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Examining the Role of Women's Labor Participation in CO_2 Emissions in Saudi Arabia

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ABSTRACT

Women can play an active role in determining environmental quality, and Saudi women's share in the labor market is increasing considerably. Women's participation is still low in the labor market, and their participation might affect the aggregated environmental situation. Therefore, we explore the effect of Women's Labor Participation (WLP) on CO_2 emissions in Saudi Arabia from 1990 to 2022 by employing a cointegration technique. The Environmental Kuznets Curve (EKC) is tested and substantiated in the long run, but it is not verified in the short run. WLP raises CO_2 emissions. Thus, women's labor market entry has environmental consequences. Moreover, trade openness also contributes to CO_2 emissions over a long period of time. Nevertheless, its short-term impact is environmentally pleasant. The study recommends checking environmental problems out of WLP by developing gender-responsive environmental policies. So, gender equality and sustainable growth would be targeted simultaneously.

Keywords: Women Labor Participation, CO_2 Emissions, Trade Openness, The EKC

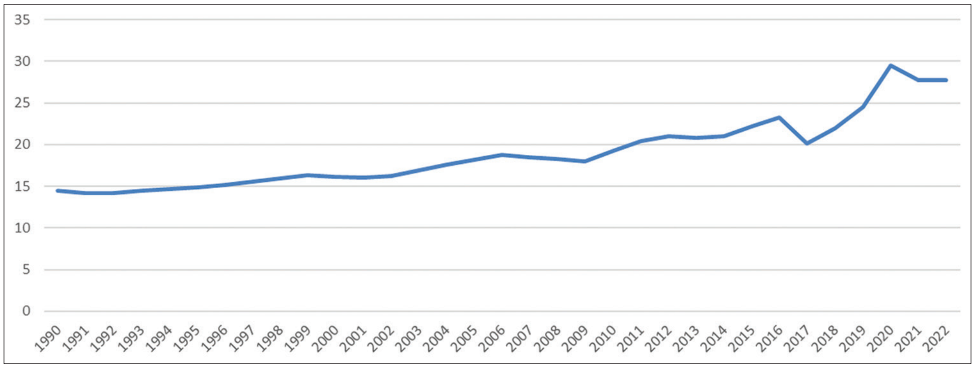
JEL Classifications: O44, Q56, J16, E24

1. INTRODUCTION

In the recent decade, there have been many achievements in improving the role of women in Saudi Arabia. There are many legal reforms in favor of women's rights to empower them in the social and economic walks of life. For instance, women are allowed to drive and may move and travel with freedom without male company (El-Bakr, 2022). Moreover, women have also been empowered in terms of their economic lives with employment in the labor market in different economic sectors. There are still challenges and opportunities in the way of women, and removing such problems would accelerate women's economic participation (Alessa et al., 2022). Once we talk about women's economic empowerment, we cannot ignore the role of education and skills. Alsubaie (2022) found that enhancing education and skills improved women's economic empowerment in Saudi Arabia. Other than education and skills, the empowerment of women in their health issues is also important. Nevertheless, the poor health of the women would be a hurdle in the way of women's empowerment (Okonofua and Omonkhua, 2021). In addition, social initiatives may also help empower women in their economic lives. Thus, women can participate in production, which could have an effect on emissions. Moreover, women may uplift the income status of the household, which could increase aggregated demand. Thus, women might significantly contribute to the economy, society, and environment of any economy.

Women's political participation is also important, which would help to design the country's policies in favor of women (Alkhaled, 2021; Al-Qahtani, 2020). To display women's economic contribution, Figure 1 shows women's labor participation as a percentage in Saudi Arabia. WLP has had a mostly positive trend from 1990 to 2016. In the year 1990, WLP was 14.44%, which increased to 23.23% in the year 2016. However, the positive trend remained mild during 1990–2016.

Figure 1: Women's labor participation (WLP) in percentage



Afterward, it declined from 2016 to 2018 but improved drastically after 2018. The highest percentage (29.55%) was observed in the year 2020. Later, it declined by a small amount. But, still, the WLP was observed at 27.75% in the year 2022. Thus, Figure 1 shows a drastic improvement in WLP since 1990. After discussions of improvement in WLP, it is very important to watch its role in environmental sustainability. The literature has argued that women may have a significant role in determining the environment (Wickramasinghe, 2011; Arora-Jonsson, 2011). For instance, women would increase the aggregated production in the country because of additional production because of WLP. Particularly, WLP in the industry would raise emissions if the industry was not using clean technologies. However, WLP in the service sector might be neutral for the environment. Moreover, WLP could surely raise total transport in an economy and could raise emissions by using fossil fuels. Furthermore, WLP might contribute to household income, and aggregate demand can be raised in an economy. Particularly, the chance of consumption is high because women mostly work for family needs.

While working on macroeconomic studies on pollution, economic growth is a significant factor. For instance, economic growth at first needs energy and would pollute the environment with a scale effect. However, the environment may improve with the existence of technique and composition effects. For instance, economies would shift to cleaner technologies and production processes to save the environment and improve better standard of living (Costanza, 1995). Side by side, clean technologies may also be adopted to reduce the environmental pressure of industrialization, which is called the technique effect (Komen et al., 1997). Furthermore, the composition of industries would also shift in favor of clean processes, or industries may shift to a less-polluted services sector. The literature suggested the Environmental Kuznets Curve (EKC) hypothesis testing (Panayotou, 1993). In addition, trade openness (TO) may affect pollution in a country. For instance, dirty industries may transfer to developing economies in the presence of free trade (Zhang, 2014). So, it depends on the nature of the exports. If the production of exports is energy-intensive, then exports could pollute economies. Similarly, the population may rise out of imported products if these products are energy-intensive. On the other hand, trade openness would have a pleasant environmental effect, as trade may facilitate the development of tight environmental regulations (Abimanyu, 1996).

Before a decade, WLP was very low in Saudi Arabia, which imitates the unutilized potential of the Saudi economy and society (Alessa et al., 2022). A sudden shift in women's economic participation may have environmental outcomes because of the increasing volume of the economy and the unutilized potential of the Saudi economy. However, probing the environmental role of women is somewhat insufficient in the world and ignored in the Saudi context. Thus, the present study contributes to the existing environmental literature by investigating the effects of WLP, TO, and economic growth on CO_2 emissions in Saudi Arabia.

2. LITERATURE REVIEW

Literature has signified the role of women in pollution. Wickramasinghe (2011) argued for the prominent role of women in the sustainable forestry and agriculture sectors through the management of resources and environmental conservation efforts. If women would increase the efficient use of such natural resources, then they may reduce ecological problems. Raghuram et al. (1998) discussed the importance of political women's rights related to environmental and ecological issues. The authors argued that the gender equity approach would help raise ecological sustainability efforts. Particularly, the involvement of women in environmental decisions would mitigate emissions, as women can help reduce emissions from household consumption. Moreover, Le and Nguyen (2020) claimed that women's education would help in achieving sustainable practices to contribute to environmental conservation. However, women faced many challenges in the way of education and environmental initiatives. Thus, solutions to educational problems faced by women could significantly contribute to environmental conservation and sustainability. Particularly, environmental education would mitigate emissions if energy efficiency could be achieved. Arora-Jonsson (2011) argued that women had low resources and high cultural expectations. Thus, these expectations are hurdles in the way for women to adopt sustainable practices to mitigate climate change. Moreover, solving these hurdles would improve women's participation in climate change mitigation measures. Duflo (2012) analyzed the impact of WLP on sustainable economic development. The author argued that WLP would help them participate in environmental projects, which need intensive policies to improve the gender's economic status (Kabeer, 2020).

There is a scant literature on empirical evidence on the environmental effects of women. Thus, we focus on other important variables while reviewing the empirical literature. For instance, Nasim et al. (2023) examined 58 developing countries from 2000 to 2022 and found an association between trade and pollution. The author recommended strategic government spending to optimize the economic and environmental outcomes of trade and foreign investment. Pham et al. (2023) analyzed Vietnam from 1990 to 2019 and showed that Renewable Energy Consumption (REC), energy efficiency, and trade would help to mitigate emissions. Thus, the authors suggested adopting the latest technologies for REC and energy efficiency to combat emissions. Kayabas (2023) examined Mexico from 1980 to 2021 and found the EKC in Mexico. Further, trade expansion and sea transportation reduced CO_2 emissions. However, energy usage raised emissions. Lalon et al. (2023) explored Bangladesh from 1972 to 2021 and found that trade accelerated CO_2 emissions. Thus, exports and imports contributed to emissions because of the production and consumption of trade items.

Hoang and Tuan (2023) investigated China and reported that trade and income raised CO_2 emissions. However, green finance and REC mitigated emissions. Thus, green financing policies mitigate emissions by adapting REC. However, the environmental effects of trade must be considered. Adebayo et al. (2023) examined Mexico from 1965 to 2021 and found that energy usage helped to raise income levels. Moreover, trade also uni-directionally increased economic growth. Thus, economic improvements can raise questions about the environment. Rehman et al. (2021) investigated Pakistan in the asymmetrical model and found that decreasing REC increased CO_2 emissions and increasing REC mitigated CO_2 emissions. In addition, FDI and trade also had a significant effect on CO_2 emissions. Thus, TO is harmful to such a developing economy. Ahmed et al. (2019) analyzed some poor countries from 1980 to 2014 and reported the EKC. Moreover, energy usage and income raised emissions' intensity. In addition, exports were also responsible for raising emissions' intensity. Again, these findings showed that poor countries' trade has environmental problems.

Within an Arab context, Azzam (1970) explored the role of women in water management in the Arab world and argued that inclusive gender equality policies would raise the efficiency of the use of water in the water-scarce Arab world. However, the author ignored the possible environmental outcomes of Saudi women's economic participation. Some Saudi literature works on the environment by ignoring the impact of women in determining the environment. For instance, Mahmood and Alkhateeb (2017) investigated and reported the EKC, and trade reduced CO_2 emissions. Thus, trade became an environmental blessing for the Saudi economy. Kahia et al. (2021) examined Saudi Arabia from 1990 to 2016 and found 2-way causality among REC, emissions, and income. So, these variables are affecting each other with reverse effects. Alajmi (2021a) analyzed the Saudi economy from 1980 to 2017 and found that income, electrification, and population enhanced CO_2 emissions. Moreover, energy demand showed an upward trend during the study period. Baloch et al. (2018) explored Saudi Arabia from 1971 to 2016 and found that electrification increased CO_2 emissions. In the same manner, income increased CO_2 emissions. However, financial instability had an insignificant effect on CO_2 emissions.

Mighri and Sarkodie (2024) examined Saudi Arabia using quarterly data from 1990–2021 and found that green technology reduced CO_2 emissions at higher quartiles. Thus, clean technologies are mitigating emissions. Moreover, bidirectional causality was also found in these variables. However, both causality and impact results varied at lower, middle, and upper quantiles. Raggad (2018) investigated the Saudi economy and found the positive effects of income and energy usage on emissions. However, urbanization mitigated emissions. Daly and Abdouli (2023) analyzed the Saudi economy and revealed a 2-way causality between emissions and income, TO, and emissions. Moreover, income accelerated emissions. Samargandi (2017) examined the EKC in Saudi Arabia but reported a positive effect from different sources of CO_2 emissions. Even the industry and service sectors had greater effects. Moreover, technological innovation could not affect CO_2 emissions. It showed a low level of innovation in this economy.

Xu et al. (2018) scrutinized Saudi Arabia from 1971–2016 and found that financial development and electrification accelerated CO_2 emissions, and electrification showed a greater effect as electrification was produced from fossil fuels. However, globalization could not influence CO_2 emissions. Mahmood (2023) examined Saudi Arabia from 1968 to 2021 using carbon intensities data from different sources and found the EKC in some investigated sources. Moreover, trade mitigated carbon intensities from some sources. However, foreign investment showed mixed results in different sources of carbon intensities. Moreover, resource rents contributed to increased carbon intensities from all sources. Raggad (2020) examined Saudi Arabia from 1971 to 2014 in nonlinear analysis and showed that energy usage and income accelerated emissions. Moreover, decreasing financial development accelerated CO_2 emissions. Alajmi (2021b) examined Saudi Arabia from 1990 to 2016 and found that energy usage and population accelerated emissions. Moreover, the effects were found to be greater in electrification compared to the transport sector.

Alkhathlan and Javid (2015) inspected Saudi Arabia from 1971 to 2013 and found that income accelerated CO_2 emissions in a quadratic relationship. Moreover, total oil consumption and transportation contributed to CO_2 emissions. Thus, oil is pollution-oriented. Mahmood et al. (2020) examined the Saudi economy and substantiated that oil prices accelerated emissions over a long period but not over a short period. Alkhathlan and Javid (2013) used disaggregated energy data and found that oil usage and electrification enhanced CO_2 emissions. Even so, the long-run effects were greater. However, gas usage reduced CO_2 emissions. Thus, gas was relatively less polluted. Alkhateeb et al. (2020) analyzed the Saudi economy from 1971 to 2014 and found the EKC. Moreover, secondary education helped in reducing CO_2 emissions, but primary education could not affect CO_2 emissions. Thus, higher education is needed to learn about the environmental problems of the country. Mahmood et al. (2020) explored the Saudi economy from 1970 to 2014 and substantiated that urbanization accelerated CO_2 emissions. However, gasoline prices mitigated CO_2 emissions with a low gasoline demand. Abro et al. (2022) explored Saudi Arabia from 1972 to 2018 and found that financial development and globalization mitigated CO_2 emissions. Moreover, energy resource efficiency also helped to mitigate CO_2 emissions.

The literature signifies the role of women in determining the environment. However, the empirical testing of this effect is ignored in the context of the Saudi economy. Thus, we extend the literature by exploring the effects of WLP, TO, and income on CO_2 emissions in the Saudi economy to address this literature gap and contribute to hands-on policymaking.

3. METHODS

The literature has signified the potential role of women in determining the environment (Wickramasinghe, 2011; Arora-Jonsson, 2011). Thus, we hypothesize the effect of women's labor participation on CO_2 emissions. The women might affect emissions in two ways. First, the production side could have a direct rise in emissions with excess output because of WLP. Secondly, the indirect effect of rising community income could raise aggregated demand and consumption. Thus, environmental problems can be sourced from the production and consumption sides. Moreover, we cannot ignore the environmental impact of income. Particularly, economic growth had a nonlinear effect on pollution (Grossman and Krueger, 1991). The start of the growth process would boost energy demand and emissions with a scale effect. However, technique and composition may emerge after the scale effect, which would potentially reduce the pollutant emissions. In addition, trade is a very important variable in determining CO_2 emissions, which is responsible for the transfer of emissions through trade (Peters et al., 2011). Exports could raise emissions from their production. Imports could raise emissions if energy-intensive items are imported and consumed. So, we worked on the effects of aggregated trade on emissions. We assume this model:

$$CO2_t = f(GDPC_t, GDPC_t^2, WLP_t, TO_t) \quad (1)$$

$CO2_t$ is a natural log of CO_2 emissions per capita and is sourced from the Global Carbon Atlas (2023). $GDPC_t$ is Gross Domestic Product (GDP) per capita and $GDPC_t^2$ is a square of $GDPC_t$. TO_t is a natural log of the total trade percentage of GDP. WLP_t is a natural log of the percentage of women in the total labor force. All data is taken from 1990-2022 and all data except $CO2_t$ is taken from World Bank (2023). The unit root is tested by Ng and Perron (2001) through the following statistics:

$$MZ_a^d = \left[\frac{X_T^d}{T}\right]^2 \cdot \frac{1}{2k} - \frac{f_0}{2k} \quad (2)$$

$$MSB^d = \sqrt{\frac{k}{f_0}} \quad (3)$$

$$MZ_t^d = MZ_a^d . MSB^d \quad (4)$$

$$MPT_T^d = [Kc^2 + (1-c)/T]\frac{X_T^d}{f_0} \quad (5)$$

After the above tests, the cointegration test of Pesaran et al. (2001) is utilized. For this purpose, the Autoregressive Distributive Lag (ARDL) model is applied in the following way:

$$\Delta CO2_t = a_0 + a_1 CO2_{t-1} + a_2 GDPC_{t-1} + a_3 GDPC_{t-1}^2 + a_4 WLP_{t-1} + a_5 TO_{t-1} + \sum_{i=1}^{j} a_{6i}\Delta CO2_{t-i} + \sum_{i=0}^{j} a_{7i}\Delta GDPC_{t-i} + \sum_{i=0}^{j} a_{7i} GDPC_{t-1}^2 + \sum_{i=0}^{j} a_{8i}\Delta WLP_{t-i} + \sum_{i=0}^{j} a_{9i}\Delta TO_{t-i} + e_{1t} \quad (6)$$

$$\Delta CO2_t = b_0 ECT_{t-1} + \sum_{i=1}^{j} b_{1i}\Delta CO2_{t-i} + \sum_{i=0}^{j} b_{2i}\Delta GDPC_{t-i} + \sum_{i=0}^{j} b_{3i} GDPC_{t-1}^2 + \sum_{i=0}^{j} b_{4i}\Delta WLP_{t-i} + \sum_{i=0}^{j} b_{5i}\Delta TO_{t-i} + e_{2t} \quad (7)$$

Equations 6 and 7 show that the ARDL framework is more dynamic, which has the power to control endogeneity in the model and also capture the effects with the lag of the variables. Moreover, it has the ability to capture both long and short periods results. It may be applied in a mixed order of integration. It provides non-spurious results due to using stationary series. The inclusion of lagged differences variables would help to ensure more reliable results (Pesaran et al., 2001). From equation 6, $a_1=a_2=a_3=a_4=a_5=0$ will be tested by the bound test to verify the cointegration in a model. Further, the long run results can be estimated by using normalized coefficients of lagged-level variables a_2, a_3, a_4, and a_5, which will be normalized by a_1. The terms in equation 6 are put to solve the endogeneity problem. From equation 7, coefficient b will capture the short run effects. Moreover, the presence of a short run relationship will be verified with a negative coefficient of ECT_{t-1}.

4. DATA ANALYSIS

Unit root testing is a pre-condition to proceed with cointegration. Table 1 depicts that all dependent and independent variables in ARDL equation 6 are non-stationary at their levels and stationary at their differences. The order of integration is one.

The bound test is based on the chosen lag lengths in equation 6 and the F-value is 5.2046, which is larger than I(1) at 1% in Table 2. Thus, a strong cointegration is found between the concerned variables in Equation 6. Furthermore, diagnostic tests validate the soundness of the estimated model with more than 0.1 P-values in the case of tests.

Table 1: Ng-Perron results

	MZa	MZt	MSB	MPT
CO_{2t}	−8.9834	−2.1098	0.2349	10.1806
$GDPC_t$	−11.0299	−2.3180	0.2102	8.4150
$GDPC_t^2$	−10.8606	−2.3005	0.2118	8.5386
WLP_t	−10.7445	−2.2870	0.2129	2.4015
TO_t	−12.4744	−2.4922	0.1998	2.3396
ΔCO_{2t}	−24.3260***	−3.4792***	0.1430**	3.7962***
$\Delta GDPC_t$	−18.8096**	−3.0654**	0.1630**	4.8526**
$\Delta GDPC_t^2$	−19.0447**	−3.0845**	0.1620**	4.7931**
ΔWLP_t	−23.2133**	−3.3884**	0.1456**	1.1482***
ΔTO_t	−22.3467**	−3.4146**	0.1431**	4.0353**

Figure 2: Stability test

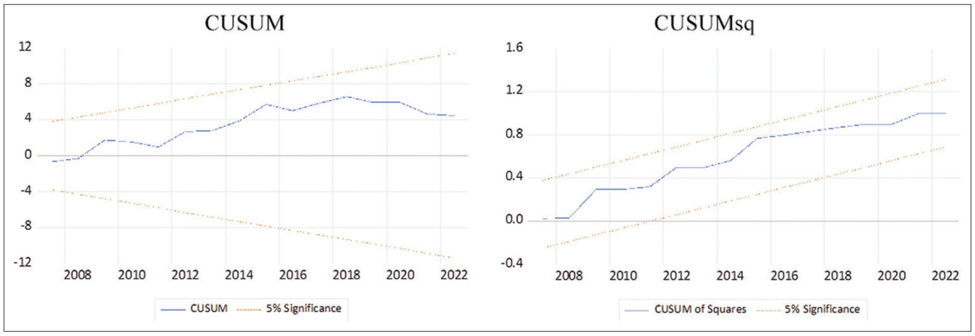


Table 2: Bound and diagnostic tests

Dependent variable	Bound test	Heteroscedasticity	Serial correlation	Normality	Functional form
ΔCO_{2t}	5.2046	1.2105 (0.3211)	1.0062 (0.4338)	1.8310 (0.4003)	1.5229 (0.2258)
	Critical bounds		At 10%	At 5%	At 1%
	I (0)		2.402	2.850	3.892
	I (1)		3.345	3.905	5.173

Table 3: ARDL results

Variable	Coefficient	S.E.	t-value	P-value
Long run				
$GDPC_t$	33.5259	10.5945	3.16447	0.0031
$GDPC_{t2}$	−1.6598	0.5269	−3.1500	0.0032
WLP_t	0.1891	0.0694	2.7236	0.0097
TO_t	0.3513	0.1472	2.3868	0.0221
Intercept	−168.5350	52.9603	−3.1823	0.0029
Short-run				
$\Delta CO2_{t-1}$	0.3520	0.1201	2.9319	0.0058
$\Delta CO2_{t-2}$	0.4878	0.1273	3.8317	0.0005
$\Delta GDPC_t$	4.4023	6.8071	0.6467	0.5219
$\Delta GDPC_t^2$	−0.1733	0.3410	−0.5083	0.6144
ΔWLP_t	0.1419	0.0562	2.5236	0.0169
ΔTO_t	0.0536	0.1432	0.3745	0.7102
ΔTO_{t-1}	−0.2842	0.1475	−1.9264	0.0619
ECT_{t-1}	−0.7503	0.1246	−6.0220	0.0000

In the long run, $GDPC_t$ carries an inverted U-shaped effect on CO_2 emissions in Table 3, which is evidence of the EKC in this economy with a turning point of 24327. The presence of EKC in the Saudi economy is also reported by past studies (Mahmood and Alkhateeb, 2017; Mahmood, 2023; Alkhateeb et al., 2020). However, a few studies could not find the EKC in the Saudi economy (Samargandi, 2017; Alkhathlan and Javid, 2015). With this empirical evidence, it is realized that the presence of environmental problems arises from economic growth at the first stage of the EKC. Economic growth increases the demand for products, which may result in more industrialization. Industrialization would have a permanent increase in energy demand, which would contribute to air and water emissions. In the same way, demand for transportation, automobiles, trucks, ships, and planes, may also increase due to higher industrial and urban activities. On the consumption side, rising income levels would accelerate the demand for all products, which would raise energy demand and emissions. Saudi Arabia has a major reliance on fossil fuels for energy, a big source of emissions. WLP accelerated emissions. A 1% increase in WLP is raising 0.1891% of CO_2 emissions. Even though the response of CO_2 emissions is less than unity, WLP is still responsible for environmental degradation. This result verifies the fact of a sudden jump in women's participation in the labor market, which eventually raised economic activities and energy consumption instantly. For instance, the sudden increase in WLP can lead to increased production, consumption, and economic output. Thus, pollution may increase from the production side of women-related economic activities. On the other hand, increasing income due to WLP may increase pollution-oriented consumption, i.e., usage of more cars, fuels, air conditioning, and other energy-intensive consumption. Particularly, the effect of pollution out of production may be more intense if WLP is raised mostly in the industrial sector. However, WLP in the service sector may not have immediate environmental concerns. Side by side, TO has also accelerated CO_2 emissions. However, Mahmood and Alkhateeb (2017) reported the opposite findings in Saudi Arabia. Based on the results of the present study, a 1% increase in TO may increase 0.3513% of CO_2 emissions. Thus, increasing total trade raises emissions. Oil production is naturally pollution-oriented in the Saudi export sector. Moreover, the consumption side of imports is also pollution-oriented due to highly energy-intensive imported products, i.e., imports of cars, air conditioning, and other energy-intensive utilities. The positive effect of TO intensifies the perception that both exports and imports are pollution-oriented.

The parameter of ECT_{t-1} is negative and corroborates the short period associations. Moreover, two consecutive lags of CO_2 emissions have positive effects on current CO_2 emissions. Thus, increasing emissions positively affects future emissions. $GDPC_t$ and its square have insignificant effects on CO_2 emissions. So, the EKC is not validated. WLP has a positive coefficient in relation to CO_2 emissions. 1% increment in WLP is increasing 0.1419% of CO_2 emissions in the short run. Thus, women's labor participation is increasing economic activity. So, the additional increment in production carries an environmental problem. Particularly, the income effect of WLP seems to be more prominent in the short run, as a sudden rise in women's income may shift the lifestyle of women in women's income-dependent households. Thus, this situation may raise energy usage and emissions. Lag of TO mitigated CO_2 emissions. This short-run result matches Mahmood and Alkhateeb's (2017) results.

Figure 2 depicts CUSUM and CUSUM square tests, which have the ability to conclude about the stability of results. The lines are within critical bounds. Thus, the estimated results are stable. So, the conclusions drawn from the results are robust and reliable. Thus, WLP has environmental problems due to rising economic activities and pollution.

5. CONCLUSION

We worked on the relationship between women's labor participation and emissions. For this purpose, the Saudi data was collected for a maximum available range from 1990 to 2022, and the ARDL technique was applied. The cointegration and short-period association are corroborated in the model. The analysis concludes the existence of the EKC in Saudi Arabia, with a point of inflection at 24327. The Saudi economy was founded in the first phase of the EKC as per the current income level. Therefore, economic growth has environmental problems in the Saudi economy. Economic growth is supported by the production of goods and services. Thus, such additional production is raising energy usage and emissions as the Saudi economy mostly depends on fossil fuels. Moreover, rising income would give rise to consumption, which raises emissions on the demand side. Moreover, women's labor participation increased CO_2 emissions. Thus, a sudden shift in an upward trend in women's labor participation increased economic activities and CO_2 emissions consequently. This result has a 2-dimensional effect on the environment. First, a direct effect of increasing the GDP of the countries is produced by women. Such production contributed to emissions. Moreover, the indirect effect comes from the demand side. For instance, rising WLP increases household income, which increases the demand for energy in income-dependent households. Furthermore, trade openness raised emissions over a long period of time. However, it reduced emissions in a short period with its one-year lag. These long-run results explain that Saudi exports and imports significantly contribute to Saudi CO_2 emissions. The Saudi export sector mainly depends on oil exports. On the other hand, Saudi imports are also consuming more energy. Thus, both branches of TO contribute to CO_2 emissions.

Based on the findings, we recommend initiating women-related projects with green technologies so the environmental effects can be controlled with women's labor market entry. Moreover, trade should be promoted in clean industries and should be replaced by clean types of exports and imports to save the environment from trade openness in the long run. The present study recommends that future studies should care about more dimensions of women's economic participation to capture their broader role in the environment.

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