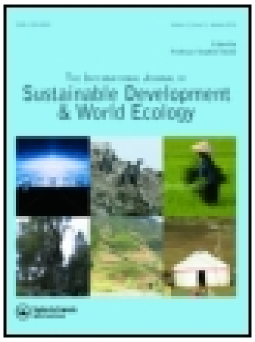

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Modeling a sustainable Saudi Arabian economy: the real issues

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This paper develops a macroeconomic framework for creating a competitive and sustainable Saudi Arabian economy, taking into account the interrelationships among social, environmental, and economic factors. The objective of the research is to build a model that will allow for evaluating the effects of a wide range of emissions abatement policies on economic growth and development. The research methodology is grounded in econometric modeling of the Saudi economy over the period 1980–2010. The estimated parameters of the model were used to project long-term gross domestic product (GDP) growth paths based on three environmental degradation abatement scenarios. The results suggest that the sustainability of economic growth in Saudi Arabia critically depends on aggressive emissions-reduction policies since policy scenarios corresponding to higher pollution cuts yielded higher, sustained long-term GDP. The results also broadly reject the Environmental Kuznets Curve (EKC) hypothesis, implying that a turning point in the relationship between CO_2 emissions and per capita GDP is yet to be attained.

Keywords: sustainable development; optimum growth model; environmental challenges; Saudi Arabia; oil subsidy; Environmental Kuznets Curve; CO_2 emissions

1. Introduction

The Kingdom of Saudi Arabia (KSA) is the world's largest holder of oil resources, accounting for a quarter of the global oil reserves. For decades, its vast oil resources have supported mega socioeconomic development projects and generous oil subsidies, which have, however, encouraged large domestic oil consumption. On current trends, Saudi Arabia is likely to consume more oil than it will be exporting, and this will have two serious implications for the economy. First, as domestic oil consumption increases, oil exports will fall, leading to a decline in foreign exchange earnings and government revenues, which will severely constrain the ability to executive ambitious infrastructure development programs. Second, oil is a nonrenewable resource and, in the absence of diversification and a credible energy-mix policy, oil reserves could be grossly depleted with devastating consequences for future generations.

In addition to fiscal constraints, overreliance on fossil fuel to support the industrialization agenda could exacerbate environmental concerns, which could further undermine the sustainability of the Saudi economy. Mindful of these concerns, the Saudi government had established the King Abdullah City for Atomic and Renewable Energy (KACARE) to mitigate the consequences of some of these environmental challenges. However, these initiatives are at a nascent stage and it will require strong political will to make them achieve the desired objectives.

The main objective of this paper is to develop a macroeconomic model that incorporates economic, social, and environmental factors for generating parameters that will be consistent with a sustainable growth path for the Saudi Arabian economy. The model is used to perform gross domestic product (GDP) growth projections based on three scenarios of carbon dioxide (CO_2) emission reduction policies. The model is also used to test the so-called Environmental Kuznets Curve (EKC) hypothesis, which propagates an inverted-U shaped relationship between per capita income and environmental pollution, analogous to the income–inequality relationship postulated by Simon Kuznets. Understanding the nature of the relationship between economic growth and environmental factors will undoubtedly help policymakers formulate appropriate policies that could help promote a sustainable economy.

Section 2 of the paper provides an overview of the Saudi Arabian economy, highlighting challenges and opportunities, followed by the literature review in Section 3. Section 4 of the paper focuses on the methodological framework, while Section 5 analyzes the results. Section 6 pulls together the main conclusions of the paper.

2. Overview of the Saudi Arabian economy

2.1. *Growth performance*

During the past four decades the Saudi Arabian economy has expanded tremendously, driven largely by oil wealth, which has propelled massive government spending, buoyed private sector activities, and laid the foundation for solid economic fundamentals. Indeed, the growth

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performance of Saudi economy, especially during the boom period 2003–2008, has been impressive. Thereafter, economic growth decelerated dramatically, due to the 2008 global financial crisis, before picking up momentum again a couple of years later (Figure 1). In fact, the rapid growth in GDP over the years has catapulted Saudi Arabia into the Group of the top 20 (G20) richest nations in the world.

Given the overwhelming reliance of the economy on the oil sector, Saudi Arabia has undoubtedly benefitted from the high oil prices and output seen over the years. Oil prices, in both nominal and real terms, have jumped from less than $3 per barrel in the 1970s to over $100 per barrel during the past five years (Figure 2). However, since July 2014, oil prices had plummeted from $107 per barrel to below $50 per barrel in September 2015, leading to a substantial decline in government revenue, with serious implications for fiscal policy. Already, the Saudi authorities have started feeling the adverse effect of the oil price fall as they have begun drawing down the country's foreign reserves, issuing local currency bonds, and cutting spending on non-priority projects. It is estimated that Saudi government revenues will fall by over $80 billion in 2015, resulting in a budget deficit equivalent to 20% of GDP (International Monetary Fund, IMF 2015a). This contrasts sharply with the huge fiscal surpluses the kingdom has recorded over the past 15 years, where fiscal surplus reached a record level of 32% of GDP (Figure 3).

2.2. *Key challenges and their drivers*

Despite the solid economic fundamentals, the Saudi economy has faced a number of challenges in its quest to creating sustainable economic growth and development. These decades-old challenges revolved around diversification of the economy, human capital development, job creation, labor market flexibility, and financial system deepening. Diversifying production and exports as well

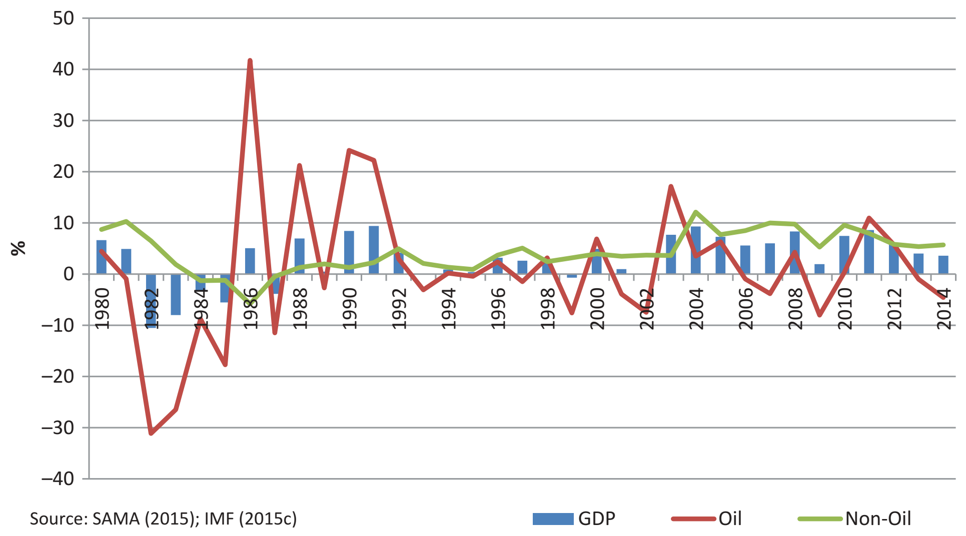

Figure 1. Saudi Arabia: Growth Rate of Oil and Non-Oil GDP (%).

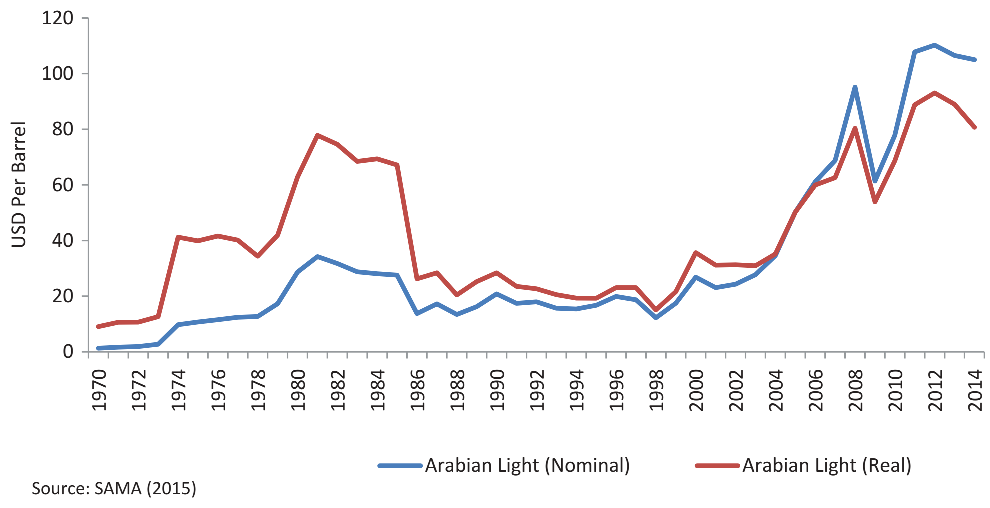

Figure 2. Trends in Arabian Light Oil Prices (1970–2013).

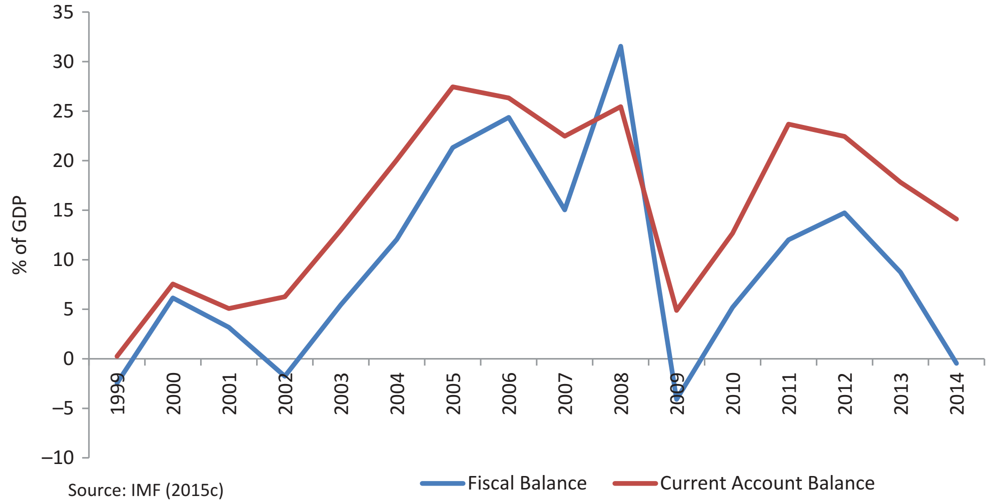

Figure 3. Saudi Arabia: Fiscal and Current Account Balances.

as boosting the competitiveness of the kingdom would be a springboard for creating jobs and overcoming unemployment problems. This must, however, be complemented with reform of the education system to equip the labor force with the relevant skills and knowledge that enhances employability in the private sector. Such a strategy would lift the kingdom out of the current equilibrium of low-growth-high-unemployment situation and thereby help create a sustainable, knowledge-based economy capable of addressing the challenges of the twenty-first century.

The issue of diversification is undoubtedly critical to the sustainability of the Saudi and other oil-rich Gulf Cooperation Council (GCC) economies. Estimates of the exports diversification index, based on the inverse of the well-known Herfindhl–Hirschman concentration index, show that the GCC countries have not made tangible progress in diversifying their economies. The UAE appears to be the most diversified economy in the region, whilst Kuwait and Saudi Arabia are the least diversified (Salisu & Taher 2012).

Challenges for diversifying the economic structure of the Saudi economy are real. For one, the kingdom's absorptive capacity is relatively low, which means that there is a limit to which it can absorb and efficiently utilize the huge inflows of oil money. Thus, utilizing the oil wealth would require a holistic but gradual approach to the development agenda including building human and physical capital endowments of the kingdom. Yet another problem relates to the challenges arising from the rapidly growing domestic consumption of fossil fuel in the country, especially in the power, transportation, and water desalination sectors. These challenges escalate as a result of rising population growth, urbanization, industrialization, and expansion of transportation systems.

It is noteworthy that the environmental challenges in Saudi Arabia are also partially associated with rising standards of living and industrial development, as there appears to be a positive relationship between environmental pollution and the kingdom's per capita income (Figure 4). This is in line with findings from a number

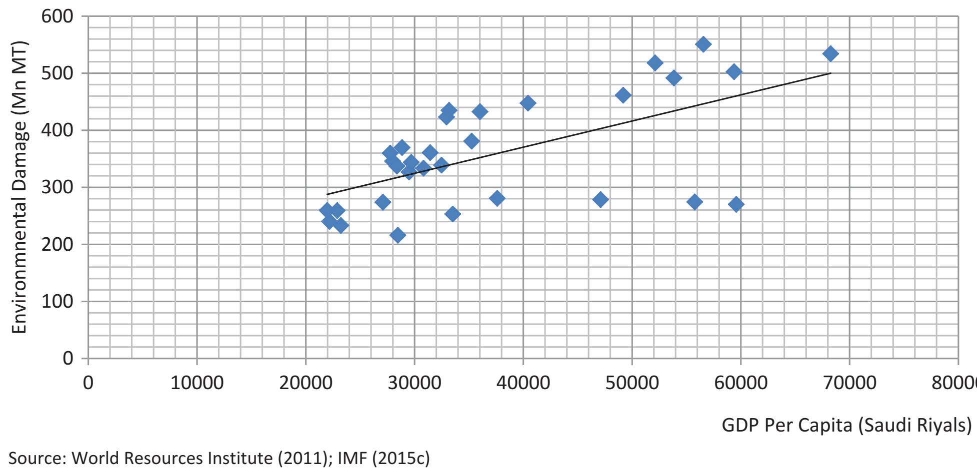

Figure 4. Saudi Arabia: Relationship Between GDP Per Capita and Pollution (1980–2011).

of empirical studies that revealed a positive correlation between industrialization and environmental degradation (World Bank 2012).

Despite the socioeconomic challenges, Saudi Arabia has all the necessary ingredients to build a prosperous, industrial economy capable of creating jobs and boosting income and productivity and on a sustainable basis. According to the International Monetary Fund (IMF 2015b), the medium-term outlook of Saudi Arabia is positive, and the non-oil private sector of the economy is projected to continue the strong growth seen in recent years. The kingdom also has a young population that is increasingly becoming informed and educated. As it enters into its working-age years, there is a tremendous opportunity to boost growth and raise living standards further. With appropriate policy measures, the kingdom can turn most of these ecological challenges into environmental business opportunities, as has been done elsewhere around the world.

3. Literature review

At the heart of economic growth sustainability is the debate about how economic activity and policy affect the environment in which the economic activity itself takes place. In general, such a debate in the empirical literature has centered on a number of issues. These include the nature and extent of the relationship between income growth and environmental degradation; the role of other factors such as population growth, income distribution, international trade, and time- and-space-dependent variables in an income–environment relationship; the implications of ecological thresholds and irreversible damages for the inverted-U-shaped relationship between environmental degradation and economic growth; and the role of environmental policy in explaining the shape of the income–environment relationship.

There have been several attempts to investigate the theoretical underpinnings of the so-called EKC. Some of the earlier studies include Selden and Song (1994), Xepapadeas (1997), and De Bruyn et al. (1998). More recent studies, however, include Islam (2001), Panayotou (2003), Castiglione et al. (2012), Yaduma et al. (2013), Anjum et al. (2014), Chow and Jie (2014), and Stern (2014). These empirical studies have found mix evidence about the so-called EKC. While some of these studies have found strong evidence of an inverted U-shaped relationship between certain types of environmental pollutants and per capita GDP (e.g. Selden & Song 1994; Anjum et al. 2014; Chow & Li 2014), others (e.g. Xepapadeas 1997; Stern 2014) have found no discernible evidence for the EKC hypothesis.

Thus, the results from the former group of studies suggest that, up to a certain level of income per capita, some types of emissions are positively related with economic growth but thereafter emissions tend to decline despite rising levels of per capita income. In the latter case, however, the results have revealed the existence of a negative relationship between pollutants and economic development. This is not surprising because the link between economic growth and pollution can be altered by emission-preventative measures including ‘changing the structure of production and moving away from high-toxic intensive industry to low-toxic intensive high-technology industry and/or introducing clean technologies (e.g. best-practice technologies) that would allow output growth without excess emissions’ (Xepapadeas 1997).

Indeed, the importance of other factors of production, especially technological change or technological progress, on pollution can also have a significant effect in altering the link between economic growth and environmental emissions. For example, Islam (2001, p.287) has pointed out that: ‘technologies developed and designed to combat global warming can reduce greenhouse gas (GHG) emissions, reduce the adverse effects of GHG and global warming, and help adapt to the circumstances caused by global warming’. This suggests that the characteristics of production and abatement technology and their evolution with income growth underlie the shape of the income–environment relationship. However, as Stern (2014) has argued, the true form of the emissions–income relationship is likely to be monotonic, but the curve shifts down over time. In other words, in developed economies, emissions-reducing technological change can alter the scale effect of rising income per capita on emissions, resulting in substantial reductions in emissions per capita in those countries. In contrast, however, the effects of rising income in rapidly growing emerging economies can overwhelm the emissions-reducing contribution of technological change.

4. Methodology

From the foregoing discussion, it can be understood that most of the empirical studies that have attempted to investigate the relationship between economic growth and the environment have combined elements of an economic model with those of an ecosystem model. We will follow the methodological approaches used in those studies to specify and estimate a sustainable socioeconomic-ecological model for the Saudi Arabian economy.

As stated earlier, an important characteristic of the Saudi Arabian economy is its overwhelming dependence on fossil fuel, which is a major contributor to environmental degradation. Thus an optimal economic growth model for the country must incorporate the linkages between environmental pollution and the level of national output. As a result, the model that is proposed here will try to unravel the link between economic growth and environmental pollutants via a production function in which environmental variables are introduced in addition to conventional inputs such as labor and capital. The stylized form of the production function can be written as follows:

$$Y = G.A.K^{a}.L^{1-a}.t \tag{1}$$

$$G = [1 - TC/Y]/[1 + DM/Y] \qquad (2)$$

where:

Y = Gross Domestic Product (GDP) in real terms

L = Labor input

K = Capital stock

G = Output scaling factor due to emissions controls and environmental damage

A = Growth of technological progress

TC = Total cost of reducing environmental emissions

DM = Damage from environmental emissions (GHG and waste)

a = Elasticity of output with respect to capital

t = time trend

Equation (1) describes the production function of the overall economy where real GDP depends not only on the usual factor inputs of capital, K, and labor, L, but also on technological progress, A, and an environmental scaling factor, G, which captures the net environmental pollution. The *a priori* expectation is that capital, labor, and technological progress are assumed to have positive impacts on output, while the emissions-output scaling variable (G) is expected to have a mixed impact depending on the relative magnitude of the emissions abatement measure. A do-nothing approach toward emissions abatement will result in a negative impact on output, while an ambitious emissions reduction policy might mitigate some of the adverse impacts of environmental damage on output. Assuming Equation (1) to be linear in logarithms, taking logs and differentiating with respect to time will yield an equation describing the determinants of the growth rate of GDP, with estimated parameters representing the elasticities of output with respect to each of the explanatory variables.

Equation (2) shows that the environmental-output scaling factor, G, itself is jointly determined by costs of emissions abatement and environmental damage, where the environmental damage function, in turn, is defined by nonlinear scaling parameters as proposed by Islam (2001). To reduce the output loss caused by environmental damage, policymakers will have to formulate a number of environmental protection measures that will reduce emissions and the total cost of such measures.

Equations (1)–(2) can be estimated either simultaneously or by a reduced-form equation. Most of the environment-growth models in past empirical studies often tended to use reduced-form equations for ease of estimation, but such a system suffers from identification problems. Hence we shall rely on a systems-wide approach, such as two-stage least squares, to estimate the linkages between economic growth and the environment for Saudi Arabia.

5. Analysis of results

The model was estimated over the period 1980–2010 with the E-Views statistical software using two-stage least squares regression. Three sets of results were obtained from the regression equations based on three sets of emissions-output scaling factors (G1, G2, and G3). Equation (1) in Table 1 shows the estimated parameters for the model corresponding to emissions-output scaling factor

Table 1. Estimated Economic Growth Regressions for Saudi Arabia, 1980–2010.

Independent Variable	Baseline Scenario (Equation (1))	Pessimistic Scenario (Equation (2))	Optimistic Scenario (Equation (3))
C	−34.878***	−50.620***	−5.811
	(−3.443)	(−2.837)	(−0.470)
G1	−10.214***		
	(−7.066)		
G2		−28.443**	
		(−2.068)	
G3			−0.075*
			(−1.521)
INV	0.105	0.293**	0.176**
	(1.381)	(2.377)	(2.333)
LF	0.367***	0.022	0.595***
	(3.999)	(0.183)	(6.629)
TFP	13.209***	18.190***	3.591
	(3.917)	(3.059)	(0.872)
Adjusted R-squared	0.961	0.903	0.978
F-statistic	188.691	71.337	297.487
Akaike info criterion	−3.24	−2.321	−3.755
Schwarz criterion	−3.009	−2.089	−3.515
Hannan–Quinn criterion	−3.165	−2.245	−3.684
Durbin–Watson statistic	0.958	1.055	1.272
No. of observations	31	31	27

Note: INV = Investment (change in capital); LF = Labor Force; TFP = Total Factor Productivity; G1, G2, & G3 = emissions-output scaling factors corresponding to 5%, 1%, and 10% emissions cuts, respectively.

All independent variables are in natural logarithms; *, **, and *** represent 10%, 5%, and 1% significance levels, respectively; figures in parentheses are absolute values of *t*-statistics.

G1, which is based on a 5% emissions reduction scenario – a baseline scenario. As expected, the estimated coefficients of all explanatory variables are in line with the *a priori* expectations and are statistically significant at the various levels, except for the coefficient of investment. The negative coefficient of the net environment degradation variable suggests that net environmental damage reduces economic growth. The estimated coefficient of G1, at −10.22%, implies that, with a 5% cut in environmental pollution, *ceteris paribus*, net environmental degradation could reduce Saudi Arabia's GDP by 10% vis-à-vis a do-nothing approach. The overall goodness of fit of the model, as demonstrated by the F-statistic, is robust. The equation, however, seemingly appears to suffer from the econometric problem of serial correlation as implied by the low Durbin–Watson statistics. This is not, however, of major concern since the data is in a first log difference form.

The estimated coefficients of all independent variables in Equation (2) in Table 1 are also in line with theoretical expectations. They are also statistically significant at the 10% level except for the coefficient of the labor force, which is positive but not statistically significant. Here again, of particular interest is the estimated coefficient of the emissions-output scaling variable, G2, which is based on a 1% emissions abatement policy – a pessimistic scenario. Since the emissions reduction measure in G2 (1%) is lower than that in G1 (5%), it has a much larger negative impact on GDP (−28.4%). The statistical fit of the model is also good, as suggested by the high F-statistic.

Finally, the estimated regression Equation (3) in Table 1 corresponds to an emissions-output scaling factor, G3, which is based on a 10% cut in emissions – an optimistic scenario. All estimated coefficients in this equation have the correct expected signs and are statistically significant, except for the coefficient of total factor productivity. Given the much larger emissions cut in this equation, the impact of environmental degradation on output is reduced considerably, suggesting that the higher the emissions cut, the smaller the impact of environmental damage on output. Here again, the huge F-statistic attests to the overall goodness of fit of the model.

5.1. *Economic growth forecasts*

Based on the estimated coefficients of the model, out-of-sample projections of GDP were carried out for the years 2011–2030 corresponding to the three emissions abatement of 1%, 5%, and 10%. Under a near do-nothing approach or a limited emissions cut of 1%, economic growth has been sluggish, with real GDP rising slowly from SAR 2172 billion in 2011 to SAR 2540 billion by 2030. In contrast, projections based on a 5% cut in CO_2 emissions are expected to boost the kingdom's real GDP to SAR 2920 billion by the year 2030 (Table 2). However, with more ambitious cuts (10%) in environmental emissions, Saudi Arabia could see a sustained increase in GDP to SAR 3954 billion by 2030. Thus, the deeper the cuts in emissions, the larger the values of GDP (Table 2). It therefore pays for policymakers to pursue a more ambitious emissions abatement policy to promote sustainable economic growth and development.

Table 2. Saudi Arabia: GDP Under the Three Emissions Abatement Scenarios.

		Period		
Indicator	Model	2011	2020	2030
GDP (Billion SAR)	Pessimistic	2172	2245	2540
	Baseline	2172	2451	2920
	Optimistic	2172	2700	3954
Emissions Abatement Rate (%)	Pessimistic	0.01	0.01	0.01
	Baseline	0.05	0.05	0.05
	Optimistic	0.10	0.10	0.10

Source: Based on the estimated parameters of the regression equations in Table 1.

5.2 *Testing for structural breaks*

Econometric techniques such as the cumulative sum of squares of regression errors (CUSUM) are often used to test for structural breaks in relationships in a regression equation over time. Thus the CUSUM or its squares can be used to test for stability in the income–environment relationships. We deployed such a technique to test for the EKC hypothesis where the forecasted values of GDP obtained from the model in Table 1 were used in the following emissions–income regression equation, in the tradition of Islam (2001):

$$E = [1 - \mu]\sigma Y \qquad (3)$$

where:

E = Environmental emissions

μ = Rate of emissions reduction (the emissions control rate)

σ = Ratio of the uncontrolled emissions to GDP

Equation (3) shows the relationship between environmental emissions and real GDP where such a relationship is also influenced by the following key parameters: the rate of emissions reduction (μ), which is a policy variable under the control of the policymakers, and the uncontrollable emissions (σ) that is directly related to economic activity but outside the control of policymakers.

We used the CUSUM-squares from Equation (3) to test the stability of the relationship between income and environmental emissions, as a proxy for testing the EKC hypothesis, using a two-step approach. First, we estimated the GDP equation for the period 1980–2010 using Equations (1) and (2) based on the three emissions abatement scenarios to perform out-of-sample projections of GDP for 2011–2030. Second, we ran another regression for the entire period 1980–2030 based on Equation (3) and we then invoked the CUSUM-squares to test the structural breaks.

The test was conducted on a regression of CO_2 emissions on GDP per capita and its squares, as a quadratic equation to reflect the inverted-U shape of the EKC. As we are only interested in testing the stability of the relationship over time between CO_2 emissions and per capita GDP, we relied on a graphical analysis of the CUSUM-squares of regressions corresponding to the three values of GDP derived from the three emissions abatement scenarios (1%, 5%, and 10%).

Figures 5, 6, and 7 show the plots of the CUSUM squares for the three equations. It is noteworthy that the two equations corresponding to 1% and 5% emission cuts have exhibited dual structural breaks (1991 and 2025 in both cases, as illustrated by Figures 5 and 6, respectively).

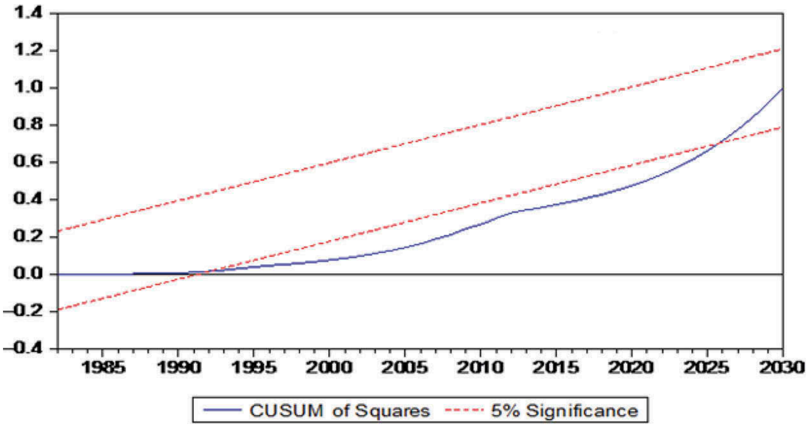

Figure 5. CUSUM-sqd Regression of CO_2 Emissions on Per Capita GDP (1% Cut in Emissions).

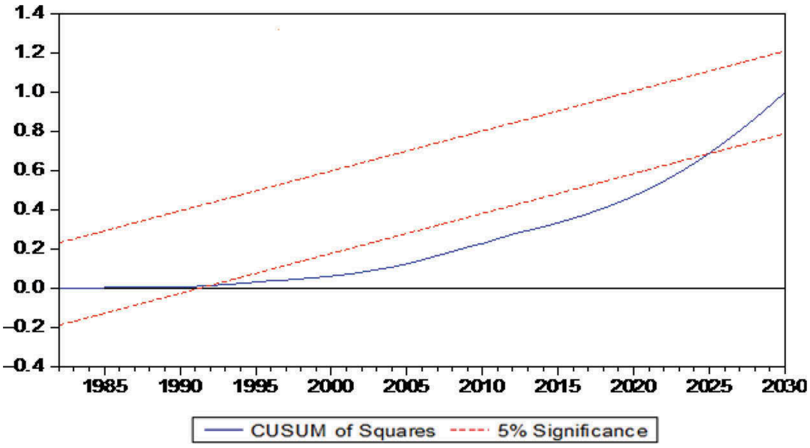

Figure 6. CUSUM-sqd Regression of CO_2 Emissions on Per Capita GDP (5% Cut in Emissions).

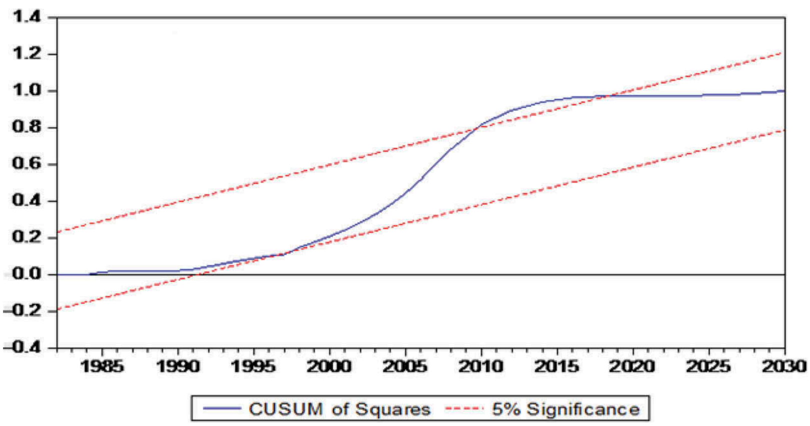

Figure 7. CUSUM-sqd Regression of CO_2 Emissions on Per Capita GDP (10% Cut in Emissions).

In the case of the equation corresponding to a 10% emissions reduction scenario, however, four structural breaks were observed in the relationship between CO_2 emissions and real per capita GDP (1997, 1998, 2010, and 2019) as illustrated in Figure 7.

Indeed, the results from the CUSUM analysis suggest that there is no concrete evidence of a unique turning point in the relationship between environmental emissions and per capita income in Saudi Arabia, as implied by the EKC hypothesis. This further suggests that putting in place credible measures to tackle environmental degradation in Saudi Arabia will enable the economy to grow sustainably. Therefore, emissions reduction policy matters for the promotion of a greener, competitive, and sustainable Saudi economy.

6. Conclusions

This paper has developed and estimated a model for sustainable economic growth, which incorporates social, environmental, and economic factors in the production process. Three equations for real GDP were estimated based on three environmental-output scaling factors corresponding to three emissions abatement scenarios. Based on the estimated parameters of the model, projected values of real GDP (both within-sample and outside-sample) were used in a secondary emissions–income equation for the period 1980–2030 to test the EKC hypothesis.

The key findings from the statistical exercises suggest that sustainability of economic growth in Saudi Arabia critically depends on aggressive emissions-reduction policies since policy scenarios corresponding to higher emission cuts yielded higher long-term GDP. In contrast, less-ambitious emissions abatement policies are associated with low economic growth. The findings also provide no discernible evidence on the presence of the EKC hypothesis.

The research has fulfilled its objectives by making valuable contributions to theory, practice, and policy. In terms of the theoretical literature, the research has contributed to the economic growth theory by incorporating social and environmental factors in addition to the standard factors of production such as labor, capital, and technological progress. Empirically, the lessons from Saudi Arabia suggest that environmental challenges are intertwined with economic activity, suggesting that measures aimed at boosting economic growth and development must be complemented with measures for enhancing environmental quality. Thus, concrete pollution abatement measures and 'green' investment strategies must be pursued alongside efforts aimed at increasing production and consumption. The kingdom should take proactive actions in investment in clean energy technology to diversify the economy away from fossil fuel and to conserve oil for future generations.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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