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Article

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The pattern of international trade between Bangladesh and USA: Heckscher–Ohlin and Rybczynski analysis

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Abstract

Purpose – Research based on Bangladesh–US trade data examines the Heckscher–Ohlin model and the Rybczynski hypothesis in this study.

Design/methodology/approach – Ordinary least square (OLS) techniques are used in this study, which relies on data from the NBER International Trade and Geography Data and the UN Comtrade Database for the years 2018 and 2008.

Findings – The research shows that trade between the United States and Bangladesh follows Heckscher–Ohlin and Rybczynski's trade predictions. According to the study, since labor is in plentiful supply in Bangladesh, Bangladesh's labor-based sectors have a higher US labor-to-capital import shares than US capital-based industries. As Bangladesh has not changed significantly from a labor-based country since 2008, it retains the same pattern even though the share of US unskilled labor-based sectors imported from Bangladesh decreased in 2018.

Originality/value – The findings of this study have a wide range of implications for both trade theory and policy debates between Bangladesh and the United States.

Keywords International trade, Heckscher–Ohlin model, Rybczynski model, Romali's prediction

Paper type Research paper

1. Introduction

In international trade, the renowned model named the Heckscher–Ohlin involves two nations, two production factors such as labor and capital, and two goods. According to the model, the export of a country depends on those goods that need the abundance factor of the country to be produced and imported on those goods that use a relatively lower factor of the country (Heckscher, 1919; Ohlin, 1933). In other words, country produce more goods and services which are suitable to be produced using its abundance factor and export the goods and services, whereas they won't specialize in producing those goods which are not suitable to be produced with their abundance factor rather import those goods from the other countries. Such as, countries with a high labor-to-capital ratio produce more of those goods which intensively use labor and import those goods which intensively use capital to be produced.



Thus, the Heckscher–Ohlin theory describes the trade pattern between countries based on the relative intensity and abundance factors of production. Furthermore, the Heckscher–Ohlin theory practically implies that the two countries have achieved trade balances based on trade patterns, product specialization and natural resource availability. This theory also aids in reducing the trade deficit between countries, achieving balance of payment and maintaining the exchange rate pattern. Rybczynski analysis supports the Heckscher–Ohlin theory where this hypothesis facilitates showing the effect of output by changes in factors of endowment.

However, there is some variance about the theory in some empirical evidence. One of the most prominent oppositions to Heckscher–Ohlin's theory is the empirical test of [Leontief \(1953\)](#). Using the US data of 1947, Wassily Leontief conducted the first empirical investigation of the trade model of Heckscher–Ohlin. Assuming the US was a capital-based country in 1947, Leontief conducted his study. So, as per the trade model of Heckscher–Ohlin, the amount of export of those goods which need capital to be produced increases, and the amount of import of those goods which need labor to be produced increases as well. However, the test with 1947 data by Leontief shows the contrary. And later, this opposite theory of the Heckscher–Ohlin model was named the Leontief Paradox. Leontief Paradox has inspired lots of economists to conduct extended Heckscher–Ohlin trade analysis with empirical data to support the theory. These extended theories take account of more factors that were not explained in the Heckscher–Ohlin theory, such as many countries, many products, technological advancement, skilled and unskilled human capital, differentiation in production, etc. Among many extended Heckscher–Ohlin models, this paper examines the [Romalis \(2004\)](#) paper on extended Heckscher–Ohlin theory ([Heckscher, 1919](#); [Ohlin, 1933](#)), taking the empirical data from Bangladesh and the United States from 2008 to 2018. In other words, the quasi-Heckscher–Ohlin prediction ([Romalis, 2004](#)) states that countries are able to produce and export more of the goods and services that need the abundant production factor of the country, and in this way, the country captures the larger portions of world production and trade in those goods. Again, the quasi-Rybczynski effect states that if countries change their factor of abundance from one factor to another, their share of world production and trade will also shift to those commodities which intensively use the new abundance factor of the country ([Rybczynski, 1955](#)).

This paper aims to examine the prophecy in the case of Bangladesh exports to the US industries by using Romalis' empirical methodology taking data of commodity imports of US using the US Economic Census of 2008, and import commodity data of 2008–2018 using the CD-ROM regarding trade data of US Census. Consistent with the quasi-Heckscher–Ohlin model, US import industries that use labor intensively import more commodities from those countries whose production and exports are labor-intensive, and like that, US capital-based import industries import commodities from those countries whose production and exports are capital-intensive. Because it is assumed that each country has the same production technology, differences in factor (labor/capital) prices (wage/rent) are the primary cause of product differentiation. As a result, countries produce and export more goods that make extensive use of their relatively inexpensive factor of production. In 2008, Bangladesh had more unskilled labor than skilled labor relative to the US ([Bangladesh Economic Review, 2008](#)). Therefore, according to the quasi Heckscher–Ohlin Model, Bangladesh's product share becomes high in those US import industries that use unskilled labor intensively. As Bangladesh had more unskilled labor, the relative price of unskilled labor was low. So, Bangladesh would emphasize producing unskilled labor-based commodities and export them more. According to [Romalis \(2004\)](#), 2008 data of US unskilled labor-based industries would represent a higher share of Bangladesh's commodities. There would be seen an inverse relationship between the independent and dependent variable. Here, the main independent

variable is the US import industry's skill intensity, and the dependent variable is the Bangladesh portion of whole imports from the US for every industry. Bangladesh is rapidly growing in the economy and its export pattern has been transforming from unskilled labour-based production to more skilled-based and capital-based production ([Bangladesh Bureau of Statistics, 2018](#)). Over the last 2 decades, the capital of Bangladesh has grown a lot, and it has been gaining more skilled labor in its urban centers and towns. This paper compares 2008 US import data with 2018 import data to examine the impact of the quasi-[Rybczynski \(1955\)](#) model. This research's major objective is to find a US-Bangladesh trade pattern and to see whether the data supports the [Romalis \(2004\)](#) theory of commodity structure and factor proportions.

Other sub-objectives are:

- (1) Finding out the validity of the trade model of Heckscher–Ohlin using the US-Bangladesh export-import data.
- (2) Examining Rybczynski effect on the trade pattern of Bangladesh over the years.

The rest of the paper is structured in a following manner. The second section discusses theoretical and empirical concerns. The methodology is discussed in the third section. The empirical results are reported and discussed in section four. The fifth section concludes with policy suggestions.

2. Literature review

2.1 Quasi-Heckscher–Ohlin predictions

[Heckscher \(1919\)](#) and [Ohlin \(1933\)](#) developed the Heckscher–Ohlin theory about trade among countries, which states that nations have to produce and export the goods that are produced by their most abundant factor of production. Based on this, [Leontief \(1953\)](#) opposes the popular thought of the US as a capital-abundant country and shows that as the US exports more labor-based commodities, it is a labor-abundant country relative to the world. But in later years, Leontief proved controversial. With the factor proportions technique, [Jones \(1956\)](#) again proves the Heckscher–Ohlin theory of trade. [Davis \(1995\)](#) proves that elements of Heckscher–Ohlin theories are applied to trade between industries and technical differences in trade between industries matter more than increasing returns. [Schott \(2003\)](#) has shown that data does not support the one-size-fits-all homogeneity and supports the Heckscher–Ohlin theory. Fischer and Samuelson (1980) analyze the Heckscher–Ohlin model using a continuum of commodities, two countries, two factors and demand functions of Cobb–Douglas. They show that elasticity of substitution plays a vital role in measuring the comparative outcomes and impacts of variations on production factor bequests, which are well defined if endowments of factors remain the same, factor prices, are equal, and the geographic pattern of production remains unspecified. To analyzing the new Heckscher–Ohlin model, [Kemp \(1966\)](#) shows that countries gain not only from international trade but also from international investment. So, the quasi-Heckscher–Ohlin prediction states that countries produce and export the commodities that need to be produced with the abundant factor of the country, and in this way, countries seize larger portions of global manufacture as well as trade in those goods.

2.2 Quasi-Rybczynski prediction

[Rybczynski's \(1955\)](#) theory states that in the standard two production factors, two nations and two good theories, when one factor increases, the goods production that needs those increased factors intensively to be produced increases and the other goods production decreases. In later years, a lot of other researchers researched this theory using different

dimensions. For example, [Jones \(1956\)](#) generalizes the Rybczynski theory and, according to [Jones \(1956\)](#), when factors of production increase at diverse proportions, the production of the goods that use those increased rates increases at a greater rate than other factors. After analyzing Rybczynski's theory on the net and gross output effects, [Flam \(1979\)](#) postulates that net output changes are greater than gross output changes and net output changes of non-traded goods depend on the factor changes. Analyzing the Rybczynski model with the three numbers of factors and two numbers of goods, [Suzuki \(1985\)](#) proves that at the constant price of commodities, factor endowment always increases production of the goods that need to use the factor intensively which statement is supported by [Uddin and Akhter \(2019\)](#), [Banihashemi et al. \(2019\)](#). With n commodities as well as n inputs, [Inoue \(1981\)](#) proves the Rybczynski theorem in the context of the Stolper–Samuelson model. So, the quasi-Rybczynski effect states that if countries change their factor of abundance from one factor to another, their share of world production and trade also shifts to those commodities which intensively use the new abundance factor of the country.

2.3 *Romalis paper descriptions*

By including many countries and a continuum of commodities, [Romalis \(2004\)](#) extended the Heckscher–Ohlin theory by generalizing Fischer and Samuelson (1980) and [Krugman \(1980\)](#). [Romalis \(2004\)](#) also included the iceberg transportation costs when determining the structure of goods and pattern of trade. He was assumed that, there was differentiation in production. This assumption allowed him to find out the production and trade patterns using commodities data without the equalization of the factor price. [Romalis \(2004\)](#) further explained the models of [Krugman \(1980\)](#) and Fischer and Samuelson (1980) by emphasizing the transition between the equalized price of the factor and factor copiousness and wanted to study the relationship between factor price abundance and trade pattern with the trade data of commodities. Therefore, he was argued that behind the trade between countries, there are two reasons. One of them is the difference in relative abundance and proportions of factors, and the other is the differentiation of products and special economies of scale. Mainly, [Romalis \(2004\)](#) emphasized two predictions: a quasi-Heckscher–Ohlin prediction as well as a quasi-Rybczynski effect. This paper also focuses on these two predictions based on empirical evidence.

2.4 *Other reviews*

[Lundahl \(2022\)](#) and [Morrow \(2022\)](#) focus on the Heckscher–Ohlin model and support the theory with the help of comparative advantages and the Ricardian model. [Marjit and Das \(2022\)](#), [Olyanga et al. \(2022\)](#) create a Heckscher–Ohlin–Samuelson model and show that international finance has no impact on changing trade patterns; rather, it is the movement of labor and machines that can change the pattern of trade. Taking data from 2002 to 2019 and using the ARDL technique, [Umair et al. \(2022\)](#) show that Pakistan follows the Heckscher–Ohlin trade theory and gravity model of trade, and they find that remoteness, GDP distance, land, labor and capital endowment have a significant positive impact on the bilateral trade while population scale has a significant negative impact on the bilateral trade. In the case of trade and labor supply, health issues, safety issues and the minimum wage play an important role in stabilizing the labor market ([Dadzie, 2013](#); [Gurmu, 2019](#); [Puig-Barrachina et al., 2020](#); [Sousa et al., 2014](#); [Starr, 1981](#)). Human rights and democracy in the institutions can also increase the country's trade as well as increase labor efficiency ([Yan et al., 2022](#)). Emphasizing FDI-led investment as intermediary steps until Bangladesh's exports become higher than imports, [Hossain \(2021\)](#) suggests that Bangladesh should produce the goods for which it has comparative advantages following the Heckscher–Ohlin model. According to [Chaisse and Chakraborty \(2021\)](#), the WTO has been working on antidumping activities,

which may help to reduce trade inequality and the trade deficit. In addition, they also demonstrate the trade policy between developing and developed countries where trade liberalization plays an important role in enhancing international trade. The role of the WTO in maintaining environmental sustainability, trade agreements and review of trade policies is also analyzed by [Chaisse and Matsushita \(2013\)](#). However, using the panel gravity model, [Shahriar et al. \(2021\)](#) state that, Bangladesh raises exports in the leather industry and readymade garments which are support the Heckscher–Ohlin model. According to [Baskaran et al. \(2011\)](#), dispersed networks have more impact on bilateral trade than concentrated networks. It states that with a dispersed network system, factor endowment differentials rise in the trade between countries. [Bajona and Kehoe \(2010\)](#) argue regarding the Heckscher–Ohlin theory that, based on elasticity, countries with varying beginning capital per labor endowments may show convergent or divergent nature, and the value of indicators that may suggest convergent nature in a globe with no trade may show divergent nature. In a bilateral export-import study between Bangladesh and India, [Sikdar et al. \(2006\)](#) argue that although Bangladesh's trade relations with India have been deficit-driven, which has widened significantly over time, increasing free trade between the two countries improves their trade relationship and, as a result, economic ties become stronger. In doing an empirical investigation into the Heckscher–Ohlin model, [Subasat \(2003\)](#) postulates that the majority of research focused on confirming whether the model is valid by concentrating on its ability to anticipate trade relationships is not relevant. Examining immigration impact or endowment tremors on US local production combinations explained by the Rybczynski trade theory, [Hanson and Slaughter \(1999\)](#) argue that national production-mixture vagaries are largely equal to national endowment variations and the disparity in the nation's factor demand is reliable. [O'Rourke and Williamson \(1999\)](#) find a relationship among factor prices, commodity prices and endowments that supports Heckscher–Ohlin's theory. It also demonstrates that discoveries and commerce do not affect the world's economy and trade. [Lahiri and Ono \(1995\)](#) show that, Cournot oligopoly for the two countries model also follows the Heckscher–Ohlin model. [Chen \(1992\)](#) also proves the long-run equilibrium of the Heckscher–Ohlin model using the dynamic methodology. [Suzuki \(1985\)](#) states that, assuming a normal two-good and three-factor model, the enlargement of a production factor usually raises the production of the goods that employ the expended component intensely, at a stable price level. [Ethier \(1972\)](#) proves the Heckscher–Ohlin and Rybczynski theorem for non-traded goods.

3. Methodology

3.1 Theoretical framework and model specification

At first, it is assumed that factor intensity reversals do not exist. As shares of a factor are constant in each industry, industries are rearranged by ranking from lowest to highest factor intensity in one country, for example, the US. The empirical procedure of [Romalis \(2004\)](#) has been followed here and the calculation of factor intensities in his paper is used with the structured data of trade. However, [Romalis \(2004\)](#) follows [Hall and Jones \(1999\)](#) and [Barro and Lee \(2001\)](#) to define skill intensity. For regression, this paper uses three independent variables: the US industry's skill intensity, capital intensity and raw material intensity. So, the independent variables of the model are skill intensity (z), capital intensity (k), and raw material intensity (m) in US industries, whereas the dependent variable, x_i , is the share of Bangladesh commodities in US imports in industry i , which is measured by the ratio of US imports from Bangladesh into industry i and the total imports into the industry i .

Two-factor model:

$$\ln x_i = \beta_0 + \beta_1 \ln z_i + u_i \quad (1)$$

Here, Skill intensity z_2 is calculated by the ratio of non-production workers and total employment in each industry of the US.

Three-factor model:

$$\ln x_i = \beta_0 + \beta_1 \ln z_{3i} + \beta_2 \ln k_{3i} + u_i \quad (2)$$

Here, Capital intensity k_3 is measured as a portion of each industry of total value added in the US. And skill intensity z_3 now turns to $z_2 (1-k_3)$.

Four-factor model:

$$\ln x_i = \beta_0 + \beta_1 \ln z_{4i} + \beta_2 \ln k_{4i} + \beta_3 \ln m_{4i} + u_i \quad (3)$$

Raw material intensity m_4 is the ratio of raw material inputs and the sum of the raw materials and value-added. Capital intensity is now equal to $k_4 = k_3(1-m_4)$ and skill intensity is now equal to $z_4 = z_3(1-m_4)$.

3.2 Model estimation techniques

On the basis of the cross-section data, this paper uses the ordinary least square (OLS) method for empirical analysis (Gujarati, 2004). It is justified by the Romalis (2004) paper, which conducts OLS by imposing simple linear specifications to find out the relationship between US-industry import share and the factor intensities. Following Romalis (2004), Clements (2007) also uses OLS techniques to find out the trade pattern between the US and China regarding the extended Heckscher–Ohlin model and Rybczynski model. For finding out the relationship between exports and economic growth, Ali *et al.* (2017) state that OLS is the best method because it provides significant output. According to Krueger and Lewis-Beck (2008), OLS is followed by the highest percentage of researchers for publishing their papers in the selected best journals. The advantages of OLS are that it is easy to use, it is easily understandable and it meets classical linear assumptions. It also provides blue estimators.

3.3 Data sources

Regressions connecting the skill intensity of each industry to Bangladesh's proportion of US imports per industry are used to examine the Heckscher–Ohlin forecast. This paper has taken US industry-based data from NBER International Trade and Geography Data for the year 2018 and 2008 and US-Bangladesh and US-world commodity trade data from UN comtrade database for the years 2018 and 2008 [1].

- (1) US industry-based data with NAICS commodity code are collected from NBER International Trade and Geography Data for the years 2018 and 2008.
- (2) US-Bangladesh and US-World commodity trade data with six digit-HS codes are collected from UN Comtrade Database for the years 2018 and 2008.
- (3) Industry-based data and trade data are merged by combining NAICS and HS code.

4. Results and estimations

4.1 Descriptive statistics

Tables 1 and 2 give descriptive information about the variables in 2008 and 2018. Here, in Table 1, two-factor model, the average skill intensity is the highest. In the three-factor model mean of skill intensity is higher than the mean of capital intensity and raw material intensity and in the four-factor model, mean of raw material intensity is higher than the mean of capital intensity and skill intensity. The raw material intensity in the four-factor model has the

Table 1.
Summary of 2018 data

Variable	Variable	Mean	Standard deviation	Minimum	Maximum
Dependent variable	Share of Bangladesh commodities of US imports, x	0.0004	0.0012	0.00000015	0.0097337
Two-factor model	Skill intensity, z2	0.302	0.117	0.13907	0.68354
Three-factor model	Skill intensity, z3	0.297	0.114	0.13819	0.65935
	Capital intensity, k3	0.013	0.022	0.00028	0.16601
Four-factor model	Skill intensity, z4	0.156	0.079	0.03056	0.41678
	Capital intensity, k4	0.007	0.016	0.00011	0.12809
	Raw material intensity, m4	0.490	0.124	0.22840	0.81451

Table 2.
Summary of 2008 data

Variable	Variable	Mean	Standard deviation	Minimum	Maximum
Dependent variable	Share of Bangladesh commodities of US imports, x	0.001	0.003	0.00000114	0.013
Two-factor model	Skill intensity, z2	0.311	0.111	0.13	0.645
Three-factor model	Skill intensity, z3	0.303	0.105	0.129	0.628
	Capital intensity, k3	0.023	0.032	0.001	0.175
Four-factor model	Skill intensity, z4	0.168	0.084	0.05	0.428
	Capital intensity, k4	0.014	0.022	0.00033	0.123
	Raw material intensity, m4	0.459	0.137	0.231	0.783

highest dispersion shows the higher fluctuation of raw materials in different industries of the USA.

Here, in [Table 2](#), in two-factor model, average of skill intensity is the largest. In the three-factor model mean of skill intensity is higher than the mean of capital intensity and raw material intensity and in the four-factor model, mean of raw material intensity is higher than the mean of capital intensity and skill intensity. The raw material intensity in the four-factor model has the highest dispersion shows the higher fluctuation of raw materials in different industries of the US.

So, comparison between the variables remains same in 2018 and 2008. But in 2018, average share of Bangladesh commodities of US imports, x is higher with lower dispersion than in 2008. Average of skill intensity was decreased in 2018 than in 2008 in all the models. Also average of capital intensity was remaining lower in both three-factor and four-factor model in 2018 but their dispersion decreases than in 2008. In 2018, average raw material intensity become rises with lower dispersion than in 2008.

4.2 Empirical analysis: the Heckscher–Ohlin prediction

[Table 3](#) shows the regressions results for the data of 2018 where dependent variable is import share of Bangladesh in US industries. In three different column of the table shows the coefficient, standard error and t statistics for three different models – two variables model, three variables model and four variables model.

As expected, all coefficients are negative, indicating an inverse relationship between Bangladesh's export share in US industries and all three independent variables. In second case, the coefficient of skill intensities is negative and significant. That means Bangladesh exports more to those US industries that use unskilled labor. Bangladesh has a lower export

Table 3.
Regression results for
2018 data

Variables	Two variables Ln _x	Three variables Ln _x	Four variables Ln _x
lnz2	−1.350* (0.715)		
lnz3		−0.724 (0.720)	
lnz4			−0.937 (0.731)
lnk3		−0.720*** (0.237)	
lnk4			−0.836*** (0.242)
lnm4			−3.877** (1.569)
Constant	−11.77*** (0.939)	−14.55*** (1.290)	−19.55*** (2.806)
Observations	77	77	77
R ²	0.045	0.150	0.176

Note(s): Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

x_i = Industry wise Bangladesh's share in US imports

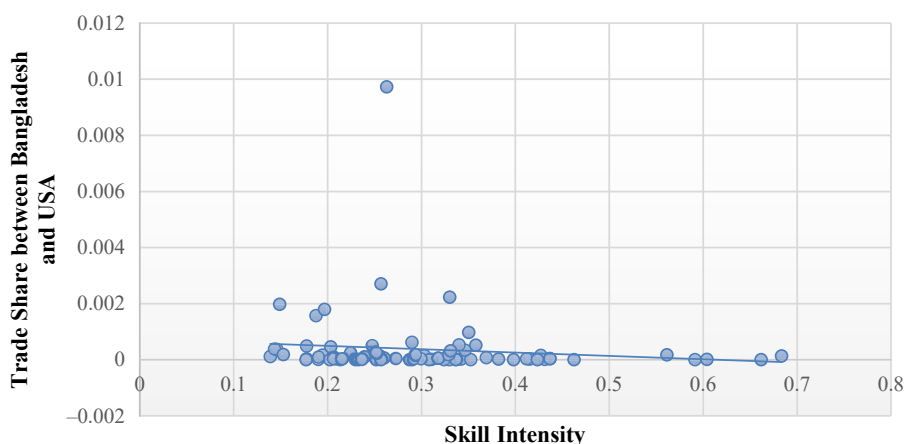
z3, z4, z5 = skill intensity of US industries

k3, k4 = capital intensity of US industries

m4 = raw material intensity of US industries

share in the high-skilled labor-based industry in the United States than the US average. As Bangladesh is an unskilled labor-based country (Haque and Azmat, 2015; Sen, 2002), this data supports the Heckscher–Ohlin theory of trade (Heckscher, 1919; Ohlin, 1933) also supported by Leamer (1995). The scatter graph below also indicates the same. Here, the x -axis represents skill intensity and the y -axis represents the import share of US industries from Bangladesh in 2018. The downward-sloping trend line indicates that with higher skill intensity, industries in the US import fewer commodities from Bangladesh. And the slope of the trend line is significant at a 10% level of significance (see Figure 1).

In the three and four-factor model, coefficients of capital intensity and raw material intensity are negative and significant which indicates that in more capital and raw material-based US industries, Bangladesh has a lower share of exports. The sign of coefficients of skill intensity in both three and four-factor models are negative but insignificant. This is because with capital and raw material, in the US skill has less effect on production. It also supports the Heckscher–Ohlin theory of trade (Heckscher, 1919; Ohlin, 1933).

**Figure 1.**
Relationship between
US–Bangladesh trade
share and skill
intensity of US
industries, 2018

4.3 Empirical estimation: the quasi-Rybczynski forecast

To evaluate if the Bangladesh–US trade relationship has a quasi-Rybczynski impact, this paper needs to examine at two periods of time to see if Bangladesh’s output allocation has evolved over time. This shift in production distribution is investigated by examining how the coefficients of the factor intensities vary over time. To go there, this paper uses data from the United States Census Bureau’s trade statistics CD-ROM for 2008 to conduct the same regressions on Bangladesh’s proportion of US imports (1), (2) and (3) (see Table 4).

The negative sign of factor intensity coefficients for 2008 remained the same as negative correlated, maintaining the Heckscher–Ohlin prediction from 2008 to 2018. Here, in all three models, coefficients of skill intensity are significant, and this supports the Romalis (2004) prediction of the Heckscher–Ohlin model (Heckscher, 1919; Ohlin, 1933). As Bangladesh’s production pattern has not changed so much from unskilled labor-based to skilled labor-based, this also supports Rybczynski’s theory (see Figure 2). In the figure, the x -axis represents skill intensity, and the y -axis represents the import share of US industries from Bangladesh in 2008. The downward-sloping trend line indicates that with higher skill intensity, industries in the US import fewer commodities from Bangladesh. And at a 5% level of significance, the slope of the trend line is significant. It also demonstrates that the slope of

Variables	Two variables Ln x	Three variables Ln x	Four variables Ln x
lnz2	−2.428** (0.954)		
lnz3		−2.054* (1.057)	
lnz4			−1.832* (1.044)
lnk3		−0.347 (0.319)	
lnk4			−0.291 (0.318)
lnm4			−0.352** (1.753)
Constant	−12.34*** (1.222)	−13.45*** (1.578)	−14.60*** (3.401)
Observations	43	43	43
R -squared	0.136	0.157	0.211

Note(s): Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
 x_i = Industry wise Bangladesh’s share in US imports
 $z3, z4, z5$ = skill intensity of US industries
 $k3, k4$ = capital intensity of US industries
 $m4$ = raw material intensity of US industries

Table 4.
Regression results for
2008 data

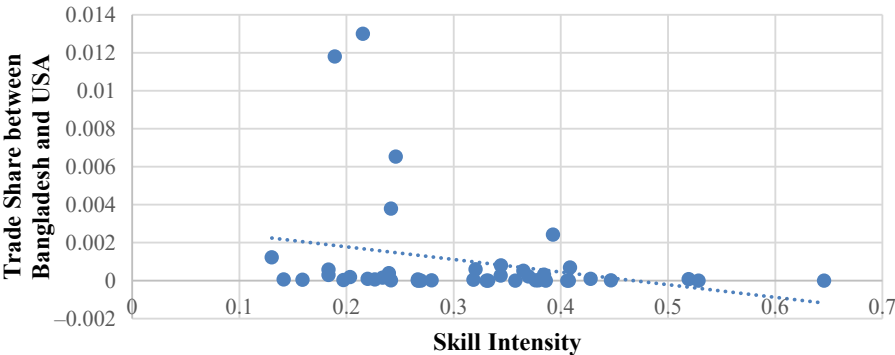


Figure 2.
Relationship between
US–Bangladesh trade
share and skill
intensity of US
Industries, 2008

the trend line in 2008 was around 1.79 times higher than the slope of the trend line in 2018. It means the effect of a change in skill intensity in US industries is lower in 2018 than in 2008.

For more close analysis, this paper has used the same HS code commodity data of 2008 and 2018 to investigate the pattern which shows as follows. Here, this paper analyzes the import share of the same twenty-five industries from Bangladesh and their intensity of skill, capital and raw material (see Table 5).

Here, in the two-factor model, both coefficients of skill intensity are negative and significant. It means that high-skill intensity-based industries have a lower import share from Bangladesh, which means a similar result to Otsuka and Ben-Mazwi (2022). In 2018, the effect decreases as the coefficient's value becomes lower. In the 2008 three-factor model, coefficients of skill intensity and capital intensity are negative, but the only significant coefficient is that of skill intensity. In the 2018 three-factor model, the coefficient of skill intensity is positive but insignificant when capital intensity's coefficient is significant and it has a negative sign. So, in 2008, there existed a significant inverse relationship between trade share in US industries and skill intensity, and in 2018, there existed a significant inverse relationship between trade share in US industries and the capital intensity of US industries. It supports the Rybczynski (1955) theorem as Bangladesh remains an unskilled labor-intensive country in both 2008 and 2018. The decision from the four-factor model of selected industries in the US is inconclusive as in the 2008 four-factor model, no coefficient is significant, whereas in the 2018 four-factor model, only the coefficient of capital intensity is negative and significant. So, here, for the same selected industries according to the same HS codes between 2008 and 2018, two-factor model and three-factor model support both the theory of Heckscher–Ohlin and Rybszynski theory with a negative significant sign as Bangladesh remains a labor-intensive country and exports products that are produced using mostly labor-intensive techniques.

4.4 Diagnostics test

Here, this paper conducted two diagnostic tests such as multicollinearity and heteroscedasticity for the adequacy of the model. For multicollinearity, this paper uses VIF technique and for heteroscedasticity, this paper uses Breusch–Pagan/Cook–Weisberg test (Gujarati, 2004). In Table 6, the value of VIF for each regression has been given. The rule is that if the value of VIF is greater than 10, then there exists multicollinearity in the model. As here, in all regression the value of VIF is much less than 10, then it concludes that the regressions are free from multicollinearity problem.

In Table 7, the probability of chi square (χ^2) test statistic for all regressions has been given separately. Here, null hypothesis is there is constant variance that is no heteroscedasticity. The rule is that when test statistic significant then null hypothesis is rejected and it proves the heteroscedasticity problem in the model. As here, all the probability value of chi-square test statistic for all the regression is greater than the 5% level of significance, the all test statistics are insignificant and thus null hypothesis cannot be rejected. So, this model is free from heteroscedasticity problem also. As this paper is based on cross section data, it ignores the autocorrelation problem of the residuals.

5. Conclusion and recommendations

To have an optimum trade policy, it is very important to know about the trade pattern of the country. As Bangladesh is a fast developing nation in the 21st century, the government of Bangladesh needs to understand its trade pattern and then take the necessary policies. Among the various trade theories, the most common two are the Heckscher–Ohlin trade theory (Heckscher, 1919; Ohlin, 1933) and the Rybczynski trade theory (Rybczynski, 1955). In short, Heckscher–Ohlin trade theory postulates that a country should export those products

Table 5.
Regression for
Bangladesh's share of
US Imports by same
Industry in 2008
and 2018

[illegible]

in which it has a factor abundance to produce, and on the other hand, Rybczynski (1955) theory states that if a country changes its factor abundance from one factor to another, then it should change its export pattern also. On the basis of these theories, this paper examined the trade pattern of Bangladesh to the United States and to see whether the data supports the Romalis (2004) theory of commodity structure and factor proportions. So the main theme is to determine whether Bangladesh follows the Heckscher–Ohlin trade pattern of exporting goods in abundance as well as whether Bangladesh follows the Rybczynski hypothesis of changing factor abundance leading to a change in trade pattern. The paper uses simple OLS techniques, taking US industry-based data from NBER International Trade and Geography Data for the years 2018 and 2008 and US–Bangladesh and US–World commodity trade data from the UN Comtrade Database for the years 2018 and 2008. However, three models are used to investigate the topic, with the independent variables being skilled labor intensity, capital intensity, and raw material intensity, and the explained variable being the proportion of US industry that imports from Bangladesh. For the first time, only skilled labor intensity has been included as an independent variable. In the second model, skill intensity and capital intensity have been included as independent variables and in the third model, skill intensity, capital intensity and raw materials have been included as independent variables. Again, the results are compared between the years 2008 and 2018 to determine any change in the country's trade pattern. As expected, it has been shown in the analysis that quasi Heckscher–Ohlin anticipation and quasi Rybczynski anticipation of the Romalis (2004) model support the empirical evidence of trade between Bangladesh and the US. Here, in all three models, all coefficients are negative, indicating an inverse relationship between Bangladesh's export share in US industries and skill intensity, capital intensity and raw material intensity in US industries. That means Bangladesh exports more to those US industries that use unskilled labor. The data also shows that Bangladesh is changing its production techniques from unskilled labor-based industries to skilled labor and capital-based production and is also exporting those commodities. But still, in 2008 and 2018, Bangladesh remained a labor-abundant country. So, there is little change between the 2008 and 2018 trade patterns in the country. Finally, this paper contributes to the theoretical work and policy debate on the trade pattern between Bangladesh and the United States in a variety of ways. Exports are crucial to Bangladesh for earning foreign exchange and reducing the trade deficit. According to the findings, Bangladesh follows the Heckscher–Ohlin trade pattern; that is, Bangladesh has a greater incentive to export labor-based products to the United States. The government should

Mean VIF	Three variables	Four variables	Results
2018	1.09	2.17	Below 10, so there is no multicollinearity
2008	1.15	2.09	Below 10, so there is no multicollinearity

Table 6.
Test for
multicollinearity

Null Hypothesis, H_0 : Constant variance				
Year	Two variables ($\text{prob} > \chi^2$)	Three variables ($\text{prob} > \chi^2$)	Four variables ($\text{prob} > \chi^2$)	Decision
2018	0.4842	0.3900	0.5961	p value is greater than 0.05. So, null hypothesis cannot be rejected. That means there is no heteroscedasticity
2008	0.7098	0.6654	0.6719	p value is greater than 0.05. So, null hypothesis cannot be rejected. That means there is no heteroscedasticity

Table 7.
Test for
Heteroscedasticity
(Breusch-Pagan/Cook-
Weisberg test for
heteroscedasticity)

consider labor-based and export-oriented policies such as export subsidy, export promotion, lower interest rate, freight-free services, letter of credit and others when increasing exports. Labor-based products such as readymade garments should be compensated by the government, and the government should be aware of raising the doing business index. At the same time, by undergoing proper training and supporting policies, labor efficiency may be increased. Also, health issues, safety issues and minimum wage law-related policies should be ensured, and the establishment of policies on human rights and democracy in the institutions is also important because those initiatives can increase trade for the country. Moreover, to effectively establish these policies, overall infrastructural and institutional development is also needed. Finally, this study can help policymakers make trade decisions between the countries. A decisive limitation of this research is that it is only based on the US–Bangladesh trade relationship. But Bangladesh also has a trade relationship with other countries. Further research can take a look at this subject or particular issues because of Heckscher–Ohlin and Rybczynski effects can also be determined based on trade relationships with other countries or different trade unions.

Note

1. *Data availability status*: the data repositories doi: [10.17632/jk7kz2gthm](https://doi.org/10.17632/jk7kz2gthm).

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