A Classroom Experiment on the Specific Factors Model

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[Abstract]

This paper proposes a classroom-experiment approach to interrogate the specific factors model. Its design differs from earlier work in that students can observe both the factor prices in two different sectors, and the society's welfare. Students participate as factor owners and can produce both of two kinds of goods by allocating their resources to maximise their teams' welfare. Their resource endowment, relative prices, and trade rules vary round by round. Based on the outcomes, students discuss the impacts of relatively abundant resources, relative prices and trade rules on team welfare, individual income and the gains from trade. This classroom experiment could foster better learner understanding of the specific factors model, both individually and collectively.

Keywords: Specific factors model; experiment design; economics education; international trade

JEL: A22; F16; C90

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1   Introduction

In theory, international trade is mutually beneficial to the countries engaged in it. However, in the real world, governments commonly protect sectors of their countries' economies from import competition, and trade also has substantial effects on income distribution within each trading nation, leading to its benefits often being distributed unevenly. Krugman, Obstfeld, and Melitz (2018) articulated two main reasons for international trade's strong effects on the income distribution: inmobile resources among industriesand different production requirements among industries. These reasons cause the factor owners may gain and loss from trade.

Following Ricardo (1891) and Viner (1932), the well-known specific factors model, as extended by by Samuelson (1971) and Jones (1971), was developed to deepen our understanding of international trade and trade policies. The trade effects are not only on a country as a whole, but on the distribution of income among production sectors. For example, Malki, Thompson, and Yeboah (2009) utilised it to predict the impact of Free Trade Area of the Americas on the textile and appearel industries in North Carolina, and found that it led to income redistribution across six labour skill groups, as well as generally higher wages due to rising product prices. Several similar models have since been developed from those of Jones and Samuelson: for example, by Bliss (2003), Melvin and Waschik (2001) and Dogan and Akay (2016).

To illustrate the variants of the specific factors model in the classroom, Tohamy and Mixon (2003) employed 'what-if' questions within prepared spreadsheets that allowed students to look into the workings of the model and change its structure. As well as providing important advantages over 'black-box' presentations, this approach gave students an opportunity to practise their use of spreadsheet software. Similarly, Gilbert and Oladi (2011) Heckscher-Ohlin-Samuelson model, built in Excel software, combines a numerical description of the equilibrium with various common textbook geometric manipulations. This allows its users to instantly observe the impacts of modifications to the model's parameters and exogenous variables, both numerically and graphically. The areas that can be observed in this way include specific factors, factor proportions, the general equilibrium of trade and industrial policy, trade disputes, and preferential trading agreements.

Unlike these numerical simulations, the classroom-experiments approach allows students to experience the relationship of the production process to the trading system and to witness the precision with which economic theory predicted. As Oxoby (2001) suggested, this pedagogical tool provides a means of empirically

demonstrating abstract concepts; and when the related activities are thoroughly prepared, interaction amongst students can lead to a profound understanding of factor allocation, employment and income distribution.

Dickie (2006), Kaplan and Balkenborg (2010), Emerson and English (2016) and Raboy (2017), among others, have suggested that classroom experiments increase learning motivation. In part, this may be because they allow students to put themselves in economic agents' shoes, and thus not only gain a working understanding of economic concepts, but also learn to take economic decisions and evaluate the consequences. For instance, Yamarik (2018) classroom experiment that mimicked trade between the U.S. and Japanese automobile industries illustrated the gains from intra-industry trade, as well as how efficiency gains and economic recession can impact individual firms' performance.

The purpose of this study's focal experiment is to provide students with a basic grounding in the specific factors model and its use. More specifically, it is designed to help students (1) understand how a mobile factor will respond to product price changes by moving across sectors; (2) explain why trade will generate both winners and losers in the short run; (3) see how differences in resources generate specific patterns of trade; and (4) comprehend the arguments in favour of free trade, despite the existence of losers.

This approach is divided into two phases. In the first, without being informed about the specific factors model, students participate as factor owners and produce two kinds of goods by allocating their resources to maximise their respective teams' welfare. Their resource endowment, the prices of the two goods, and trade rules vary in each of the four rounds. The second phase, based on the results of the first, provides a powerful illustration of the specific factors model via student discussion of the impacts of relative resource abundance, relative prices and trade rules on team welfare, individual income and gains from trade. In addition, engagement with one another in small groups equips the students, both individually and collectively, with a better understanding of the interaction between factor owners.

The remainder of this article is structured as follows. Section 2 presents its theoretical model and predictions; section 3, its experimental design and findings; and the final section, its conclusions. All experimental materials, include instructions, control questions, individual and group record sheets, and discussion questions, are provided in appendices section.

2   The Model

2.1 In a Closed Economy

In an economy with two products, goods 1 and 2, and three factors (*H*, *S*, and *C*), the allowances of the factors are $\bar{H}$, $\bar{S}$ and $\bar{C}$, respectively. When addressing the issue of income distribution among the three factors, we assume that the two production functions have fixed proportions. The production functions of an economy's production possibilities in a three-factor specific factors model can be described as:

$$G_1(S, H_1) = \min \ \left\{\frac{S}{3}, \sqrt{2H_1}\right\} \tag{1}$$

and

$$G_2(C, H_2) = \min \ \left\{\frac{C}{4}, \sqrt{4H_2}\right\} \tag{2}$$

where G_1 and G_2 are respectively the production quantities of goods 1 and 2. The specific factors model assumes that one production factor (*H*) is mobile between sectors, while the two others (*S* and *C*) are sector-specific. The mobile factor *H*, $H = H_1 + H_2$, is used to arrive at G_1 and G_2 respectively; *S* can only produce good 1; and *C* can only produce good 2. In prior studies, the mobile factor has usually been used to illustrate the labour movement between industries.

2.1.1 Production possibilities

Each country uses its resources to maximise production. The input cost (wages, or rent of inputs) is revenue divided by the amount of inputs. As we assume that *H* is perfectly mobile between industries, the factor owner's income must be identical between industries. We simplified the model by assuming the factors are complements, so that production requires a fixed proportion of factors. This implies that the marginal rate of technical substitution of the mobile factor for the specific factor is either zero, or infinite. Thus, factors cannot be substituted for one another to maintain a constant output.

To analyse the production possibilities of the economy, we need only to ask how its mix of outputs changes as the mobile factor is shifted from one sector to the other. Given sufficient specific factors, the slope of the production possibility frontier (PPF) defines the rate at which production of good 1 can be replaced by the production of good 2. The PPF function for the mobile factor allowance $\bar{H}$ is

$$\frac{(G_1)^2}{2} + \frac{(G_2)^2}{4} = \bar{H} \tag{3}$$

The slope of PPF is also known as the marginal rate of transformation (MRT $= 2\frac{G_1}{G_2}$).

If the specific factors are insufficient to complement production, the latter is constrained and the shape of PPF is knife-edged.

For a specific factor supply, the resource allowances are $\bar{S}$ and $\bar{C}$, and the resource allocations cannot exceed the allowances, which can be written as

$$3G_1 \leq \bar{S}; \qquad \text{and} \qquad 4G_2 \leq \bar{C} \qquad (4)$$

This implies that the marginal products of specific factors are constant, $MPS = \frac{1}{3}$ and $MPC = \frac{1}{4}$. When the quantity of the mobile factor exceeds the requirement for it, an additional specific factor gives a constant return to the production. On the other hand, given a sufficient specific-factor supply, the marginal products of mobile factor H ($MPH_1 = \frac{\partial G_1}{\partial H_1} = \frac{1}{\sqrt{2H_1}}$ and $MPH_2 = \frac{\partial G_2}{\partial H_2} = \frac{1}{\sqrt{H_2}}$) are diminishing returns in both sectors.

2.1.2 Social welfare

The social welfare of the economy is calculated as

$$W = G_1 G_2 \qquad (5)$$

The marginal rate of substitution ($MRS = \frac{\partial W / \partial G_1}{\partial W / \partial G_2} = \frac{G_2}{G_1}$) is the rate at which a consumer can give up some amount of one good in exchange for another good while maintaining the same level of welfare. In an autarkic economy, an efficient production combination exists when the MRS equals the MRT. If all the specific factors are present in sufficient quantity, the relationship between two products is $2(G_1)^2 = (G_2)^2$, and efficient production is achieved when the mobile resource is used completely. This further implies that the mobile resource is allocated equally to both sectors ($H_1 = H_2$).

2.1.3 Determination of relative prices

In terms of production functions, an economy is economically efficient when its production possibility frontier is at a tangent to the relative price $\frac{P_1}{P_2}$. It is intuitive that an increase in the relative price of P_1 will move production from G_1 to G_2. As mentioned earlier, given a sufficient quantity of the specific factors, products' negative relative prices will equal the MRS; and thus, $\frac{P_1}{P_2} = \frac{G_1}{G_2}$. And when the mobile factor is allocated equally across two sectors, relative prices will be $\frac{P_1}{P_2} = \sqrt{\frac{1}{2}}$. The price of G_1 is cheaper than that of G_2. Thus, once can intuit that, at any given level

of mobile factor, the production of good 1 will be more than that of good 2.

2.1.4 Factor prices and income distribution

Now we turn to a consideration of factor prices, which could represent either the rent of capital resources or wages paid to labour. The profit-maximising rule will drive the factor allocation up to the point where the value produced by an additional factor equals the cost of that factor. This means that the prices of S and C depend on the product prices $\frac{1}{3}P_1$ and $\frac{1}{4}P_2$, respectively. The owners of those specific factors face a fixed return for additional input, and their incomes are $\frac{1}{3}P_1S$ and $\frac{1}{4}P_2C$, respectively.

The mobile factor's owner, meanwhile, faces a diminishing return in both sectors. In good 1's sector, the demand curve for the mobile factor describes the value of an additional H_1, which is the marginal product of H_1 multiplied by the price of one unit of G_1, MPH_1P_1. This sector achieves equilibrium when that value is equal to the factor price in both sectors. Therefore,

$$P_1MPH_1 = P_2MPH_2 \tag{6}$$

and the relationship between mobile resource allocation and relative prices is $\frac{H_1}{H_2} = \frac{1}{2}\left(\frac{P_1}{P_2}\right)^2$. Due to the diminishing return, the marginal product decreases as the quantity of factor increases. The factor owner will find that his or her factor's price has risen, but not proportionately to the rise in P_1. Thus, the real factor price of good 1 falls, while the real factor price of good 2 rises. The values of the marginal product of the mobile factor across sectors will be equal, meaning that additional units of that factor create the same value in both sectors. This reflects information about the effects of price changes on resource owners' income levels. The mobile factors' owners' total income is, $P_1\sqrt{\frac{H_1}{2}} + P_2\sqrt{H_2}$, i.e., the aggregate income from the two sectors. Since the mobile factor is not tied to one sector or the other, the impact of changes in its price on factor owners is ambiguous, and depends on the society's preference for the two goods.

2.2 International Trade in the Specific Factors Model

When international trade is taken into account, the market does not achieve equilibrium simply because the MRS equals the MRT. In other words, the relative price of a product does not depend on domestic production and consumption, but on an exogenous factor determined by relative supply and demand worldwide. Here, we denote the world prices for the two goods as P_1^w and P_2^w, and calculate the the

world relative price as P_1^w/P_2^w. The economy arrives at consumption equilibrium when the world relative price equals the MRS, $\frac{P_1^w}{P_2^w} = \frac{G_2}{G_1}$, and at production equilibrium when the world relative price equals the MRS, $\frac{P_1^w}{P_2^w} = 2\frac{G_1'}{G_2'}$, with G_1' and G_2' denoting the consumption of good 1 and good 2.

If the world relative price is higher than the domestic relative price, P_1/P_2, consumers in a given country will demand relatively more G_2 than G_1, and its economy will therefore export G_1 and import G_2. In other words, countries will export whichever good has a relative price below the world relative price. The world relative price may differ from the domestic price before trade for two reasons. First, as in the Ricardian model, countries differ in their production technologies; and second, countries differ in terms of their endowments of the factors specific to each industry. After trade commences, the domestic relative price will equal the world relative price; and as such, the relative price in the exporting sector will rise, and that in the sector competing with imports will fall, leading to an expansion of the former and a contraction of the latter.

2.2.1 Income redistribution and the gains from trade

To assess the effects of trade on a particular factor, we can look at how relative price changes translate into changes in income distribution. In a closed economy, the output of a product equals its consumption, and relative price is determined by domestic outputs. In an open economy, on the other hand, international trade makes it possible for the mix of products consumed to differ from the mix produced; and relative price is determined exogenously, i.e., by world supply and demand.

Income-distribution effects arise for two reasons: firstly, that the specific factors cannot move from one sector to another; and secondly, that changes in a national economy's production combination have differential effects on the demand for different production factors. It is reasonable to expect that differences in resource allowances will act as incentives to international trade, which in turn could affect products' relative price. More specifically, we assume that in the sector whose relative price increases, the specific factor owner will gain, and that the other sector, the specific factor owner will lose. In other words, trade benefits the factor specific to the export sector, while harming the factor specific to the import sector; and its effects on the mobile factor remain ambiguous.

3   Experiment Design

This experiment should be conducted in a classroom setting, and before it commences, students should read the instructions provided as Appendix 1, and answer the set of 14 control questions provided at the end of the instructions to test their understanding of the rules. However, to save time in class, this can be done as online homework. Play is designed to last for one hour, and once it ceases, a list of questions is provided for a further 30-minute discussion. Thus, the entire process can be completed in less than two hours.

During play, all participants are organised into teams of three, representing factor owners in a country. Each team uses its own record sheet (see Appendix 2), and each student, a separate individual record sheet (Appendix 3). In each round, each player receives a card that represents his or her role as the owner of resource S, C or H. Every card is also marked with a number (either 1 or 2), which multiplied by 15 is that resource's allowance, i.e., either 15 or 30. The sizes of these resource allowances imply the relative abundance of the production factors. Following Deardorff (1982), each team/country is expected to export goods whose production is intensive in factors with which it is abundantly endowed.

Each team works together to make two products by allocating their resources according to the production requirements set forth in the instructions. Disagreements about such allocations are resolved by a majority vote of the team members. Resources S and C are specific to G_1 and G_2 respectively, while resource H is used for both products. To simplify the procedure, production functions are set in fixed proportions, with no possibility of substituting one resource for another.

In each of the game's four rounds, participants are asked to produce by allocating their resources, with the goal of maximising their teams' welfare which as noted above is arrived at by multiplication of two types of consumption. Importantly, the welfare function is diminishing: i.e., as consumption of one good increases, the team is more willing to forgo the consumption of another good to maintain the same welfare level. In the first two rounds, no trade is allowed, and consumption equals production. Thereafter, trade is allowed in fixed proportions: in round 3, players can exchange 2 units of good 2 for 1 unit of good 1, or vice versa; and in round 4, the exchange rate becomes 1 unit of good 2 for 2 units of good 1. Consumption is equal to the number of *ex post* trading products.

After play ends, the students are given a few minutes to record the results on their individual sheets and to calculate prices and their individual incomes. In rounds 1 and 2, when no trade is allowed, the price of good 2 is set as the standard

and the price of good 1 is determined by it and by production levels. The individual incomes of specific factor owners rise as product prices increase and more resources are used. However, the individual incomes of mobile factor owners are ambiguous due to their resource being used in two sectors.

The discussion questions regarding the results of play (provided as Appendix 4) firstly guide the students to consider how production changed due to different resource allowances and rules. Secondly, they prompt examination of the impact on the team's welfare; and finally, they focus on income distribution and the gains from trade among resource owners in different sectors based on their resource allowances, individual incomes and relative product prices.

4   Conclusion

It is anticipated that this study's proposed classroom experiment-based learning approach will achieve the goal in international trade education. Learning by playing an experiment could enhance students' interests. The system of resource endowments, relative prices, and trade rules featured in this experiment can be replicated in an educational context to account for different international trading scenarios. The students' work in small groups will allow them to experience the types of interaction that occur between factor owners in the economy. It will encourage students to think about the impacts of trade on productivity, income distribution and the gains from international trade. This classroom experiment could foster better learner understanding of the specific factors model, both individually and collectively.

This game has four rounds. You will play in a team of three players, each of whom will be given one card. Each of the three card suits represents a different type of resources (♥H, ♠S, ♣C). Your *allowance* (H/S/C) is *the card number times 15*, i.e., either 15 or 30.

* Inputs & Production *

Within the allowance, you can allocate the inputs to produce two types of goods (good 1 and good 2) with your team mates. Production of one unit of good 1 requires a combination of (the production level times half of the level, $G_1 \times G_1/2$) units of ♥H ($H1$) and 3 units of ♠S (S). The production of one unit of good 2 requires a combination of (the production level times one-fourth of the level, $G_2 \times G_2/4$) units of ♥H ($H2$) and 4 units of ♣C (C). Remember! The resources used must not exceed your allowance, and your production should be an *integer*.

The following tables show production examples and their corresponding resource requirements.

G_1 Production	1	2	3	4	5	6	7
♥H ($H1$)	$\frac{1}{2}$	2	$4\frac{1}{2}$	8	$12\frac{1}{2}$	18	$24\frac{1}{2}$
♠S (S)	3	6	9	12	15	18	21

G_2 Production	1	2	3	4	5	6	7
♥H ($H2$)	$\frac{1}{4}$	1	$2\frac{1}{4}$	4	$6\frac{1}{4}$	9	$12\frac{1}{4}$
♣C (C)	4	8	12	16	20	24	28

* Trade *

In Rounds 1 and 2, you are *not allowed to trade*. In Rounds 3 and 4, you will be given the prices of the two goods, you will be allowed to trade both of them with the experimenter. The trading volume should be a *non-negative integer*.

- In round 3, you can exchange two G_1 for one G_2, or vice versa.
- In round 4, you can exchange one G_1 for two G_2, or vice versa.

Your trading decisions must be agreed to by a majority of your team members, i.e., by at least two people.

<div align="center">

* Team Welfare *

</div>

The goal of each team is to achieve the highest welfare, computed using the formula $(W = G_1 \times G_2)$. In rounds 3 and 4, welfare is simply the post-trading quantities of products.

Control Questions:

Q1. How many cards will you get in each round?   (1 card per person or 3 per team)

Q2. Can you exchange your cards with other players?   (No)

Q3. Your goal in this game is to... (make your *team welfare* as high as possible)

Q4. If your team allowance is 30♥, 15♠, and 15♣, can you produce 5 G_1 and 4 G_2? (No. Such production would require 16.5♥ $((= \frac{5^2}{2} + \frac{4^2}{4}),$ 15♠ and 20♣)

Q5. If your team allowance is 30♥, 15♠, and 15♣, can you produce 4 G_1 and 3 G_2? (Yes. Such production requires 10.25♥ $(= \frac{4^2}{2} + \frac{3^2}{4}),$ 12♠ and 12♣)

Q6. To produce 5 units of G_1 and 5 units of G_2, how many units of ♠ do you require? $(3 \times 5 = 15)$

Q7. To produce 2 units of G_1 and 4 units of G_2, how many units of ♠ do you require? $(3 \times 2 = 6)$

Q8. To produce 5 units of G_1 and 3 units of G_2, how many units of ♥ do you require? $(\frac{5^2}{2} + \frac{3^2}{4} = 14\frac{3}{4})$

Q9. To produce 4 units of G_1 and 3 units of G_2, how many units of ♥ do you require? $(\frac{1}{2} \times 4^2 + \frac{1}{4} \times 3^2 = 10\frac{1}{4})$

Q10. To produce 3 units of G_1 and 5 units of G_2, how many units of ♣ do you require? $(4 \times 5 = 20)$

Q11. In rounds 1 and 2, what's the team welfare for the production combination of 2 G_1 and 3 G_2 ? $(W = 2 \times 3 = 6)$

Q12. In round 3, if you produce 2 G_1 and 3 G_2, can you have 4 G_1 after trading? (No, because you would have to give up 2 G_2 for each 1 G_1 that you received. Thus, to gain 2 additional G_1, you would need to start with 4 G_2, not 3 G_2)

Q13. In round 4, if you produce 2 G_1 and 3 G_2, can you have 4 G_1 after trading? (Yes. Because you can trade 2 G_1 for 1 G_2, you can gain 2 additional G_1 by giving up 1 G_2)

Q14. In round 4, if you produce 2 G_1 and 3 G_2, can you have 4 G_2 after trading? (Yes. Because you can trade 2 G_1 for 1 G_2, you can gain 1 additional G_2 by giving up 2 G_1)

Appendix 2. Team Record Sheet   Team: _____

Name: _____   **Student ID:** _____

Name: _____   **Student ID:** _____

Name: _____   **Student ID:** _____

Step 1. Please record your resource allowances

Round	♥ H	♠ S	♣ C
1			
2			
3			
4			

Step 2. Please decide your production (G_1 and G_2) by allocating your resources

Round	G_1			G_2			Team welfare
	Used Resource ♥H1	Used Resource ♠S	Output (G_1)	Used Resource ♥H2	Used Resource ♣ C	Output (G_2)	$W = G_1 \times G_2$
1							
2							
3							
4							

Step 3. Trade to achieve higher welfare

Round	Sell (G_1 or G_2)	Buy (G_1 or G_2)	After-trade Good 1 ($G_1{'}$)	After-trade Good 2 ($G_2{'}$)	**New Team Welfare** $W' = G_1{'}G_2{'}$
3					
4					

11

Name: _____ **Student ID:** _____

Step 1. Record your card suit, number and resources used

Round	Allowance ($\heartsuit H$, $\spadesuit S$, $\clubsuit C$)	Used resources ($\heartsuit H$, $\spadesuit S$, $\clubsuit C$)
1		
2		
3		
4		

Step 2. Record your production plan and calculate your individual income

Round	Good 1 (G_1)	Price 1 $(P_1 = 4\frac{G_1}{G_2})$	Score (1) = $P_1 S/3$ or $P_1 \frac{1}{\sqrt{2H_1}}$	Good 2 (G_2)	Price 2 (P_2)	Income (2)= $P_2 C/4$ or $P_2 \frac{1}{\sqrt{H_2}}$
1					4	
2					4	
3		8			4	
4		4			8	

* Price Determination *

In rounds 1 and 2, the price of G_2 is $P_2 = 4$. The price of G_1 is $P_1 = 4\left(\frac{G_1}{G_2}\right)$. If G_2 is zero, let $P_1 = 30$.

In round 3, the prices of G_1 and G_2 are fixed as 8 and 4 respectively. In round 4, the prices of G_1 and G_2 are 4 and 8 respectively.

* Individual Income *

Your individual income depends on the prices of the two goods and your resource use. If you hold card $\spadesuit S$ your income is $\frac{1}{3}P_1 S$. If you hold card $\clubsuit C$, it is $\frac{1}{4}P_2 C$; and if you hold card $\heartsuit H$, your income is based on the production of goods 1 and 2, using the formula $(P_1 \frac{1}{\sqrt{2H_1}} + P_2 \frac{1}{\sqrt{H_2}})$.

Appendix 4. Post-experiment Discussion:

1. The Hecksher-Ohlin theorem suggests that a country where a certain factor is abundant exports the good whose production depends intensively on that factor. Do you agree with this theorem?
2. Did you trade in rounds 3 and 4? If not, why did you choose not to? Regardless of whether you traded, did your team's welfare end up higher than in rounds 1 and 2?
3. Do you feel that your trading plan was the same as other teams'? If not, what was different about it?

Using the formulae below, please populate the table with the correct prices and your individual income. Please answer the following questions.

Round	Good 1 (G_1)	Price 1 ($P_1 = 4\left(\frac{G_1}{G_2}\right)$)	Product value ($PV_1 = P_1 \times G_1$)	Good 2 (G_2)	Price 2 (P_2)	Product value ($PV_2 = P_2 \times G_2$)
1					4	
2					4	
3		8			4	
4		4			8	

4. Did you tend to trade goods whose production depended intensively on factors with which your team was abundantly endowed? Did your behaviour support or go against the Ricardian Theorem?
5. Would a different relative price between goods have altered your production plan in rounds 3 and 4? Discuss the impact of the relative price change on income distribution, product value and the production plan.
6. Considering your individual incomes, did the factor owners all gain from trade? If not, discuss why the gains from trade were not equally spread.
7. In a non-trading scenario, could you devise a compensation plan for transferring income from a specific factor owner to another that would make everyone better off than they would be if they traded instead?

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