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Unlocking trade potential: gender equality, economic complexity and trade openness in the Developing-8 (D-8) countries

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Abstract

Purpose – Prioritizing the shift from a traditional economy towards complex integrated economies has been the top priority among policymakers to achieve sustainable development goals (SDGs). Countries involved in economic integration must safeguard their labor markets. The Developing-8 (D-8) is an alliance of economic cooperation including Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey, all of which are among the world's largest labor-abundant countries but have insufficient attention toward labor market policies, especially in gender roles. This issue motivated this study, which aims to investigate the impact of economic complexity on trade through with the interaction of gender equality.

Design/methodology/approach – The annual data for the panel of D-8 countries from 1990 to 2020 were collected. The Driscoll and Kraay (D-K) regression was employed for empirical investigation after observing the presence of autocorrelation, heteroscedasticity and cross-sectional dependency (CSD) across the sample.

Findings – Findings show that the economic complexity index (ECI) and gender equality (GE) have a significant impact on trade openness (TO). Moreover, the interaction of GE and ECI strengthens the relationship between ECI and TO. Therefore, both factors worked together to enhance the trading system by supplying the nation with highly sophisticated and complex products.

Research limitations/implications – Policymakers in D-8 countries should enable equal access to resources, investment and decision-making for both men and women. This leads toward stubble, innovative and complex products that enhance trade and goodwill in the international market.

Originality/value – This study incorporated GE as an interaction term in economic complexity and TO in D-8 countries for the first time, to the best of the authors' knowledge.

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Keywords Economic complexity (EC), Trade openness (TO), Gender equality (GE), Developing-8 (D8), Driscol Kraay (DK)

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1. Introduction

International trade significantly impacts economic progress by enhancing productivity, creating opportunities and reducing poverty and has become a key policy discourse for resource diversification and dissemination (Sepehrdoust *et al.*, 2019; World Bank, 2023). Nevertheless, effective trade policy focuses on economic complexity by leveraging unique capabilities, accessing resources and stimulating the growth of varied and complex businesses by engaging in international trading (Hidalgo and Hausmann, 2009; Hidalgo, 2021). However, the effect of international integration on enhancing human capital without discriminating against their socio-political status is crucial. According to Romer, developing nations face numerous problems such as limited technical abilities as well as access to novel techniques (Romer, 1993; Romijn, 1998). Thus, by accepting a trade openness (TO) policy, these problems can be overcome, which boosts technical know-how and innovation (Grossman and Helpman, 1990). Traditional economic and trade theory, globalization, economic policies and openness to trade are generally regarded as having equal benefits for both men and women (Von Hagen, 2014). Conversely, research over the last two decades has progressively shown that trade policy-related instruments including agreements, facilitations and negotiations have differentiating implications for men and women, due to disparities in their skills and capabilities (Burgoon and Hiscox, 2008).

Therefore, gender-inclusive trade policy is crucial to reap the full potential of international trade in economic growth since women make a significant portion of human capital (Akter *et al.*, 2019; Zhu *et al.*, 2023; Rocha and Piermartini, 2023). United Nation's sustainable development goals (*SDGs2030 Agenda*) emphasize that addressing gender equality (GE) issues in all spheres including trade and development is crucial for promoting equitable and long-term economic growth (United Nations, 2015; Boserup *et al.*, 2013). The World Bank also recognizes GE's role as an instrument for economic development (WDR, 2012), arguing that GE is smart economics since it "can improve economic efficiency and other development outcomes" (World Bank, 2022). Therefore, countries with a larger pool of labor force and human capital should focus more on their gender-inclusive trade policies in order to increase their share in global trade and economic growth. For instance, Developing-8 (D8) is an alliance of economic cooperation including Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey, which are the world's largest labor-abundant countries. The combined population of these countries' accounts for one-seventh of the global population, or approximately 1.1 billion people, and 1.4% of global trade (Ministry of Foreign Affairs, 2022). Despite the dynamic labor force and significant share in global trade, the labor market enactment is not auspicious in these countries, especially in terms of GE. The Global Gender Gap Report (2023) revealed that most of the D-8 countries are least performers in terms of the Gender Inequality Index. Therefore, this study intends to examine the interaction effect of GE in driving the relationship between complexity and TO in D8 countries.

The contribution of this study is threefold. Firstly, the choice of D8 countries is deliberate, based on their socio-economic importance, being the most populated countries with a significant share in global gross domestic product (GDP) and trade but, less emphasis is given toward their gender-inclusive trade policies. However, the temporal choice of this study was confined to the availability of data. Secondly, this study has the potential to provide significant insight that can lead to the development of an integrated approach to economic complexity and GE while framing trade policy. This study fills a lacuna in the literature as few studies explored the relationship between economic complexity, GE and trade, such as Busse and Spielmann (2006), Özyol (2020), Cakir *et al.* (2021), Wicaksana and Rahmawati (2023), Safi *et al.* (2023) and Wang *et al.* (2023), among others.

Finally, this study employed a novel econometric technique, i.e. Driscoll and Kraay (D-K) model, to minimize the cross-sectional dependency (CSD) and heterogeneity's issues for the panel of D8 from 1990 to 2020 that were less evident in previous literature. The rest of the work

is structured as follows: Section 2 presents a literature review; Section 3 presents a theoretical framework; Section 4 presents methodology, data, variables' sources and the econometric technique; Section 5 presents a discussion of results and the final section concludes the study.

2. Literature review

The extensive corpus of research on trade and gender highlights the need for comprehensive analysis of innovative trading, economic complexity and GE. TO refers to the liberalization of cross-border exchanges of commodities and services (Ramirez *et al.*, 2023). Openness to trade plays a key role in boosting economic growth as well as development (Audi and Ali, 2017; Kumari *et al.*, 2023). Increased TO opens up new international markets and investment in new sectors, improving the product quality of domestic firms and increasing export diversification and economic complexity. Economic complexity evaluates the nation's sophisticated and complex exports that are competitive to participate in worldwide trading (Abdi *et al.*, 2023; Adam *et al.*, 2023). In addition, productive capabilities are a vital element of exports (Khayati, 2021), which improves trade policy.

Nevertheless, the economic complexity of any country is determined by how diverse its products are, which improves economic growth (Hartmann *et al.*, 2017). A study conducted by Hidalgo and Hausmann (2009) found that complex and sophisticated exports in nations improve the trading system. The mixed literature is available on the bidirectional relationship between TO and economic complexity. For instance, Nguyen and Su (2021) found that TO enhanced economic complexity, whereas economic complexity increased the level of exports (Cakir *et al.*, 2021). However, İspiroğlu (2021) discovered that only TO increased economic complexity, but the impact of economic complexity on TO is not clear. In many cases, empirical studies proved that governments with sophisticated, complex and diverse export products are majorly involved in worldwide trading, which attracts foreigners for investing (Xie and Yin, 2023).

The major concern of economies in international trade is how to enhance their productive capabilities and uniqueness to make their products more attractive and competitive to gain strength and build repute for their exports in the world trade market. Policymakers identified that productive capabilities can be enhanced through improvement in human capital that is the most important resource in trade (Alvarado *et al.*, 2023). Among human capital, the role of women is very important, as women make up a significant portion of human capital, almost 50% of the total labor force worldwide. Women participation in trade can enhance economic complexity and competitiveness in global trading (Akhtar *et al.*, 2023; Betz *et al.*, 2023). Despite the important role of women in enhancing trade and economic progress, few economies have managed to attain GE (Pelton and Pelton, 2019). This is because equal access to opportunities is a prerequisite for GE to attain the potential benefits of international integration. The policymakers are now concerned with framing gender-inclusive trade policies for better economic outcomes (Ofori *et al.*, 2023).

Thus, whenever a country opens its trade system, money and the workforce move to firms that can enable efficient utilization of these resources (IMF, 2023). However, TO, while promoting opportunities, innovation, productivity and poverty reduction, has different implication for GE (Ghaderi *et al.*, 2023; Suryandaru, 2023; Hasan and Du, 2023). It facilitates technical advancement and resource transfer between developed and impoverished countries (Gong *et al.*, 2023). Through competitive impact, TO might lessen the gender gap in the labor market caused by discrimination based on taste (Black and Brained, 2004; Yahmed, 2010; Ben Yahmed and Bombarda, 2020). But on the other hand, it also affects women's skill set in emerging economies due to cultural norms and resource constraints, making it harder for them to enter the workforce (Oishi and Wie, 2023; Ul-Haq *et al.*, 2023; Ouyang *et al.*, 2023).

Female empowerment and their capability of gaining education as well as resources provide a more complex, sophisticated and diverse production, which all enhances the openness to trade (Voumik *et al.*, 2023). But insufficient care is being given toward GE while framing trade policies (Zhu *et al.*, 2023). Therefore, incorporating GE into trade policy has the potential to enhance the growth of countries. GE ensures equitable access to education, investment, resources, opportunities, entrepreneurship and participation in the business environment for men and women (Reshi and Sudha, 2023; Bayramov *et al.*, 2023). Evidence proves that female's empowerment as well as equal engagement in the trading system can have a beneficial effect on openness to trade and then growth of an economy (Fröhlich *et al.*, 2023). For instance, female empowerment and their capability of gaining education as well as resources provide a more complex, sophisticated and diverse production, which enhances the openness to trade (Voumik *et al.*, 2023). Moreover, female engagement in trade can improve trade policy since women think more creatively and have a better innovative idea, specifically in arts, handicrafts, textiles, etc. Thus, providing women with more facilities, as well as greater accessibility to infrastructure facilities, can promote productivity and trade and accomplish long-term economic growth.

Since women are engaged more in the agriculture sector in most developing countries, empirical evidence suggests that in agrarian economies, the participation of female in the agricultural sector increases economic growth through rising productivity. For instance, a study conducted by Rasheed *et al.* (2020) in Pakistan proved that the participation of women in the agricultural sector increases agriculture exports. Similar evidence found that in Bangladesh, rice production in the agricultural sector boosts the country's exports through the participation of females in this sector (Rahman *et al.*, 2016). Moreover, various studies also proved that economic growth beneficially boosts through productivity of rice exports through female participation (Saradamoni, 1987; Arya *et al.*, 2012; Borah and Sharma, 2015; Edeoghon *et al.*, 2019). The literature highlights the role of TO, economic complexity and GE in promoting economic growth and development. However, the interplay between these factors is complex and requires further investigation. Understanding the synergistic influence of these variables might provide policymakers with important insights into promoting fair and sustainable economic growth. However, an exhaustive review of the literature suggests that few studies have been conducted on the effects of economic complexity index (ECI) and GE on TO. Evidence found a positive association between economic complexity, GE and TO (United Nations, 2010; Khayati, 2021). In addition, economic complexity and GE at the same time led to enhanced TO and economic performance in developing nations (United Nations, 2010; Khayati, 2021). However, few studies have been conducted on the impact of economic complexity, TO and interaction effect of GE.

None of the study has incorporated interaction of GE in driving the relationship between economic complexity and TO in D8 countries to the best of the authors' knowledge. The novelty of the current study is to investigate the impact of economic complexity jointly with GE on TO on D-8 countries, and this is the first study that investigates this combined impact on TO.

2.1 Romer hypothesis

Developing countries face numerous challenges to enhance and sustain economic growth. Paul Romer presented a hypothesis called the "Romer hypothesis" to recognize the dynamic forces of economic growth and development, specifically in the case of developing economies (Romer, 1993). The Romer hypothesis indicates that inflation (INF) is minimal in open and small economies. Romer claims that economic growth is derived not only from the investment in physical capital (like land and equipment) but also from investment in human capital (health and education) R&D as well as high-tech progress (Izushi and Huggins, 2004). According to Romer, developing nations face numerous problems such as limited technical abilities as well as access to novel techniques (Romijn, 1998). Thus, by accepting a TO policy, these problems can be overcome, which boosts technical know-how and innovation (Grossman and Helpman, 1990).

3. Theoretical framework

This study is based on the endogenous growth theory. The endogenous growth theory holds that an economy's internal dynamics dictate long-run economic growth (Romer, 1994). Internal factors, in particular, are the forces that influence technological transformation possibilities and incentives (Howitt, 2010).

Furthermore, the pace of growth of an economy is assessed by the growth rate of production per worker, which is dictated by the rate of growth of technical progress. Economic complexity diversifies the goods and services, which increases exports and trade as well (Mariani *et al.*, 2015). On the other hand, GE increases the percentage rate of female engagement in textile, clothes and other sectors, which enhances exports and trade (Busse and Spielmann, 2006). Moreover, economic complexity jointly with gender quality gave more benefits and strengthened the trade sector. The conceptual framework of the current study is presented in Figure 1.

Based on the theoretical framework, following hypotheses are formulated for the present study.

H1. Economic complexity has a positive and significant impact on the level of TO.

H2. GE has a positive and significant impact on the level of TO.

H3. The interaction of GE enhances the positive effect of economic complexity on TO.

4. Methodology

To determine how the interaction of GE drives the relationship between economic complexity TO, this study formulated the model that is given below:

$$TO = f(ECI, GE, ECI * GE, GDP, NRR, ER, INF) \quad (1)$$

To transform the model of the study into a linear function,

$$TO_{it} = \alpha + \beta_1 ECI_{it} + \beta_2 GE_{it} + \beta_3 ECI * GE_{it} + \beta_4 GDP_{it} + \beta_5 NRR_{it} + \beta_6 ER_{it} + \beta_7 INF_{it} + \varepsilon_{it} \quad (2)$$

where $\beta_1\,\beta_2\,\beta_3\,\beta_4\,\beta_5\,\beta_6\,\beta_7$ are the coefficients of ECI, GE, ECI with interaction term GE (ECI*GE), GDP, natural resources rents (NRR), exchange rate (ER) and inflation (INF). The symbol i denotes the cross-section of the D-8 countries, the symbol t represents the time from 1990 to 2020 and α is the intercept term and ε shows the error term.

This study included annual data from D-8 countries from 1990 to 2020 and applied the D-K regression approach. The panel is made up of ($n = 8$) cross sections with ($T = 31$) time-series dimensions, and the sample size of observations is 248. TO is the dependent variable, and the data were gathered from the World Bank Indicators (WDI). The data of ECI are collected from

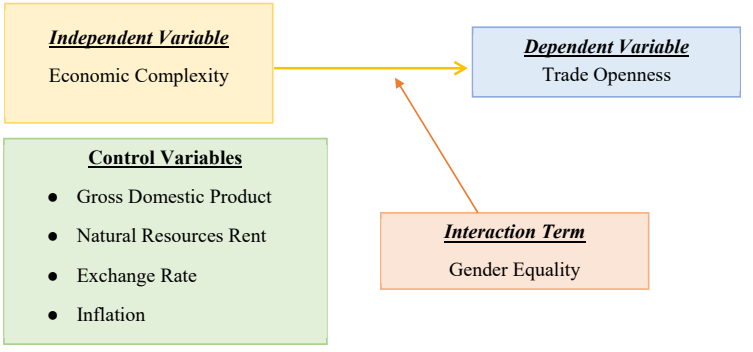

Figure 1.
Theoretical framework

Source(s): Authors' own creation

Observatory of Economic Complexity (OEC) and Our World in Data. The proxy of GE is the labor force participation rate of female to male ratio, and the data were gathered from the WDI. The rest of the variables' data (GDP, NRR and ER) are also collected from WDI. The proxy of GDP and NRR is GDP growth as an annual percentage and the total NRR (% of GDP), respectively. The proxy for INF is the annual % growth rate of consumer prices, which is collected from the WDI and presented in Appendix (see Appendix Table A1).

4.1 Estimation procedure

The method described by Jaccard and Turrisi (2003) is used to estimate the interaction between economic complexity and GE. It implies the estimation of the auxiliary regression of the product of economic complexity and GE as a regression against the variables independently. In the current investigation, the formula for evaluating the interaction effect is given below:

$$ECI_{it} * GE_{it} = \alpha_o + \alpha_1 ECI_{it} + \alpha_2 GE_{it} + \nu_{it} \tag{3}$$

The error term (white noise) is represented by v.

For empirical investigation, the first step is to check CSD. Breusch *et al.* (1980) provided a method for estimating CSD. It is determined by the residuals of a regression model computed for every country in the model. The H0 shows that there is no CSD, meaning that residuals vary between countries. This CSD test's equation is given below:

$$CSD_{BP} = T \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} P_{ij} \tag{4}$$

Furthermore, an extension of the Breusch–Pagan test was introduced by Pesaran (2004). It depends on the residuals of a model computed for each participant and takes the spatially related structure in the panel's data into consideration. It is resistant to heteroscedasticity and is ideal for large panels with t (time) greater than n (sample nations). It may be used for both stationary and nonstationary panel data, and this CSD test equation is given below:

$$CSD_P = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} P_{ij} \tag{5}$$

After checking the CSD in the panel model, the next step is to determine whether the regression model's slope coefficients are homogeneous among countries in the panel or not. Pesaran and Yamagata (2008) developed the test of slope homogeneity, which is based on the residuals of a regression model computed for every single country. The equation of this test is given below:

$$\Delta_{SHT} = (N)^{\frac{1}{2}} (2K)^{-\frac{1}{2}} \left(\frac{1}{N} S - K \right) \tag{6}$$

$$\Delta_{ASHT} = (N)^{\frac{1}{2}} \left(\frac{2K(T-K-1)}{T+1} \right)^{-\frac{1}{2}} \left(\frac{1}{N} S - K \right) \tag{7}$$

The next step is to check stationarity of variables. Pesaran (2007) introduced a test of stationarity with CSD and heterogeneity in the error structure and coefficients, respectively. It calculates the order of lag as well as the autoregressive procedure for every single individual in the model and depends on the augmented Dickey–Fuller (ADF) test. The equation of this stationary test is as follows where $\overline{Y}_{t-1}$ and $\Delta \overline{Y}_{i,t-1}$ represents the cross-sectional means:

$$\Delta Y_{it} = \alpha_i + \beta_i Y_{i,t} + \gamma_i \overline{Y}_{t-1} + \sum_{j}^{q} \gamma_{ij} \Delta \overline{Y}_{i,t-j} + \sum_{j=0}^{q} \gamma_{ij} \Delta Y_{i,t-j} + \varepsilon_{it} \tag{8}$$

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF \tag{9}$$

The current research utilized D-K econometric model developed by Driscoll and Kraay (1998). The D-K model is a "nonparametric method" to evaluate the average of regressors and errors. It gives appropriate results when the model has problems, e.g. "cross-section dependency, autocorrelation as well as heteroscedasticity" (Jalil, 2014). Moreover, this method gives substantial outcomes in the presence of these problems. It can be used and gives significant outcomes even the model's data set is balance and/or unbalance, big and/or small. The econometric equation of D-K approach is given below.

$$Y_{i,t} = X_{i,t}\delta + e_{i,t} \tag{16}$$

This D-K model is revised model that permit error to be autocorrelated, heteroscedastic and cross-section dependent. Ordinary least squares (OLS) regression can be used to evaluating this model based on assumptions and the model is.

$$S_T = \gamma_0 + \sum_{a=1}^{n(T)} w(a,n)\left(\gamma_a + \gamma_a'\right) \tag{17}$$

The modified Bartlett weights W (a, n(T)) = 1-a/(n(T)+1) assure smoothness of the data set's autocovariance function and positive semi-definiteness of S^aT, with greater-order lags getting fewer weights within the previous equation (Newey and West, 1987). The (K+1) (K+1) matrix δa is given below:

$$\gamma_a = \sum_{t=a+1}^{T} k_t(\delta)k_{t-a}(\delta)' with\, k_t(\delta) = \sum_{k=1}^{T}(\delta) \tag{18}$$

where hit (δ) is a total of particular time t momentarily conditions that vary from 1 to N (t), in which N varies with t.

5. Results and discussion

Table 1 presents the descriptive statistics of the selected variables. The mean, minimum, maximum and standard deviation are presented. The range of TO is 0.164–2.204, with a mean of 0.579 and a standard deviation of 0.45. The ECI has a range of −2.764 to 1.033, with a mean of −0.524 and a standard deviation of 0.805. GE has a mean value of 0.442 and a standard deviation of 0.219. GE ranges between 0.122 and 0.897. The interaction between the ECI and GE ranges from −0.367 to 0.322, with a mean of 0.000 and a standard deviation of 0.133. The GDP, NRR and ER range from −0.145 to 0.123, 0.001 to 0.36 and 0.003 to 42000, respectively. Furthermore, the GDP, NRR and ER mean values are 0.026, 0.087 and 2619.206, respectively. GDP, NRR and ER standard deviations are 0.034, 0.087 and 6721.556, respectively.

Table 2 presents the results of CSD test, slope heterogeneity, second-generation unit root test cointegration and multicollinearity test. The probability values of CSD and slope heterogeneity tests in models are less than 0.05 indicates presence of CSD and slope heterogeneity.

This study used Wald test to identify the group-wise heteroscedasticity and the Wooldridge test to check the autocorrelation. The existence of autocorrelation was demonstrated by the probability value being smaller than 0.05. The results of both tests conclude that heteroscedasticity and autocorrelation between variables in the models shown in second panel of Table 2.

Table 2 also presents the unit root results, cross-sectional augmented panel unit root test (CIPS) stationary test's results show that GDP, NRR and INF are I(0), while TO, ECI, GE,

ECI*GE and ER are I(1). Findings of the cross-sectional augmented Dickey–Fuller (CADF) unit root test indicate that TO, ECI, GE, ECI*GE, NRR and ER are the first difference-stationary except for GDP and INF are stationary at I(0). The lower panel presents the

Variable	Mean	Std. Dev	Min	Max
TO	0.579	0.45	0.164	2.204
ECI	−0.524	0.805	−2.764	1.033
GE	0.442	0.219	0.122	0.897
ECIGE	0.000	0.133	−0.367	0.322
GDP	0.026	0.034	−0.145	0.123
NRR	0.087	0.087	0.001	0.36
ER	2619.206	6721.566	0.003	42000
INF	13.763	17.131	−1.139	105.215

Source(s): Authors' own work using Stata

Table 1.
Descriptive statistics

Cross-sectional dependence test			Slope heterogeneity test		
Test	Model 1	Model 2		Model 1	Model 2
Breusch-Pagan LM	0.000***	0.000***	Delta	0.000***	0.000***
Pesaran scaled LM	0.000***	0.000***	Adj.Delta	0.000***	0.000***
Pesaran CD	0.000***	0.015**			

	Wooldridge test			Walt test	
Test statistics	Value	Test statistic	Value	df	Probability
Model 1					
F-Statistics	16.318	*F*-statistic	245.3468	(8, 240)	0.000
Prob > *F*	0.005	Chi-square	1962.774	8	0.000
Model 2					
F-Statistics	26.248	*F*-statistic	233.1029	(8, 240)	0.000
Prob > *F*	0.001	Chi-square	1864.823	8	0.000

	CIPS		CADF	
Variables	At level	At 1st difference	At level	At 1st difference
TO	−1.738	−5.033***	−1.694	−3.594***
ECI	−2.182	−4.018***	−1.928	−3.580***
GE	−1.314	−3.887***	−1.462	−2.844***
ECI*GE	−1.635	−4.313***	−1.769	−3.368***
GDP	−3.654***		−2.662***	
NRR	−2.620***		−2.051	−3.891***
ER	−1.946	−3.955***	−1.993	−3.352***
INF	−3.782***		−3.178***	

	Wester Lund cointegration test	
	Model 1 Variance Ratio	Model 2 Variance Ratio
Statistics	−1.3475	1.6635
p-value	0.0889*	0.0481**
Mean VIF	1.18	All variables <5

Note(s): * Shows pro.val<0.1, ** shows pro.val<0.05, *** shows pro.val<0.01
Source(s): Authors' own work using Stata

Table 2.
Result of unit root, cross-sectional dependency, slope heterogeneity cointegration and VIF test

variance inflation factor (VIF) and cointegration results. The results show that there is no evidence of multicollinearity as mean VIF is less than 5 for all variables. The results confirm the presence of co integration in the series.

The D-K model is most appropriate for analysis as suggested by Jalil (2014), which is applied in the current study. Table 3 presents the findings of the D-K model. The coefficient of ECI is positive and significant, indicating that one percent rise in ECI causes a 0.458 and 0.456% increase in TO in D-8 countries. A significant beneficial association between the ECI and TO shows that economically complex countries are more open to trade. Several things influence this connection. First, more economically sophisticated countries are better equipped to generate a broader range of goods and services, making them more appealing trading partners. This discovery is identical to the research results of Hidalgo and Hausmann (2009) and confirmed the Romer hypothesis in D-8 countries. In addition, the level of TO tends to be enhanced through economic complexity, because higher economic complexity means more productive capabilities. Thus, products are more diversified and sophisticated, which makes them more competitive in foreign markets that in turn stimulates the TO in a country. The findings proved that economic complexity improved the trade performance, which aligns with the Romer hypothesis in endogenous growth theory. This theory states that growth occurs due to internal factor like know-how, technological advancement and human capital. Similarly, economic complexity shows the sophisticated and diversified production because of technological advancement and productive know-how.

The findings indicate that GE boosts TO at a 1% level of significance, with an average rise in the TO of 0.686% over the long term for every 1% increase in GE. This finding validates the Romer hypothesis in D-8 countries, which is similar to the study of Busse and Spielmann (2006).

GE can boost TO, i.e. women are frequently engaged in areas that are particularly sensitive to trade, such as textiles and clothes, and boosting female participation in these sectors can assist to enhance a country's exports. Moreover, through GE, when women have equal rights in schooling and job opportunities, it increases the productive and skillful labor, which in turn enhances the productivity level and helps facilitate openness to trade. GE in the labor market decreases discrimination and increases the effectiveness as well as the competitiveness of productivity, which in turn boosts the trade nationally and internationally.

The coefficient of interaction term (ECI*GE) is significant and positive at a 1% level of significance indicates that GE strengthens the positive impact of economic complexity on TO. The total effect of ECI and GE on TO can be expressed as (0.456 + 0.340 GE), which reveals that improvement in GE stimulates the positive effect of economic complexity on TO. The total effect of ECI can be demonstrated as (0.686 + 0.340ECI), which reveals that higher

Variables	Coef	*p*-value
ECI	0.456	0.000***
GE	0.686	0.000***
ECI*GE	0.340	0.000***
GDP	−0.361	0.654
NRR	2.417	0.000***
ER	−0.00002	0.000***
INF	−0.004	0.000***
Constant	−0.423	0.000***
Prob > *F*	0.000***	
R^2	0.7099	
Root MSE	0.2457	

Note(s): * Shows pro.val<0.1, ** shows pro.val<0.05, *** shows pro.val<0.01
Source(s): Authors' own work using Stata

Table 3.
Regression with Driscoll–Kraay standard errors dependent variable: TO

economic complexity enhances the positive effect of GE on TO. Nations with high levels of GE have a larger proportion of female labor force involvement, which may contribute to economic variety and innovation, as well as increased trade. In addition, a country with high economic complexity along with equal access of women in education and employment as men boosts the skillful, experienced workforce in the labor market, which enhances economic activities. This finding is consistent with Romer's notion in endogenous growth theory outcomes, indicating that collected know-how, technological advancement and effective use of human capital leads to the growth of an economy through improving trade system. This development of economic activities through skillful and experienced labor force leads to improved exports and trade. GDP has negative effect on TO, which shows that a 1% increase in GDP reduces TOP by 0.361%. This result is identical to the study of Jayathilaka *et al.* (2022) in Asia and Africa. It indicates a rise in GDP enhances the products' demand and whether demand rise from supply creates INF and reduce TO. The coefficient of NRR is 2.417% and significant at 1%, indicating that rise in NRR, when managed properly, may provide a source of revenue for infrastructure, education and other development activities and ultimately enhances trade. The revenue generated from NRR can be utilized in underdeveloped areas and to invest in diversifying export base to stimulate TO.

The ER has a negative and significant impact on TOP, at a 1% level of significance. This indicates that increase in ER depreciates the domestic currency, increases cost for exports and reduces its competitiveness in international market along with increase in imports bill and discourages trade. These results are consistent with the previous study of Caporale and Doroodian (1994), Cho *et al.* (2002) and Adedeji (2023).

Moreover, the results proved that INF has a negative impact on TO. For instance, a 1% rise in INF reduces the TO by 0.004%. This finding is similar to the results of Sakanko and Joseph (2019) and Chhabra and Alam (2020). An increase in INF increases the cost of production, which decreases the purchasing power, weakens the currency and, ultimately, hampers the production and then decreases the imports and exports.

6. Conclusion

The current paper intends to examine the impact of economic complexity on TO with the interaction of GE in D-8 countries. The data were collected from 1990 to 2020 from different sources to achieve the objectives of this study. The choice of variables of current study are grounded on the Romer hypothesis, which states that economic growth attained through investment in human, physical and technological capital. This study employed the D-K regression model approach because of the presence of autocorrelation and heteroscedasticity along CSD. The findings revealed that economic complexity and GE have a significant and positive effect on TO. This study reveals an interesting finding that GE strengthens the positive impact of economic complexity on TO. This entails that both forces worked together to strengthen the trading system by providing nations with highly sophisticated as well as complex products, as well as equal access to resources, investment and decision-making for women.

6.1 Policy implications

Policymakers should develop complementary measures that promote both economic complexity and GE. Effective policies that focus on investing in education and technological inventions that diversify the productive method and raise the level of exports, which helps to enhance the level of competitive exports in global markets, are needed. As the result of the current study showed, GE raises the level of economic complexity. Thus, policymakers should adopt and implement policies that address and reduce gender disparities and create a more stable environment for domestic and foreign trade. As the

findings of this study proved economic complexity jointly with GE increased TO, the government should prioritize gender-inclusive policies, for instance, policies that give equal access to women in education and employment and give opportunities to invest in businesses. This could enhance GE and, in turn, boost economic complexity through a skillful and diverse labor force, innovation, effective allocation of resources and then foster TO and sustainable development in a country.

6.2 Ideas for future research

The current study investigates the direct and indirect impact of economic complexity and GE on TO in D-8 countries at an aggregate level. Future research may analyze how various regions or sectors influence trade through economic complexity and GE at a broader temporal choice with an extended framework.

Corrigendum

It has come to the attention of the publisher that the article "Unlocking trade potential: gender equality, economic complexity and trade openness in the Developing-8 (D-8) countries" by Saima Sajid, Syed Saqlain Ul Hassan, Shafique Ur Rehman, Maryam Arooj, and Md Nazmus Sadekin, published in the *International Journal of Social Economics*, Vol. ahead-of-print, No. ahead-of-print, https://doi.org/10.1108/IJSE-11-2023-0908, displays the authors' affiliations incorrectly. This error was introduced during the submission process. The incorrect affiliations have been corrected as follows: Saima Sajid (Department of Economics, Faculty of Administrative and Management Sciences, GC Women University Sialkot, Sialkot, Pakistan) has been corrected to Saima Sajid, Department of Economics, Faculty of Administrative and Management Sciences, GC Women University Sialkot, Sialkot, Pakistan.

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Appendix

Variables	Symbol	Proxy	Period	Source
Trade Openness	TO	Exports plus imports as % of GDP	1990–2020	WDI
Economic Complexity Index	ECI	ECI index measured by diversity and ubiquity	1990–2020	OEC, OWID
Gender Equality	GE	Labor force participation rate female to male ratio	1990–2020	WDI
Gross Domestic Product	GDP	GDP per capita growth as annual %	1990–2020	WDI
Natural Resources Rents	NRR	Total natural resources rents as % of GDP	1990–2020	WDI
Exchange Rate	ER	Official Exchange Rate as LCU per US$, period average	1990–2020	WDI
Inflation	INF	Inflation, consumer prices, annual %	1990–2020	WDI

Source(s): Authors' own work

Table A1.
Variables' description

Dependent variable: To	OLS Model 1	OLS Model 2	FGLS Model 1	FGLS Model 2
ECI	0.458 (0.000)***	0.456 (0.000)***	0.458 (0.000)***	0.456 (0.000)***
GE	0.694 (0.000)***	0.686 (0.000)***	0.699 (0.000)***	0.686 (0.000)***
ECI*GE	0.545 (0.000)***	0.340 (0.000)***	0.545 (0.000)***	0.340 (0.009)***
GDP	0.436 (0.389)	−0.361 (0.460)	0.436 (0.756)	−0.361 (0.425)
NRR	2.549 (0.000)***	2.417 (0.000)***	2.549 (0.000)***	2.417 (0.000)***
ER	−0.00003 (0.000)***	−0.00002 (0.000)***	−0.00003 (0.000)***	−0.00002 (0.000)***
INF	−0.0004 (0.829)		−0.0004 (0.825)	
INF*		−0.004 (0.000)***		−0.004 (0.000)***
Constant	0.300 (0.000) ***	0.423 (0.000)***	−0.352 (0.000)***	0.423 (0.000)***
Prob > F	0.000***	0.000***	0.000***	0.000***
R^2	0.6968	0.7099	0.6968	0.7099
Adjusted R^2	0.6863	0.7014	Panel: Homoskedastic	Panel: Homoskedastic
Root MSE	0.2530	0.2457	Correlation: No autocorrelation	Correlation: No autocorrelation

Table A2.
Robustness tests

Note(s): * Shows pro.val<0.1,** shows pro.val<0.05, *** shows pro.val<0.01
Source(s): Authors' own work

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