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Saudi Non-Oil Exports before and after COVID-19: Historical Impacts of Determinants and Scenario Analysis

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Abstract: The diversification of the economy including its exports is at the core of Saudi Vision 2030. The vision targets to raise non-oil export from 16% to 50% of non-oil GDP by 2030. Achieving this, in addition to other goals, necessitates a better understanding of the non-oil export relationship with its determinants. However, we are not aware of a study that estimates the impacts of the determinants on Saudi non-oil exports covering the recent years of reforms and low oil prices and that conducts simulations for future. The purpose of this study is to develop an econometric modeling framework for Saudi non-oil export that can enhance informing the policymaking process through empirical estimations and simulations. For estimations, we applied cointegration and equilibrium correction methodology to the annual data for the period 1983–2018. Results show that Middle Eastern and North African countries' GDP, as a measure of foreign income, and Saudi Arabia's non-oil GDP, as a measure of production capacity, have statistically significant positive effects on Saudi non-oil exports in the long run. The real effective exchange rate (REER), as a measure of competitiveness, also exerts a positive effect in the long run if it depreciates and vice versa. Furthermore, our findings support the Export-led growth concept, which articulates that export can be an engine of economic growth and does not support the Dutch disease concept, which highlights the consequences of the resource sector for the non-resource tradable sector for Saudi Arabia. Macroeconometric model-based simulations conducted up to 2030 reveal out that the Saudi non-oil export is more responsive to the changes in REER than any other determinants. The simulation results also show that non-oil manufacturing makes a three times larger contribution to the future expansion of non-oil exports than agriculture. Moreover, the simulations discover that finance, insurance, and other business services, as well as transport and communication play an important role in improving the Saudi non-oil export performance in the coming decade. The key policy recommendation is that measures should be implemented in a coordinated and balanced way to achieve non-oil exports and other targets of the Vision.

Keywords: Saudi Arabia; non-oil exports; exchange rate; cointegration; Autometrics; policy simulations

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1. Introduction

It has long been recognized that exports can play an important role in economic sustainability (and to some extent social sustainability and environmental sustainability) by increasing employment, attracting investment, especially foreign direct investment, and new technologies, creating positive externalities for other sectors. All of these can lead to an expansion of economic activity, an increase in income levels, and a reduction in poverty—key elements of sustained inclusive economic growth (see e.g., [1–4]).

Saudi Arabia's existing economic model has facilitated substantial improvements in the country's human development indicators and has provided efficient physical infrastructure, although it relies heavily on oil revenues. Key indicators of Saudi Arabia's economy, such as economic activity, fiscal revenues, export earnings and foreign exchange, are largely directly related to the hydrocarbon sector. In 2019, the oil sector's shares in the gross domestic product (GDP), exports and government budget revenues were 41%, 77% and 64%, respectively. Although the non-oil GDP share in total GDP has increased steadily in recent years, the hydrocarbon sector still accounts for a major fraction of Saudi Arabia's GDP [5].

Saudi exports are similarly dominated by oil. Since 2002, oil exports have steadily increased owing to rising global oil prices and growing international demand. The only exceptions to this steady growth are the periods of the global financial crisis and 2014 oil price collapse. Saudi Arabia's non-oil exports also increased approximately seven-fold from 2002 to 2019, with an annual average growth rate of 12.5%, although this largely consists of oil-related products, such as chemicals and plastics.

The literature discusses that if a single source of revenues has a large share, but it is nonrenewable and highly volatile, it may create difficulties in maintaining a certain level of economic growth in the long run [6–15]. Additionally, [16], among others, argue that oil demand growth is likely to slow over time. Challenges may arise both internally (such as growing population with growing energy demand, expansion of energy-intensive and petroleum-related sectors) and externally (such as energy efficiency, technological advances, growing share of renewable energy, measures to mitigate climate changes, electrical vehicles, and changes in social preferences) and can reduce oil exports.

As relying on one sector can create challenges for long-term growth, diversification is important. According to [17,18], economic diversification can encourage job creation. With diversification, more than one sector is active, contributing to the country's economic activities. Moreover, ref. [19] indicates that a country with a poor export basket often suffers from export instabilities resulting from unstable global demand. Export diversification is one way to alleviate this constraint. Thus, export diversification has become more urgent for all oil-based economies, including Saudi Arabia.

To address the above-mentioned issues, in 2016, the Saudi government launched Saudi Vision 2030, a reform plan that aims to reduce dependency on oil and diversify the country's economic resources. The diversification of non-oil exports is among its chief goals. The plan specifically targets increasing the share of non-oil exports in the non-oil GDP from 16% in 2016 to 50% in 2030. To achieve this goal, the government has introduced various incentive programs to develop the capabilities of Saudi companies, improve their competitiveness and expand their global reach. The Saudi Export Development Authority and the Saudi Export-Import Bank (EXIM) are part of this strategy and aim to promote the development, diversity, and competitiveness of Saudi exports; provide export financing, guarantees, and export credit insurance with competitive advantages; increase confidence in Saudi exports and support their development into new markets; reduce the risk of non-payment.

Non-oil exports are an important component of Saudi Arabia's economic diversification, as they can play crucial roles in sustained inclusive economic growth through four major channels. First, non-oil exports will reduce total export instability, as oil is subject to international price volatility. According to [20], export diversification may help reduce exposure to external shocks and macroeconomic volatility and increase economic growth. Second, Saudi Arabia's non-oil exports will help create employment opportunities in the private sector for young people and the growing workforce. Third, the expansion of non-oil exports will create demand for other tradable and non-tradable sectors' products, leading to a positive spillover effect. Fourth, the literature shows that enhancements in exports are mainly related to attracting foreign direct investments from abroad, which can contribute to productivity and efficiency growth in the entire economy through technology transfers and its positive externalities (see e.g., [21–23]).

Existing empirical studies do not provide sufficient insights into the main determinants of non-oil exports in Saudi Arabia. A few studies examine the importance of economic diversification for Saudi Arabia and other Gulf Cooperation Council (GCC) countries. However, none of them assess the impacts of the determinants of non-oil exports and makes projections for coming years. Thus, this study aims to develop a modeling framework for Saudi non-oil exports using novel methods to support the policymaking process.

The study contributes to the literature on Saudi Arabia's non-oil exports in several ways. Importantly, unlike many previous studies in this field, including those on Saudi non-oil exports, we develop a two-stage modeling framework. First, we estimate a non-oil export equation, which allows us to examine the historical impacts of theoretically articulated determinants on non-oil exports. Second, we incorporate the estimated equation into the general equilibrium KAPSARC Global Energy Macroeconometric Model (KGEMM). This integrated model allows us to assess how variables included in the non-oil export equation as well as other policy-relevant variables will affect Saudi non-oil export in the future (until 2030). Hence, this study's policy suggestions are not only the result of single-equation estimations, which is the partial equilibrium framework used in most previous export studies, but also simulations using the general equilibrium framework, that is, the KGEMM—an energy-sector augmented, hybrid macroeconometric model. Macroeconomic models provide more comprehensive representations of processes than single equations do. They allow for both feedback loops and assessments of the effects of other variables and policy levers in addition to those in the single equation framework. These features are especially important for forecasting/projections of the dependent variable but are missing in a single equation framework (e.g., [24–27]). For example, GDP and the real effective exchange rate (REER) are treated as exogenous variables in the analysis and forecasting of exports when a single equation is used. However, these variables should be treated as endogenous given the nature of their data generating processes. This study also makes a few other contributions. First, we do not just estimate the historical relationship between non-oil exports and their determinants. Instead, we also provide insights into the outlook for non-oil exports until 2030 using policy scenario analyses. Second, our theoretical framework allows us to examine the demand- and supply-side determinants of exports alongside relative prices whereas previous studies mostly used the demand-side determinants. Non-oil export development is the cornerstone of the economic diversification plan of Saudi Vision 2030. Therefore, not only the demand-side but also the supply-side aspects of this development should be examined to better inform decision-making process. Third, we use various estimation and test methods to obtain robust empirical findings and provide well-grounded policy recommendations. For example, we apply Autometrics, a new machine learning algorithm for computer-automated model selection with super saturation in a general-to-specific modeling strategy framework to the non-oil exports relationship. This algorithm offers many advantages over traditional modeling approaches [28–30]. Finally, our estimations and simulations account for the recent low oil prices, COVID-19 and the post-COVID-19 recovery.

The rest of the paper is structured as follows. Section 2 provides some stylized facts about export diversification in Saudi Arabia, and Section 3 surveys existing studies on Saudi Arabia. We discuss our theoretical framework in Section 4. Section 5 describes the data sources, definitions of the variables and econometric methodology. Section 6 reports the estimation and test results, and Section 7 discusses the empirical findings. Section 8 presents the policy simulation analysis, and Section 9 concludes the study and outlines some policy insights.

2. Export Diversification in Saudi Arabia

In Saudi Arabia, oil exports are crucial for government revenues and the country's development. Oil's share in Saudi Arabia's total GDP has gradually declined from 65% in 1991 to 42% in 2019. Correspondingly, the share of private sector economic activity in the total GDP has increased from 20% in 1991 to 41% in 2019 (Figure 1).

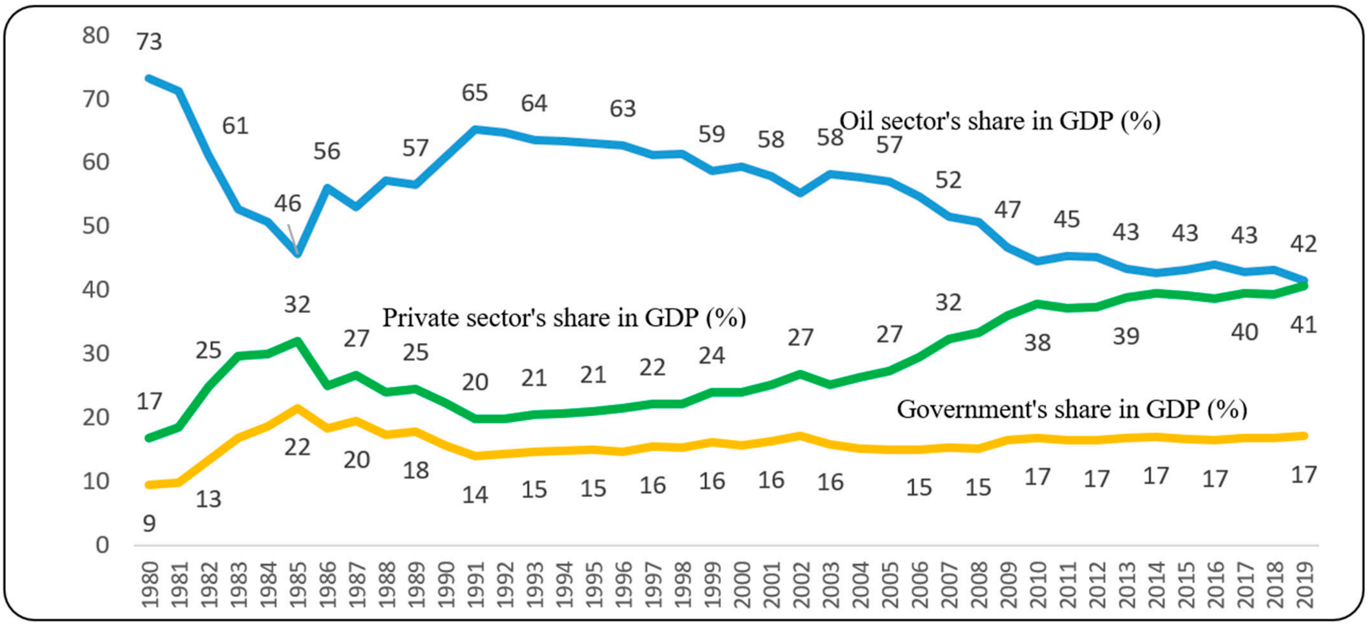

Figure 1. Sectoral contributions to Saudi Arabia's aggregate GDP. Source: The Authors' calculation using [5] data.

Saudi Arabia's economy has evolved significantly over the last two decades. The non-oil private sector was initially small, but its growth has outpaced that of the overall economy, with annual real GDP growth of 4.3% from 1980 to 2019. By comparison, real oil GDP grew at a rate of 1.2% over this period. The changing shares of oil and private sector GDP in the total GDP reflect the Saudi economy's transformation and highlight the private sector's role in the economy. The non-oil private sector's contribution particularly increased since 2003. The Saudi economy benefited from the sharp rise in oil prices between 2003 and 2013 before the oil price collapse in 2014. Government spending increased during this period, which helped boost private sector activity (see e.g., [31,32]). Owing to the development of the industrial and services sectors, among others, the oil sector's relative size has fallen since 2003.

Oil exports account for a major share of Saudi Arabia's total exports and are greatly influenced by price fluctuations in the international oil market. Over the last five decades, the international oil market has undergone significant changes. Geopolitical events, natural disasters and fluctuations in the world economy have strongly impacted oil prices and, consequently, Saudi Arabia's oil exports. Figure 2 illustrates the shares of Saudi Arabia's oil and non-oil exports in its total GDP. It shows that Saudi Arabia's oil exports vary with global oil prices and oil market demand. Since 1980, the share of oil exports in the total GDP has ranged from 61% in 1980 to 21% in 2016. In the 1980s, Saudi Arabia's oil exports comprised an average share of 35% of the GDP, but this share fell to 30% in the 1990s. In the 2000s, the average share of oil exports in the total GDP increased to 42% due to increases in oil prices and demand. From 2010 to 2019, however, this share reduced slightly to 34% owing to the oil price collapse in 2014. Additionally, Figure 2 shows that non-oil exports' share in the total GDP is increasing steadily although it is quite small compared to the oil exports' share over the period. The share of non-oil exports in the total GDP was 1.9% in the 1980s, reaching 8% in 2018.

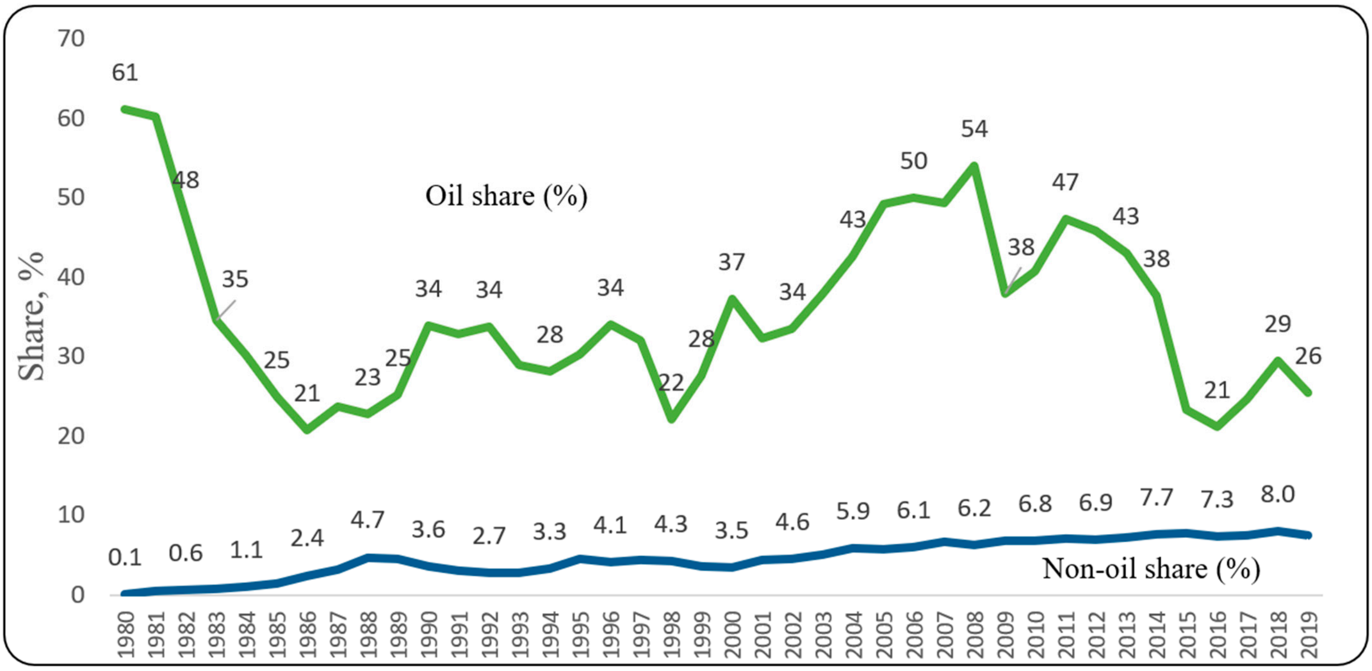

Figure 2. Shares of Saudi Arabia's oil and non-oil exports in GDP. Source: The Authors' calculation using [5] data.

Figure 3 presents the shares of oil and non-oil exports in Saudi Arabia's total exports. During the 1980s, oil exports accounted for 93% of total exports on average, but this share exhibited a decreasing trend. For instance, in 1980, oil exports accounted for approximately 99% of all exports, but by 1989, this share had fallen to 85%. The demand for oil from Saudi Arabia and other OPEC countries collapsed after 1981 owing to high oil prices [33–35]. Between 1981 and 1985, Saudi Arabia's oil exports fell from 9 million barrels per day (MMb/d) to less than 3 MMb/d. In the 1990s, oil exports accounted for 89% of total exports on average, ranging from 84% to 90%. Oil exports increased in the early 1990s to fill the supply gap created by the embargo on Iraqi and Kuwaiti oil. In the 2000s, Saudi Arabia's oil and total exports steadily increased since 2004 owing to rising global oil prices and international demand for oil. In 2008, the contribution of oil exports to total exports reached 90%. However, Saudi Arabia's exports were significantly affected by the oil price collapse in 2008 due to the global financial crisis. Oil prices collapsed again in 2014–2016 owing to a supply glut. Figure 3 also shows the Saudi economy's progress toward export diversification over the last four decades. The share of non-oil exports in total exports increased from an average of 6.8% in the 1980s to 11% in the 1990s. Non-oil exports have increased on average since 2003. Its share remained fairly steady from 2000 to 2010 but increased to 19% on average from 2010 to 2019. The private sector's growing contribution to the overall economy over the last decade, however, is not fully reflected in the share of non-oil exports in total exports. This result may be due to the low added value of exports. The petrochemical sector comprises a major share of non-oil exports, while the construction and agriculture sectors have quite small shares.

Since Saudi Arabia's oil exports have fluctuated considerably over time due to many factors, including changing conditions in oil markets and oil producers, and regional geopolitical events [34,36], diversifying Saudi Arabia's exports and identifying alternative revenue sources for long-term sustainable economic growth deserve special attention, as highlighted in Saudi Vision 2030.

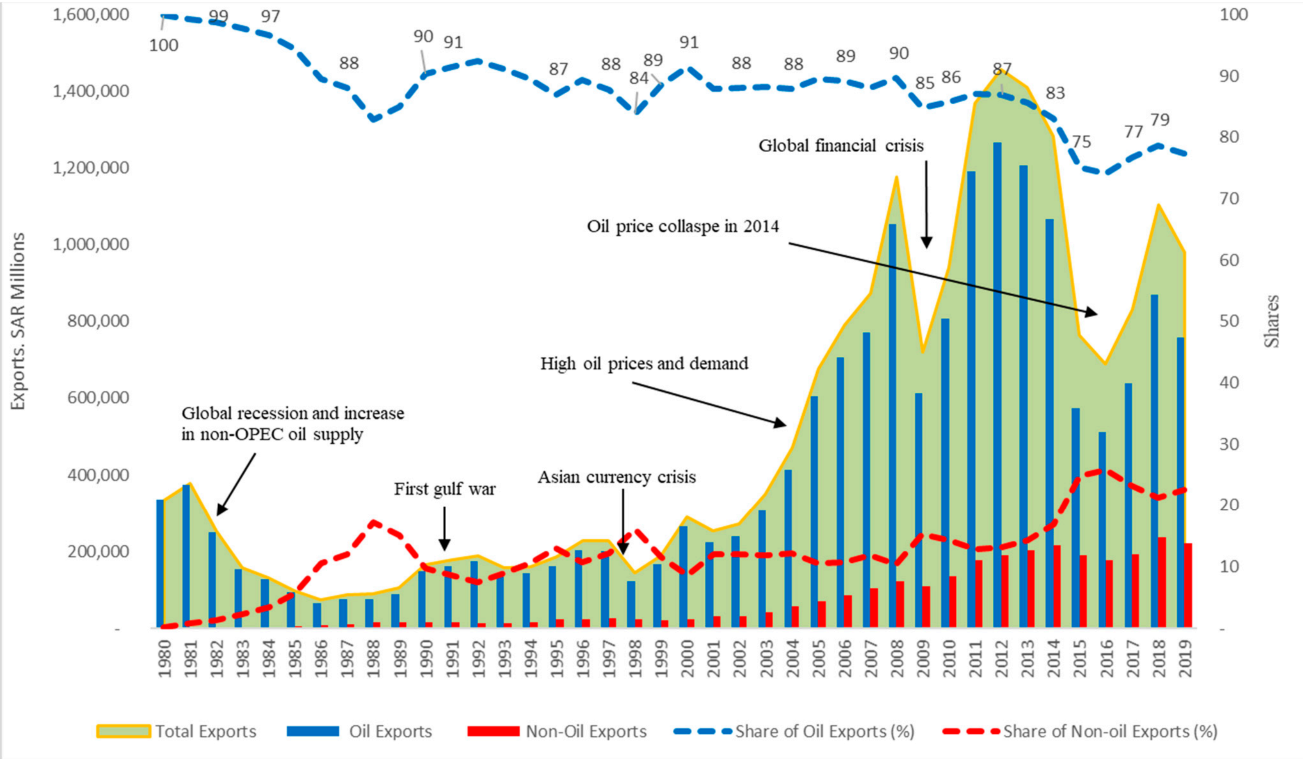

Figure 3. Saudi Arabia's oil and non-oil exports and their share in total exports. Source: The Authors' calculation using [5] data.

3. Literature Review

The earliest theories of international trade, such as the Heckscher-Ohlin (HO) model, are dominated by the principle of comparative advantage. This principle essentially states that countries export products that use their abundant and cheap production factors and import those that use their scarce factors. Neoclassical economists emphasize that countries specialize in producing and exporting based on their comparative advantages. According to the HO model, Saudi Arabia has a comparative advantage in producing and exporting oil. However, an overreliance on single export product can exacerbate macroeconomic volatility, as discussed in the literature.

In contrast to this classical concept of specialization, the new idea of economic diversification emerged in the discipline of economic development. For example, [37] states that developing countries require substantial investments to move from their current backward state toward economic development. These theories are premised on the idea that developing countries' dependence on primary goods production and exports creates risk. Such countries' macroeconomic stability is vulnerable to commodity shocks, price fluctuations and declining terms of trade, especially because primary goods have low-income elasticities of demand [38]. The studies by [39,40] assert that the HO model's recommendations may not hold in the face of uncertainty. Instead, uncertainty reduces overall world trade, as risk-averse commodity producers decrease production.

Many studies analyze the benefits of export diversification theoretically and empirically. The studies by [41–43] argue that economic growth is not motivated by comparative advantage. Instead, it is motivated by the diversification of countries' investments in new activities. [44] test the hypothesis of diversification-led growth for Chile using the Cobb–Douglas production function for the period 1962 to 2001. They conclude that export diversification based on natural resources can play an important role in the growth process. [45] find that the concentration of export earnings reduces growth by impeding productivity. However, the negative effect of abundant natural resources on growth disappears when they control for the concentration of exports. [19] finds that export concentration has been detrimental to developing countries' economic growth in recent decades. [46,47] find a hump-shaped pattern of export diversification using large panel datasets.

Some previous studies also focus on Saudi Arabia. [12] examines Saudi Arabia's economic diversification efforts. He investigates the share of the private sector in the GDP, of oil exports in total exports and of oil revenues in total revenues. His analysis concludes that oil remains the main driver of the economy. A similar study by [48] analyzes Saudi Arabia's economic diversification based on investments in education, entrepreneurship, international tourism and oil production. Using the fully modified ordinary least squares method, the authors conclude that oil production contributed the most to Saudi Arabia's economic growth from 1970 to 2014.

Ref. [49] argues that the private sector and human capital development remain two critical factors in driving Saudi Arabia's economic diversification. She argues that these factors can support the transition to a more sustainable knowledge-based economy by providing income from renewable and productive resources. [50] suggest a mix of vertical and horizontal diversification strategies for GCC countries. They recommend that GCC countries create linkages in existing industries with a focus on exports and technological upgrades. Their conclusions are based on the diversification experiences of other oil exporters such as Indonesia, Malaysia, and Mexico.

Ref. [51] examine the potential diversification of Saudi Arabia's manufactured exports. They use a special autoregressive panel model covering 77 of Saudi Arabia's trading partners from 2000 to 2016. Their evidence suggests that GDP, GDP per capita, trade freedom, bilateral exchange rates and the trade intensity index strongly impact Saudi Arabia's bilateral manufactured exports.

Ref. [52] examines the role of governance and oil rents in economic diversification. She considers a panel of 11 oil exporters in the Middle East and North Africa (MENA) from 1996 to 2017 using various econometric approaches. Her main finding suggests that the growth of these oil exporters is strongly and positively influenced by oil rents. The results for the interaction between a governance index and oil rents show that these two variables' combined effect effectively promotes diversification.

Very few studies empirically investigate the determinants of the non-oil exports of oil-exporting countries. [53] examines the performance of Nigeria's non-oil exports from 1970 to 1990. The results indicate that domestic market conditions strongly influence the behavior of Nigeria's non-oil exports. [54] find that the REER appreciation is negatively associated with Azerbaijan's non-oil exports from the third quarter of 2002 to the third quarter of 2009. Non-oil GDP, by contrast, is positively associated with non-oil exports. [55] investigates the nonlinear relationship between the real exchange rate and Azerbaijan's non-oil exports from 2000 through 2010. This analysis uses the threshold and momentum threshold autoregressive approaches. The empirical evidence indicates that the variables exhibit a long-term relationship with symmetric rather than asymmetric adjustments toward the equilibrium.

In summary, many previous studies have investigated export diversification. Their empirical findings suggest that export diversification may positively affect economic growth by increasing productivity, reducing exposure to external shocks, and reducing macroeconomic volatility. However, no prior study has focused on the determinants of Saudi Arabia's non-oil exports to our best knowledge. This gap is critical to fill. A growing body of literature shows that sustainable growth can be largely driven by export diversification (e.g., [42,50,56]). Thus, it is imperative to identify the key determinants of Saudi Arabia's non-oil exports.

4. Theoretical Framework for Saudi Non-Oil Exports

This study is based on international trade theory. This theory was mainly developed by [57–60], among others. Following the existing literature on trade flows between countries, we investigate the determinants of Saudi Arabia's non-oil exports using a reduced-form export model. This type of model is widely used in empirical analyses of international trade [58,61–65]. Using a reduced-form export model allows us to avoid the simultaneous equation bias arising from estimating demand and supply functions separately [63,66]. It also allows us to represent both demand- and supply-side factors in the equation. The demand-side factors include importers' incomes and the ratio of the price of exports to the prices of competing goods in the import markets. The supply-side factors include exporters' production capacities and the ratio of export prices to domestic prices [58,61,64–66].

We derive a reduced-form model for Saudi Arabia's non-oil exports by following the existing literature [61,62,64–67]. This model is derived from the traditional demand for and supply of these exports. Based on the theoretical framework provided in Appendix A, we specify the following equation for Saudi Arabia's non-oil exports:

$$x_t^d = \beta_0 + \beta_1 * reer_t + \beta_2 * y_t^{noil} + \beta_3 * y_t^f + \varepsilon_t. \quad (1)$$

Here, x_t^d is non-oil exports, and $reer_t$ is the real effective exchange rate, a measure of international competitiveness. y_t^{noil} is the gross value added of the non-oil sector, which is a proxy for domestic production capacity. Finally, y_t^f is the GDP of Saudi Arabia's main trading partners. Lowercase letters indicate that a variable is used in its natural logarithmic form. The β_i's are the coefficients that we estimate econometrically. We expect to observe a negative relationship between non-oil exports and the REER (i.e., $\beta_1 < 0$) because of the definition of the latter. We expect non-oil exports to exhibit positive relationships with domestic production capacity and external demand (i.e., $\beta_2 > 0$ and $\beta_3 > 0$).

5. Data and Econometric Methodology

5.1. Data

We use annual data for the variables for the period from 1980 to 2018. Following previous studies, we use the REER as a measure of the real exchange rate. The REER is a more comprehensive measure than the bilateral real exchange rate. REER is also considered as a measure of price competitiveness in the international trade literature. To measure foreign income, we consider the real GDP of Middle Eastern and North African countries rather than that of all of Saudi Arabia's trading partners. This choice is because Saudi non-oil exports are mainly directed to Middle Eastern and North African countries. For example, [5] data show that, on average, over 27% of non-oil Saudi exports from 2005 to 2019 were to the other five GCC countries.

Table 1 provides a description of each variable and data source. The panels in Figure 4 illustrate the natural logarithmic (log) levels and the growth rates (d) of the variables.

Table 1. Variables and their descriptions.

Variable Notation	Variable Definition	Data Source
XGNOIL	Non-oil merchandise exports, in millions of 2010 SAR	The data on non-oil merchandise exports in nominal values are from [5]. The values are converted into real values using a non-oil GDP deflator that equals 100 in the base year of 2010.
REER	Real effective exchange rate	The REER is based on the consumer price index, which equals 100 in the base year of 2010. The International Monetary Fund defines the REER as the weighted average value of the local currency relative to several foreign currencies, divided by a price deflator. The data are from the International Financial Statistics of the International Monetary Fund. An increase in REER means an appreciation of the SAR.
GDP_MENA	The GDP of the Middle East and North Africa, in millions of 2010 USD	The values in USD are from from the World Bank's World Development Indicators. They are multiplied by the bilateral exchange rate between the SAR and the USD and divided by 10^6 so that all variables, except for REER, are in same units.
GVANOIL	Gross value added of the non-oil sector, in millions of 2010 SAR	This is the Saudi GDP excluding the value added in the mining and quarrying, oil refinery sectors and net taxes. Non-oil GDP values are obtained from [5].

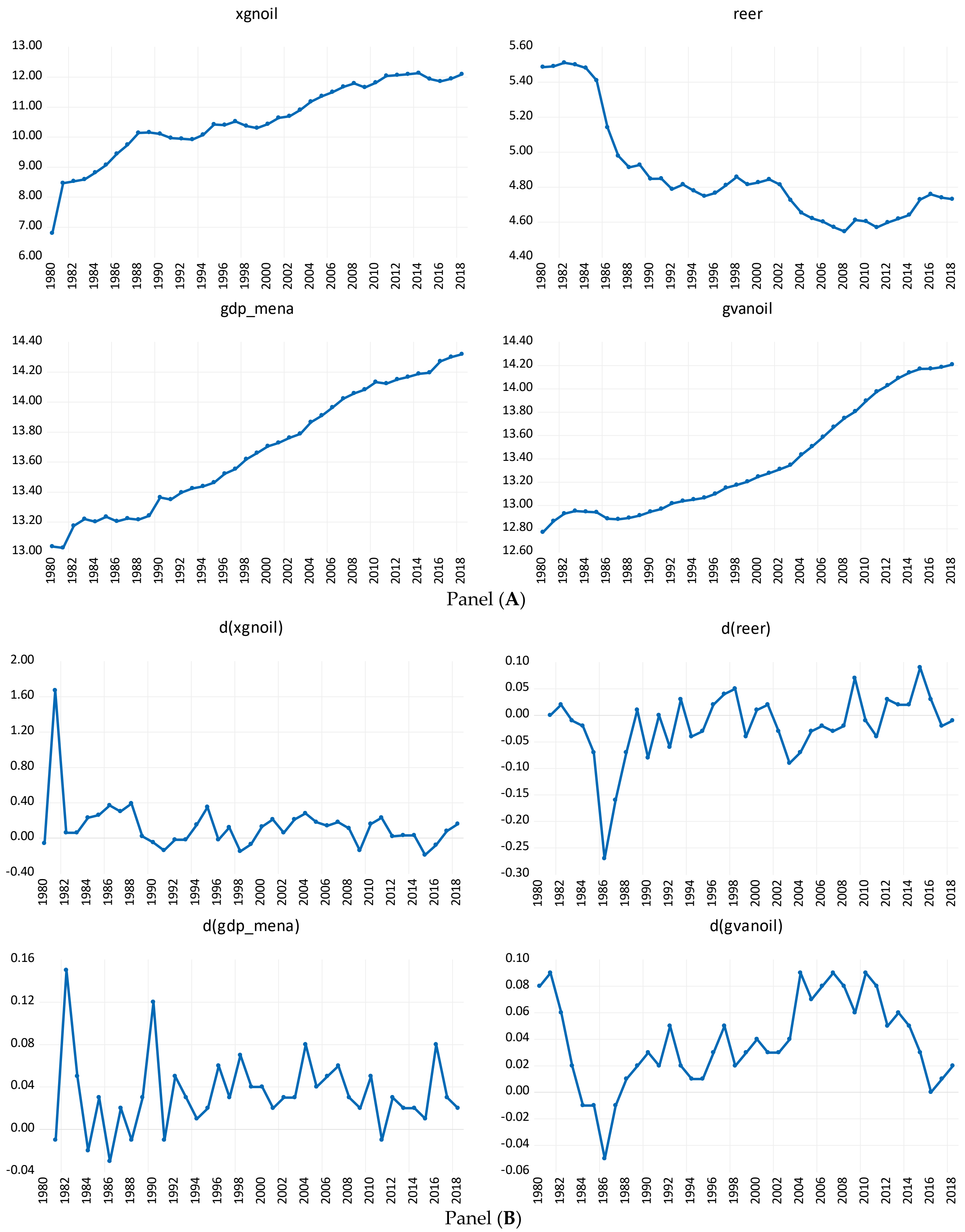

Figure 4. Graphs of the log levels and growth rates of the variables. Panel (**A**). Log levels of the variables; Panel (**B**) Growth rates of the variables.

5.2. Econometric Methodology

This section describes the empirical assessment strategy. We first check the time series properties of the variables by employing the augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and ADF structural breakpoint unit root tests. ADF structural breakpoint unit root test can account for potential structural breaks in the variables under consideration. For cointegration test and long-run estimations, we primarily use Johansen's reduced rank method and vector equilibrium correction model (VECM) [68–70]. Unlike single equation-based or residual-based cointegration methods, the system-based tests, such as Johansen's reduced rank method, can identify multiple cointegrated relationships among the variables. The point is that incorrect identification of the number of cointegrating relationships that the variables establish can result in information loss and, more importantly, an omitted variable bias issue if the equilibrium correction term of the other cointegrating relationship is statistically significant in the equilibrium correction specification of the variable in interest [71–73]. As a robustness check, we employ autoregressive distributed lag (ARDL) bounds testing [74,75]. We also apply the Engle–Granger residual-based approach [76] using dynamic ordinary least squares (DOLS). Lastly, for the short-run estimations, we utilize the equilibrium correction model (ECM) in the general-to-specific modeling strategy framework using Autometrics with super saturation. The comparison of Autometrics with other similar methods and the details of the econometric methodology are described in Appendix B to conserve space in the main text.

6. Empirical Results

The empirical results of the unit root and cointegration tests are provided in Appendix C. Based on the ADF, PP and ADF with structural break tests, we conclude that all variables are non-stationary in their log levels. However, they are stationary in the first differences of their log levels. The unit root test results are provided in Table A1 of Appendix C. The results of the cointegration tests are reported in Table A2. Specifically, we report the results of the Johansen, ARDL bounds and Engle–Granger residual-based tests in Panels A, B and C of Table A2, respectively. They all confirm the existence of long-run relationship among the variables. The Johansen cointegration test further indicates that the variables have only one long-run relationship.

6.1. Long-Run Estimation and Testing Results

Table 2 reports the long-run estimates of Saudi Arabia's non-oil exports (Equation (1)) based on the VECM, ARDL and DOLS.

Table 2. Long-run estimates using the VECM, ARDL and DOLS.

Variables	VECM	ARDL (2,3,1,3)	DOLS
$reer_t$	−1.44 *** (−5.992)	−1.17 *** (−5.025)	−1.20 *** (−5.157)
gdp_mena_t	0.64 (1.527)	0.82 ** (2.227)	0.85 ** (2.271)
$gvanoil_t$	1.07 *** (3.726)	1.08 *** (4.563)	1.00 *** (5.312)
Constant	6.26	−10.33 *** (−2.872)	−9.55 ** (−2.205)
Adj. R^2	0.99	0.99	0.98
SER	0.12	0.06	0.11
SC	−0.84	−1.89	−1.65

Notes: t-values are given in parentheses; *** and ** denote statistical significance at the 1% and 5% levels, respectively; Adj. R^2 = adjusted coefficient of determination; SER = standard error of regression; SC = Schwarz information criterion; The VECM results correspond to the case where the loading (SoA) coefficients of the explanatory variables are assumed to be zero (The assumption holds as the sample χ^2 (3) and associated probability are 5.43 and 0.14, respectively). Estimation period: 1983–2018.

Here, we note three main observations from the results in Table 2, and we discuss the economics of the long-run estimations in the next section. First, the estimated elasticities of non-oil exports with respect to the explanatory variables are statistically significant and theoretically consistent. The VECM finds that the elasticity of non-oil exports with respect to the GDP of the Middle East and North Africa is not significant at conventional levels. This result is expected, as VECM estimations require a larger sample size than the one we use in this analysis. The restriction that this elasticity is zero, i.e., $\beta_{GDP\_MENA} = 0$ produces the sample $\chi^2(4)$ and associated probability of 7.58 and 0.108, respectively. This shows that the elasticity is borderline significant and therefore should not be considered zero. Additionally, this restriction causes the residuals of the VECM to be serially correlated, which is a serious problem. Moreover, we assume unity and negative unity restrictions on the long-run elasticities of non-oil GDP and REER, respectively, i.e., $\beta_{GVANOIL} = 1$, $\beta_{REER} = -1$. All the five restrictions hold as statistically significant, as the $\chi^2(5)$ obtains the sample value of 7.50 with the p-value of 0.19. In this case, the elasticity of the GDP of the Middle East and North Africa increases to 0.87 with the t-value of 7.63 being highly statistically significant. Second, the magnitudes of the respective elasticities are similar across all three methods, which may indicate the robustness of the estimations. Third, the ARDL method produces smaller standard errors and a lower penalty based on the Schwarz information criterion. This result is expected based on the discussions of [74,75].

One of the benefits of the Johansen cointegration framework is that it enables researchers to test the validity of theoretical and other hypotheses/restrictions. For this study, it would be useful to test the following assumptions: (i) Can non-oil GDP and non-oil exports establish a one-to-one relationship stemming from national accounting? (ii) Can Saudi non-oil exports be in one-to-one relationship with MENA GDP? (iii) Is there any concern regarding the co-called "Dutch disease" (see, e.g., [6,7]) for Saudi non-oil exports? Technically, checking the above given assumptions means placing restrictions on the long-run elasticities of the explanatory variables in the VECM framework, that is, $\beta_{GVANOIL} = 1$, $\beta_{GDP\_MENA} = 1$, and $\beta_{REER} = -1$. Table A2 documents the results, indicating that all three restrictions cannot be rejected either individually or jointly, as the sample values of the χ^2 are smaller than respective critical values at any conventional significance levels. Interpretations of the restrictions are given in Section 7.

6.2. Short-Run Estimation Results

We estimate the general/unrestricted form of the ECM specification given by Equation (A16) in Appendix B. We use a maximum lag order of two, i.e., $p = 2$, owing to the short time span. We calculate the equilibrium correction term (ECT) using the long-run ARDL estimation in Table 2, as follows:

$$ECT_t = xgnoil_t - (-1.17 * reer_t + 0.82 * gdp\_mena_t + 1.08 * gvanoil_t - 10.33). \quad (2)$$

We use the long-run ARDL estimates for this calculation because this method typically provides more efficient estimates for small samples relative to its counterparts [74,75]. Our analysis uses a relatively small sample, and, thus, this approach is the most appropriate. We set up the general ECM specification (i.e., general unrestricted model-GUM) of $\Delta xgnoil$ with two lags for the dependent and explanatory variables, as mentioned previously, and contemporaneous values of the explanatory variables and one lag of ECT. Then, we apply the procedures of the general-to-specific modeling strategy using Autometrics with super saturation from the PcGive toolbox in OxMetrics 8.0 [29,30,77]. Here, super saturation includes impulse-indicator saturation, the change in impulse-indicator saturation, step-indicator saturation, and trend-indicator saturation. An advantage of super saturation is that these four dummy variable types can capture all kinds of outliers and breaks in the data. For example, they can capture one-time jumps or drops, blips, level shifts and breaks in development trends.

To construct the short-run model, we follow [78–80]. First, we estimated the unrestricted ECM specification. Although the estimated model passes other post-estimation tests, it does not pass the normality test. The graphical illustration of the unrestricted model's residuals clearly shows that the non-normality most likely stems from the residuals' abnormal behavior from 1992 to 1995. However, we must ensure that the unrestricted ECM specification is well-behaved in terms of post-estimation tests before moving from the unrestricted specification to the final conditional specification. For this, as a next step, we retain (fix) all the regressors in the unrestricted ECM and run Autometrics with super saturation. This process allows us to check for any significant outliers and breaks in the development path of $\Delta xgnoil$ that the aforementioned types of the dummy variables can capture. We select a relatively tight target size, i.e., 1% significance level [79,80], among others, discuss that it is recommended to select a tight significance level for the impulse indicator saturation, that is, for dummy selection, and looser significance level for the selection of economic variables. Autometrics selects only two dummy variables: one pulse dummy (I:1992) and one blip dummy (DI:1994). Having only two dummy variables selected by Autometrics may indicate that the unrestricted ECM specification was quite representative in capturing developments in $\Delta xgnoil$. The dummy variables most likely capture the lagged influences of the Gulf War. They also capture changes caused by the Saudi Arabia Fifth Development Plan for 1990–1995 that are not reflected in $\Delta gvanoil$. Now, the unrestricted ECM specification that includes the dummy variables selected by Autometrics successfully passes all post-estimation tests, including the normality test. We call it statistically congruent unrestricted ECM specification. Finally, we retain (fix) the selected dummy variables and leave the other regressors (i.e., economic variables, ECT and constant) unrestricted (unfixed) in this unrestricted ECM specification and run Autometrics on it with a target of 5% to obtain a conditional specification. The conditional/final specification is usually parsimonious, as Autometrics drops statistically insignificant regressors from the general unrestricted specification.

The selected final ECM specification and its post-estimation test results are reported in Table A3 of Appendix C. Table A3 shows that all the retained regressors in the final specification are statistically significant and theoretically interpretable. We provide theoretical interpretations in the next section. Moreover, we check the stability of the estimated relationships of non-oil exports using a set of tests. We test for coefficient and residual stability and perform the one-step, breakpoint, and forecast Chow tests (Brown et al. 1975; Chow 1960). The test results are graphically illustrated in Figure A1 in the Appendix C. Table A3 and Figure A1 show that the final specification successfully passes all post-estimation tests, including those for stability. We discuss these results in Appendix C.3 to conserve space in the main text.

We also note that our final ECM specification includes the contemporaneous value of $\Delta gvanoil$. We recall that results in Panel A of Table A2 suggest that this variable is not weakly exogenous to the long-run disequilibrium at the 10% significance level. Although this statistical evidence is weak, theoretically, the endogeneity between non-oil exports and non-oil GDP may be a concern. Export theory predicts that GDP, as a measure of production capacity, is a determinant of exports. Export-led-growth theory articulates that exports can be a driver of economic growth. Thus, to avoid possible endogeneity between these variables, we re-estimated the final ECM model using two-stage least squares (TSLS). The details of these estimations, including the search for instrumental variables to approximate $\Delta gvanoil$, are given in Appendix C.3. Table 3 presents the final ECM specification estimated with TSLS and the corresponding test statistics.

The final specification successfully passes all diagnostic tests for the residuals. These tests include the Jarque–Bera statistic for the normality and the Lagrange multiplier (LM) test for serial correlation of the residuals. The specification also passes the White test for heteroskedasticity, the autoregressive conditional heteroscedasticity (ARCH) test and the Ramsey RESET test for the miss-specification of the functional form. In addition, the J-statistic of 2.97 with probability of 0.81 indicates that the null hypothesis of over-identification is valid cannot be rejected. This means that the selected instruments are valid/reasonable. Also, all regressors in the final specification are statistically significant and theoretically interpretable. Additionally, the estimates including the elasticities from TSLS in Table 3 are very close to those in Table A3 of Appendix C estimated by ordinary least squares. This finding also indicates the robustness of the TSLS estimations. We discuss the elasticities and their interpretations in the following section.

Table 3. TSLS estimation of the final ECM specification.

Variables	Coefficient		t-Statistic		
ECT_{t-1}	−0.626 ***		−10.31		
$\Delta xgnoil_{t-1}$	0.194 **		2.37		
$\Delta reer_t$	−1.730 ***		−10.77		
$\Delta reer_{t-1}$	0.454 **		2.25		
$\Delta reer_{t-2}$	−0.996 ***		−5.46		
Δgdp_mena_t	−0.652 **		−2.31		
Δgdp_mena_{t-1}	−0.532 **		−2.33		
Δgdp_mena_{t-2}	0.563 **		2.28		
$\Delta gvanoil_t$	2.876 ***		7.10		
$\Delta gvanoil_{t-2}$	−1.823 ***		−4.54		
$DP1992$	−0.314 ***		−5.01		
$\Delta DB1994$	−0.147 ***		−4.05		
Post-Estimation Test Results					
Test	**F-statistic**	***p*-value**	**Test**	**F-statistic**	***p*-value**
Serial correlation LM [A]	1.646	0.200	Heteroskedasticity	0.762	0.681
ARCH	5.91×10^{-5}	0.994	Normality [B]	0.016	0.992
Ramsey RESET	0.7159	0.500	J-statistic	2.973	0.812

Notes: The dependent variable is $\Delta xgnoil$. ** and *** indicate statistical significance at the 5% and 1% levels, respectively. [A] indicates that the serial correlation test statistic is the Chi-squared statistic rather than the F-statistic. [B] indicates that the normality test statistic is the Jarque–Bera statistic not the F-statistic. The J-statistic tests the null hypothesis that the over-identifying restrictions are valid. Estimation period: 1983–2018.

7. Discussion

The unit root tests documented in Table A1 of Appendix C2 show that all variables are non-stationary in their log levels. However, they are stationary in the first differences of their log levels, that is, in their growth rates. Thus, the means, variances and covariances of the log levels of the variables change over time. Since these values do not follow mean-reverting processes, any policy, socioeconomic situation or other shocks to these variables may cause a permanent change. Moreover, as the variables are non-stationary, they may have a common stochastic trend. In that case, we can conclude that the variables are cointegrated, that is, they have a long-run relationship. We test this possibility using three different cointegration methods for robustness. The results in Table A2 suggest that non-oil exports, the REER, Middle Eastern and North African countries' GDP and Saudi non-oil GDP are cointegrated. In other words, these variables have a theoretically meaningful relationship. Put differently, the relationship among their levels is not meaningless and should be explained using international trade theory. Thus, we need to estimate this level relationship numerically to understand the magnitudes of the impacts, which would be useful for policy analysis and projections. To this end, we estimate the impacts of the explanatory variables on non-oil exports using the ARDL, VECM and DOLS to obtain robust results. The results in Table 2 demonstrate that non-oil exports establish a meaningful relationship with its theoretically predicted determinants. The numerical values, that is, the long-run elasticities from the ARDL, VECM and DOLS are very similar. Given the small sample size, this finding supports the robustness of the empirical results.

Table 2 shows that a 1% depreciation (appreciation) of the REER of SAR leads to a 1.2–1.4% long-run increase (decrease) in non-oil exports, keeping other factors unchanged. The relatively larger magnitude of the elasticity than unity indicates that Saudi Arabian non-oil exports are elastic to the REER. The REER is theoretically and empirically considered a primary measure of an economy's international trade competitiveness [81–85]. The sign of this finding indicates that the appreciation (depreciation) of the national currency can harm (support) Saudi Arabia's exports, which is consistent with export theory (see Equation (A9) in Appendix A). The intuition behind this result is that when the national currency appreciates, domestic goods and services become more costly to foreigners. Usually, domestic producers, who export their goods and services, are price takers and have little or no influence on international market prices. Thus, if a country's currency appreciates, foreigners will tend to buy goods and services from other countries' producers. From the empirical analysis, it appears that this explanation holds for Saudi Arabian non-oil exports, although these exports have the following two features. First, non-oil production and exports are key aspects of the government's diversification strategy. Hence, both are greatly supported by the government. For example, the Fiscal Balance Program, which is part of Saudi Vision 2030, offers support packages for a number of non-oil sectors to maintain their competitiveness (Fiscal Balance Program 2017). Second, Saudi Arabia's non-oil exports are mostly directed to its neighbors, such as Middle Eastern and North African states. Thus, competing in the Middle East and North Africa is easier than competing in other international markets in Europe, Asia, or America.

Next, we find that a **1%** rise in Middle Eastern and North African countries' GDP increases Saudi Arabia's long-run non-oil exports by **0.6–0.9%**, *ceteris paribus*. This finding is also consistent with the theory of export demand, as discussed in Appendix A. This theory explains that a country's exports are part of the aggregate demand of importing countries, which is positively associated with their income. Hence, if importing countries have more income, they can import more non-oil exports from Saudi Arabia.

Table 2 also shows that Saudi Arabian non-oil exports and non-oil GDP have **a one-to-one relationship** in the long run. Put differently, non-oil export performance improves by **1%** if non-oil GDP, as a combined measure of domestic production capacity and services, increases by **1%**. This finding shows that both non-oil tradable sectors—such as agriculture and non-oil manufacturing—as well as non-tradable sectors – such as the services – support non-oil export development. The positive role of the non-oil tradable sectors in the growth of non-oil exports is consistent with the supply-side theoretical formulation (see Equation (A2) in Appendix A). In that sense, the former acts as a measure of domestic production capacity. Moreover, keeping other conditions unchanged, it is intuitive that the production of non-oil tradable goods should be expanded to increase non-oil exports. The positive impact of non-tradable sectors on non-oil export performance is consistent with theoretical and empirical studies. Clearly, export performance is not driven only by the production capacity of the tradable sector and prices (real exchange rate). Other important factors can affect export performance, including infrastructure and services. The availability of necessary infrastructure and service elements (e.g., transportation, utilities, communication, and financial services) reduces production and transportation costs and avoids delays. Conversely, a lack of these elements exerts a negative influence on export performance according to theoretical and empirical studies [86–93]. The elasticity of non-oil GDP is greater than that of Middle Eastern and North African countries' GDP. This implies that domestic production capacity and services can contribute to non-oil export development to a greater extent than foreign income can. However, the results of the assumed restrictions on the long-run elasticities in Table A2 show that both elasticities can be considered unity. Non-oil exports have a one-to-one relationship with non-oil GDP, and this is in line with national accounting, which articulates that GDP is equal to the sum of consumption, investment and net exports. The results also indicate that Saudi non-oil exports can be in a one-to-one relationship with MENA GDP in the long run. Although unrestricted estimations provide that REER elasticity of non-oil exports is greater than negative unity, an assumed negative unity restriction cannot be rejected across estimations (We also tested the negative unit elasticity of non-oil exports with respect to REER in ARDL and DOLS estimations, as we did for the VECM framework. We found that negative unit elasticity restriction also cannot be rejected in these estimations.). If this restriction could be rejected, it would mean that the appreciation of REER causes a greater reduction in non-oil exports than the magnitude of the appreciation. This could be interpreted as one of the symptoms of the so-called "Dutch disease". In our case, the data do not support the assumption of REER-related Dutch disease for Saudi non-oil exports. Dutch disease is a common concern for many developing natural resource exporting economies [94,95]. Of course, it is not enough just to examine REER and decide whether a given country is affected or not affected by Dutch disease, as there are other assumptions concerning this disease that have to be empirically tested (see, e.g., [55,96]). We did not test the other assumptions as the investigation of Dutch disease is beyond the scope of this study.

Next, we consider the short-run findings reported in Table 3. The net short-run impacts of the REER and Saudi non-oil GDP on non-oil exports have the same signs as their long-run impacts, which are negative and positive, respectively. By contrast, the impact of Middle Eastern and North African countries' GDP is negative in the short run. A **1%** depreciation (appreciation) in the REER of the SAR increases (decreases) the growth rate of non-oil exports by **1.7%** contemporaneously and by **1.0%** after two years, while it decreases (increases) the growth rate of non-oil exports by **0.5%** after one year. The cumulative short-run impact of the REER is greater than its long-run impact. In other words, a permanent **1%** decrease (increase) in the SAR REER increases (decreases) non-oil exports by **2.8%** $(=(-1.728 + 0.454 - 0.997)/(1 - 0.194))$. Given that the REER is the price ratio and, thus, is considered a measure of international trade competitiveness, we can interpret this finding as follows. In the short run, Saudi Arabia's non-oil industry and agriculture products are noticeably sensitive to changes in the relative prices. As a developing economy, Saudi Arabia is not as competitive in international markets as other exporter countries, particularly developed countries, are. However, in the long run, Saudi export firms will become more technologically developed, productive and efficient due to various factors, including government support. This support is in line with Saudi Vision 2030, which has non-oil diversification as its key target. Saudi export firms will also invest in research and development and accumulate experience, thereby becoming creative and innovative. Hence, they will be able to increase their market shares in the long run. As a result, they will become more competitive and, thus, less sensitive to price changes in the long run than in the short run.

A **1%** increase in the growth rate of non-oil GDP first increases the growth rate of non-oil exports by **2.4%** in the current year. However, it decreases the growth rate of non-oil exports by **1.9%** after two years. Thus, the net effect of non-oil GDP, which reflects production capacity, on non-oil exports is positive. This result is in line with its long-run impact.

A **1%** increase (decrease) in the growth rate of Middle Eastern and North African countries' GDP has the following short-run effects. It decreases (increases) the growth rate of non-oil exports by **0.7%** in the current year and **0.5%** in the following year and increases (decreases) non-oil exports by **0.6%** after two years. The latter effect is in line with our long-run findings, which also indicate a positive relationship. We offer two explanations for the negative relationship between these variables in the short run. First, when non-oil exports increase, the income of export firms and, thus, overall income level, increases. In turn, domestic demand for goods and services, including those that are exported, increases. Since non-oil exports are incentivized and prioritized by the government, meeting domestic demand may be the first priority in the short run. Thus, non-oil exports will not be as responsive to Middle Eastern and North African countries' GDP as they previously were. As a result, the growth rate of non-oil exports may decrease in the short run while the growth rate of these countries' GDP increases. Second, a decrease in the growth rate of Middle Eastern and North African countries' GDP is related to an increase in the growth rate of Saudi non-oil exports in the current and following years. We consider the case in which the GDP growth rate in Middle Eastern and North African countries decreases for one or two years. In this case, it is reasonable to expect Saudi Arabia to export non-oil goods to other trading partners, such as Asian or other African countries. By nature, the growth rate of Middle Eastern and North African countries' GDP cannot decrease continuously for a long time. However, it is very likely to decline in the short run owing to wars; geopolitical issues; or political, social, or economic unrest, among other reasons (e.g., the situations in Syria, Iraq, Egypt, Libya, Lebanon, etc.). We can also observe graphs of both variables' growth rates (Panel B of Figure 1). In general, declines in the growth rate of Middle Eastern and North African countries' GDP correspond to increases in the growth rate of non-oil exports. Statistically, we find a negative correlation of 21% between the two variables in the short run.

Table 3 shows that the speed of adjustment coefficient is $-\mathbf{0.63}$. Thus, Saudi Arabia's non-oil exports revert 63% of the way back to their long-run equilibrium relationship with their determinants one period after a shock. Such shocks may stem from policies or other factors. This adjustment process is relatively fast. Our interpretation of this result is that the Saudi government considers non-oil export development to be a key element of non-oil diversification. This notion is in line with Saudi Vision 2030. Thus, the government will help non-oil exports adjust to their long-run path if they are off track.

Finally, Table A2 reports the hypothesis that weak exogeneity of non-oil GDP can be rejected at the 10% significance level. The economic interpretation of this result is that there is a feedback effect from non-oil exports to non-oil GDP, and this might suggest that the so-called "export-led growth" concept is applicable for Saudi Arabia. This concept articulates that exports can play an important role in the economic growth of a country through different channels. These include creating positive externalities by employing a more efficient institutional structure and production methods, thereby leading to economies of scale, weakening foreign exchange barriers, and making foreign markets more accessible. Other positive externalities include intensive technological innovation triggering economic growth and dynamic knowledge transfer [21,23,97–99], inter alia. This finding may be particularly worth considering, as Saudi Vision 2030 highlights diversification, including exports diversification, as a main strategy of non-oil economic growth.

8. Policy Simulation Analysis Using the KGEMM

This section describes policy simulation analyses for non-oil exports under different scenarios from 2021 to 2030 using the KGEMM. We aim to examine the effects of changes in various factors on the performance of Saudi Arabia's non-oil exports. We specifically examine factors that can be changed via policy measures. In this section, we first describe the KGEMM and the underlying assumptions for the simulation analyses. Then, we discuss the results of the analyses.

8.1. Brief Overview of the KGEMM

The KGEMM is a policy tool that assesses the impacts of internal decisions by Saudi policymakers and changes in the global economy on Saudi Arabia's energy-macroeconomic environment [100]. It is a general equilibrium, energy-sector augmented, hybrid macroeconometric model that combines theory-driven and data-driven approaches. A number of studies discuss that a hybrid type macroeconometric model outperforms a purely theory-based model such as a dynamic stochastic general equilibrium model or a computable general equilibrium model, and a purely data-based model such as an unrestricted VAR [25–27,101–103]. The KGEMM contains eight interacting blocks that represent Saudi Arabia's macroeconomic and energy linkages, as Figure 5 schematically illustrates. The model includes more than 700 annual time series variables that are classified as endogenous or exogenous. The exogenous variables mainly represent domestic policy, global energy and the global economy. The endogenous variables are determined by behavioral equations that are estimated econometrically or identities that are mainly constructed based on the System of National Accounts. The long-run and short-run relationships among the variables are estimated using the cointegration and ECM frameworks, respectively. Thus, there are two versions of the model. The long-run version, such as the Fair model [104,105], is based on the estimated long-run (cointegrated) equations. The short-run version is based on the estimated ECM equations [106,107].

We use the long-run version of the model, as our simulation analysis covers 10 years. Detailed discussions of each version are available from the authors upon request. Details about the KGEMM can be found in [100]. The edition of the KGEMM employed here is slightly different from that documented by [100] due to the things below. The non-oil export equation developed in this study was incorporated into the KGEMM by replacing the old one and the model solved consistently. Its database has been updated, and most of the behavioral equations have been re-estimated until 2019. Also, the projections account for the impact of COVID-19 and post-COVID-19 recovery.

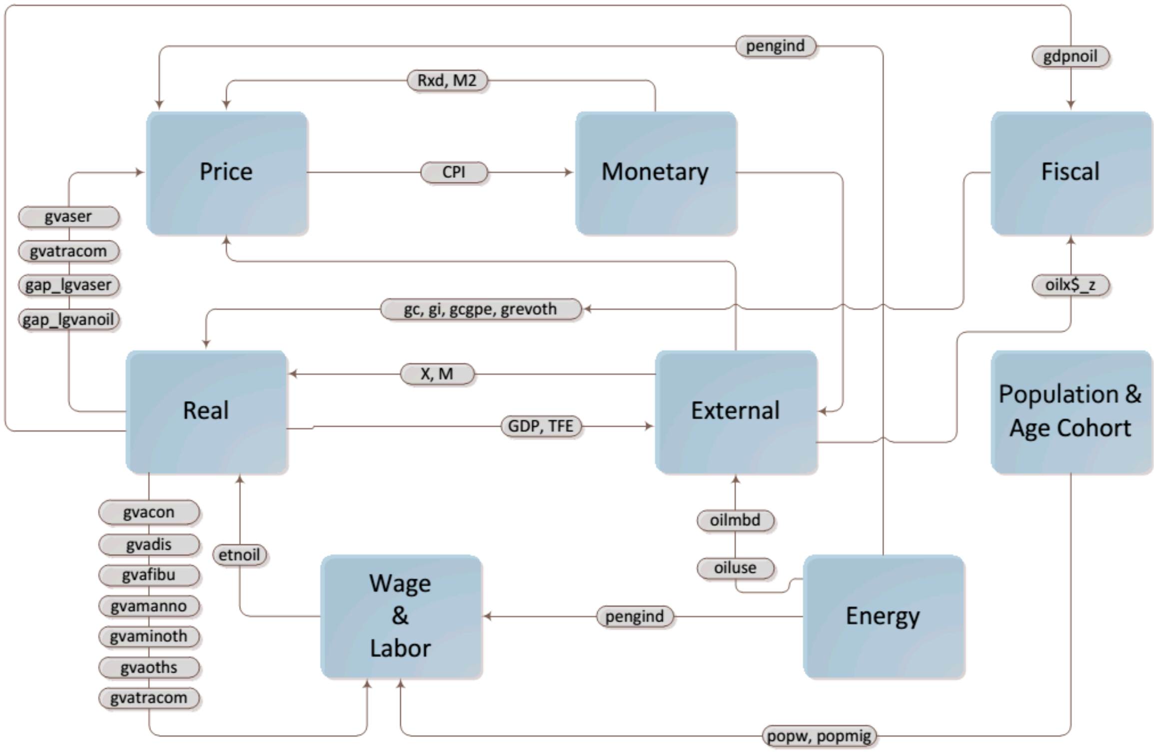

Figure 5. Schematic illustration of KGEMM. Source: [100].

8.2. Underlying Assumptions for the Simulation Analysis and Their Policy Relevancy

We perform seven scenarios. We provide a brief description of each scenario and discuss their policy relevancy. The first and second KGEMM simulations analyze the effects of the appreciation and depreciation of the REER, respectively, which shows the impact of changes in international competitiveness on non-oil exports in the coming decade. The third and fourth scenarios simulate non-oil exports effects of the non-oil tradable sectors while the last three scenarios assess the impacts of the non-tradable sectors. Both non-oil tradable and non-tradable sectors are part of non-oil GDP—a determinant of the non-oil exports in Equation (1).

In the first and second scenarios, we increase and decrease the REER by 10%, respectively. In this way, we assess the impacts on non-oil exports of a deterioration and improvement in Saudi Arabia's international price competitiveness through appreciation and deprecation, respectively, of the real values of the SAR against a basket of currencies of Saudi Arabia's main trading partners. Since the REER in the KGEMM is determined endogenously as the product of the nominal effective exchange rate (*NEER*) and the ratio of domestic prices (*CPI*) to the main trading partners' prices (*CPIW*) [see [100]), we treated it as exogenous in order to change its values in the first two simulations. Alternatively, one can also play with the components of the REER to simulate impacts on non-oil exports or other variables of interest. In this context, the nominal exchange rate of SAR to USD has been fixed at 3.75 since 1987. The government would not abandon the fixed exchange rate regime because it is beneficial for economic development overall, according to previous studies (e.g., [108]) and assessments by international organizations such as the International Monetary Fund. Thus, changes in the domestic economy affect non-oil exports mainly through *CPI* and the nominal exchange rate of the SAR against the currencies of major trading partners other than the US, while the impact of global price changes can be simulated via *CPIW*. We consider two scenarios with changes of the same magnitude in opposite directions (i.e., appreciation and depreciation). The reason is that previous studies find that real exchange rates may have asymmetric impacts on exports. Put differently, appreciations and depreciations of the domestic currency of the same magnitude may not cause decreases and increases in exports of the same magnitude. This empirical paradigm can be also considered for oil-exporting economies such as Saudi Arabia. Understanding how the real exchange rate movements caused by policy interventions (e.g., domestic reforms) can shape non-oil exports clearly has policy relevancy. These scenarios are also relevant to policies related to competitiveness. It is worth noting that establishing global competitiveness is one of the crucial goals of Saudi Vision 2030. The vision aims to improve Saudi Arabia's overall rank in competitiveness, from 25th in 2016 to within the top 10 by 2030. Achieving this goal requires a significant improvement in international trade competitiveness.

The third and fourth scenarios examine the effects of increases in the value added of agriculture and non-oil manufacturing, respectively, on non-oil exports. Generally, these two scenarios investigate the effects of the tradable sectors on non-oil exports. To provide policy-friendly results, we examine each sector's impact on exports separately. These scenarios are relevant to the main idea of Saudi Vision 2030, which aims to diversify the non-oil economy, including exports. The vision targets raising the share of non-oil exports in non-oil GDP from 15% in 2016 to 50% in 2030. Policymakers may wish to consider that the production and exports of the non-oil economy can support one another. Exports cannot be increased to the desired level if the non-oil tradable sectors (i.e., agriculture and non-oil manufacturing) are not sufficiently developed. Moreover, increasing Saudi non-oil exports caused by global demand will lead to the development of the non-oil tradable sectors and other sectors through spillover effects, according to export-led growth theory and empirical studies conducted for Saudi Arabia [21,97,109–112].

The last three scenarios simulate the impacts of services on non-oil export performance. As previously discussed, export performance is not just affected by the production capacity of the non-oil tradable sectors and the price ratio (i.e., the REER). Infrastructure and services are also important factors that policymakers should focus on. Providing the necessary levels of infrastructure and service elements (e.g., transportation, utilities, communication and financial services) reduces production and transportation costs and helps avoid delays. The provision of communication and power infrastructure and services is important in explaining patterns of comparative advantage, while the provision of roads is important in explaining patterns of absolute advantage [113]. A lack of infrastructure and services negatively influences export performance. We consider the effects of various service components individually rather than as a whole. In this way, our simulation analysis can provide more detailed policy recommendations.

Specifically, we consider the components of the so-called new Global Infrastructure Index, following [92,114]. These components are transport, telecommunication, energy and finance. The Saudi National Account (SNA) reports "Transport, Storage and Communication" as one economic activity sector, which covers land transport and transport via pipelines, air and water transport, warehousing and support activities for transportation, postal and courier activities in addition to the communications activities. The economic activity sector in SNA titled "Electricity, Gas and Water" represents the activity of providing electric power, natural gas, steam, air-conditioning, collection, treatment and distribution of water. Finally, the economic activity sector of "Finance, Insurance, Real Estate and Business Services" in SNA is the best available measure of financial services.

Lastly, we consider a reference scenario, that is, the business-as-usual (BaU) scenario. We compare this scenario with the seven scenarios described here. Table 4 outlines the assumptions of these scenarios.

Table 4. Underlying assumptions for the simulations, 2021–2030.

		Change in the Industrial Electricity Price
Reference case	BaU	The REER is projected to change from 111.09 in 2021 to 72.76 in 2030. GVAAGR is projected to grow from 58,724.00 million 2010 SAR in 2021 to 65,483.00 million 2010 SAR in 2030. GVAMANNO is projected to grow from 213,180.00 million 2010 SAR in 2021 to 294,070.00 million 2010 SAR in 2030. GVAU is projected to grow from 32,719.00 million 2010 SAR in 2021 to 40,268.00 million 2010 SAR in 2030. GVATRACOM is projected to grow from 157,640.00 million 2010 SAR in 2021 to 235,230.00 million 2010 SAR in 2030. GVAFIBU is projected to grow from 269,600.00 million 2010 SAR in 2021 to 396,940.00 million 2010 SAR in 2030.
Scenario 1	S1	The REER is projected to be 10% higher than in the BaU scenario in each year of the simulation period.
Scenario 2	S2	The REER is projected to be 10% lower than in the BaU scenario in each year of the simulation period.
Scenario 3	S3	GVAAGR is projected to be 10% higher than in the BaU scenario in each year of the simulation period.
Scenario 4	S4	GVAMANNO is projected to be 10% higher than in the BaU scenario in each year of the simulation period.
Scenario 5	S5	GVAU is projected to be 10% higher than in the BaU scenario in each year of the simulation period.
Scenario 6	S6	GVATRACOM is projected to be 10% higher than in the BaU scenario in each year of the simulation period.
Scenario 7	S7	GVAFIBU is projected to be 10% higher than in the BaU scenario in each year of the simulation period.

Notes: REER = real effective exchange rate; GVAAGR = gross value added in agriculture, forestry and fishing sector; GVAMANNO = gross value added in non-oil manufacturing sector; GVAU = gross value added in electricity, gas and water sector; GVATRACOM = gross value added in transport, storage and communication sector; GVAFIBU = gross value added in finance, insurance, real estate and business services sector.

All six variables in the table are originally endogenous in the KGEMM, as they are determined by identities and behavioral equations. However, we switched them to exogenous variables to conduct the simulation analysis. This and other technical details of the model and simulations can be obtained from the authors upon request. The reference case projections for these variables, as with those of other variables in the model, explicitly or implicitly account for the COVID-19 outbreak and low oil prices. Thus, they decline in 2020.

8.3. Results of the Projections

Figure 6 illustrates the projected paths of non-oil exports in the seven scenarios and in the reference case (i.e., the BaU scenario). Tables 5 and 6 report the percentage deviations of the scenarios (S1–S7) from the BaU scenario.

In the reference case, the KGEMM projects that non-oil exports will decline by 15.4% in 2020 from 167,197.56 million 2010 SAR in 2019. This decline is due to the deterioration in both demand- and supply-side factors caused by COVID-19 and low oil prices. Exports then increases to 163,970.00 million 2010 SAR in 2021, assuming a V-shaped recovery. Exports continue to grow at an annual average rate of 12% through 2030. For comparison purposes, readers should note that in June 2020, Oxford Economics forecasted that non-oil exports would decline by 21.31% in 2020. An annual average growth rate of 12% is very reasonable considering the historical growth rates of non-oil exports (see Panel B of Figure 4).

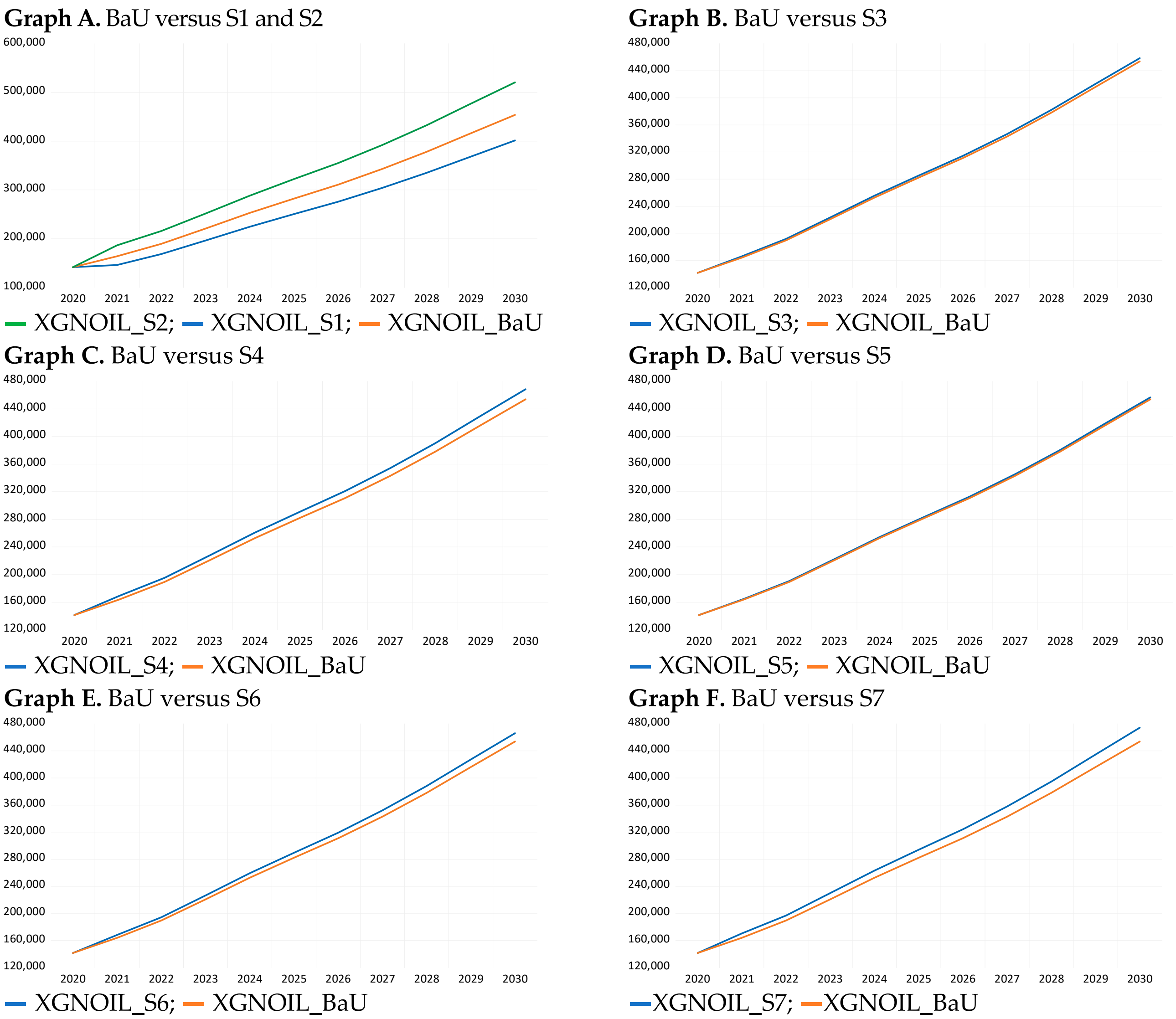

Figure 6. Projected paths of non-oil exports, XGNOIL.

Table 5. Deviations of scenarios S1–S4 from the BaU scenario, percentage changes.

Year	REER_S1	XGNOIL_S1	REER_S2	XGNOIL_S2	GVAAGR_S3	XGNOIL_S3	GVAMANNO_S4	XGNOIL_S4
2021	10.00	−10.93	−10.00	13.72	10.00	1.13	10.00	3.31
2022	10.00	−11.03	−10.00	13.88	10.00	1.12	10.00	3.14
2023	10.00	−11.07	−10.00	13.95	10.00	1.12	10.00	3.21
2024	10.00	−11.11	−10.00	14.00	10.00	1.11	10.00	3.25
2025	10.00	−11.13	−10.00	14.02	10.00	1.08	10.00	3.24
2026	10.00	−11.15	−10.00	14.06	10.00	1.07	10.00	3.27
2027	10.00	−11.16	−10.00	14.09	10.00	1.06	10.00	3.29
2028	10.00	−11.18	−10.00	14.12	10.00	1.05	10.00	3.32
2029	10.00	−11.20	−10.00	14.14	10.00	1.04	10.00	3.34
2030	10.00	−11.22	−10.00	14.17	10.00	1.03	10.00	3.36
Average	**10.00**	**−11.12**	**−10.00**	**14.01**	**10.00**	**1.08**	**10.00**	**3.27**
Derived elasticity		**−1.11**		**−1.40**		**0.11**		**0.33**

Table 6. Deviation of scenarios S5–S7 from the BaU scenario, percentage changes.

Year	GVAU_S5	XGNOIL_S5	GVATRACOM_S6	XGNOIL_S6	GVAFIBU_S7	XGNOIL_S7
2021	10.00	0.61	10.00	2.49	10.00	3.89
2022	10.00	0.60	10.00	2.54	10.00	4.00
2023	10.00	0.62	10.00	2.60	10.00	4.11
2024	10.00	0.62	10.00	2.63	10.00	4.18
2025	10.00	0.61	10.00	2.63	10.00	4.20
2026	10.00	0.61	10.00	2.66	10.00	4.26
2027	10.00	0.61	10.00	2.67	10.00	4.31
2028	10.00	0.61	10.00	2.69	10.00	4.36
2029	10.00	0.61	10.00	2.70	10.00	4.42
2030	10.00	0.61	10.00	2.72	10.00	4.47
Average	**10.00**	**0.61**	**10.00**	**2.63**	**10.00**	**4.22**
Derived elasticity		**0.06**		**0.26**		**0.42**

Some of the simulation analysis findings are worth mentioning. First, non-oil export performance appears to be more sensitive to the REER, a measure of competitiveness, than to any other factor. This result may imply that the primary consideration in policy measures regarding non-oil exports should be improving their competitiveness. Second, competitiveness has an asymmetric impact on non-oil export performance, as comparisons of scenarios 1 and 2 with the reference case show (see Graph A of Figure 6 and columns 1–5 of Table 5). Numerically, on average, a 10% appreciation of the SAR against a basket of Saudi Arabia's main trading partners' currencies reduces non-oil exports by 11.1%. By contrast, a 10% depreciation of the SAR leads to a 14.0% increase in non-oil exports from 2021 to 2030.

Third, non-oil manufacturing's contribution to non-oil export performance is three times greater than that of agriculture, on average. The corresponding derived elasticities are 0.33 and 0.11, respectively (see Table 5). This finding is supported by statistics of the agriculture and non-oil manufacturing exports. Specifically, [5] data show that the average share of agricultural, animal and food products in total non-oil exports was 6.9% in 2005–2019. The remaining 93.1% comprises petrochemical products, construction materials and other goods. Our finding is also explained by the fact that producing agricultural goods in Saudi Arabia is very costly owing to its harsh climate and terrain [115]. Hence, it would be very difficult for Saudi agricultural products to compete in international markets. By contrast, Saudi Arabia has comparative advantages stemming from cheap energy resources in non-oil manufacturing, particularly in oil-related products such as petrochemicals.

Fourth, the simulation results show that infrastructure and services are as important as other factors in the development of non-oil exports. To provide more detail for policymaking, we consider electricity, gas and water (GVAU); finance, insurance and other business services (GVAFIBU); and transport and communication (GVATRACOM) service sectors instead of aggregate services. Table 6 reports that the key contributor among these sectors is GVAFIBU. On average, a 10% increase in this sector's value added expands non-oil exports by 4.22% according to scenario 7. The derived/implied elasticities of non-oil exports with respect to GVAU and GVATRACOM are 0.06 and 0.26 based on scenarios 5 and 6, respectively.

Our explanations for the findings above are as follows. Since Saudi Arabia's electricity, gas and water sector is already well-developed, it cannot play a major role in the expansion of non-oil exports in the future. The opposite explanation holds for the finance, insurance and other business services sector. Many studies show that this sector, and particularly the financial market have large room for development in Saudi Arabia, as is typical for developing economies [116–119]. The development of this sector can facilitate transactions, insurance and other procedures and, thus, can expand non-oil exports. In this regard, the transport and communication sector falls between the other two sectors. In Saudi Arabia, this sector is developed to a certain degree, but further development can advance non-oil exports' performance in the future. The finding of positive impact of non-tradable sector on non-oil export may imply that there is no evidence for the consequence of Dutch

Disease in the Saudi economy, which is usually occurs as a negative relationship between the former and latter. Of course, a robust conclusion on Dutch Disease requires a detailed investigation, which is beyond the aim and scope of our study, but at least, the estimation and simulation results regarding the impacts of the real effective exchange rate and the non-tradable sector on non-oil exports, respectively invalidate the existence of Dutch Disease in the Saudi economy.

9. Concluding Remarks and Policy Insights

The diversification of the non-oil sector, including its exports, is at the core of Saudi Vision 2030. The vision aims to increase the share of non-oil exports to 50% of non-oil GDP by 2030. Achieving this goal and other targets requires a better understanding of the relationships in the economy, to implement effective policy measures. Gaining a better understanding, in turn, requires comprehensive empirical analyses to identify the main determinants of non-oil exports. However, to our best knowledge, no prior research quantifies the impacts of determinants on Saudi Arabia's non-oil exports in recent years and makes projections for future. Incorporating recent data that cover domestic reforms, transformations and low oil prices is critical. This need, among others, motivated us to conduct this research.

Our econometric estimations found that Middle Eastern and North African countries' GDP, as a measure of foreign income, is positively associated with Saudi non-oil exports. Similarly, Saudi Arabia's non-oil GDP, as a measure of domestic production capacity, is positively associated with Saudi non-oil exports. The REER, as a measure of competitiveness, has a positive impact in the long run if it depreciates and vice versa. Moreover, there is evidence of the export-led growth concept for Saudi Arabia, although it is weak and there is no evidence of Dutch disease, although we did not test all the hypotheses of it. Finally, 63% of any deviation from the long-run equilibrium relationship of Saudi non-oil exports caused by policy or other shocks is corrected after one year.

We also conducted policy simulation analyses using a macroeconometric model through 2030. We found that Saudi non-oil exports' future performance is more responsive to changes in the REER, a measure of competitiveness, than to any other determinants. Regarding domestic production capacity, the contribution of non-oil manufacturing to non-oil exports is three times greater than that of agriculture. Additionally, the simulations suggest that infrastructure and service are as important as the other determinants in enhancing Saudi non-oil exports' performance in the coming decade.

We briefly discuss some policy insights derived from the econometric estimations and policy simulation analyses. When implementing policies, the authorities may wish to consider that non-oil exports are quite sensitive to real exchange rate movements (i.e., appreciations and depreciations). Although the nominal bilateral exchange rate of the SAR to the USD has been fixed since 1987, the REER of the SAR, which measures price competitiveness, can still change. Effective coordination among the different policies that are currently being implemented in Saudi Arabia to achieve Saudi Vision 2030 is therefore necessary. For example, domestic reforms (e.g., expatriate levies, a value added tax, other taxes, prices, and fees) have been implemented since 2016. These reforms are part of the vision's Fiscal Balance Program. Conceptually, they could lead to high production costs for goods and services and thereby high domestic prices, which would not be favorable competitiveness of non-oil exports in the short- to medium-term. Meanwhile, the Vision emphasizes raising Saudi Arabia's international competitiveness position to among the top 10 globally, and expanding the share of non-oil exports in non-oil GDP to 50% by 2030. Implemented policy measures to achieve the targets above should be coordinated efficiently. A successful example of such a coordinated policy would be the implementation of support package for industry that the government already adopted. The package aims to make energy intensive industries more energy efficient and globally competitive, and covers industry-agnostic and -specific measures with six main themes (Fiscal Balance Program 2017).

Policymakers may also wish to consider that the non-oil sector, which comprises tradable and non-tradable goods, promotes non-oil exports. In particular, the authorities should note that non-oil manufacturing can boost non-oil exports more than agriculture can. Initiatives to promote non-oil manufacturing development are highlighted in vision realization programs such as the National Industrial Development and Logistics Program, National Transformation Program and Fiscal Balance Program.

The finding that infrastructure and service elements are important for boosting non-oil export performance may also be of interest to policymakers. Special care should be taken to further develop the finance, insurance and other business services, as well as the transport and communication. A roadmap for the development of these infrastructure and service elements, including initiatives and targets, is well established in the Vision's realization programs such as the National Transformation Program and National Industrial Development and Logistics Program.

Administrative, legislative, and other measures also can be considered to boost non-oil export performance directly and indirectly, as the data support the export-led growth strategy for Saudi Arabia. Such measures may include the provision of legal support for exporting companies, marketing and advertising of export products, formulation of supply chain and export strategies, and consideration of potential buyers. They may also include e-commerce, product registrations and certifications, participation in trade fairs, specialized training, and financial support for export companies. Measures can also involve discovering international markets and designing guidelines for various countries' markets. Many of these measures are well established by the Saudi Export Development Authority, an independent national authority that seeks to develop Saudi non-oil exports.

Although this study uses state-of-the-art econometric methodology and employs a general equilibrium, rather than a partial equilibrium, modeling framework, it has certain limitations. One of the limitations is that only aggregate non-oil exports are considered. However, it would be more informative if policymakers knew the relationships between different non-oil export products so that they could take product-specific measures. Additionally, low frequency data (e.g., quarterly or monthly) could be used in the empirical analysis, which would capture seasonality effects. However, such data are not available to us. Lastly, although we use the GDP of the Middle East and North Africa as a measure of foreign income, the GDP of all Saudi Arabia's main trading partners can be constructed and used as a robustness check. We believe that these limitations are worth considering for future research.

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Appendix A. Theoretical Framework

Appendix A.1. Demand for Saudi Non-Oil Exports

We assume that Saudi Arabia is a price taker for non-oil exports in the global market. Thus, the prices of Saudi Arabia's non-oil exports are exogenously determined in the international market. We specify that Saudi Arabia's non-oil exports are a function of the relative price of exports (i.e., the ratio of the price of Saudi Arabia's non-oil exports to the prices of competing goods in the international market). They are also a function of a scale variable that represents the foreign demand for Saudi Arabia's non-oil exports. Thus, Equation (A1) expresses demand for Saudi non-oil exports in the rest of the world.

$$lnX_t^d = \gamma_0 - \gamma_1 ln\left(\frac{P^*}{P^w}\right)_t + \gamma_2 lnY_t^f, \quad \text{(A1)}$$

where X_t^d is the quantity of non-oil exports demanded and P^* is the price of Saudi Arabia's non-oil exports in the foreign currency. P^w is the price of competing goods in the international market, and Y^f is the real GDP of the major trading partners for Saudi Arabian non-oil exports.

Equation (A1) is specified in natural logarithms. Thus, γ_1 and γ_2 are the relative price and the real income elasticities, respectively. An increase in the price of Saudi non-oil exports relative to that of competing goods is expected to reduce the demand for Saudi non-oil exports. Thus, the sign of γ_1 is negative in Equation (A1). Non-oil exports are expected to increase with an increase in the real income of the main trading partners (i.e., $\gamma_2 > 0$).

Appendix A.2. Supply of Saudi Non-Oil Exports

The supply of Saudi non-oil exports is specified as a log-linear function of Saudi Arabia's real non-oil GDP and the relative price of exports. The former indicates the country's productive capacity, and the latter is the ratio of export prices to domestic prices. This relationship is expressed in Equation (A2).

$$lnX_t^s = \delta_0 + \delta_1 ln\left(\frac{P^*}{\overline{P}^d}\right)_t + \delta_2\, Y_t^{noil}, \quad \text{(A2)}$$

where X_t^s is the supply of Saudi Arabia's non-oil exports. $\overline{P}^d$ is defined as P^d/e. Here, P^d is the price of non-oil export goods in the domestic market in SAR. e is the nominal exchange rate per unit of foreign currency relative to the SAR. Y_t^{noil} is Saudi Arabia's non-oil GDP, which is a proxy for domestic production capacity.

We assume that, as the prices of non-oil exports increase relative to domestic prices, the production of non-oil export goods will become more profitable. Exporters therefore supply more in this case. The supply of exports is expected to increase as the country's production capacity increases. Thus, we expect both δ_1 and δ_2 to be positive.

Appendix A.3. Market Equilibrium

The demand and supply equations can be written as follows:

$$lnX_t^d = \gamma_0 - \gamma_1 lnP_t^* + \gamma_1 lnP_t^w + \gamma_2 lnY_t^f, \quad \text{(A3)}$$

$$lnX_t^s = \delta_0 + \delta_1 lnP_t^* - \delta_1 ln\overline{P}^d + \delta_2 Y_t^{noil}. \quad \text{(A4)}$$

We assume equilibrium conditions for the demand and supply of exports (i.e., $lnX_t^s = lnX_t^d = X$). Solving (A3) and (A4) for lnP_t^* yields the following expression:

$$\begin{aligned} \delta_0 + \delta_1 lnP_t^* - \delta_1 ln\overline{P}^d + \delta_2 Y_t^{noil} &= \gamma_0 - \gamma_1 lnP_t^* + \gamma_1 lnP_t^w + \gamma_2 lnY_t^f, \\ (\delta_1+\gamma_1) lnP_t^* &= \gamma_0 - \delta_0 + \delta_1 ln\overline{P}^d + \gamma_1 lnP_t^w - \delta_2 Y_t^{noil} + \gamma_2 lnY_t^f, \\ lnP_t^* &= \tfrac{\gamma_0-\delta_0}{(\delta_1+\gamma_1)} + \tfrac{\delta_1}{(\delta_1+\gamma_1)} ln\overline{P}^d + \tfrac{\gamma_1}{(\delta_1+\gamma_1)} lnP_t^w - \tfrac{\delta_2}{(\delta_1+\gamma_1)} Y_t^{noil} \\ &\quad + \tfrac{\gamma_2}{(\delta_1+\gamma_1)} lnY_t^f. \end{aligned} \tag{A5}$$

We substitute Equation (A5) into Equation (A3) and solve for lnX_t^d.

$$\begin{aligned} lnX_t^d &= \gamma_0 - \gamma_1 \Big[\tfrac{\gamma_0-\delta_0}{(\delta_1+\gamma_1)} + \tfrac{\delta_1}{(\delta_1+\gamma_1)} ln\overline{P}^d + \tfrac{\gamma_1}{(\delta_1+\gamma_1)} lnP_t^w - \tfrac{\delta_2}{(\delta_1+\gamma_1)} Y_t^{noil} + \\ &\quad \tfrac{\gamma_2}{(\delta_1+\gamma_1)} lnY_t^f \Big] + \gamma_1 lnP_t^w + \gamma_2 lnY_t^f, \\ lnX_t^d &= \tfrac{\gamma_0\delta_1+\gamma_1\delta_0}{(\delta_1+\gamma_1)} - \tfrac{\gamma_1\delta_1}{(\delta_1+\gamma_1)} ln\overline{P}^d + \tfrac{\delta_1\gamma_1}{(\delta_1+\gamma_1)} lnP_t^w + \tfrac{\gamma_1\delta_2}{(\delta_1+\gamma_1)} Y_t^{noil} \\ &\quad + \tfrac{\gamma_1\gamma_2}{(\delta_1+\gamma_1)} lnY_t^f, \end{aligned} \tag{A6}$$

$$lnX_t^d = \frac{\gamma_0\delta_1+\gamma_1\delta_0}{(\delta_1+\gamma_1)} + \frac{\delta_1\gamma_1}{(\delta_1+\gamma_1)} ln\left(\frac{P_t^w}{\overline{P}^d}\right) + \frac{\gamma_1\delta_2}{(\delta_1+\gamma_1)} Y_t^{noil} + \frac{\delta_1\gamma_2}{(\delta_1+\gamma_1)} lnY_t^f, \tag{A7}$$

$$lnX_t^d = \alpha_0 + \alpha_1 ln\left(\frac{P_t^w}{\overline{P}^d}\right) + \alpha_2 Y_t^{noil} + \alpha_3 lnY_t^f, \tag{A8}$$

where $\alpha_0 = \frac{\gamma_0\delta_1+\gamma_1\delta_0}{(\delta_1+\gamma_1)}$, $\alpha_1 = \frac{\delta_1\gamma_1}{(\delta_1+\gamma_1)}$, $\alpha_2 = \frac{\gamma_1\delta_2}{(\delta_1+\gamma_1)}$ and $\alpha_3 = \frac{\delta_1\gamma_2}{(\delta_1+\gamma_1)}$.

Equation (A8) can be written in a regression form as follows:

$$lnX_t^d = \alpha_0 + \alpha_1 ln\text{REER}_t + \alpha_2 Y_t^{noil} + \alpha_3 lnY_t^f + \varepsilon_t. \tag{A9}$$

where, ε_t represents the error term. REER $= \frac{P_t^w}{\overline{P}^d}$. In other words, the real effective exchange rate (REER) is the price of foreign goods relative to domestic goods, expressed in a common currency. In this definition, an increase in REER means depreciation of the domestic currency because *e* is defined as per unit of foreign currency relative to the SAR as mentioned above. It is noteworthy that international organizations such as the International Monetary Fund or the World Bank construct REER in a way that its increase means appreciation of the domestic currency because they define *e* as per unit of domestic currency (the SAR in our case) relative to foreign currency.

As previously mentioned, one advantage of the reduced-form export equation is that it represents both demand- and supply-side factors along with relative prices. This study investigates the role of economic activity, including the tradable and non-tradable sectors, in the development of non-oil exports. In theoretical terms, Saudi non-oil exports represent the demand of Saudi Arabia's trading partners, who import these products. Meeting this demand depends not only on the production of the required amount of non-oil goods (i.e., non-oil tradable sectors) but also on other factors. Such factors include transportation, communication and other services (i.e., non-tradable sectors). For example, whether freight transport can deliver the required goods to Saudi Arabia's trading partners quickly and efficiently is a key factor. Another factor is whether banking and insurance and other commercial and business services can facilitate transactions and other operations related to non-oil exports.

To account for the role of domestic economic activity, we consider the difference between the total GDP and oil sector GDP, which yields non-oil sector GDP. We use non-oil sector GDP because Saudi Arabia's oil sector is mainly determined by changes in global energy markets. One may consider that oil revenues may be used to finance government expenditures to develop the tradable and non-tradable sectors. This spending may be on investment projects, support packages, soft loans and other activities that can foster non-oil export performance. However, these indirect effects of the oil sector are reflected in the non-oil GDP, which we include in our specification. Moreover, non-oil economic activity comprises tradable and non-tradable goods, which Saudi Arabian policymakers and authorities can influence. In this way, non-oil GDP differs from other determinants of exports, such as trading partners' income. Hence, Equation (A9) can help policymakers understand the role of non-oil economic activity in the development of non-oil exports. We separately consider the roles of the production capacity of non-oil tradable goods and non-tradable such as services in the policy simulations so that decision-makers can take the necessary measures.

Appendix B. Econometric Methodology: Unit Root and Cointegration Tests, Long- and Short-Run Estimation Methods

Appendix B.1. Unit Root Test

Cointegration implies that if the variables are not stationary and have no long-run (cointegrating) relationship, the regression results of these variables are spurious. In this case, the stationary forms of the variables should be used in regression analyses. Alternatively, if the non-stationary variables have a cointegrating relationship, then the regression results are not spurious and can be interpreted as long-run parameters [76].

Since most economic variables trend over time stochastically, it is important to check their stationarity using unit root (UR) tests to prevent spurious results. This study uses the augmented Dickey–Fuller (ADF) test [120], one of the most widely used UR tests in empirical research. The ADF test equation, including the intercept and trend, can be expressed as follows:

$$\Delta y_t = b_0 + vt + b_1 y_{t-1} + \sum\nolimits_{i=1}^{l} \gamma_i \Delta y_{t-i} + e_t. \quad \text{(A10)}$$

Here, y_t is a given variable to be tested for a UR, b_0 is a constant term and Δ is the first difference operator. i is the particular lag order, l represents the maximum number of lags, t is the linear time trend and e_t denotes white noise residuals.

The ADF sample value is the t-statistic for b_1. If this value is less than the critical ADF values in absolute terms at different significance levels, the null hypothesis of a UR cannot be rejected. Hence, we can conclude that y_t is a non-stationary variable. If the t-statistic is greater than the critical ADF values in absolute terms, the null hypothesis of a UR can be rejected. Thus, the variable is not non-stationary.

We also use Phillips-Perron (PP) and ADF with structural break UR tests in the empirical analysis [73]. We do discuss the UR tests here as they are widely used in the literature, but such discussions can be found in [73,120,121], among others.

Appendix B.2. Cointegration Test and Long-Run Estimation Methods

Appendix B.2.1. Johansen Cointegration Method

The vector error correction model (VECM) developed by [68,69] can be expressed as follows:

$$\Delta y_t = \pi y_{t-1} + \sum\nolimits_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \mu + \varepsilon_t \quad \text{(A11)}$$

where y_t is an $(n \times 1)$ vector of the n endogenous or modeled variables of interest and μ is an $(n \times 1)$ vector of constants. Γ is an $(n \times (k-1))$ matrix of short-run coefficients, and ε_t is an $(n \times 1)$ vector of white noise residuals. Finally, Π is an $(n \times n)$ coefficient matrix.

If the matrix Π has a reduced rank, that is, if $0 < r < n$, it can be divided into two matrixes. One is an $(n \times r)$ matrix of loading coefficients, α, and the other is an $(n \times r)$ matrix of the long-run coefficients, β. α represents the importance of the cointegration relationships in the system's individual equations and the speed of adjustment to disequilibrium. β indicates the long-term equilibrium relationship. Thus, $\Pi = \alpha\beta'$.

When testing for cointegration using Johansen's reduced rank regression approach, the following logic applies. First, we estimate the matrix Π in an unrestricted form. Second, we test whether the restriction implied by the reduced rank of Π can be rejected. Namely, the rank of Π characterizes the number of independent cointegrating vectors. This rank is determined by the number of its characteristic roots that are different from zero.

Appendix B.2.2. Dynamic Ordinary Least Squares

For the empirical analysis of the non-oil exports equation, we employ dynamic ordinary least squares (DOLS), as advocated by [122,123]. This approach enables the construction of an asymptotically efficient estimator that eliminates the feedback in the cointegrating system. This method involves augmenting the cointegrating regression with the lags and leads of differenced variables. This augmentation ensures that the resulting error term of the cointegrating equation is orthogonal to the entire history of the stochastic regressors' innovations. [123], among others, provide a detailed explanation of DOLS.

In case of the lags and leads of ΔX_t in the level regression, DOLS can be expressed as:

$$x_t^d = X_t'\beta + D_{1t}'\gamma_1 + \sum_{j=-q}^{r} \Delta X_{t+j}'\delta + \vartheta_{1t}. \tag{A12}$$

where, X_t is the vector of explanatory variables, i.e., $reer_t$, y_t^{noil} and y_t^f. This method's main assumption is that adding q lags and r leads of the differenced regressors absorbs the long-run correlation between u_{1t} and u_{2t}. Note that the least squares estimate of $\theta = (\beta', \gamma')'$ have the same asymptotic distribution as those obtained from the fully modified ordinary least squares and canonical cointegrating regression models. The asymptotic variance matrix of $\hat{\theta}$ can be estimated by computing the covariance of the usual ordinary least squares (OLS) coefficients. In this computation, however, we substitute the usual estimator for the variance of residual ϑ_{1t} with an estimator of the long-run variance of the residuals. An alternative method is to use a robust heteroscedasticity- and autocorrelation-consistent estimator of the coefficient covariance matrix.

Appendix B.2.3. Autoregressive Distributed Lag (ARDL) Bounds Testing Method

The general form of the ARDL specification of Equation (A9) can be written in terms of the short-run and long-run relationships as follows:

$$\begin{aligned}\Delta x_t^d = \alpha_0 \quad &+ \alpha_1 x_{t-1}^d + \alpha_2\, reer_{t-1} + \alpha_3 y_{t-1}^{noil} + \alpha_4 y_{t-1}^f + \sum_{i=1}^{3} \gamma_i \Delta x_{t-i}^d + \\ &\sum_{i=0}^{3} \delta_i \Delta reer_{t-i} + \sum_{i=0}^{3} \theta_i \Delta y_{t-i}^{noil} + \sum_{i=0}^{3} \vartheta_i \Delta y_{t-i}^f + \epsilon_t.\end{aligned} \tag{A13}$$

We adopt a general-to-specific modeling strategy to estimate Equation (A13) [28,74,75]. The number of lags of the differenced variables is selected based on the Schwarz information criterion, which is preferable for small samples. Refs. [74] and [75], among others, recommend this approach. Given the short time span of our sample, we choose a maximum lag order of three to estimate Equation (A13). The final estimated equation is selected based on whether it satisfies all diagnostic tests. These tests are the serial correlation Lagrange multiplier, White heteroskedasticity, autoregressive conditional heteroskedasticity (ARCH), normality in the residuals and Ramsey RESET tests for the appropriateness of the functional form. The F-bound test for the joint significance of the lagged level variables is applied to the final specification.

The null hypothesis of no cointegration in Equation (A13) is $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. The alternative hypothesis is $H_1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$. The cointegration bounds test provides two asymptotic critical values. The first is a lower critical value assuming that the explanatory variables are stationary in levels, I (0). The second is an upper critical value assuming that the explanatory variables are non-stationary in levels but are stationary in first differences, I (1). If the F-statistic is below the lower bound critical value, there is no cointegration among the variables. If the F-statistic is above the upper bound critical value, the variables have a cointegration relationship. If the F-statistic is between the upper and lower bound critical values, the results are inconclusive, and further investigation is needed.

After we determine that the variables in the empirical analysis have a long-run relationship, we can use the selected ARDL model to identify the long-run and short-run coefficients. For the calculation of the long-run coefficients, we assume that all the differenced variables in Equation (A13) are zero in the long run. Thus, the long-run equation of x_t^d corresponding to Equation (A13) is as follows:

$$x_t^d = \beta_0 + \beta_1 reer_t + \beta_2 y_t^{noil} + \beta_3 y_t^f \tag{A14}$$

where $\beta_i = \frac{\alpha_i}{-\alpha_1}$, $i = 0, \ldots 3$.

The short-run equation corresponding to Equation (A13) can be expressed as:

$$\begin{aligned} \Delta x_t^d = \theta_0 + \sum_{i=1}^{3} \gamma_i \Delta x_{t-i}^d + \sum_{i=0}^{3} \delta_i \Delta reer_{t-i} + \sum_{i=0}^{3} \theta_i \Delta y_{t-i}^{noil} + \sum_{i=0}^{3} \vartheta_i \Delta y_{t-i}^f \\ + \varphi ECT_{t-1} + \epsilon_t \end{aligned} \tag{A15}$$

where $ECT_t = x_t^d - (\beta_0 + \beta_1\ reer_t + \beta_2 y_t^{noil} + \beta_3 y_t^f)$.

Equation (A15) is known as the equilibrium/error correction model, and φ is the speed of adjustment coefficient.

Appendix B.3. Equilibrium Correction Model (ECM) Estimation Using the General-to-Specific Modeling Strategy with Autometrics

In econometric analysis, model selection from a set of candidate variables is one of the fundamental tasks (For details on the different model selection approaches and their comparative performance, see [124–127]). In order to address this issue, several methods have been proposed in the literature. These methods include, but are not limited to, Stepwise regression [128], the least absolute shrinkage and selection operator (LASSO) proposed by [129], the adaptive LASSO proposed by [130,131], and Autometrics developed by [29,132].

Stepwise regression is a widely used approach for selecting variables in empirical analyses. However, in various situations, this method does not ensure consistent selection [125,133]. On the other hand, the LASSO procedure has some important limitation with respect to the proper selection of covariates and the exclusion of redundant information, apart from bias [126,133–135]. Moreover, LASSO variable selection is consistent under certain condition [130]. Refs. [135,136] argue that the LASSO is unable to select the correct subset of key covariates without adding some noise to model. Unlike LASSO, the adaptive LASSO is selection-compliant under a general design condition, but it cannot be directly implemented if the predictor dimension is larger than the sample size (see [133] and references therein).

A recently revised version of Autometrics algorithm introduced by [29] uses a tree-path search to detect and eliminate statistically insignificant variables subject to diagnostic tests. Autometrics has integrated many features of econometrics to achieve the highest degree of completeness for an automatic procedure [125]. Ref. [79] argue that successful selection of econometric model requires robustness against many potential problems including outliers, shifts, omitted variables, incorrect distributional shape, non-stationarity, miss-specified dynamics, non-linearity, as well as inappropriate exogeneity assumptions. Model selection by Autometrics with tight significance levels and bias correction is a useful approach that addresses the above-mentioned issues [29,30,78,79,127,137]. Ref. [124] conclude that Autometrics is preferable to LASSO or adaptive LASSO in small sample sizes as a result of comparative analysis they conducted.

As mentioned in the main text, we estimate ECM in the general-to-specific framework [28] with Autometrics for the short-run analysis. This process comprises two main stages. First, we estimate a general unrestricted ECM. This model includes the maximum lags of the explanatory and dependent variables and contemporaneous values of the explanatory variables and one lag of ECT, which is constructed using the residuals of the long-run relationship as described above. In our case, the general unrestricted ECM can be expressed as follows:

$$\Delta x_t^d = a_0 + \sum_{i=1}^{p} b_i \Delta x_{t-i}^d + \sum_{i=0}^{p} c_i \Delta reer_{t-i} + \sum_{i=0}^{p} d_i \, \Delta y_{t-i}^{noil} + \sum_{i=0}^{p} e_i \, \Delta y_{t-i}^{f} + f ECT_{t-1} + \epsilon_t \tag{A16}$$

The maximum lag order p can be specified using several methods. These methods can include an information criterion (e.g., the Akaike or Schwarz criterion), a time-dependent rule or the frequency of the time series used. Perron (1989) suggests that if the data are quarterly and the number of observations is small, a maximum lag order of four is appropriate. Alternatively, in the case of a small number of annual observations, one or at most two lags can be considered as the maximum lag length.

The second step in the process is attempting to obtain a more parsimonious ECM specification by excluding statistically insignificant variables while perform a battery of post-estimation tests, such as autocorrelation, serial correlation, normality, heteroskedasticity and miss-specification tests, on the last specification. For this step, we use Autometrics with super saturation in the PcGive toolbox in OxMetrics 8.0 [29,30,77].

Note that if the explanatory variables ($reer_t$, y_t^{noil} and y_t^f) are weakly exogenous to the cointegrating system, Equation (A16) can be estimated using OLS without any information loss [138,139] and the parsimonious specification of the equation obtained from Autometrics can include the contemporaneous values of the explanatory variables if they are statistically significant. If the explanatory variables are not weakly exogenous, different methods can be used to properly estimate the ECM to address the endogeneity issue. One approach is to exclude the contemporaneous value(s) of the explanatory variable(s) from Equation (A16) and then apply Autometrics. Another approach that circumvents this issue is to estimate a system of simultaneous ECM equations for the dependent and explanatory variables. This system includes the contemporaneous values of explanatory variables. A third approach is using two-stage least squares (TSLS) or another instrumental variable method to re-estimate the obtained parsimonious ECM specification that includes the contemporaneous value(s) of the explanatory variable(s). The first approach omits useful information that can contain in the contemporaneous value(s) of the explanatory variable(s). The second approach has some system-specific complications (e.g., achieving order and rank conditions for identification purpose) and disadvantages (e.g., an issue in one equation contaminates others in the system). Thus, the third approach is preferable from the practical point of view. Note that applying the instrumental variable method in the cointegration and ECM framework is not unusual in the literature [140–144].

Appendix C. Econometric Estimations and Testing Results

Note that x^d, $reer$, y^{noil} and y^f are represented by $xgnoil$, $reer$, $gdpnoil$ and gdp_mena in the empirical analysis (estimations and testing) and simulations.

Appendix C.1. Unit Root Test Results

The results of the ADF, PP and ADF with structural break UR tests are reported in Table A1.

Table A1. Unit root test results.

ADF Unit Root Test							
	Level				**First Difference**		
Variables	t-stat	*C*	*T*	k	t-stat	*C*	*T*
xgnoil	−2.838		x	0	−5.389 [a]	x	
reer	−2.543	x		1	−3.500 [b]	x	
gdp_mena	−2.347		x	0	−7.204 [a]	x	
gdpnoil	−3.099		x	1	−3.156		x
PP Unit Root Test							
xgnoil	−2.844		x		−5.424 [a]	x	
reer	−2.279	x			−3.462 [b]	x	
gdp_mena	−2.348 [c]		x		−7.147 [a]	x	
gdpnoil	−1.286		x		−3.290 [c]	x	
SB Unit Root Test							
gdpnoil	−3.613				−5.606 [b]		

Notes: The maximum lag order is set to three, and the optimal lag order (k) is selected based on the Schwarz criterion. [a, b, c] indicate rejection of the null hypothesis at the 1%, 5% and 10% significance levels, respectively. The critical values for the tests are taken from [145]. Note that the final UR test equation can take one of three forms: intercept (*C*), intercept and trend (*T*) or none of these. x indicates that the corresponding option is selected in the final UR test equation based on statistical significance or insignificance. The critical values for the structural break UR tests are taken from [146].

The UR test results reveal that all of the series are non-stationary in levels and stationary in first differences except *gdpnoil*. The null hypothesis of non-stationarity, or a UR for all variables, cannot be rejected. We draw this conclusion because the sample t-statistics are less than the respective critical values in absolute terms. For the first differences of the variables, however, the null hypothesis can be rejected. Here, the respective sample t-statistics are greater than the critical values in absolute terms. The ADF UR test results for the first difference of *gdpnoil* suggest that the series is non-stationary. However, the PP UR test results suggest stationarity of Δ*gdpnoil* at the 10% significance level.

Figure 4 in the main text indicates a structural break in the *gdpnoil* series. Thus, to capture the effect of this structural break, we employ the ADF test with a structural breakpoint. We select a maximum lag length of three and choose the Schwarz information criterion to specify the optimal lag order in the structural break UR test. We use a trend, intercept, and intercept and trend breaks in the test equation if they are statistically significant. The test shows that *gdpnoil* are non-stationary as the sample t-statistic of −3.6 is less than the respective critical values in absolute terms. However, the non-stationarity of Δ*gdpnoil* can be rejected in favor of stationarity with a structural break as the sample t-statistic of −5.6 is greater than the respective critical values in absolute terms (see Table A1). Thus, we conclude that all the variables are non-stationary in their log levels but stationary in the first differences of their log levels. In other words, they can be considered *I* (1) series. The results of the ADF tests with and without structural breaks and the PP test all support this conclusion.

Appendix C.2. Cointegration Test Results

Once the order of integration of the variables included in the analysis is identified as *I* (1), we test the existence of a cointegrating relationship. We employ the three cointegration methods discussed in the previous section. Table A2 shows the results.

Table A2. Cointegration test results.

Panel A: Johansen Cointegration and Vector Autoregression Residual Diagnostic Test Results					
Johansen Cointegration Test Summary					
Test Option:	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**
Data trend:	None	None	Linear	Linear	Quadrati
Level equation:	None	Only *C*	Only *C*	*C* and *T*	*C* and *T*
Trace:	3	2	1	2	4
Max-Eig:	3	2	1	0	0
Test Results for Option (c)					
Null hypothesis:	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	
λ_{trace}	55.4 ***	27.15	11.24	1.23	
λ_{max}	28.26 ***	15.91	10.01	1.23	
Diagnostic Test Results					
Serial Correlation Test:	Test Statistic (*p*-Value)	Normality Test:	Test Statistic (*p*-Value)	Heteroskedasticity Test:	Test Statistic (*p*-Value)
Lag 1	25.9 (0.06)		7.864 (0.45)		180.6 (0.13)
Lag 2	16.5 (0.42)				
Testing Restrictions on the Long-Run Elasticities:					
Null hypothesis:		$\beta_{GVANOIL} = 1$	$\beta_{GDP\_MENA} = 1$	$\beta_{REER} = -1$	Joint
χ^2		0.93	1.64	1.28	3.30
Weak Exogeneity Test Results					
Null hypothesis:	$\alpha_{XGNOIL} = 0$	$\alpha_{REER} = 0$	$\alpha_{GDP\_MENA} = 0$	$\alpha_{GVANOIL} = 0$	Joint
χ^2	5.87 **	0.03	3.47	2.98	5.43
Panel B: ARDL cointegration and residual diagnostic tests					
F-value from the bounds test for cointegration: 13.776 ***					
Diagnostic Test Results	Test Statistic (*p*-Value)			Test Statistic (*p*-Value)	
Normality Test	1.437 (0.487)		Serial Correlation Test	2.096 (0.149)	
ARCH Test	0.531 (0.471)		Heteroskedasticity Test	0.429 (0.941)	
Ramsey RESET	0.278 (0.784)				
Panel C: Engle–Granger cointegration test results					
Tests			Test Statistic (*p*-Value)		
Engle–Granger tau-statistic			−4.009 (0.109)		
Engle–Granger z-statistic			−33.361 (0.003)		

Notes: The null hypothesis in the serial correlation Lagrange multiplier test is that there is no serial correlation at lag order h of the residuals. The system normality test uses the null hypothesis that the residuals are multivariate normal. The White heteroskedasticity test takes the null hypothesis of no cross terms heteroskedasticity in the residuals. C and T indicate the intercept and trend, respectively. r is the rank of the Π matrix, that is, the number of cointegrated equations; λ_{trace} and λ_{max} are the trace and max-eigenvalue statistics, respectively; *** and ** denote rejection of the null hypothesis at the 1% and 5% significance levels, respectively. The critical values in the Johansen cointegration test are taken from [147]. The critical values in the bounds testing are taken from [75,148]. Estimation period: 1983–2018.

To apply Johansen's reduced rank cointegration method, we first estimate a vector autoregression (VAR). We consider a maximum of three lags of the endogenous variables (i.e., *xgnoil*, *reer*, *gdp_mena* and *gvanoil*) and an exogenous intercept variable. Unlike in the ARDL estimation, we do not include the DB9596 blip dummy variable, which takes values of 1 and −1 in 1995 and 1996, respectively in the VAR estimations. The reason is that it does not improve the post-estimation test results. Instead, it weakens the statistical significance of the null hypothesis of no serial correlation, which is a serious issue in VAR estimations. We select the optimal lag order of two based on the Schwarz criterion. The estimated VAR with two lags is well-behaved in terms of stability. The residual diagnostic tests, that is, the serial correlation Lagrange multiplier, normality and residual heteroskedasticity tests, are satisfied. Panel A of Table A2 reports these results. Since all diagnostic tests are satisfied, we transform the VAR to a VECM following methodology in [149]. Then, we perform a Johansen maximum likelihood cointegration test to check whether the variables are cointegrated. Both the trace and max-eigenvalue statistics of the Johansen cointegration test suggest only one cointegrated relation among the variables in test option (c). This option is the most preferred option for the empirical analyses of economic relationships (see Panel A of Table A2). Additionally, the weak exogeneity test results indicate that only *xgnoil* is not weakly exogenous to the long-run relationship at the conventional statistical significance level of 5%. The results show that *gdp_mena* and *gvanoil* are weakly exogeneous at the 5% significance level. We also find strong statistical evidence for the weak exogeneity of *reer*. The hypothesis that *reer*, *gdp_mena* and *gdpnoil* are jointly weakly exogenous cannot be rejected as well.

We also perform a bounds test for cointegration, and the results are documented in Panel B of Table A2. We estimate an unrestricted ARDL specification with a maximum lag order of three for the variables. We also include the dummy variable $DB9596$ in the estimations. This variable captures the large jump in the residuals in 1995, which is followed by a drop in 1996. Excluding this dummy variable leads to several problems. First, the p-value of the sample F-statistic for the null hypothesis of no serial correlation weakens from 0.149 to 0.105. Second, the null hypothesis of no ARCH effect cannot be accepted, as the p-value of the sample F-statistic declines considerably from 0.472 to 0.014. Third, the null hypothesis of no heteroskedasticity cannot be accepted, as the p-value of the sample F-statistic decreases considerably from 0.941 to 0.019. Finally, the elasticity of *xgnoil* with respect to *gdp_mena* decreases from 0.817 to 0.359 and becomes statistically insignificant, with a p-value of 0.309. We choose an ARDL (2,3,1,3) specification based on the Schwarz criterion, following [74,75]. In other words, the optimal lag orders of 2, 3, 1 and 3 are selected for *xgnoil*, *reer*, *gdp_mena* and *gdpnoil*, respectively. ARDL (2,3,1,3) performs well in terms of the post-estimation serial correlation, normality, White heteroskedasticity and ARCH tests. Additionally, the Ramsey RESET test suggests no miss-specification in the functional form. The sample F-statistic from the bounds test for cointegration using the intercept but no trend in the level equation is 13.8. This value is greater than the upper bound critical F-statistic at the 1% significance level regardless of whether [75] or [148] critical values are considered. This finding suggests the null hypothesis of no cointegration can be rejected and the alternative hypothesis of cointegration can be accepted.

Lastly, we also perform the Engle–Granger cointegration test. The results are reported in Panel C of Table A2. The z-statistic and tau-statistic of the Engle–Granger test reject the null hypothesis of no cointegration at the 1% and borderline 10% significance levels, respectively suggesting that the variables establish a long-run relationship.

The results of the ARDL bounds test and the Engle–Granger residual-based test confirm the findings of the Johansen reduced rank test, that is, the variables are cointegrated.

Appendix C.3. Final ECM and the Search for Instrumental Variables

Our final, that is, parsimonious ECM specification obtained from Autometrics using OLS is reported in Table A3.

Table A3. The final ECM specification from the OLS estimate.

Variables	Coefficient	t-Statistic
ECT_{t-1}	−0.626 ***	−10.40
$\Delta xgnoil_{t-1}$	0.194 **	2.37
$\Delta reer_t$	−1.728 ***	−10.90
$\Delta reer_{t-1}$	0.453 **	2.25
$\Delta reer_{t-2}$	−0.997 ***	−5.47
Δgdp_mena_t	−0.649 **	−2.32
Δgdp_mena_{t-1}	−0.530 **	−2.33
Δgdp_mena_{t-2}	0.563 **	2.28
$\Delta gvanoil_t$	2.864 ***	7.94
$\Delta gvanoil_{t-2}$	−1.815 ***	−4.74
$DP1992$	−0.314 ***	−5.02
$\Delta DB1994$	−0.147 ***	−4.05

Post-Estimation Test Results

Test	F-statistic	p-value	Test	F-statistic	p-value
Serial Correlation LM	2.3104	0.123	Heteroskedasticity	1.020	0.505
ARCH	2.903×10^{-5}	0.996	Normality	0.684 [A]	0.711
Ramsey RESET	0.716	0.500			

Notes: The dependent variable is $\Delta xgnoil$; ** and *** indicate statistical significance at the 5%, and 1% levels, respectively. [A] indicates that the normality test statistic is the Chi-squared statistic rather than the F-statistic. Estimation period: 1983–2018.

Figure A1 illustrates the results of the stability tests for the final ECM specification from Autometrics.

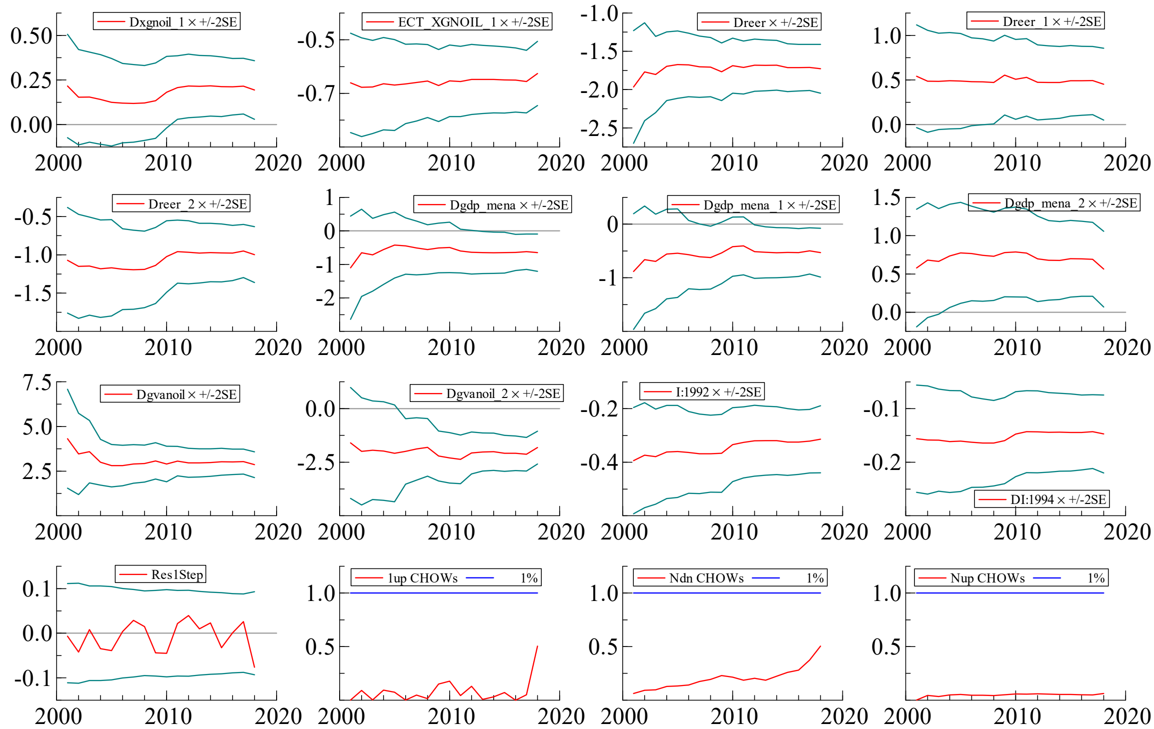

Figure A1. Stability test results.

The first 12 graphs in the figure show that many of the estimated coefficients are statistically significant and stable. In particular, the coefficient of ECT_XGNOIL_{t-1}, which is the disequilibrium of the long-run relationship with one lag, is stable and significant. We draw this conclusion because none of the recursively estimated coefficients (i.e., the red lines) demonstrate remarkable instability or become statistically zero toward the end of the period. They do exhibit a slight shift after 2010. However, the 13th graph illustrates that the recursively estimated residuals of the final ECM specification are stable over the period. They (red line) do not cross the error band (green lines) at any single point, including in 2010, and they remain close to zero. Finally, the last three graphs illustrate the results of the one-step, breakpoint and forecast Chow tests, respectively. They indicate that the null hypothesis of no breakpoint cannot be rejected in any year of the sample period. This finding holds even for 2010 and 2016–2018, periods in which a domestic energy price and fiscal reforms were implemented, and oil prices declined tremendously. Thus, we conclude that there is no structural break in the relationship between non-oil exports and their determinants during the period 1983–2018.

As mentioned in the main text, we estimate the final ECM using TSLS owing to potential endogeneity between the contemporaneous values of $\Delta gvanoil$ and $\Delta xgnoil$ although the statistical evidence is weak. Following the literature on estimating instrumental variables, we considered different variables that could be valid instruments. To be valid, an instrument must meet the following conditions. First, the order condition must hold. Second, an instrument for $\Delta gvanoil$ should be highly correlated with $\Delta gvanoil$ but very weakly correlated with the residuals of the estimation. Third, the instrument must obey the rank condition and, fourth, an instrument should improve the statistical properties of the estimations. Although it is very difficult to find a strongly valid instrument, our final set of instrumental variables is the following:

$$ECT_{t-1},\ \Delta xgnoil_{t-1},\ \Delta xgnoil_{t-2},\ \Delta reer_t, \Delta reer_{t-1},\ \Delta reer_{t-2},\ \Delta gvanoil_{t-1},\ \Delta gvanoil_{t-2},$$
$$\Delta gdp\_mena_t,\ \Delta gdp\_mena_{t-1},\ \Delta gdp\_mena_{t-2},$$
$$DP1992,\ \Delta DP1994,\ \Delta etnoil_t,\ \Delta csnoil_t,\ \Delta csnoil_{t-1},\ \Delta etnoil_{t-1}$$

where $\Delta csnoil$ and $\Delta etnoil$ are the growth rates of non-oil capital stock and non-oil employment, respectively. $DP1992$ and $DP1994$ are the pulse dummy variables that take the value of one in the years of 1992 and 1994, respectively and zero otherwise. Non-oil capital stock is constructed using non-oil investments, the depreciation rate of 5% and the initial capital-output ration of 1.5 in the Perpetual Inventory Method framework. The data for the investment measured in SAR millions at 2010 prices and for the employment measured in thousand people were collected from OEGEM (2020) and GaStat (2020). Our main instrumental variables here are the growth rates of non-oil employment and non-oil capital stock and their lagged values as we are concerned about endogeneity of the growth rate of the non-oil value added, $\Delta gvanoil$ in Equation (A16). The other instruments mentioned above are used to satisfy the order and rank conditions. The estimated final ECM specification using the list of the instrumental variables above is reported in Table A3 of the main text. The obtained Cragg-Donald statistic from the Weak Instrument test indicated the validity of the selected instruments. We also performed the Regressor Endogeneity (Durbin–Wu–Hausman) test, and the results indicate that $\Delta gvanoil$ is not endogenous anymore.

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