9	$IIA = IIAL^{0.4} \times IIAK^{0.1}$	Production of A in country II
10	$IIB = IIBL^{0.1} \times IIBK^{0.4}$	Production of B in country II
11	$UI = 2 \times (IA - Ae)^{0.5} \times (IB + Be)^{0.5}$	Utility of country I
12	$UII = 2 \times (IIA + Ae)^{0.5} \times (IIB - Be)^{0.5}$	Utility of country II
13	$Ae = Be \times P$	Balance of Trade
14	$IA - Ae = (IIB + Be) \times PI$	Consumption Ratio of country I
15	$(IIB - Be) \times PII = IIA + Ae$	Consumption Ratio of country II

Objective functions

Country I and country II maximize their respective utility functions during their own move, and after customs union the model maximize the total utility.

$$U_I = 2 \times A_1^{0.5} \times B_1^{0.5} = 2 \times (IA - Ae)^{0.5} \times (IB + Be)^{0.5}$$

$$U_{II} = 2 \times A_2^{0.5} \times B_2^{0.5} = 2 \times (IIA + Ae)^{0.5} \times (IIB - Be)^{0.5}$$

$$TUtility = UI + UII$$

III. Simulation Results and analysis

A. Stage 0, initial endowments

Both countries have same technology in producing goods A and B. Assume the production functions for goods A and B are both decreasing return to scale. Industry A is a labor-intensive industry and industry B is a capital-intensive industry.

$$IA = IAL^{0.4} \times IAK^{0.1}, \quad IB = IBL^{0.1} \times IBK^{0.4}$$

$$IIA = IIAL^{0.4} \times IIAK^{0.1}, \quad IIB = IIBL^{0.1} \times IIBK^{0.4}$$

Table 3 Variables values in stage 0, Initial endowments

Stage0 Initial endow- ments	IAL	IBL	IAK	IBK	IIAL	IIBL	IIAK	IIBK	IA	IB	IIA	IIB	Ae	Be	UI	UII
	15000	15000	5000	5000	5000	5000	15000	15000	109.7	78.9	78.9	109.7	0	0	186.1	186.1

B. Stage 1, autarky

Country I and country II optimize their production of goods A and B to maximize their utilities. Factors of production capital and labor are not allowed to flow between country I and II.

Table 4 Variables values in stage 1, country I in autarky

Stage1 autarky	IAL	IBL	IAK	IBK	IA	IB	UI
	24000.05	5999.96	2000.01	8000	120.83	86.91	204.95

Table 5 Variables values in stage 1, country II in autarky

Stage1 autarky	IIAL	IIBL	IIAK	IIBK	IIA	IIB	UII
	8000	2000.01	5999.96	24000.05	86.91	120.83	204.95

C. Stage 2, customs union

Country I and country II form a customs union to engage in free trade. Factors of production capital and labor are not allowed to flow freely between countries.

Table 6 Variables values in stage 2, customs union

Stage2 customs union	IA	IB	IIA	IIB	UI	UII	Ae	Be	P	PI	PII
	129.45	79.60	79.60	129.45	209.05	209.05	24.93	24.93	1.00	1.00	1.00
	IAL	IBL	IAK	IBK	IIAL	IIBL	IIAK	IIBK	Tutility		
	26002.70	3997.30	2890.49	7109.51	7109.51	2890.49	3997.30	26002.70	418.00		

As can be seen in the result table, with free trade in two countries, the utilities of both countries increase compared with in autarky.

D. Stage 3, currency union

Country I and country II further integrate to form a currency union. Factor of production capital flows freely between the countries but labor does not. In this stage, another equation ($Ae = Be$) is added to the model, otherwise there would be numerous possible solutions.

Table 7 Variables values in stage 3, currency union

Stage3 currency union	IA	IB	IIA	IIB	UI	UII	Ae	Be	P	PI	PII
	129.45	79.60	79.60	129.45	209.05	209.05	24.93	24.93	1.00	1.00	1.00
	IAL	IBL	IAK	IBK	IIAL	IIBL	IIAK	IIBK	Tutility		
	26002.70	3997.30	2890.49	7109.51	7109.51	2890.49	3997.30	26002.70	418.00		

As can be seen in the result table, by allowing capital to flow freely between two countries, all of the variables stay the same and the utilities of two countries do not improve. This result shows Paul Samuelson's theory "Factor Price Equalization", which says that if both countries have identical production technology and free trade, there is no need for free flow of factors.

E. Stage 4, economic and monetary union

Country I and country II economies integrate in an economic and monetary union. Factors of production, capital and labor, flow freely between countries.

Table 8 Variables values in stage 4, Economic and Monetary Union

Stage4 economic and monetary union	IA	IB	IIA	IIB	UI	UII	Ae	Be	P	PI	PII
	110.12	110.12	110.12	110.12	220.23	220.23	0	0	NA	NA	NA
	IAL	IBL	IAK	IBK	IIAL	IIBL	IIAK	IIBK	Tutility		
	16000	4000	4000	16000	16000	4000	4000	16000	440.47		

As can be seen in the result table, with free flow of capital and labor, the resource are reallocated in two countries and the utilities of both countries increase as a result. This counterintuitive result seems to be contradicting with “Factor Price Equalization”. In fact, the differences between stage 3 and stage 4 are caused by the basic settings of the production functions. The production functions in this model are decreasing return to scale, thus the optimal distribution of factors should not only consider factor price equalization, but also economy of scale.

IV. Conclusion

The economic model that we build can successfully represent the impact of optimal tariff policy. Several important conclusions are drawn from our simulation results:

1. By participating in international trade, both countries are better off.
2. According to Factor Price Equalization theorem, with same production functions, allowing for free flow of labor and capital has the same outcome with only allowing for free trade.
3. Economy of scale can also affect the optimal allocation of labor and capital, in addition to factor price equalization.
4. The integration process of EU has benefited member countries only because the production technologies among different countries are different, otherwise economic and monetary union has the same effect with customs union.