

Saudi Non-oil Exports Before and After COVID-19: Historical Impacts of Determinants and Scenario Analysis

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Key Points

he diversification of the non-oil sector, including its exports, is at the core of Saudi Vision 2030. This study investigates Saudi non-oil exports in a novel way. Specifically, it differs from previous studies on this topic owing to its modeling framework. This study's modeling framework first estimates the non-oil export equation, which allows us to examine the historical impacts of theoretically articulated demand- and supply-side determinants on non-oil exports. This is done using Autometrics, a state-of-the-art algorithm for computer-automated model selection in the general-to-specific modeling strategy framework, with super saturation. Then, we incorporate the estimated equation into the KAPSARC Global Energy Macroeconometric Model (KGEMM). This integrated model can simulate the impacts of the determinants and other variables relevant to policymakers on non-oil exports in the near future.

The main results of the empirical estimations and KGEMM scenario analysis through 2030 are as follows:

Non-oil exports and their determinants have a long-run (cointegrated) relationship.

All else being equal, a 1% depreciation (appreciation) of the Saudi riyal's real effective exchange rate (REER) leads to a 1.2% to 1.4% increase (decrease) in Saudi non-oil exports. The future performance of Saudi non-oil exports responds more to the changes in REER than to any other determinants.

A 1% rise in the gross domestic product (GDP) of Middle Eastern and North African countries increases Saudi non-oil exports by 0.6%-0.9%, *ceteris paribus*.

A 1% increase in Saudi non-oil GDP leads to a 1% increase in non-oil exports, *ceteris paribus*. Regarding production capacity, the contribution of non-oil manufacturing to the future performance of non-oil exports is three times that of agriculture.

The long-run equilibrium relation between non-oil exports and the aforementioned determinants is reasonably persistent. Specifically, a deviation in this relationship caused by a policy change or other shock reverts 63% of the way back to the equilibrium within one year.

Infrastructure elements such as finance, insurance, other business services, transport and communication will be important in improving Saudi Arabia's non-oil export performance in the coming decade.

For Saudi Arabia, data supports 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 consequences of the resource sector for the non-resource tradable sector.

Key Points

The following policy insights derived from this research may be useful for the authorities in increasing the performance of non-oil exports.

As a measure of price competitiveness, the REER — a ratio between prices in Saudi Arabia and the rest of the world — has certain implications for non-oil export performance. This relationship may necessitate effective coordination among the various policies currently being implemented in Saudi Arabia to achieve the objective of Saudi Vision 2030.

The non-oil sector, comprising tradable and non-tradable goods, supports non-oil exports. Specifically, non-oil manufacturing can boost non-oil exports more than the agricultural sector can. Infrastructure is crucial for boosting non-oil export performance. In this regard, special care should be taken to develop finance, insurance, other business services, transport and communications further. These infrastructure elements have a significant positive influence on non-oil exports.

The export-led growth concept might be worth considering, as Saudi Vision 2030 highlights diversification, including exports diversification, as a main strategy for non-oil economic development.

1. Introduction

S audi Arabia's existing economic model has facilitated substantial improvements in the country's human development indicators and has provided efficient physical infrastructure. However, 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 (SAMA 2020).

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 sevenfold 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.

Owing to its heavy reliance on the hydrocarbon sector, it may be difficult for Saudi Arabia, as it has been for other oil-exporting countries, to achieve sustainable economic growth. Challenges may arise both internally and externally. On the internal front, Saudi Arabia faces an overreliance on oil revenues to finance public sector functions. Other challenges include the public sector's dominance in the economy, a reliance on foreign labor and the growing local workforce's dependence on the public sector. On the external front, many factors may reduce Saudi Arabia's oil exports and, thus, its oil revenues going forward. As Fattouh and Sen (2019) argue, oil demand growth is likely to slow over time. Energy efficiency, technological advances, measures to mitigate climate change, electrical vehicles and changes in social preferences may all reduce oil demand. Uncertainty in the global oil market and oil price volatility may also adversely affect sustainability of the Saudi oil export revenues. The oil price collapse eroded oil-related revenues and forced abrupt government spending cuts. These cuts, in turn, caused the slowdown in the growth of economic activity in Saudi Arabia. As the literature discusses, having a single dominant source of income with high volatility creates difficulties in maintaining a certain level of economic growth in the long run (Albassam 2015; Alhowaish and Al-shihri 2010; Auty 1993; Horschig 2016; Mobarak and Karshenasan 2012).

As relying on one sector can create challenges for a country, diversification is important. According to Devaux (2013) and Kayed and Hassan (2011), economic diversification can encourage job creation. With diversification, more than one sector is active, contributing to the country's economic activities. Moreover, Hesse (2009) 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.

1. Introduction

The diversification of non-oil exports is among its chief goals. The plan specifically targets increasing non-oil exports' share 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 Saudi companies' capabilities, improve their competitiveness and expand their global reach. It has also taken other important steps such as adopting a private sector stimulus package and establishing the Saudi Export-Import (EXIM) Bank. The Saudi EXIM Bank has several key objectives. It aims to promote the development, diversity and competitiveness of Saudi exports and provide export financing, guarantees and export credit insurance services with competitive advantages. It also strives to enhance confidence in Saudi exports to support their penetration of new markets, reduce non-payment risk and provide export credit facilities.

Non-oil exports are an important component of Saudi Arabia's economic diversification, as they can play crucial roles in sustainable economic growth and new job creation. Diversification from oil to non-oil exports will likely contribute to Saudi Arabia's output growth through four major channels. First, non-oil exports will reduce export instability, as oil is subject to price volatility. They will help minimize the economy's exposure to the volatility and uncertainty in the global oil market. According to Agosin, Alvarez and Bravo-Ortega (2012), 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. 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 spillover effects (see e.g., Feder [1982]; Grossman and Helpman [1995]; Goldberg and Klein [1998]).

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 assesses the impacts of the determinants of non-oil exports. Thus, this study aims to develop a modeling framework for non-oil exports using novel methods, to help inform 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 KAPSARC Global Energy Macroeconometric Model (KGEMM). This integrated model allows us to simulate the impacts of the theoretically articulated determinants and other policy-relevant variables on non-oil exports. Hence, this study's policy recommendations are not simply derived from single equation estimations, which most previous export studies utilize. Instead, we also perform simulation analyses using the KGEMM — an energy-sector augmented, hybrid macroeconometric model. Macroeconomic models provide more comprehensive representations of processes than single equations do. They allow for feedback loops and estimations of the effects of other variables and policy setups in addition to

those of theoretically articulated determinants in the single equation framework (e.g., Beenstock and Dalziel [1986]; Cusbert and Kendall [2018]; Hasanov [2019]; Ballantyne et al. [2020]). For example, non-oil GDP and the real effective exchange rate (REER) are treated as exogenous variables in a single equation model of non-oil exports. However, these variables should be treated as endogenous given the nature of their data generation 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 through 2030 using policy scenario analyses. Second, our theoretical framework allows us to examine the demand- and supply-side determinants of exports alongside relative prices. Non-oil export development is the cornerstone of the economic diversification plan of Saudi Vision 2030. Thus, different aspects of this development should be explored. Third, we use various estimation and test methods to obtain robust empirical findings and provide well-grounded policy recommendations.

For example, we use Autometrics, a new algorithm for computer-automated model selection with super saturation (i.e., impulse-indicator saturation, change in impulse-indicator saturation, step-indicator saturation, and trend-indicator saturation) in a general-to-specific modeling strategy framework. This algorithm offers many advantages (Campos, Ericsson, and Hendry 2005; Doornik 2009; Hendry and Doornik 2014) over traditional modeling approaches. 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 methods. 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 derived from the results. n 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).

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 from 2003 to 2015. 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., Al-Moneef and Hasanov 2020; Hasanov et al., 2020). Owing to the development of the industrial, services and other sectors, the oil sector's relative size has fallen since 2003.





Source: The authors' calculation using Saudi Arabian Monetary Agency (SAMA 2020) data.

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 with the 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 Saudi Arabian Monetary Agency (SAMA 2020) 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.² 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 after 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 again collapsed in 2014-2016 owing to a supply glut (see Figure 3).





Source: The authors' calculation using Saudi Arabian Monetary Agency (SAMA 2020) data.

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 as a proportion of total exports have increased on average since 2003. This proportion 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 value added of exports. The petrochemical sector comprises a major share of non-oil exports, while the construction and agriculture sectors have quite small shares.

Saudi Arabia's oil exports have fluctuated over time, and many factors have played a role in shaping the fluctuation. The major factors include changing oil market conditions, interactions with other OPEC producers, and regional geopolitical events (Alkhathlan, Gately and Javid 2014; Fattouh and Sen 2015). These factors have caused high volatility in Saudi Arabia's oil exports. In this context, diversifying Saudi Arabia's exports and identifying alternative revenue sources for long-term economic growth deserve special attention as highlighted in Saudi Vision 2030. 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 a 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, Rosenstein-Rodan's (1943) big push model 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 (Naudé and Rossouw 2008). Ruffin (1974) and DeRosa (1991) 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. Hausmann and Rodrik (2003), Hausmann, Hwang and Rodrik (2007) and Hausmann and Klinger (2006) argue that economic growth is not motivated by comparative advantage. Instead, it is motivated by the diversification of countries' investments in new activities. Herzer and Nowak-Lehnmann (2006) 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. Lederman and Maloney (2003) 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. Hesse (2009) finds that export concentration has been detrimental to developing countries' economic growth in recent decades. Imbs and Wacziarg (2003) and Cadot, Carrère and Strauss-Kahn (2011) find a hump-shaped pattern of export diversification using large panel datasets.

Some previous studies also focus on Saudi Arabia. Albassam (2015) 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 Euchi, Omri and Al-Tit (2018) 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. Bokhari (2017) 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. However, her study is not based on any empirical evidence. Cherif and Hasanov (2014) 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.

Gouider and Haddad (2020) 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.

Matallah's (2020) study 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 1996-2017 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. Lukonga (1994) examines the performance of Nigeria's non-oil exports from 1970-1990. The results indicate that domestic market conditions strongly influence the behavior of Nigeria's non-oil exports. Hasanov and Samadova (2010) find that the REER is negatively associated with Azerbaijan's non-oil exports from the third guarter of 2002 to the third guarter of 2009. Non-oil GDP, by contrast, is positively associated with non-oil exports. Hasanov (2012) 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. This gap is critical to fill. A growing body of literature shows that sustainable growth is largely driven by export diversification (e.g., Cherif and Hasanov [2014]; Hausmann, Hwang and Rodrik [2007]; Papageorgiou and Spatafora [2012]). Thus, it is imperative to identify the key determinants of Saudi Arabia's non-oil exports.

his study is based on international trade theory. This theory was mainly developed by Leamer and Stern (1970), Goldstein and Khan (1985), Rose and Yellen (1989) and Rose (1990), among others. Following the existing empirical 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 (e.g., Arize [1990]; Chinn [2005]; Dayal-Gulati and Cerra [1999]; Goldstein and Khan [1985]; Jongwanich [2010]; Yue and Hua [2002]). Using a reduced-form export model allows us to avoid the simultaneous equation bias arising from estimating demand and supply functions separately (Dayal-Gulati and Cerra 1999; Goldstein and Khan 1978). 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 (Arize 1990; Goldstein and Khan 1978, 1985; Jongwanich 2010; Yue and Hua 2002).

We derive a reduced-form model for Saudi Arabia's non-oil exports by following the existing literature (e.g., Arize [1990]; Bushe, Kravis and Lipsey [1986]; Chinn [2005]; Goldstein and Khan [1978]; Jongwanich [2010]; Yue and Hua [2002]). 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:

$$x_t^d = \alpha_0 + \alpha_1 reer_t + \alpha_2 y_t^{noil} + \alpha_3 y_t^f + \varepsilon_t.$$
(1)

Here, x_t^d is non-oil exports, and $reer_t$ is the real effective exchange rate (REER), 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 α_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.*, $\alpha_1 < 0$) because of the definition of the latter (see Table 1). We expect non-oil exports to exhibit positive relationships with domestic output capacity and external demand ($\alpha_2 > 0$ and $\alpha_3 > 0$).

5. Data and Econometric Methodology

5.1 Data

We use annual data for the variables for the period 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 is and 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, SAMA's (2020) 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.

Variable Notation	Variable Definition	Data Source
		The data on non-oil merchandise exports in nominal values
VCNOU	Non-oil merchandise exports, in millions of	are from SAMA (2020). The values are converted into real
	2010 Saudi riyals	values using a non-oil GDP deflator that equals 100 in the
		base year of 2010.
		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
DEED	Real effective exchange rate	value of the local currency relative to several foreign
REER		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
REER GDP_MENA		appreciation of the Saudi riyal.
		The GDP of the Middle East and North Africa. GDP_MENA
	CDR in millions of 2010 United States	is multiplied by the bilateral exchange rate between the
GDP_MENA	(U.C.) dellare	Saudi riyal and the U.S. dollar so that all variables are in
	(0.5.) dollars	same units. The data are from the World Bank's World
		Development Indicators.
GVANOU	Gross value added of the non-oil sector, in	Saudi Arabia's non-oil GDP value is obtained from SAMA
GVAINOIL	millions of 2010 Saudi riyals	(2020).

Table 1. Variables and their descriptions.

The panels in Figure 4 illustrate the natural logarithmic (log) levels and the growth rates (d) of the variables.

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 tests can account for potential structural breaks in the variables under consideration. For cointegration tests and long-run estimations, we primarily use Johansen's reduced rank method (Johansen 1988; Johansen and Juselius 1990, 1992). Unlike single equationbased or residual-based cointegration methods, the Johansen method is the only test that can identify multiple cointegrated relationships among the variables. As a robustness check, we employ autoregressive distributed lag (ARDL) bounds testing (Pesaran and Shin 1998; Pesaran, Shin and Smith 2001). We also apply the Engle-Granger residual-based approach (Engle and Granger 1987) using dynamic ordinary least squares (DOLS). Lastly, for the short-run estimations, we utilize the equilibrium correction model (ECM) in the generalto-specific modeling strategy framework using Autometrics with super saturation. The details of the of the econometric methodology are described in Appendix B to conserve space in the main text.

he 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 C-1 of Appendix C. The results of the cointegration tests are reported in Table C-2. Specifically, we report the results of the Johansen cointegration, ARDL bounds and Engle-Granger residual-based tests in Panels A, B and C of Table C-2. They all confirm the existence of a 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 ofSaudi Arabia's non-oil exports (Equation 1)based on the vector error correction model(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	0.113
SC	-0.84	-1.89	-14.65

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

Notes: t-values are given in parentheses; *** and ** denote statistical significance at the 1% and 5% levels, respectively; Adj. R²=Adjusted coefficient of determination; SER=Standard error of regression; SC=Schwarz information criterion; 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 three independent variables are statistically significant and theoretically consistent for all three methods.³ 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 Pesaran, Shin and Smith (2001) and Pesaran and Shin (1998). 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., Corden [1984]; Corden and Neary [1986]) 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, $\beta_{GVANOIL} = 1$, $\beta_{REER} = -1$, and $\beta_{GDP_MENA} = 1$. Table C-2 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 form of the ECM specification given by equation (B7) in Appendix B. We use a maximum lag order of two owing to the short time span. We calculate the error correction term (ECT) using the long-run ARDL estimation in Table 2, as follows:

 $ECT_t = xgnoil_t - (-1.17 * reer_t + 0.82 * gdp_mena_t + 1.08 * gvanoil_t - 10.33).$ (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 (Pesaran and Shin 1998; Pesaran, Shin and Smith 2001). This analysis uses a relatively small sample, and, thus, this approach is the most appropriate.

We set up the general ECM specification of *∆xgnoil* with two lags for all variables and one lag of ECT, as mentioned previously, and contemporaneous values of the explanatory variables. 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 (Doornik 2009, chap. 4; Doornik and Hendry 2009; Hendry and Doornik 2014). 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 variables can capture all types 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 Section 6 of Hendry (2020) for the conditional model selection. First, we specify a general unrestricted ECM. 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 specification is well-behaved in terms of post-estimation tests before moving from the unrestricted to the final conditional specification. Hence, 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 *Axgnoil* that the aforementioned dummy variables can capture. We target a 1% significance level given the number of observations.

Autometrics selects only two dummy variables: one pulse dummy (I:1992) and one blip dummy (DI:1994). Having only two dummy variables being statistically significant may indicate that the unrestricted ECM specification is quite representative in capturing developments in $\Delta x gnoil$. 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 *Agvanoil*. The unrestricted ECM specification that includes the dummy variables selected by Autometrics successfully passes all post-estimation tests, including the normality test. Finally, we run Autometrics on the unrestricted ECM specification with the dummy variables with a target of 5% to obtain a conditional specification.

The selected final specification and its post-estimation test results are reported in Table C-3 of Appendix C. Table C-3 shows that all of 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, Durbin, and Evans 1975; Chow 1960). The test results are graphically illustrated in Figure 7 in the Appendix. Table C-3 and Figure 7 show that the final specification successfully passes all post-estimation tests, including those for stability. We discuss these results in Appendix C to conserve space in the main text.

We also note that our final ECM specification includes the contemporaneous value of $\Delta gvanoil$. The results in Panel A of Table C-2 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 increasing exports can be a driver of economic growth. Thus, to avoid possible endogeneity between these variables, we 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.

Variables	Coefficient	t-statistic
ECT _{t-1}	-0.626***	-10.31
$\Delta x gnoil_{t-1}$	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
ΔDB 1994	-0.147***	-4.05

Table 3. TSLS estimation of the final ECM specification.

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	5.91E-05	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 rather than the F-statistic. The J-statistic tests the null hypothesis that the overidentifying restrictions are valid. Estimation period: 1983-2018.

The final specification successfully passes all diagnostic tests for the residuals. These tests include the Jarque-Bera statistic for the normality of the residuals and the Lagrange multiplier (LM) test for serial correlation. The specification also passes the White test for heteroskedasticity, the autoregressive conditional heteroskedasticity (ARCH) test and the Ramsey RESET test for the misspecification of the functional form. In addition, the J-statistic of 2.97 with a p-value of 0.81 indicates that the null hypothesis for

overidentification is valid. Thus, the selected instruments are reasonable. Based on these tests, we can conclude that the estimated short-run elasticities are all statistically significant and theoretically interpretable. Additionally, the estimates including the elasticities in Table 3 are very close to those in Table C-3 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.

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he unit root tests documented in Table C-1 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 or other shock 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 C-2 suggest that non-oil exports, the REER, Middle Eastern and North African countries' GDP and Saudi non-oil GDP are cointegrated. In other words, the levels of 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 independent variables on non-oil exports using the ARDL, VECM and DOLS estimators to get robust results. The results in Table 2 demonstrate that non-oil exports establish a meaningful relationship with the theoretically predicted determinants. The numerical values, that is, the long-run elasticities for the different estimators, 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 Saudi riyals leads to a 1.2%-1.4%

long-run increase (decrease) in non-oil exports, keeping other factors unchanged. The relatively large magnitude of the elasticity indicates that Saudi Arabian non-oil exports are highly responsive to the REER, a measure of price competitiveness. The REER is theoretically and empirically considered a primary measure of an economy's international trade competitiveness (e.g., Balassa [1964]; Di Bella, Lewis, and Martin [2007]; Lipschitz and McDonald [1992]; Samuelson [1964, 1994]). 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 characteristics. First, non-oil production and exports are key aspects of the government's diversification strategy. Hence, these economic activities 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 sectors. This support is intended to mitigate the possible negative effects of domestic energy prices and fiscal reforms on non-oil activity and competitiveness (FBP 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 production capacity and infrastructure, increases by 1%. This finding shows that both non-oil tradable sectors, such as agriculture and non-oil manufacturing, as well as the infrastructure and service sectors support non-oil export development. The positive role of the non-oil tradable sector 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-oil non-tradable sectors such as infrastructure 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. The availability of necessary infrastructure 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 (Ahmad, Jaini, and Zamzamir 2015; Clark, Dollar, and Micco 2004; Donaubauer et al. 2018; Duval and Utoktham 2009; Estache and Wren-Lewis 2011; Limao and Venables 2001; Rehman, Noman, and Ding 2020; Yeaple and Golub 2002). The elasticity of non-oil GDP is greater than that of Middle Eastern and North African countries' GDP. This result may imply that domestic production capacity and infrastructure 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 C-2 show that both elasticities can be considered unity. Non-oil exports having a one-to-one relationship with non-oil GDP is in line with national accounting, which articulates that GDP is equal to the sum of consumption, investment and net export. 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.⁵ 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.' Dutch disease is a common concern for many developing natural resource exporting economies (Davis 1995; Arezki and Ismail 2013). Of course, it is not enough just to examine REER and decide whether a given country is affected by

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Dutch disease, as there are other assumptions concerning this disease that have to be empirically tested (see e.g., Kalcheva and Oomes [2007]; Hasanov [2013]). In our case, data does not support the assumption of REER-related Dutch disease for Saudi non-oil exports.

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 nonoil exports have the same signs as their longrun 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) of the REER of the Saudi rival 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 appreciation of the Saudi rival increases (decreases) non-oil exports by 2.8% (=(-1.73+0.454-0.996)/(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 incomes of export firms and, thus, overall income, increase. 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 nonoil 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 -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 C-2 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 (see Feder [1983]; Balassa [1978]; Ram [1985, 1987]; Goldberg and Klein [1998], *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.

his 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. It can also evaluate the interactions between the global economy and Saudi Arabia's energy-macroeconomic environment (Hasanov et. al. 2020). The KGEMM is a general equilibrium, energysector augmented, hybrid macroeconometric model that combines theory-driven and datadriven approaches (e.g., Hendry [2018] ; Gervais and Gosselin [2014]; Cusbert and Kendall [2018]; Ballantyne et al. [2020]; Jelić and Ravnik [2021]). It 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 or identities that are mainly constructed based on the System of National Accounts. The long-run and short-run relationships among the exogenous variables are estimated using the cointegration and ECM frameworks, respectively. Thus, there are two versions of the model. The long-run version, like the Fair model (Fair 1993, 1979), is based on the estimated long-run (cointegrated) equations. The short-run version is based on the estimated ECM equations (Buenafe and Reyes 2001; Welfe 2013).





Source: Hasanov et al. (2020).

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 Hasanov et al. (2020). The edition of the KGEMM employed here is slightly different from that documented by Hasanov et al. (2020). Its data have been updated, and most of the behavioral equations have been re-estimated through 2019. The projections account for the impact of COVID-19 and post-COVID-19 recovery.

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

e consider 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. These estimates indicate the effect of international competitiveness on non-oil exports at a given time. In the KGEMM, the REER is endogenous. It is determined as the product of the nominal effective exchange rate (NEER) and the ratio of domestic prices (CPI) to the main trading partners' prices (CPIW). This formulation allows us to simulate the impact of domestic energy prices and other reforms on competitiveness. The nominal exchange rate of Saudi riyals to U.S. dollars has been fixed at 3.75 since 1987. Thus, the changes in the domestic economy impact non-oil exports mainly through the consumer price index (CPI) and nominal exchange rate of SAR to main trading partners' currencies other than the U.S.In the first scenario, we increase the REER by 10%, assuming that the increase stems from the CPI. This increase in the CPI translates to an increase in the REER of the same magnitude. Thus, we check the impacts on non-oil exports if the value of the Saudi riyal appreciates against a basket of Saudi Arabia's main trading partners' currencies. In the second scenario, we decrease the REER by 10% and simulate the effects on non-oil exports.

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 (e.g., Hasanov [2012]). Understanding how exchange rate movements caused by policy interventions 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 twenty-fith 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, as they form a feedback loop. Exports cannot be increased to the desired level if the non-oil tradable sectors (i.e., agriculture and non-oil manufacturing) are not sufficiently productive. Moreover, increasing global demand for Saudi non-oil exports will boost the development of the non-oil tradable sector. These effects will boost the entire economy, according to export-led growth theory and empirical studies conducted for Saudi Arabia (Balassa 1978; Edwards 1993; Faisal, Tursoy, and Resatoglu 2017; Feder 1983; Kalaitzi and Chamberlain 2020; Saeed and Hatem 2017).

The last three scenarios consider the impacts of infrastructure on non-oil export development. As previously discussed, export performance is not just affected by the production capacity of the non-oil tradable sector and the price ratio (i.e., the REER). Infrastructure is also an important factor that policymakers should focus on. Providing the necessary levels of infrastructure 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 is important in explaining patterns of comparative advantage, while the provision of roads is important in explaining patterns of absolute advantage (Arif, Javid, and Khan 2021). A lack of infrastructure negatively influences export performance. We consider the effects of various infrastructure components individually rather than examining the impact of infrastructure in aggregate. 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 Donaubauer, Meyer, and Nunnenkamp (2015) and Rehman, Noman, and Ding (2020). These components are transport, telecommunication, energy and financial infrastructure. The Saudi National Account reports "Transport, Storage and Communication" as one economic activity sector. The economic activity sector of "Electricity, Gas and Water" can represent energy infrastructure. Finally, the economic activity sector of "Finance, Insurance, Real Estate and Business Services" is the best available measure of financial infrastructure.

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.

Change in the industrial electricity price				
		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 riyals in 2021 to 65,483.00 million 2010 riyals in 2030.		
		GVAMANNO is projected to grow from 213,180.00 million 2010 riyals in 2021 to 294,070.00 million 2010 riyals in 2030.		
Reference case	BaU	GVAU is projected to grow from 32,719.00 million 2010 riyals in 2021 to 40,268.00 million 2010 riyals in 2030.		
		GVATRACOM is projected to grow from 157,640.00 million 2010 riyals in 2021 to 235,230.00 million 2010 riyals in 2030.		
		GVAFIBU is projected to grow from 269,600.00 million 2010 riyals in 2021 to 396,940.00 million 2010 riyals 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.		

Change in the industrial electricity price

Notes: REER=real effective exchange rate; GVAAGR=gross value added in agriculture, forestry and fishing;

GVAMANNO=gross value added in non-oil manufacturing; GVAU=gross value added in electricity, gas and water;

GVATRACOM=gross value added in transport, storage and communication; GVAFIBU=gross value added in finance, insurance, real estate and business services.

All six variables in the table are originally endogenous in the KGEMM, as they are determined by identity and behavioral equations. However, we changed 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, like 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 different scenarios and in the reference case (i.e., the BaU scenario).

Figure 6. Projected paths of non-oil exports.

Tables 8 and 9 report the percentage deviations of the simulated scenarios (S1-S7) from the BaU scenario.

Graph D. XGNOIL projections, BaU versus S5

In the reference case, the KGEMM projects that non-oil exports will decline by 15.4% in 2020 from 167,197.56 million 2010 Saudi riyals 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 recover to 163,970.00 million 2010 Saudi riyals in 2021, assuming a V-shaped recovery. Exports continue to grow at an annual average rate of 12% through 2030. For comparison purposes, 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).

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

Veer		XGNOIL	REER	XGNOIL	GVAAGR	XGNOIL	GVAMANNO	XGNOIL
rear	REER SI	S1	S2	S2	S3	S3	S4	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		4 4 4		1 40		0.11		0.00
elasticity		-1.11		-1.40		0.11		0.33

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

Voor	GVALLS5		GVATRACOM			VONOIL S7	
	GVAU 55	AGNOIL 55	S6	XGNOIL SO	GVAFIBU 57	AGNOL 57	
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 reported in Figure 6 and Tables 5-6 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 decisions regarding non-oil exports is 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 1-4 of Table 5). Numerically, on average, a 10% appreciation of the Saudi riyal 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 rival leads to a 14.0% increase in non-oil exports from 2021 to 2030.

Third, non-oil manufacturing's contribution to nonoil 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 related to agriculture and non-oil manufacturing exports. Specifically, SAMA (2020) data show that the average share of agricultural, animal and food products in total non-oil exports was 6.9% from 2005 to 2019. The remaining 93.1% comprises petrochemical products, construction materials and other goods. This finding is also explained by the fact that producing agricultural goods in Saudi Arabia is very costly owing to its harsh climate and terrain (e.g., Hasanov and Shannak [2020]). Hence, it would be very difficult for Saudi agricultural products to compete in international markets. By contrast, Saudi Arabia has some comparative advantages stemming from cheap energy resources in non-oil manufacturing, particularly in oil-related sectors such as petrochemicals.

Fourth, the simulation results show that infrastructure is as important as other factors in the development of non-oil exports. To provide more detail for policymaking, we divide aggregate infrastructure into utilities; finance, insurance and other business services; and transport and communication. Table 6 reports that the key contributor among these sectors is the finance, insurance and other business services sector. On average, a 10% increase in this sector expands non-oil exports by 4% according to scenario 7. The respective derived elasticities for utilities and transport and communication are 0.06 and 0.26 based on scenarios 5 and 6, respectively.

Our explanations for these findings are as follows. Since Saudi Arabia's utilities 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, is not welldeveloped in Saudi Arabia, as is typical for developing economies (e.g., Al-Hamidy [2012]; Al-Yousef [2000]; Fasano-Filho and Wang [2001]; Looney [1989]). 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 the non-oil non-tradable sector on non-oil exports may imply that there is no evidence of a Dutch Disease consequence in the Saudi economy, which usually occurs as

a negative relationship between the former and latter. Of course, to make a conclusion regarding 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 real exchange rate and the non-tradable sector on non-oil exports invalidate the existence of Dutch Disease in the Saudi economy.

9. Concluding Remarks and Policy Insights

he diversification of the non-oil sector, including its exports, is at the core of Saudi Vision 2030. The vision targets increasing 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 conducting empirical analyses to identify the main determinants of non-oil exports. However, little to no prior research quantifies the impacts of these determinants on Saudi Arabia's non-oil exports in recent years. Incorporating recent data that cover domestic energy price and fiscal reforms 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 production capacity, is positively associated with Saudi non-oil exports. The REER, 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 caused by a policy or other shock 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 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 is as important as the other determinants in enhancing Saudi non-oil exports' performance in the coming decade.

We briefly describe some policy insights derived from the econometric estimations and simulation analyses. When implementing policies, the authorities may wish to consider that non-oil exports are very sensitive to currency movements (i.e., appreciations and depreciations of the rival). The nominal bilateral exchange rate of the Saudi rival to the U.S. dollar has been fixed since 1987. However, the REER of the Saudi rival, which measures price competitiveness, can still change as it is a ratio between domestic prices and foreign prices. 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 energy price reforms and fiscal reforms (e.g., expatriate levies, a value added tax and other taxes and fees) have been implemented since 2016. These reforms are part of the vision's Fiscal Balance Program. These reforms could lead to high domestic prices and high production costs for goods and services, which would weaken competitiveness of nonoil exports conceptually. Meanwhile, a vision realization program emphasizes raising Saudi Arabia's international competitiveness position to among the top 10 globally. Vision 2030 also aims to expand the share of non-oil exports in non-oil GDP to 50% by 2030. These policies should be coordinated efficiently to achieve the targets above. A successful example of such a coordinated policy would be the implementation of support packages for industry. Such packages can mitigate the potential harmful effects of domestic energy price and fiscal reforms on the sector's competitiveness (FBP 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. Policy measures that can expand non-oil manufacturing, such as support packages, soft loans, and simplification of bureaucratic and administrative procedures, may be implemented. Such initiatives, among others, are also highlighted in vision realization programs such as the Fiscal Balance Program, National Transformation Program and Non-oil Industrial Development Program.

The finding that infrastructure 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 sector and the transport and communication sector. These infrastructure elements can have significant positive influences on non-oil exports. A roadmap for the development of these infrastructure elements, including initiatives and targets, is well established in the Vision's programs. Finally, policymakers may wish to think about administrative, legislative, and other measures to boost non-oil export performance directly and indirectly, as the data supports 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.

Endnotes

¹ Saudi Export Development Authority, https://www.saudiexports.sa/en.

² See Dargay and Gately (2010), Alkhathlan, Gately and Javid (2014) and Cappelen and Choudhury (2000).

³ 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 reported results in the table correspond to the case where the loading (SoA) coefficients of the explanatory variables are assumed to be zero. If we additionally assume unity and negative unity restrictions on the long-run elasticities of non-oil GDP and REER, respectively, all the five restrictions hold as statistically significant, as the $\chi^2(5)$ gets 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.

⁴ 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.

⁵ The simulation can also be performed using the NEER. However, we choose not to use this variable. Although this rate is not fixed, it does not reflect Saudi exchange rate policy preferences. The government will not abandon the fixed exchange rate regime because it is beneficial for economic development overall, according to previous studies (e.g., Alkhareif and Qualls [2016]).

⁶ Unlike in the ARDL estimation, we do not include the *DB*9596 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.

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Appendix A. Theoretical Framework

A.1. Demand for Saudi Non-oil Exports

e 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 (1) expresses demand for Saudi non-oil exports in the rest of the world.

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

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 γf 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 elasticity, 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, we expect that $\gamma_1 < 0$. Non-oil exports are expected to increase with an increase in the real income of Middle Eastern and North African countries (i.e. $\gamma_2 > 0$).

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).

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

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 Saudi riyals. e is the nominal exchange rate per unit of foreign currency relative to the Saudi riyal. 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.

A.3. Market Equilibrium

The demand and supply equations can be written as follows:

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

$$lnX_t^s = \delta_0 + \delta_1 lnP_t^* - \delta_1 lnP^a + \delta_2 Y_t^{hou}.$$
(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:

$$\delta_{0} + \delta_{1} ln P_{t}^{*} - \delta_{1} ln \bar{P}^{d} + \delta_{2} Y_{t}^{noil} = \gamma_{0} - \gamma_{1} ln P_{t}^{*} + \gamma_{1} ln P_{t}^{w} + \gamma_{2} ln Y_{t}^{f},$$

$$(\delta_{1} + \gamma_{1}) ln P_{t}^{*} = \gamma_{0} - \delta_{0} + \delta_{1} ln \bar{P}^{d} + \gamma_{1} ln P_{t}^{w} - \delta_{2} Y_{t}^{noil} + \gamma_{2} ln Y_{t}^{f},$$

$$ln P_{t}^{*} = \frac{\gamma_{0} - \delta_{0}}{(\delta_{1} + \gamma_{1})} + \frac{\delta_{1}}{(\delta_{1} + \gamma_{1})} ln \bar{P}^{d} + \frac{\gamma_{1}}{(\delta_{1} + \gamma_{1})} ln P_{t}^{w} - \frac{\delta_{2}}{(\delta_{1} + \gamma_{1})} Y_{t}^{noil} + \frac{\gamma_{2}}{(\delta_{1} + \gamma_{1})} ln Y_{t}^{f}.$$
(A5)

We substitute equation (5) into equation (3) and solve for lnX_t^d .

$$lnX_{t}^{d} = \gamma_{0} - \gamma_{1} \left[\frac{\gamma_{0} - \delta_{0}}{(\delta_{1} + \gamma_{1})} + \frac{\delta_{1}}{(\delta_{1} + \gamma_{1})} ln\bar{P}^{d} + \frac{\gamma_{1}}{(\delta_{1} + \gamma_{1})} lnP_{t}^{w} - \frac{\delta_{2}}{(\delta_{1} + \gamma_{1})} Y_{t}^{noil} + \frac{\gamma_{2}}{(\delta_{1} + \gamma_{1})} lnY_{t}^{f} \right] + \gamma_{1}lnP_{t}^{w} + \gamma_{2}lnY_{t}^{f},$$

$$lnX_{t}^{d} = \frac{\gamma_{0}\delta_{1} + \gamma_{1}\delta_{0}}{(\delta_{1} + \gamma_{1})} - \frac{\gamma_{1}\delta_{1}}{(\delta_{1} + \gamma_{1})} ln\bar{P}^{d} + \frac{\delta_{1}\gamma_{1}}{(\delta_{1} + \gamma_{1})} lnP_{t}^{w} + \frac{\gamma_{1}\delta_{2}}{(\delta_{1} + \gamma_{1})} Y_{t}^{noil} + \frac{\gamma_{1}\gamma_{2}}{(\delta_{1} + \gamma_{1})} lnY_{t}^{f}, \qquad (A6)$$

$$lnX_{t}^{d} = \frac{\gamma_{0}\delta_{1} + \gamma_{1}\delta_{0}}{(\delta_{1} + \gamma_{1})} + \frac{\delta_{1}\gamma_{1}}{(\delta_{1} + \gamma_{1})} ln\left(\frac{P_{t}^{w}}{\bar{P}^{d}}\right) + \frac{\gamma_{1}\delta_{2}}{(\delta_{1} + \gamma_{1})} Y_{t}^{noil} + \frac{\delta_{1}\gamma_{2}}{(\delta_{1} + \gamma_{1})} lnY_{t}^{f}, \qquad (A7)$$

$$lnX_{t}^{d} = \alpha_{0} + \alpha_{1} ln\left(\frac{P_{t}^{w}}{\bar{P}^{d}}\right) + \alpha_{2} Y_{t}^{noil} + \alpha_{3}lnY_{t}^{f}, \qquad (A8)$$

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 estimated using time series data for Saudi Arabia in the following form:

$$lnX_t^d = \alpha_0 + \alpha_1 lnREER_t + \alpha_2 Y_t^{noil} + \alpha_3 lnY_t^f + \varepsilon_t.$$
(A9)

The real effective exchange rate (REER) is the price of foreign goods relative to domestic goods, expressed in a common currency (an increase means a depreciation of REER). \mathcal{E}_t represents the error term.

As previously mentioned, one advantage of the reduced-form export equation is that is represents both demand- and supply-side factors along with relative prices. This study investigates the role of economic activity, including the tradable sector and economic and financial infrastructure, 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 but also on other factors. One such factor is infrastructure, represented by non-oil activities, such as transportation, communication and other services. 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 demand, supply and prices in global energy markets. One may consider that oil revenues may be used to finance government expenditures to develop the tradable and non-tradable (i.e., infrastructure) 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 infrastructure components so that policymakers can take the necessary measures.

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

B.1. Augmented Dickey-Fuller Unit Root Test

Cointegration implies that if the variables are not stationary and have no long-run (cointegrating) relationship, the results from regressions 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 (e.g., Engle and Granger [1987]).

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 (Dickey and Fuller 1981), 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:

$$\Delta y_t = b_0 + vt + b_1 y_{t-1} + \sum_{i=1}^{l} \gamma_i \Delta y_{t-i} + e_t.$$
(B1)

Here, \mathcal{Y}_{i} s 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 cannot discuss UR tests in detail here owing to page limitations. However, such discussions can be found in Dickey and Fuller (1981), Dolado, Jenkinson, and Sosvilla-Rivero (1990) and Enders (2015), among others.

B.2. Cointegration Test and Long-run Estimation Methods Johansen Cointegration Method

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \mu + \varepsilon_t \quad , \qquad (\text{B2})$$

where y_t is an $(n \ x \ l)$ vector of the *n* endogenous or modeled variables of interest and μ is an $(n \ x \ l)$ vector of constants. *r* is an $(n \ x \ (k-l))$ matrix of short-run coefficients, and $\boldsymbol{\varepsilon}_t$ is an $(n \ x \ l)$ vector of white noise residuals. Finally, $\boldsymbol{\Pi}$ is an $(n \ x \ n)$ 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 x r) matrix of loading coefficients a, and the other is an (n x r) matrix of cointegrating vectors β . a 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.

Dynamic Ordinary Least Squares

For the empirical analysis of the non-oil exports equation, we employ dynamic ordinary least squares (DOLS), as advocated by Saikkonen (1992) and Stock and Watson (1993). 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. Hasanov and Shannak (2020), among others, provide a detailed explanation of DOLS.

The main objective of the DOLS estimator is to eliminate feedback in the cointegrating system. This method includes the lags and leads of ΔX_t in the level regression:

$$y_t = X'_t \beta + D'_{1t} \gamma_1 + \sum_{j=-q}^r \Delta X'_{t+j} \delta + \vartheta_{1t}.$$
 (B3)

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 estimates 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 residual variance of ϑ_{1t} with an estimator of the long-run variance of the residuals. An alternative method is to use a robust heteroskedasticity- and autocorrelation-consistent estimator of the coefficient covariance matrix.

Autoregressive Distributed Lag (ARDL) Bounds Testing Model

The general form of the ARDL specification of equation (9) can be written in terms of the short-run and long-run relationships as follows:

$$\Delta x_t^d = \alpha_0 + \alpha_1 x_{t-1}^d + \alpha_2 \operatorname{reer}_{t-1} + \alpha_3 \ y_{t-1}^{noil} + \alpha_4 y_{t-1}^{mena} + \sum_{i=1}^3 \gamma_i \Delta x_{t-i}^d + \sum_{i=0}^3 \delta_i \Delta \operatorname{reer}_{t-i} + \ \sum_{i=0}^3 \theta_i \Delta y_{t-i}^{mena} + \epsilon_t.$$
(B4)

We adopt a general-to-specific modeling strategy to estimate equation (B2) (Hendry 1995; Pesaran, Shin and Smith 2001). The number of lags of the differenced variables is selected based on the Schwarz information criterion, which is preferable for small samples. Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001), among others, recommend this approach. Given the short time span of our sample, we choose a maximum lag order of three to estimate equation (B2). 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 (10) 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 between 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 estimate the long-run and short-run coefficients. For the long-run elasticity estimates, we assume that all the differenced variables in equation (B2) are zero in the long run. Thus, the long-run equation corresponding to equation (B2) is as follows:

$$x_t^d = \beta_0 + \beta_1 x_t^d + \beta_2 reer_t + \beta_3 y_t^{noil} + \beta_4 y_t^{mena}, \qquad (B5)$$

where $\beta_i = \frac{\alpha_i}{-\alpha_1}, \ i = 0, \dots 4.$

The short-run equation corresponding to equation (B4) is as follows:

$$\Delta x_{t}^{d} = \theta_{0} + \sum_{i=1}^{3} \gamma_{i} \Delta x_{t-i}^{d} + \sum_{i=0}^{3} \delta_{i} \Delta reer_{t-i} + \sum_{i=0}^{3} \theta_{i} \Delta y_{t-i}^{noil} + \sum_{i=0}^{3} \vartheta_{i} \Delta y_{t-i}^{mena} + \varphi ECT_{t-1} + \epsilon_{t}, \quad (B6)$$
where $ECT_{t} = x_{t}^{d} - (\beta_{0} + \beta_{1}x_{t}^{d} + \beta_{2}reer_{t} + \beta_{3}y_{t}^{noil} + \beta_{4}y_{t}^{mena}).$

Equation (B4) is known as the error correction model, and φ is the coefficient of adjustment.

W

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

As mentioned in the main text, we estimate ECM in the general-to-specific framework (Campos, Ericsson and Hendry 2005) with Autometrics for the short-run analysis. This process comprises two main stages. First, we estimate a general or unrestricted ECM. This model includes the maximum lags of the explanatory and dependent variables and contemporaneous values of the explanatory variables. We also estimate an error correction model (ECM) with one lag, which is constructed using the residuals of the long-run relationship. In our case, the general ECM can be expressed as follows:

$$\Delta xgnoil_{t} = a_{0} + \sum_{i=1}^{p} b_{i} \Delta xgnoil_{t-i} + \sum_{i=0}^{p} c_{i} \Delta reer_{t-i} + \sum_{i=0}^{p} d_{i} \Delta gvanoil_{t-i} + \sum_{i=0}^{p} e_{i} \Delta gdp_mena_{t-i} + fECT_{t-1} + fECT_{t-1} + \epsilon_{t}.$$
(B7)

The maximum lag order for the general ECM, *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. We perform a battery of post-estimation tests, such as autocorrelation, serial correlation, normality, heteroskedasticity and misspecification tests, on the last specification. For this step, we use Autometrics automatic model selection with super saturation in the PcGive toolbox in OxMetrics 8.0 (Doornik 2009, chap. 4; Doornik and Hendry 2009; Hendry and Doornik 2014).

Note that if the explanatory variables (*reer, gvanoil and gdp_mena*) are weakly exogenous to the cointegrating system, equation (B7) can be estimated using OLS without any information loss (e.g., Brouwer and Ericsson [1995, 1998]). This equation includes the contemporaneous values of the explanatory variables. If the explanatory variables are not weakly exogenous, different methods can be used to properly estimate the ECM. One approach is to exclude the contemporaneous value(s) of the explanatory variable(s) from equation (B7). Estimating the resulting equation using OLS can provide a parsimonious ECM specification through the general-to-specific modeling strategy. However, this approach leads to the loss of useful information. Another approach that circumvents this issue is to estimate a simultaneous system of ECM equations for the dependent and explanatory variables. This system includes the contemporaneous values of these variables. A third approach also includes the contemporaneous value(s) of the explanatory variable(s) and, thus, avoids the loss of useful information. In this approach, however, we estimate the final single equation ECM for the dependent variable using

two-stage least squares (TSLS) or another instrumental variable method. Such a method can address the endogeneity issue. The first approach omits useful information contained in the contemporaneous value(s) of the explanatory variable(s). The second approach has some system-specific complications and disadvantage/s (e.g., an issue in one equation contaminates others in the system). Thus, the third approach is preferable. Note that applying the instrumental variable method in the cointegration and ECM framework is not unusual in the literature (e.g., Enders et al. [2010]; Enders, Im and Lee [2010]; Hartley, Medlock and Rosthal [2008]; Kim, Ogaki and Yang [2007]; Marmol, Escribano and Aparicio [2002]).

Appendix C. Econometric Estimations and Testing Results

C.1. Unit Root Test Results

The results of the ADF, Phillips-Perron (PP) and ADF with structural break UR tests are reported in Table C-1.

Table C-1. Unit root test results.

ADF Unit Root Test								
			First Difference					
Variables	t-stat	С	Т	k	t-stat	С	Т	
xgnoil	-2.838	х	Х	0	-5.389a	Х		
reer	-2.543	х		1	-3.500b	х		
gdp_mena	-2.347	х	х	0	-7.204a	х		
gdpnoil	-3.099	х	х	1	-3.156	х	х	
			PP Unit F	Root Test				
xgnoil	-2.844	х	Х		-5.424a	Х		
reer	-2.279	х			-3.462b	Х		
gdp_mena	-2.348c	х	х		-7.147a	Х		
gdpnoil	-1.286	х	х		-3.290c	х		
			SB Unit I	Root Test				
gdpnoil	-3.613				-5.606b			

Notes: The maximum lag order is set to three, and the optimal lag order (k) is selected based on the Schwarz criterion. ^a, ^b and ^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 MacKinnon (1996). 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 Perron and Vogelsang (1993).

The UR test results reveal that all of the series except *gdpnoil* are non-stationary in levels and stationary in first differences. 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 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. We choose the Schwarz information criterion to specify the optimal lag order in the structural break UR test. We use general specifications with a trend, intercept, and intercept and trend break in the test equation if they are statistically significant. The test shows that the log levels of gdpnoil are non-stationary. The sample t-statistic of -3.6 is less than the respective critical values in absolute terms. However, the non-stationarity of the first differences of the log levels of gdpnoil can be rejected in favor of stationarity with a structural break. Here, the sample t-statistic of -5.6 is greater than the respective critical values in absolute terms (see Table 2). 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.

C.2. Cointegration Test Results

Once the order of integration of the variables included in the analysis is identified, we test the existence of a cointegrating relationship. We employ the three cointegration methods discussed in the previous section. Table C-2 shows the results. In the table, the most preferred option for the empirical analyses of the economic relationships is test option (c). Johansen's reduced rank method identifies one cointegrated relationship among the variables when we use this option. The weak exogeneity test results show that xgnoil is not weakly exogenous to the long-run disequilibrium at the 5% significance

level. The remaining regressors, however, are weakly exogenous. The key takeaway from these results is that although the probabilities are quite low, endogeneity issues may arise between xgnoiland gdp_mena and gvanoil. These issues can occur if the contemporaneous values of the latter two variables survive in the final ECM specification of the former variable. The results of the ARDL bounds test (Panel B) and the Engle-Granger residual-based test (Panel C) confirm the findings of the Johansen reduced rank test. These tests also show that the variables are cointegrated and there is only one such relationship.

Table C-2. 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	Quadratic
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	$r \leq l$	$r \leq 2$	$r \leq 3$	
λtrace	55.4***	27.15	11.24	1.23	
λmax	28.26***	15.91	10.01	1.23	
Diagnostic Test Results					
Carriel Correlation Test	Test Statistic	Normality	Test Statistic	Heteroskedasticity	Test Statistic
Senal Correlation Test	(P-Value)	Test	(P-Value)	Test:	(P-Value)
Lag 1	25.9 (0.055)		7.864 (0.447)		180.6 (0.126)
Lag 2	16.5 (0.417)				
Testing restrictions on t	he long-run elastic	ities:			
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 F	lesults				
Null hypothesis:	$\alpha_{XGNOIL}=0$	$\alpha_{REER}=0$	$\alpha_{GDP_MENA} = 0$	$\alpha_{GVANOIL} = 0$	Joint
χ2	5.87**	0.03	3.47	2.98*	5.43
Panel B: ARDL cointegration	n and residual diagno	ostic tests			
-value from the bounds test	for cointegration: 13	.//6***			
Diagnostic Test Results	Test Statistic (P-'	Value)		Test Statistic (P-Valu	ne)
Iormality Test	1.437 (0.487)			Serial Correlation Te	est 2.096 (0.149)
RCH Test	0.531 (0.471)			Heteroskedasticity 7	Test 0.429 (0.941)
Ramsey RESET	0.278 (0.784)			,	X Z
anel C: Engle-Granger coi	ntegration test results	6			
ests		Test St	atistic (P-Value)		
ingle-Granger tau-statistic		-4.009	(0.109)		
ingle-Granger z-statistic		-33.36	1 (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; $\lambda trace$ and λmax 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 MacKinnon, Haug, and Michelis (1999). The critical values in the bounds testing are taken from Pesaran, Shin and Smith (2001) and Narayan (2005). 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. 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 C-2 reports these results. Since all diagnostic tests are satisfied, we transform the VAR to a vector error correction model following Juselius's (2006) methodology. 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 C-2). 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.

We also perform a bounds test for cointegration, and the results are documented in Panel B of Table C-2. We estimate an unrestricted ARDL specification with a maximum lag order of three for the variables. We also include the dummy variable *DB*9596 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 gdp_mena with respect to xgnoil 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 Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001). 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 misspecification 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. This result holds regardless of whether Pesaran, Shin and Smith (2001) or Narayan (2005) critical values are considered. This finding suggests the null hypothesis of no cointegration can be rejected. Thus, the variables establish a cointegrated relationship.

Lastly, we also perform the Engle-Granger cointegration test. The results are reported in Panel C of Table C-2. The z-statistic and tau-statistic of the Engle-Granger test reject the null hypothesis of no cointegration at the 1% and 10% significance levels, respectively. Thus, the variables establish a long-run relationship.

C.3. TSLS Estimation Results for the Final ECM and the Search for Instrumental Variables

Our final ECM, estimated with OLS, is reported in Table C-3:

Table	C-3 .	OLS	estimation	of the	final	ECM	specification.	

Variables		Co	efficient	t-statistic	
ECT _{t-1}		-().626***	-10	.40
$\Delta x gnoil_{t-1}$		(0.194**	2.3	37
$\Delta reer_t$		-1	1.728***	-10	.90
$\Delta reer_{t-1}$		().453**	2.1	25
$\Delta reer_{t-2}$		-().997***	-5.	47
Δgdp_mena_t		-1	0.649**	-2.32	
Δgdp_mena_{t-1}		-1	0.530**	-2.33	
Δgdp_mena_{t-2}		C).563**	2.28	
$\Delta gvanoil_t$		2	2.864***	7.94	
$\Delta gvanoil_{t-2}$		-1	1.815***	-4.74	
DP1992		-0.314***		-5.02	
Δ <i>DB</i> 1994		-0.147***		-4.	05
Post-estimation test	results				
Test	F-statistic	p-value	Test	F-statistic	p-value
Serial Correlation LM	2.3104	0.1228	Heteroskedasticity	1.0199	0.5048
ARCH	2.9034e-05	0.9957	Normality A	0.68309	0.7107
Ramsey RESET	0.71585	0.4998			

Notes: The dependent variable is $\Delta x gnoil$; ** 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 7 illustrates the results of the stability tests for the final ECM specification from Autometrics.

Figure 7. Stability test results.

The first 12 graphs in the figure show that many of the estimated coefficients are stable and statistically significant. In particular, the coefficient of *ECT_XGNOILt-1*, which represents the long-run relationship, 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 type of shift after 2010. However, the thirteenth graph illustrates that the recursively estimated residuals of the final ECM specification are stable over the period. They do not cross the error band 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 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 $\Delta xgnoil$. Following the literature on instrumental variables estimation, we test different variables that may be valid instruments. To be valid, an instrument must meet the following conditions. First, the order condition must hold. Second, an instrument for $\Delta gvanoil$

Appendix C. Econometric Estimations and Testing Results

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 as follows:

 $ECT_{t-1}, \Delta xgnoil_{t-1}, \Delta xgnoil_{t-2}, \Delta reer_{t}, \Delta reer_{t-1}, \Delta reer_{t-2}, \Delta gvanoil_{t-1}, \Delta gvanoil_{t-2}, \Delta gdp_mena_{t}, \Delta gdp_mena_{t-1}, \Delta gdp_mena_{t-2}, DP1992, \Delta DP1994, \Delta etnoil_{t}, \Delta etnoil_{t-1}, \Delta csnoil_{t}, \Delta csnoil_{t-1}$

The estimated final ECM specification using these instrumental variables is reported in Table 3 of the main text. We perform a Weak Instrument test, and the obtained Cragg-Donald statistic shows the validity of the selected instruments. We also perform a Regressor Endogeneity (the Durbin-Wu-Hausman) test, and the results indicate that Δ gvanoil is not endogenous anymore.

Notes

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About the Project

This study was part of the KGEMM Research and Policy Studies project. The project aims to leverage the work done in developing the KGEMM model to produce policy and research studies that can help Saudi Arabian decision-makers enhance their understanding of the Kingdom's domestic and international macroeconomic-energy linkages.

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