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Examining the Role of Oil Revenues in the Long-run Developments of the Saudi Private Sector

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Abstract

This paper investigates the role of oil revenues in the Saudi private non-oil output in the long run. We conducted a long-run analysis using the annual data of the last half-century (1970-2020) following the theoretical framework developed by Esfahani et al., (2014) for oil-exporting economies. We found that real oil revenues, together with real foreign output, drive the Saudi private sector development supporting the idea that oil is a blessing, not a curse, for Saudi Arabia. Some of the findings from the econometric analysis are worth mentioning. The data show that the Saudi private output converges with the foreign output in the long run. The data support the assumption that the magnitude of the impact of nominal oil revenues on the Saudi private output can be equal to that of the real exchange rate in the long run implying that the negative effect of the real exchange rate appreciation can be completely offset by the positive influence of nominal oil revenues in the long run.

Keywords: Natural Resource; Economic Growth; Oil Revenues; Cointegration; Saudi Arabia.

JEL Classifications : *O4, O13, P28*

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1. Introduction

A large number of studies investigated the role of natural resource (such as oil) abundance on the development of nations. The overall finding of these studies is not uniform. This means that number of studies found a harmful effect of resource abundance on the development of these nations following the so-called Resource Curse concept. The examples of such studies include Gelb (1988), Auty (1993, 2001), Sachs and Warner (1995, 1997, 2001), Lane and Tornell (1996), Torvik (2002), Frankel (2010), Haber and Menaldo (2011), Sala-i-Martin and Subramanian (2013), Corrigan (2014), Borge et al. (2015), Badeeb et al., (2017), and Bekkers and Pennink (2018), among others. However, another strand of the literature concluded that resource abundance promotes the development of these nations following the so-called Resource Blessing concept. This literature includes, but not limited to, Arezki and van der Ploeg (2007), Brunnschweiler and Bulte (2008), Cavalcanti, Mohaddes, and Raissi (2011a, 2011b), Esfahani, Mohaddes, and Pesaran (2012, 2014), and Leong and Mohaddes (2011). The opposite conclusions found in the literature are explained in terms of development levels of institutions, infrastructure, business environment, efficiency of governance, stances of the fiscal and monetary policies among other various factors.

Although some work has been done on the impact of oil revenues on the Saudi economy but still more efforts are essential as the country is the world’s number one oil exporter with the second-largest proved oil reserves, at 259 billion barrels, representing 31% of proved reserves in the Middle East and 15% globally (Oil & Gas Journal, 2020). However, a deep understanding of how these oil revenues can impact economic development is crucial for policymakers to effectively manage these resources from the sustainable development standpoint. This question is of paramount importance when long-run economic development is considered. Governmental authorities should know the nature of the influence that oil revenues can exert on the long-run economic development: if it is harmful, then the factors leading to this have to be identified and addressed by implementing respective measures. Even if oil revenues are helpful for the long-run economic growth, the decision-making process should still be informed about the magnitude of such positive impact.

Given the background above, the objective of this study is to examine the impact of oil income on the private sector development in the long run in Saudi Arabia with the aim of providing policy insights that can be useful for the decision-making process.

We follow the theoretical framework, which is designed for oil-exporting economies by Esfahani et al., (2014) as a theoretical foundation of our study. In this framework, we applied integration/cointegration methods to the annual data spanning for the last half century, i.e., 1970 – 2020. The long-run relationship, that is, co-movement between real output of the private sector and nominal oil revenues, the real exchange rate and real output of the rest of the world is confirmed by the utilized cointegration tests. The key finding of the study is that oil income is one of the determinants of the private sector development in the long run, in addition to the real exchange rate and real foreign output.

Our work contributes to the growth literature of Saudi Arabia in the following two ways. To our best knowledge, this is the first study that applies an oil economy-specific growth model to the Saudi private sector output. We prefer using private sector output to total output or non-oil output mainly because of two reasons[1]. First, on average, about 59% of the total GDP came from the oil sector (GaStat statistics via SAMA, 2021) for the period 1970-2020, and the sector is mostly determined by the changes in the global oil/energy markets and, hence, is exogenous to the domestic changes and developments. When it comes to the non-oil GDP, almost 38% of it belongs to the government sector on average during the same period, and this sector is not entirely driven by the long-run market fundamentals of economic developments as there are government incentives for energy, investment, and other inputs. The second reason for considering private sector GDP is related to Saudi Vision 2030 (SV2030), which is a strategic roadmap for the development of the country. The Vision puts the development of the private sector at the heart of the long-run prosperity of the Kingdom. It has targets that are directly related to the private sector. For example, to increase the contribution of the private sector to GDP to 65% by 2030. It also targets increasing the contribution of small and medium enterprises to GDP to 35% by 2030. Even other targets set by Vision necessitate or are conditional upon the development of the private sector in the Kingdom. For example, increasing foreign direct investment share in GDP to 5.7% by 2030. All these and other targets and initiatives as well as those which are directly and indirectly related to the importance of the private sector development are outlined in the Vision

[1] It might be argued here why the government spending is not included as an explanatory variable due to the dominant position of the fiscal policy in oil exporting economies as in the Saudi economy. However, two points should be considered. First, almost every economic indicator is influenced by oil resources directly or indirectly largely or minorly in oil exporting developing economies including Saudi Arabia. Hence, the impact of the government spending and thus oil revenues on the private sector is likely to be smaller than that impact on GDP or non-oil GDP. Second, the growth model we employ in this study considers oil income as the primary explanatory variable and thus the main source of the government revenues and spending. Therefore, including the government spending in the model in addition to oil income most likely could create multicollinearity issue. Besides, investigating the role of government spending in economic growth model is beyond the scope of this study.

document (SV2030, 2017) and its realization programs.[2] Second, our study is based on the data of the recent 51 years (1970-2020), which incorporate large-scale recent events in the domestic and foreign economies, such as the oil price declines in the global energy markets since 2015, energy price and fiscal reforms in Saudi Arabia in 2016-2018, COVID-19 recession. This sample span also includes other key events that happened in the period prior to 2014, such as the positive oil price shocks in 1973 and 1979, the sharp drop in oil prices in 1986, the high oil prices, and thus the rapid economic development in 2003-2013 (a comprehensive discussion of these events can be found in Eid and Awad (2017)).

Although Esfahani et al. (2014) also considered Saudi Arabia in their study, there are four points that make our work different from theirs: sample span, measure of output as the dependent variable, data frequency, and detailed discussion and analysis of the Saudi Arabian data.

The remainder of the paper is organized as follows; section 2 delivers the survey of the relevant literature and section 3 presents the theoretical background. The data and methodology of the study are described in section 4 and section 5, respectively. Section 6 presents the findings of the econometric analysis and section 7 provides explanations for them. Finally, section 8 concludes the study with some policy insights.

2. Literature review

[2] Such as National Transformation Program, National Industrial Development and Logistics Program, Fiscal Sustainability Program, Financial Sector Development Program (see https://www.vision2030.gov.sa/v2030/vrps/ for the details of the realization programs).

An overview of the literature background will be introduced followed by an empirical research survey on Saudi Arabia as our case study for comparison.

2.1. Literature Background

Despite the fact that natural resources abundance was viewed as a "blessing" for decades, back to Adam Smith, the opposing view of "resource curse" had emerged since the 1960s owing to low performance of rich-oil countries after the oil price shocks occurred in 1970s (Gelb, 1988; Auty 1993, 2001; Sachs & Warner, 1995, 1997, 2001; Lane & Tornell, 1996;;Torvik, 2002; Frankel,2010; Haber & Menaldo 2011; Sala-i-Martin & Subramanian, 2013; Corrigan, 2014; Borge et al., 2015; Badeeb et al., 2017; Bekkers & Pennink, 2018, among others).[3]

In the same vein, another yet a phenomenon incidence, termed "Dutch disease" by the Economist when large, but temporary, discovery of gas in the 1960s in the Netherlands postulated increased exchange rate, which in turn led to appreciation resulted in deteriorations in output and employment at non-resource activities, often manufacturing (Corden & Neary 1982; Corden 1984; Gylfason 2001a; Stevens 2003, and others).

Despite a set of strong theoretical and empirical evidence claiming the existence of the "resource curse", a strand of literature and empirical works considers the positive impacts of resource abundance on economic growth. Using alternative methodological approaches also supports the positive impact of resource wealth (i.e., Arezki & van der Ploeg 2007; Brunnschweiler & Bulte 2008; Cavalcanti, Mohaddes, & Raissi 2011a, 2011b; Esfahani, Mohaddes, & Pesaran, 2012; and

[3] In the 1990s, economists largely had reached a consensus related to the existence of "resource curse" where the latter term label was coined by Auty (1993).

Leong & Mohaddes 2011). In fact, theoretical models of economic growth usually focus on technological progress and human resources as the main drivers of economic growth in the longrun, whereas possible effects of natural resources (oil exports) on the growth process are ignored (Barro,1991; Barro and Sala-i-Martin (1991); Barro and Sala-i-Martin (1992); Barro et al. (1995); and Mankiw et al. (1992); Lucas (1988), Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992)). Therefore, in this research, we will adopt the modelling framework developed by Esfahani et al. (2014).

Despite a little flourishing of research examining the nexus between oil price shocks and GDP growth in developing economies; the most existing research have been largely focused on developed, net oil-importing economics as for the US and OECD countries (e.g., Darby, 1982; Hamilton, 1983, 1986, 2003, 2009; Mork,1989; Mork and Olsen, 1994; Burbridge and Harrison, 1984; Rotemberg and Woodford,1996; Bernanke, 1983; Bernanke et al., 1997; Schmidt and Zimmermann,2007; Singer, 2007; Bjørnland, 2000; Gisserand Goodwin, 1986; Anzuini, 2007; Ferderer, 1990; Baumeister, 2008; Hooker,1996; Jiménez-Rodríguez and Sánchez, 2005)[4]. On the other hand, few studies have explored developing, net oil-exporting economies, gauging the dynamic relationship between oil price shocks and major macroeconomic factors. These studies include Eltony and Al-Awadi, 2001 for Kuwait; El-Anashasy et al., 2005 for Venezuela; Berument et al., 2010 for MENA economies; Olomola and Adejumo, 2006, Ayadi, 2005 and Akpan, 2009; all for Nigeria; Farzanegan and Markwardt, 2009 for the Iranian economy.

[4] An extended survey of the oil price and macroeconomic nexus within developed economies have been provided by Jones and Leiby (1996) and later Jones et al., (2004).

2.2. Empirical literature with the Saudi economy

Limited research has explored the relationship between oil revenue (i.e., oil export) and economic growth. These papers are Mehera and Oskoui (2007), Meharara (2008, 2009), Alkhathlan (2013), Al Rasasi et al., (2018), and Sultan and Haque (2018). All these papers suffered relatively from the misspecification phenomena as Alkhathlan (2013) for instance augmented inflation, domestic consumption and net trade in the specification. Al Rasasi et al., (2018) used only oil revenues explaining the non-oil real GDP while Sultan and Haque (2018) empirically included government spending with exports and imports as explanatory variables without strong theoretical bases.

Filling the gap in the literature, to the best of our knowledge, our paper is the first attempt to measure the oil revenues effects on the long-run private sector output in Saudi Arabia employing a growth model, which was tailored for oil-exporting economies as a time series exercise. Our research will fill the gap in the literature and will be different from current research in three folds. First, its empirical analysis is based on the long-run growth model specification developed by Esfahani et al., (2014). Second, our data span covers a very important period of huge structural changes implemented since 2016 in addition to other key events happened, such as positive oil price shocks in 1973 and 1979 and the sharp drop in 1986, the high oil prices, and the rapid economic development in 2003-2013, the oil prices decline since 2015. The post-2016 structural reforms include introducing a value-added tax (VAT) for the first time at 5%; reforming domestic energy prices on the onset of 2016, the initial deployment of renewable energy and posing special excises on tobacco and other products in addition to some levies on expats (Blazquez et al., 2021 and Hasanov et al., 2022).

3. Theoretical Framework

We rely on the theoretical framework developed by Esfahani et al., (2014). In this regard, our theoretical foundation is the same as theirs and, hence, the description of the theoretical framework in this paper might be redundant to be included as it is largely a mere exact re-production of sub-section 2.1 of Esfahani et al., (2014) Instead, we prefer to discuss below the reasons why we use this framework and its advantages, as well as the aspects that make our work different from that of Esfahani et al. (2014).

There are at least two reasons that justify why we prefer the theoretical framework of Esfahani et al., (2014) to other growth models. First, this theoretical framework has been specially designed for oil-exporting economies. The standard/textbook economic growth models, regardless of whether exogenous or endogenous growth models, do not account for the stylized facts of the oil-based economies, such as oil income that can play an important positive or negative role in the long-run development. Second, Esfahani et al.,'s (2014) theoretical framework allows to empirically test a number of interesting and policy relevant assumptions/hypotheses using a country data that cannot be tested or extracted from the standard growth models/theories. One of the key concerns for the oil-exporting economies is that oil revenues can lead to the appreciation of the real exchange rate, which leads to issues such as Dutch Disease or other forms of rent seeking. In this framework, we can test whether the negative effect of the real exchange rate appreciation on output can be fully offset by the positive effect of oil income. This is one of the important issues for authorities in their decision making of measures over the long-run development. In this context, if the impact of the nominal oil income can be equal to that of the real exchange rate in terms of magnitude, then this magnitude shows the share of capital in output. This is worth considering feature as it captures the role of capital in the long-run development without explicitly including it in the long-run model. Moreover, it can be tested whether the deterministic part of the domestic economic development follows that of the rest of the world, or it has its own growth pathway in the long run. If the former case holds true, then the domestic economy converges with the rest of the world's pattern. If it is the latter case, then the domestic economy diverges from the rest of the world. Furthermore, the framework allows one to test whether domestic economy is efficient or inefficient in catching up technological progress from the rest of the world in the long run.

It is worth mentioning the following points that make our work different from that of Esfahani et al., (2014) since they also considered Saudi Arabia in their empirical analysis. *(1). Sample span*. Esfahani et al., 2014 sample is 1979 Q1-2009 Q4 and ours is 1970-2020, covering the last more than one decade. Additionally, this decade contains important events, such as oil price declines since 2015, energy price reform in 2016, expat levy implementation in 2017, energy price reform in 2018, the implementation of VAT in 2018, and COVID-19 in 2020. These events in addition to other changes/events happened in the Saudi and the world economy until 1979 are missing in Esfahani et al., (2014). Thus, one can fairly argue that the nature and scale of these events well deserve re-consideration of Esfahani et al.,'s (2014) framework for the Saudi economy. *(2). Different measure of output as the dependent variable*. Esfahani et al., (2014) use GDP while we use private sector value added as a measure of domestic output. The following points justify the measure we suggest: (a) development of the private sector has an utmost importance in the oil-exporting economies as the government/public sector has usually large shares in these economies, and what drives the long-term growth are market fundamentals, and diversification is important in these economies; (b) GDP is the sum of oil and non-oil sectors.

One can argue that using it as a dependent variable and oil income as an explanatory variable can create the endogeneity issue as oil includes in both sides. *(3). Detailed discussion and analysis of the Saudi Arabian data*. It is commonly accepted that discussing and graphically illustrating data is important for the time series analysis. This is even more important when one does integration/cointegration analysis. Therefore, we discuss the Saudi Arabian data in detail, illustrate them graphically, and perform a battery of tests for stability in our research. *(4). Data frequency*. Esfahani et al. (2014) use quarterly data while we use annual data. If we look at the growth literature, it is evident that studies mainly consider less frequency data, such as annual or even 5-year average data (Barro,Mankiw, & Sala-i-Martin (1992). This perfectly makes sense considering that a number of studies have argued that for the long-run analysis, what matters is the span not the frequency of the data considered (see e.g., Hakkio and Rush, 1991; Perron, 1989; Shiller and Perron, 1985).

4. Data description

This study uses annual time series data spanning from 1970 to 2020. The span is dictated by the availability of the data. Table 1 shows the notations, description, and sources of the variables.

We use the natural logarithmic transformation of the variables denoted by lower-case letters in the empirical analysis following the theoretical framework and empirical analysis of Esfahani et al. (2014). Figure 1 illustrates the log levels of the variables and Table 2 records some descriptive statistics of them.

Table 1. The variables used in the analysis.

Variable	Notation	Description	Source
Gross value added in the non-oil private sector	GDPNOP	This is the value added of the goods and services produced by the private part of the non-oil sector. It is measured in real terms of million SAR at constant 2010 prices.	GaStat via SAMA (2021)
Oil income	XO	This is income from the export of oil in million USD. It is calculated as the sum of crude and refined oil exported in million barrels per year multiplied by their respective prices in USD per barrel. The required data on the crude and refined oil exports were retrieved from the Ministry of Energy via SAMA (2021). The export price for Arabian light crude oil is from OPEC via SAMA (2021). The export price for refined oil products is calculated as 20% more than the Arabian light crude oil price since there is no aggregate price for exported refined oil products available. Moreover, 20% typically falls within the average range for profit margin of producers transforming crude oil to refined oil products[5].	Constructed
Foreign output	GDPW	This is world Gross Domestic Product (GDP) measured in the real terms of million USD at constant 2010 prices. The original data were taken from WDI (2021) in USD and re-scaled to millions of USD to match GDPNOP and GREVO.	WDI (2021)
Exchange rate	ER	This is the real bilateral exchange rate of the SAR against the USD. Official (nominal) exchange rates of the SAR per USD were collected from WDI (2021). These values were deflated by the Saudi Consumer Price Index (CPI), 2010=100 to obtain the real values following Esfahani et al. (2014). An increase in the exchange rate indicates a depreciation of the SAR. CPI data, where 2010=100, were retrieved from WDI (2021).	Constructed

Note: GaStat is the General Authority for Statistics of Saudi Arabia, SAMA is the Saudi Central Bank, WDI is the World Development Indicators Database.

[5] For example, we used publicly available data from https://en.macromicro.me/collections/19/mm-oil-price/4376/crude-oil-cracking-spread-vs-wti and considered year end (December) prices, the calculated average ratio of US Crack Spread to NYMEX WTI Crude Oil Futures Price was 21.9% during 2005-2020. The US Crack Spread is the difference between US Refinery Price and NYMEX WTI Crude Oil Futures Price. This ratio is quite close to what we use in this study.

Figure 1. Time profiles of the variables.

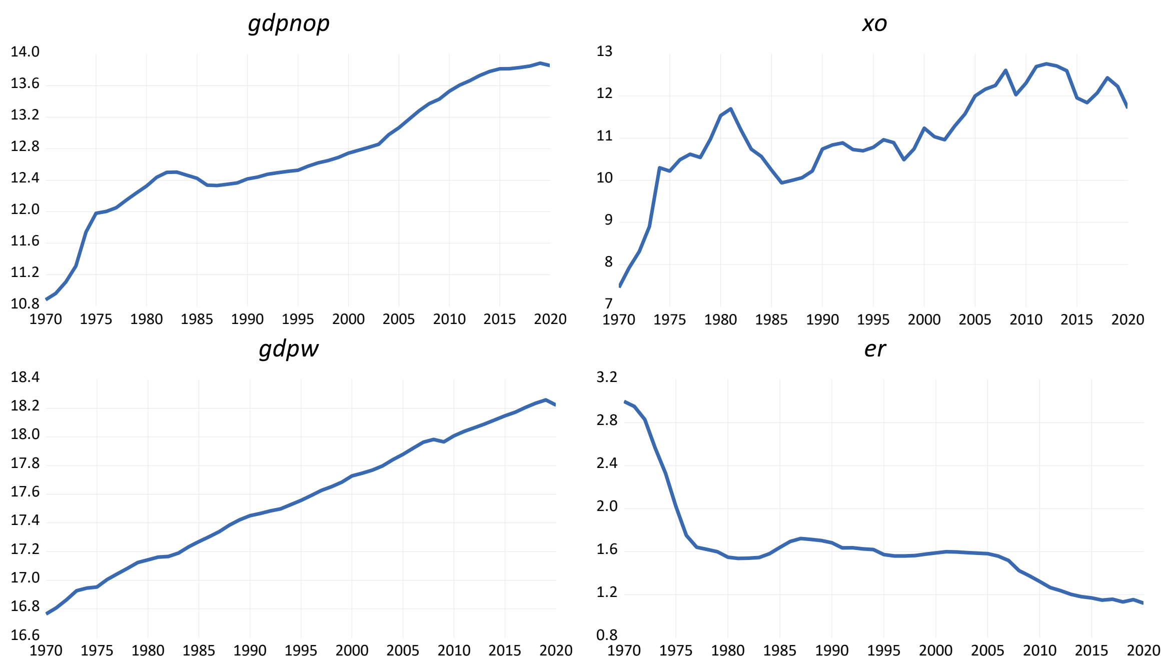


Table 2. Descriptive statistics of the log variables, 1970-2020

	gdpnop	*xo*	*gdpw*	*er*
Mean	12.70	11.02	17.56	1.63
Maximum	13.89	12.76	18.26	3.00
Minimum	10.88	7.45	16.76	1.12
Standard deviation	0.76	1.18	0.44	0.42
Coefficient of variation, %	6.02	10.71	2.50	26.01

Figure 1 illustrates that, overall, private sector output, nominal oil income and foreign output are upward trending while the real exchange rate is trending down, therefore appreciating over time although each variable has the sub periods with ups and downs. Looking at the private sector output and nominal oil revenues, one can observe that large changes in the latter are reflected in the former although it is a private sector indicator. For example, the surge in nominal oil income due to high oil prices until the early 1980s coincides with the similar expansion in the private sector GDP. Also, a relatively table developments between the late 1980s and the early 2000s are common for both variables. Moreover, large increases in the oil income since the early 2000s until the recent oil price drops and decreases hereafter all are reflected in the development path of the private sector output. Similarly, the appreciation reflected in the downtrending in real exchange rate during most of the period can be linked to the appreciation of the US dollar during the same period due the pegged exchange rate regime that SAMA is following. Finally, one can think about an existence of the long- run relationship between the variables based on such kind of co-movements of them.

5. Econometric methods

We use the augmented Dickey-Fuller (ADF; Dickey & Fuller, 1979) and Philips-Perron (PP) unit root tests (Phillips & Perron, 1988) to identify integration/stochastic properties of the variables under consideration in this research. We do not describe these tests as they are widely considered in applied econometric studies. For the cointegration test, we employ Johansen's reduced-rank approach in the vector autoregressive (VAR) / vector equilibrium correction (VEC) modeling framework (Juselius, 2006; Johansen, 1988; Johansen & Juselius, 1990). The Johansen cointegration method is a system-based test meaning that it can reveal out more than one cointegrated relationship, if they exist, unlike residual-based and single equation-based cointegration test methods (Badinger, 2004; Enders, 2015; Ericsson and MacKinnon, 2003; Pesaran et al, 2001). This is another reason why we consider Johansen's cointegration test method. Since the cointegration test and estimation of the long-run coefficients and testing assumptions are at the heart of the empirical analysis of this work, we describe the Johansen method below, although it is well-known.

The complete information on the maximum likelihood of the VEC model of Johansen (1988) and Johansen and Juselius (1990) can be expressed as follows:

$$\Delta z_t = \Pi z_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + c + e_t, \tag{1D1}$$

where z_t is an (n × 1) vector of n endogenous/modeled variables, c is an (n × 1) vector of constants, Γ represents an (n × (k − 1)) matrix of short-run coefficients, e_t denotes an (n × 1) vector of white noise residuals and Π is an (n × n) coefficient matrix. If matrix Π has reduced rank (0 < r < n), it can be split into an (n × r) matrix of loading coefficients α and an (n × r) matrix of cointegrating vectors β. The former indicates the importance of cointegration relationships in the individual equations in the system and of the speed of adjustment to equilibrium. The latter represents the long-term equilibrium relationship, so that $\Pi = \alpha\beta'$.

Johansen's reduced rank regression approach of testing for cointegration estimates matrix Π in its unrestricted form first. Then it tests whether the restriction implied by the reduced rank of Π can be rejected. In particular, the number of independent cointegrating vectors depends on the rank of Π, which is in turn determined by the number of its characteristic roots that are different from zero. The max-eigenvalue and trace test statistics are used to test for nonzero characteristic roots.

Note that multivariate stationarity and weak exogeneity tests are usually conducted under the Johansen framework using an estimated VEC model (Johansen, 1992a, b). The multivariate stationarity or trend stationarity of the *X* variable can be expressed with the null hypothesis that its long-run coefficient, β_X, is unity while the long-run coefficients of other explanatory variables are zero. If the null hypothesis cannot be rejected, then variable *X* is (trend) stationary. The rejection of the null hypothesis indicates that *X* is a unit root process. The weak exogeneity of a given *X* variable implies that the null hypothesis, that α_X is zero, cannot be rejected. This weak exogeneity indicates that the disequilibrium of the long-run relationship does not feed back onto the equation of variable *X*. If the null hypothesis of α_X being zero can be rejected, *X* is not a weakly exogenous variable, meaning that the disequilibrium of the long-run relationship feeds back onto its equation.

5.1. Small sample bias correction in the Johansen method

To reach a robust conclusion regarding the number of cointegrated relationships, we adjust the sample values of the max-eigenvalue and trace test statistics of the Johansen test using the approach suggested by Reinsel and Ahn (1992). Johansen (2002) points out that, for small samples, the max-eigenvalue or trace test statistics can be biased to reject the null hypothesis of no cointegration. Regarding this issue, Reinsel and Ahn (1992) suggest a $\frac{T-kn}{T}$ correction to these test statistics, where *k* is the lag length of the underlying VAR model, by level, and *n* and *T* are the number of endogenous variables and observations, respectively.

6. Results of the econometric analysis

6.1. Unit root test results

The ADF and PP tests are performed, and the results are documented in Table 3.

Both the ADF and PP tests results clearly fail to reject the null hypothesis of unit root for *gdpnop*, *gdpw* and *xo* as the sample values of the tests are smaller than the critical values at the conventional significance levels. They can reject the null for the first difference of these variables in addition to *er* at the 1% significance level. Although both tests suggest that *er* is a trend stationary process at the 5% significance level, we are not sure about this conclusion because of the following reasons: (i) graphical illustration of *er* in Figure 1 does not depict anything like a deterministic trend as the variable time trajectory drifting over time with quite an uneven pattern; (ii) the coefficient on the autoregressive lagged level dependent variable is estimated to be -0.15 and -0.26, respectively from the ADF and PP tests equations meaning that the autoregressive coefficients are 0.85 and 0.74, respectively - being closer to unity and zero; (iii) we ran the Kwiatkowski-Phillips-Schmidt-Shin (1992) unit root test and it rejects the null hypothesis of trend stationarity at the 5% significance level. Overall, we concluded that *gdpnop*, *gdpw*, *grevo* and *er* are the unit root process and their first differences are stationary. Put differently, the variables are integrated in order one, that is, they are I(1) processes.

Table 3: Unit root test results.

Variable	**The ADF test**			**The PP test**	
	Test value	***DC***	**k**	**Test value**	***DC***
gdpnop	-2.01	t	3	-0.72	C
gdpw	-2.23	t	1	-1.57	C
xo	-1.45	C	0	-1.57	C
er	-4.62**	t	1	-4.12**	t
Δgdpnop	-7.09***	C	0	-6.50***	C
Δgdpw	-4.05***	C	0	-3.67***	C
Δxo	-6.75***	N	0	-6.82***	N
Δer	-3.37***	N	0	-3.95***	N

Notes: ADF and PP denote the augmented Dickey-Fuller and Phillips-Perron tests, respectively. The maximum lag order is set to three suggested by the time-dependency rule of $4*(T/100)^{(2/9)}$ developed by Newey and West (1994) and used and recommended by Westerlund (2005), Westerlund and Edgerton (2005) among many others (Also, the consideration of three lags is justified by the significance of the third lag in the test equation of the variables, e.g., non-oil private GDP). T=51. The optimal lag order (k) is selected based on the Schwarz criterion in the tests. ***, ** and * indicate rejection of the null hypothesis of a unit root at the 1%, 5% and 10% significance levels, respectively. The critical values for the tests are taken from MacKinnon (1996). *DC* means deterministic components. "N" means that neither the intercept nor trend is included in the test equation. The final UR test equation can include one of the following three: intercept (*C*), intercept and trend (*t*) and none (*N*) based on the statistical significance. Estimation period: 1975–2020.

6.2. The results of the long-run analysis

First, we specify a vector autoregressive (VAR) model of the endogenous variables, that is, *gdpnop, gdpw, xo* and *er* with a maximum lag order of five[6] and include intercept and linear time trend as exogenous variables following the Johansen method (see Johansen, 1988; Johansen & Juselius, 1990; Juselius, 2006 inter alia).[7] Both the lag exclusion test and information criteria of Likelihood ratio, Schwarz and Hannan-Quinn suggest the optimal lag order of three. Moreover, the residuals of the VAR with three lags do not have any issue with the serial correlation, non-normal distribution and heteroskedasticity of the residuals as Panels A-B of Table 4 present. Also, the specified VAR model and the relationships for the log level of the variables are stable as documented in Panel D of Table 4.

[6] For the VAR/VEC estimations and testing, we follow the same sample period of the unit root testing (Otherwise, it is not consistent to use different periods for unit root test and the remaining tests and estimations, such as cointegration test, long run estimations). Starting VAR model estimations in 1975 allows us to set the maximum lag order to five.

[7] The inclusion of linear time trend is justified by its statistical significance in the VAR model as well as in the ADF and PP tests equations.

Table 4: VAR residual diagnostics and cointegration test results.

Panel A: Serial Correlation LM Test [a]

Lags	LM-Statistic	d.f.	P-value
1	21.77	16	0.15
2	18.41	16	0.30
3	10.90	16	0.82

Panel E: Johansen Cointegration Test Summary

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type:	(a) No ***C*** and ***t***	(b) Only **C**	(c) Only **C**	(d) **C** and **t**	(e) **C** and **t**
Trace:	2	2	1	2	2
Max-Eig:	2	1	1	2	2

Panel B: Normality Test [b]

Statistic	χ^2	d.f.	P-value
Skewness	0.27	1	0.60
Kurtosis	0.78	1	0.38
Jarque-Bera	1.05	2	0.59

Panel F: Johansen Cointegration Test Results for Type (c)

Null hypothesis:	*r=0*	*r≤1*	*r≤2*	*r≤3*
λ_{trace}	95.35***	50.29***	20.78	4.95
λ^{a}_{trace}	70.48**	37.17	15.36	3.66
λ_{max}	45.06***	29.50**	15.84	4.95
λ^{a}_{max}	33.31**	21.81	11.71	3.66

Panel C: Heteroscedasticity Test [c]

White	χ^2	d.f.	P-value
Statistic	245.98	260	0.72

Panel D: VAR Stability Test

Root	Modulus
0.926738 - 0.200334i	0.948144
0.926738 + 0.200334i	0.948144
0.715530 - 0.353574i	0.798121
0.715530 + 0.353574i	0.798121

Notes: [a] The null hypothesis in the serial correlation LM test is that there is no serial correlation at lag order *h* of the residuals; [b] the Lutkepohl system normality test results with the null hypothesis of the residuals are multivariate normal; [c] the White heteroskedasticity test takes the null hypothesis of no cross-terms heteroskedasticity in the residuals; χ^2 is Chi-squared; d.f. means degrees of freedom; and ***C*** and ***t*** indicate intercept and trend. *R* is the rank of the Π matrix, that is, the number of cointegrated equations. λ_{trace} and λ_{max} are the trace and max-eigenvalue statistics, while λ^{a}_{trace} and λ^{a}_{max} are their adjusted versions, respectively. *** and ** denote rejection of the null hypothesis at the 1% and 5% significance levels. The critical values for the cointegration test are taken from MacKinnon et al. (1999). Estimation period: 1975–2020.

The cointegration test results across different options of inclusion of intercept and trend are reported in Panel E of Table 4. We should focus on option (c), where both intercept and linear time trend are included in the test equation, following Esfahani et al. (2014) although we report all the cointegration test options in the table for information purposes. In option (c), both the unadjusted Trace and Max-Eigenvalue statistics of the Johansen cointegration test suggest not more than two cointegrated relationships among the variables at the 1% and 5% significance levels, respectively. This result is exactly what Esfahani et al. (2014) found for Saudi Arabia. After the degree of freedom adjustments, both the Trace and Max-Eigenvalue statistics indicate not more than one cointegration at the 5% significance level.

Once the cointegration is statistically confirmed among the variables, the level relationship among the variables is not spurious and thus, we can estimate the long-run coefficients (β) and speed of adjustment (α) coefficients. Following Esfahani et al. (2014), we restricted the coefficient of the linear time trend to zero and saw whether this theoretical hypothesis is supported by the Saudi data. This is called co-trending restriction. The hypothesis holds as the sample value χ^2 statistic is 0.10 with a probability of 0.76 (see Panel A of Table 5).

The estimated long-run coefficients are statistically significant as they are greater than their respective standard errors, in parentheses, more than twice as Panel A of Table 5 reports. In addition, the speed of adjustment coefficient for the short-run equation of *gdpnop* is expectedly negative and statistically significant at the high level indicating that the long-run relationship of the variable is stable and long-run causality runs from *xo*, *gdpw*, and *er* to *gdpnop*. This stability, found here from the VEC model reflecting short-term relationships, confirms the stability found from the VAR model representing long-term or level relationships in Panel D of Table 4. We perform further analysis of stability as it is important for the relationship under consideration. We place this analysis in the Appendix to avoid making this section too long. The results of the analysis show the stability of the estimated long-run relationship in Table 5, which further supports the finding of the stability from the VAR and VEC models.

Table 5: Long-run estimation and test results

Panel A: Testing co-trending restriction on the long-run equation:

$$\widehat{gdpnop} = \beta_0 + \beta_{xo}xo + \beta_{gdpw}gdpw + \beta_{er}er + \beta_{TREND}TREND$$

$$\beta_{TREND} = 0$$

χ^2 (1) = 0.10 [0.76]

$$\boldsymbol{\widehat{gdpnop} = -2.13 + \underset{(0.06)}{0.36xo} + \underset{(0.09)}{0.67gdpw} - \underset{(0.23)}{0.58er}}, \qquad \alpha_{gdpnop} = -0.13\ (0.04)$$

Panel B: Multivariate statistics for testing stationarity [b]

Variable:	*gdpnop*	*xo*	*gdpw*	*er*

Null hypothesis:	$\beta_{gdpnop} = 1,$ $\beta_{xo} = 0,$ $\beta_{gdpw} = 0,$ $\beta_{er} = 0$	$\beta_{gdpnop} = 0,$ $\beta_{xo} = 1,$ $\beta_{gdpw} = 0,$ $\beta_{er} = 0$	$\beta_{gdpnop} = 0,$ $\beta_{xo} = 0,$ $\beta_{gdpw} = 1,$ $\beta_{er} = 0$	$\beta_{gdpnop} = 0,$ $\beta_{xo} = 0,$ $\beta_{gdpw} = 0,$ $\beta_{er} = 1$
χ^2 (4)	37.04 [0.00]***	22.46 [0.00]***	17.49 [0.00]***	30.67 [0.00]***
Panel C: Weak exogeneity test results [c]				
Variable:	*gdpnop*	*xo*	*gdpw*	*er*
Null hypothesis:	$\alpha_{gdpnop} = 0$	$\alpha_{xo} = 0$	$\alpha_{gdpw} = 0$	$\alpha_{er} = 0$
χ^2 (1)	11.08 [0.00]***	0.82 [0.66]	2.03 [0.36]	9.62 [0.01]***

Panel D: Testing co-trending and theory restrictions assuming weak exogeneity of *xo* and *gdpw*

$$\beta_{\text{TREND}} = 0; \beta_{xo} = \beta_{er} = \alpha; \alpha_{xo} = 0;\ \alpha_{gdpw} = 0$$

χ^2 (4) = 8.79 [0.07]*

$$\widehat{\boldsymbol{gdpnop}} = -\mathbf{8.93} + \underset{(\mathbf{0.08})}{\mathbf{0.67}\boldsymbol{xo}} + \underset{(\mathbf{0.14})}{\mathbf{0.74}\boldsymbol{gdpw}} + \underset{(\mathbf{0.08})}{\mathbf{0.67}\boldsymbol{er}}, \qquad \alpha_{gdpnop} = -0.11\ (0.02)$$

Implied $\hat{\theta} = \frac{\widehat{\beta_{gdpw}}}{1-\widehat{\beta_{er}}} = \frac{0.74}{1-0.67} = 2.24$

Panel E: Testing $\hat{\theta} = 1$, i.e., technological progress in Saudi Arabia is on a par with that of the rest of the world, assuming co-trending, theory restrictions and weak exogeneity of *xo* and *gdpw* all hold.

$$\beta_{xo} + \beta_{er} = 1; \beta_{\text{TREND}} = 0; \beta_{xo} = \beta_{er} = \alpha; \alpha_{xo} = 0;\ \alpha_{gdpw} = 0$$

χ^2 (5) = 27.29 [0.00]***

Additionally, we conduct two tests: a stationarity test in the multivariate framework and a weak exogeneity test. The results of the multivariate statistics for testing stationarity suggest that the null hypothesis of trend stationarity of gdpnop, xo, gdpw and er is rejected in favor of unit root processes all at the 1% significance level (see Panel B of Table 5). It is noteworthy that the finding that er is a unit root process and not a trend-stationary process here reaffirms the earlier finding of the non-trend stationarity of er utilizing the Kwiatkowski-Phillips-Schmidt-Shin (1992) unit root test.

The results recorded in Panel C show that the null hypothesis of weak exogeneity cannot be rejected for *xo* and *gdpw,* but it can be rejected for *gdpnop* and *er*. It is noteworthy that Esfahani et al. (2014) claim that the real exchange rate should be endogenous to the long-run relationship in the theoretical framework they develop (this is what we have followed in this paper).

We jointly test the co-trending restriction and theory restrictions suggested by Esfahani et al. (2014) in the case of weak exogeneity of *gdpnop* and *xo*. The theory restriction assumes that the coefficient of the real exchange rate, β_{er}, and the coefficient of nominal oil income, β_{xo}, are the same and equal to the share of capital in output, α, as described in the theory section. The restrictions cannot be rejected at the 1% and 5% significance levels as the sample value of the χ^2 statistic is 8.79 with a probability of 0.07 (while the critical values in the case of four degrees of freedom are 13.28, 9.49, and 7.78 at the 1%, 5%, and 10% significance levels, respectively). It is worth noting that Esfahani et al. (2014) also could not reject these restrictions at the 1% and 5% significance levels but rejected them at the 10% significance level. The long-run relationship normalized for *gdpnop* being corresponding to these restrictions is expressed in Panel D of Table 5. Apparently, all the long-run coefficients and speed of adjustment coefficient are highly statistically significant. Panel D also reports that the calculated implied $\hat{\theta}$ is equal to 2.24, being higher than unity.

Lastly, we test another interesting theoretical assumption, namely whether technological progress in Saudi Arabia is at par with that of the rest of the world assuming co-trending, theory restrictions and weak exogeneity of *xo* and *gdpw* hold. The test results documented in Panel E of Table 5 show that the null hypothesis is rejected at conventional significance levels, reveling that technological progress in Saudi Arabia is at par with the rest of the world.

7. Discussion of the findings

The results of the integration analysis revealed out that the variables under consideration are stochastically drifting and their mean and variance change over time. Non-stationarity also means that any shocks to these variables can create permanent changes. The cointegration test results in Panel F of Table 4 show that the Saudi domestic output exhibits a long-run relationship with oil income, foreign output and the real exchange rate as they all share a common stochastic trend. This means that Saudi non-oil private GDP moves together with the selected variables in the long run although it can temporarily deviate from the established long-run equilibrium path due to the shocks causing perturbation. Put differently, long-run developments of the Saudi non-oil private GDP is determined by oil income, real exchange rate and foreign GDP as the theory developed by Esfahani et al. (2014) articulates. Short-run dynamics will make non-oil private GDP hover around this established long-run equilibrium path and shocks will cause temporary deviation of the Saudi non-oil private GDP from its long-run equilibrium trajectory (that is, it will come back to this trajectory). As a result, the long-run relationship that the Saudi non-oil private GDP establishes with oil income, the real exchange rate and foreign output is stable – this is confirmed by the stability test reformed on the VAR model (see Panel D of Table 4), the estimated speed of adjustment coefficients in the VEC framework (see Panels A and D of Table 5), and additional stability checks conducted in the Appendix. The finding of stability is consistent with the results of other recent studies examining Saudi Arabian output (e.g., see Hasanov et al., 2022 for the case of non-oil production).

Some useful interpretations can be extracted from the results documented in Table 5. First, it shows that the co-trending assumption holds. This means that linear trends in the non-oil private GDP cancel out with the linear trend in the explanatory variables, that is, oil income, the real exchange rate and foreign GDP. Since the co-trending assumption is supported by the data, it can be concluded that the Saudi non-oil private GDP converges with the foreign GDP in the long run. It is important to note that converging or diverging of variables is different from whether they are cointegrated or not. For example, Esfahani et al. (2014) found for the case of Iran that the variables in the domestic output equation are cointegrated, but domestic and foreign outputs do not converge.

Second, the Saudi data support the assumption that the coefficients of the oil income and the real exchange rate can be the same and equal to the capital share in the non-oil private GDP in the long run. In other words, oil income and the real exchange rate can have the same magnitude effect on the non-oil private GDP in the long run, which is 0.67. Put differently, holding other factors constant, a 1% increase (decrease) in oil revenues and a 1% depreciation (appreciation) of the SAR against USD in real terms will raise (decrease) non-oil private GDP by 0.67%. Moreover, the estimated magnitude of 0.67 is interpreted as the share of capital in the non-oil private GDP. Esfahani et al. (2014) estimated this magnitude to be 0.15 for Saudi Arabia using GDP as a measure of domestic output for the quarterly period 1979Q2–2009Q4. Comparing our estimates for the Saudi non-oil private GDP with those of existing studies would provide further insights. However, a few studies have investigated non-oil private GDP and not all of them considered exact oil income/revenues for Saudi Arabia. Al-Moneef and Hasanov (2020) assessed real non-oil private sector GDP multipliers of government capital and current expenditures to be 0.47 and 0.32, respectively, in the long run for the annual period 1983 – 2018. Al-Rasasi et al., (2019) estimated the government oil revenues elasticity of the non-oil private GDP to be 0.65 in the annual period spanning from 1970 to 2017. Eid (2015) estimated the coefficient of the share of government capital expenditure in GDP in the real non-oil private GDP per capita equation to be 0.44 using the annual data spanning between 1969 and 2014. Potential reasons that explain our estimate are close to those of the recent studies mentioned earlier, not Esfahani et al., (2014) would be domestic output measures, sample periods and data frequencies used in these studies. Moreover, considering capital share in output to be just 15% can be seen quite low for an oil-exporting economy, where usually the oil sector is dominant, and the sector is capital intensive.

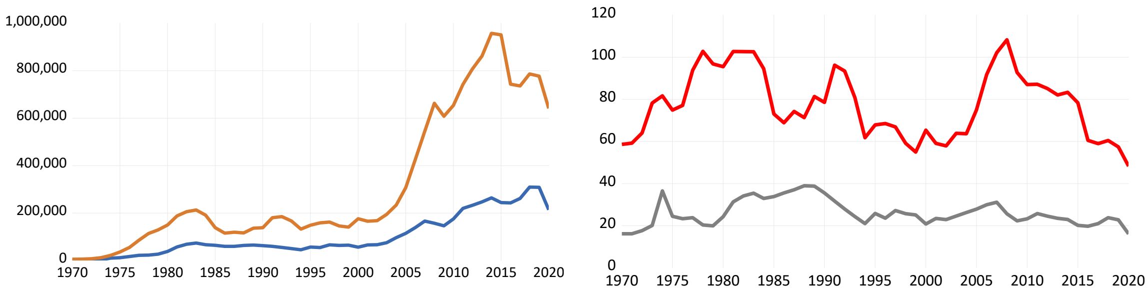
Third, comparing the impact of the real exchange rate on non-oil private GDP in the case of co-trending to the case where equal coefficients of the real exchange rate and oil income are assumed in addition to co-trending is worth considering (see Panels A and D of Table 5). Put differently, the effect is negative in the first case whereas it is positive in the second case, both are statistically significant (consider the coefficients and their standard errors in the parentheses). Theoretically, a depreciation of the domestic currency can exert positive and negative effects on the domestic output. It can boost exports since it is cheaper for foreigners to buy from that country. Resultantly, expanding exports can create positive effects on the domestic output according to the Export-Led growth theory.[8] Also, such depreciation can decrease output as imports will be more costly. Thus, the net effect can be positive if the positive effect of exports expansion overbalances the negative effect of increase in import cost and it is negative otherwise. The net effect also depends on levels of export and import- it is positive if the export level is higher than the import level and negative otherwise. Turning back to the Saudi case, the impact of the depreciation is found to be negative if no restriction is imposed on the real exchange rate (that is, its impact on the non-oil private GDP

[8] It may happen through two channels: direct production effect (i.e., to expand exports, more goods and services should be produced first) and indirect demand effect (i.e., growing exports revenues will be spent in the domestic economy entirely or partly, which will create demand for domestic goods and services to be produced).

must be equal to that of oil income). In other words, in the unrestricted case, where we allow the real exchange rate 'to speak freely', its impact is negative. This estimated negative impact of the depreciation can be justified by simply looking at the evolvements of imports and non-oil exports of Saudi Arabia over time according to the theoretical explanation provided above.[9] Figure 2 illustrates this outlook.

Figure 2: Saudi imports and non-oil exports and their shares in non-oil private GDP

Graph A. Imports and non-oil exports **Graph B.** Shares of imports and non-oil exports



Notes:
Orange and blue lines represent imports and non-oil exports, respectively, both measured in SAR Millions. Red and gray lines represent the percentage shares of imports and non-oil exports in non-oil private GDP in SAR millions, respectively.

The data on imports, exports of services and non-oil goods, and non-oil private GDP all in the nominal values of SAR millions are from GaStat via SAMA (2021).[10] Evidently, from Graph A, imports are quite higher than non-oil exports and the difference between the two tremendously grew since 2005. Statistically, the average values of imports and non-oil exports were SAR 308.6 billion and SAR 100.09 billion, respectively during 1970-2020, the former one being more than three times higher than the latter one. Additionally, Graph B illustrates that the percentage share of imports in

[9] We consider total imports but non-oil exports (which is the sum of exports of services and non-oil goods). This is because if SAR depreciates, then total imports (regardless of they are oil or non-oil related) become expensive, but only non-oil exports can expand given that oil exports are determined by the price of oil in the global energy markets and indirectly by the OPEC+ production agreements.

[10] We collected data on exports of non-oil goods for years 2005-2020 from the Foreign Trade Statistics section. The rest data on this variable as well as on imports and exports of services are from the Balance of Payments Statistics section of SAMA (2021). Non-oil exports in Figure 2 are the sum of exports of services and non-oil goods. We also considered the variables in real terms. Since such data in real terms are not entirely available to us from the public sources, we used relevant deflators (such as export deflator and import deflator). The overall picture from the real values is the same as that from the nominal values discussed above.

non-oil private GDP is considerably greater than that of non-oil exports with the period average values of 77% and 26%, respectively. These pieces of data evidence profoundly support the econometric findings of the negative real non-oil private GDP impact of the SAR depreciation. It turns out that the real exchange rate as a measure of competitiveness is important in the development of the Saudi non-oil private sector. This is because the non-oil exports share in total export is very small and the imports share in non-oil private GDP is very large.

When the restriction of equal coefficients for the real exchange rate and oil income is imposed on the output equation, then the impact of the former becomes positive (and statistically significant). Our interpretation of this finding is as follows. Statistically, the said restriction comes from the theoretical framework developed by Esfahani et al. (2014) imposing the real exchange rate to have the same magnitude impact as oil income does. Economically, this implies that if the Saudi non-oil private real GDP is expected to develop in line with the steady-state conditions of the framework, which is designed for the oil-exporting economies, then the real exchange rate of the SAR must support the non-oil private sector when it depreciates or is devaluated by the policies. This further implies that oil income alone would not be sufficient to support the developments of the non-oil private sector and the real exchange rate depreciation should exert the positive influence. Precisely, the said restriction implies that the positive impact of oil revenues should not exceed the negative effect of the appreciation of the real exchange rate given that it is commonly accepted that oil income causes an appreciation of the domestic currency in the oil-exporting developing countries, which in turn undermines the competitiveness of the non-oil sector and resultantly deters the non-oil output. In other words, this restriction implies that the positive impact of oil income should be exactly offset by the negative impact of the currency appreciation that it causes (or the other way around) so, the domestic output will be driven by the foreign output (another explanatory variable in the equation) in the long run. The Saudi data suggest that keeping other factors constant, a 1% increase in the foreign output leads to a 0.74% expansion in the non-oil private real GDP in the long run. If the real exchange rate does not have the same impact size as oil income or if its impact is statistically insignificant, it is difficult to believe that the real exchange rate supports the development of the non-oil private sector. In this case, the growth policies should not consider the model proposed by Esfahani et al. (2014) for the development of the non-oil private sector in Saudi Arabia. Moreover, Saudi policymakers should not consider exchange rate depreciation as one of the measures for economic diversification.

Lastly, the finding that technological progress in Saudi Arabia is not at par with that of the rest of the world is worth discussing. Economically, having the theta parameter not equal to the unity means that foreign output and the real exchange rate together cannot exert a unit magnitude impact on the domestic output in the long run. Put differently, the Saudi private sector cannot establish a one-to-one relationship with the rest of the world (represented by the combination of foreign output and real exchange rate). This is also evident from the implied value of the theta parameter calculated to be 2.24. Since the calculated value is greater than unity and the unit restriction is not statistically significantly supported by the data, we can interpret that the Saudi private sector is efficient in receiving technological developments from the rest of the world. We also tested whether the theta parameter can be lower than unity, and this restriction is rejected by the data, meaning that there is no inefficiency in following advanced technologies from abroad. This also can be interpreted that rent seeking or other resource curse issues (such as

Dutch Disease) are not the case for the Saudi private sector. This interpretation was also confirmed by previous studies. For example, recently, Hasanov et al. (2022) found that Dutch Disease does not exist in the Saudi economy, at least partially (that is, for the exports of non-oil goods).

8. Conclusion

Oil and its revenues have played a very important role in the development of Saudi Arabia. In addition, the private sector and its development are placed at the heart of Saudi Vision 2030 for the future sustainable development of the Kingdom. In this research, we brought together these two very important variables using the theoretical framework designed by Esfahani et al. (2014) for oil-exporting economies. We analyzed the annual data of the last half-century (1970-2020) using integration-cointegration methods. The key finding of the study is that oil income is one of the determinants of the private sector development in the long run. The immediate implication of this finding is that the oil sector and its income are a blessing, not a curse for Saudi Arabia. The other findings of the econometric analysis also have policy implications as discussed below. The data showed that the Saudi private output converges with the foreign output in the long run. One of the implications of this finding is that the Saudi economy, including its private sector, was open to various streams of globalization, such as the international flow of capital and labor. Policymakers should take measures to increase such cooperation with the rest of the world. The data support the assumption that nominal oil revenues and the real exchange rate have the same effect on the Saudi private output in terms of their magnitudes. The implication for the policymaking is that the negative effect of the real exchange rate appreciation on the private sector can be completely offset by the positive influence of nominal oil revenues in the long run. In such a setup, the private sector development will be driven by the foreign output growth. Moreover, our analysis shows that there is no inefficiency for the Saudi private sector regarding following/imitating technological progress originated from the rest of the world. This finding firstly implies that development levels of institutions, infrastructure, business environment, efficiency of governance, and stances of the fiscal and monetary policies among other various factors have been favorable for the private sector in catching up and adopting technologies from the rest of the world. It also might imply that the Saudi private sector was successful in absorbing foreign direct investment in particular. Lastly, one of the insightful data-driven findings was that the depreciation of the real exchange rate was harmful to the private sector output, but it can be useful to the sector if the long-run economic development setup/framework is followed by policymaking. In contrast, the ratio of imports to the private sector output was quite large.

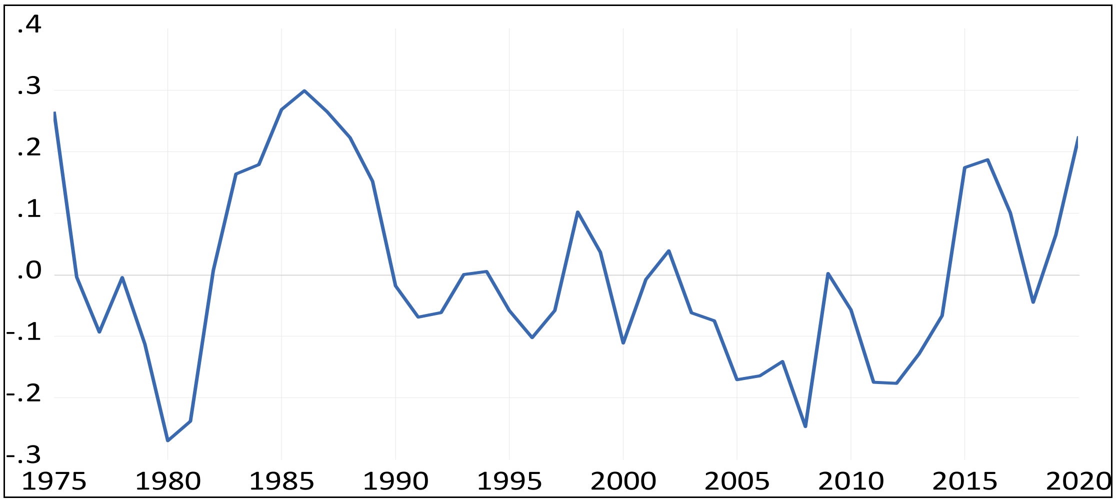
This paper can be extended in different directions in future research. First, it can be applied to other oil-exporting economies similar to Saudi Arabia using the recent data. Second, one might think about making extensions or modifications to the theoretical framework developed by Esfahani et al. (2014) to accommodate other determinants of economic growth, such as the level of institutions, and governance efficiency. Third, foreign variables can be decomposed into their components to conduct a detailed analysis regarding the extent of different foreign shocks on the private sector output. Likewise, the domestic private output can be decomposed into economic activity sectors' output to reveal out impacts of oil income and foreign changes on those sectors to produce sector-specific policy insights.

Appendix. Further tests for the stability of the long-run relationship

One might think that events such as fiscal and domestic energy price reforms and international oil price declines we mentioned earlier could lead to structural breaks and thus instability in the long-run relationship that private sector output establishes with oil income, the real exchange rate and foreign output. However, the results from the VAR (Panel D of Table 4) and VEC (Panel A and D of Table 5) models indicate that this relationship is stable over time. In this section, we perform further checks for the stability of the long-run relationship. We use deviations from the long-run relationship between private sector output and its determinants to draw inferences about the characteristics/nature of this relationship (see Castel et al., 2022; Juselius, 1992, 2006; Ogaki and Park, 1998; Chapman and Ogaki, 1993 inter alia for this type of analysis). The idea is as follows. Suppose that there are structural breaks (e.g., a level shift or a change in the slope of the development trend or both) in private sector output and/or in the effects of its determinants caused by, among other things, the major events mentioned above. Let us further assume that these breaks are not captured by researchers using deterministic components, such as trend, dummy variables (e.g., see Clements and Hendry, 1999; Hendry and Mizon, 1998) and that they also do not lead to co-breaking (e.g., see Hendry and Massmann, 2007 for a survey of co-breaking; Castel et al., 2022;). Such breaks are then reflected in the linear combination of variables, i.e., the residuals of the long run relationship, which represent deviations from that relationship. As a result, the deviations/disequilibrium from the long run relationship exhibit trending or stochastic drift/unit root behavior over the period under consideration, which indicates that the long run relationship is subject to structural break(s). We apply a battery of tests here to check this.

Figure A2.1 illustrates the calculated disequilibrium series from the long run relationship, that is, the residuals of the equation for private sector output reported in Panel A of Table 5.

Figure A2.1. Disequilibrium of the long run relationship of the private sector output.



It can be seen from the figure that the disequilibrium series has no level shift, trend or stochastic drift, giving the impression of a stationary process. As a statistical check, we regress the series on the intercept and various types of trends to examine whether there is a level shift and/or any kind of trending pattern, e.g., linear, quadratic, cubic or quartic.[11] Table A2.1 reports the regression results:

Table A2.1: Results for the disequilibrium series regressed on intercept and trend components.

Regressor	**Coefficient**	**Standard Error**	**Probability**
Intercept	-0.057857	0.559530	0.9181
trend	0.001447	0.110524	0.9896
$trend^2$	0.001329	0.006720	0.8441
$trend^3$	-7.36E-05	0.000161	0.6502
$trend^4$	9.63E-07	1.33E-06	0.4742
R^2	0.270766	Standard error of regression	0.133445
Adjusted R^2	0.199621	Sum squared resid	0.730115
F-statistic	3.805843	Probability of F-statistic	0.010117

[11] We follow Park's (1992) added variable test and include four polynomials of the deterministic trend in the regression equation.

Notes: The dependent variable is the disequilibrium series. Method: Least Squares using HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000). Sample: 1975 2020

It can be seen from the table that the effects of the intercept and the trend components on the disequilibrium series are statistically highly insignificant. This shows that the series has a zero-mean and does not exhibit any trending behavior. As a further test, we exclude the trend components from the regression equation to see if the disequilibrium series still exhibits a statistically significant zero-mean pattern. The results are reported in Table A2.2.

Table A2.2. Results for the disequilibrium series regressed on intercept.

Regressor	Coefficient	Standard Error	Probability
Intercept	0.000938	0.034126	0.9782

R^2	0.000000	Standard error of regression	0.149161
Adjusted R^2	0.000000	Sum squared resid	1.001207

Notes: The dependent variable is the disequilibrium series. Method: Least Squares using HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000). Sample: 1975 2020.

The table shows that the intercept term is highly statistically insignificant, which means that the series has zero-mean behavior even without the trend components.

Thus, one can have a very weak to no belief that the disequilibrium series could have structural break(s) as it has neither a non-zero mean nor a trending pattern. As a further test of it, we perform the multiple breakpoint test developed by Bai-Perron (1998, 2003, 2006). The advantages of this test are that it can detect up to five structural breaks and treats them endogenously. Table A2.3 reports the results of the test.

Table A2.3: The results of the multiple breakpoint test

Break Test	F-statistic	Scaled F-statistic	Critical Value
0 versus 1 break	1.67	1.67	9.63

Sequential F-statistic determined breaks: 0

Notes: Break test options: Trimming 0.05. Maximum breaks: 5. Significance level: 5%. Breaking variables: Intercept. Test type: L+1 versus L sequentially determined breaks. Test statistics employ HAC covariances (Bartlett kernel, Newey-West fixed bandwidth), assuming common data distribution. Sample: 1975 2020

The table shows that there is not even a single break in the disequilibrium series, as the scaled F-statistic is largely smaller than the critical value of the Bai-Perron (2003) F-statistic, which means that the null hypothesis of zero breaks or one break cannot be rejected.

Lastly, we consider the discussions in Enders and Lee (2012a, b) among other things, which point out that events can cause multiple breaks in a given series, leading to nonlinearity, so that the application of the tests assuming a certain number of structural breaks might not be efficient. To this end, we applied the ADF unit root test extended with the Fourier approximation to capture nonlinearities in the series caused by multiple breaks developed by Enders and Lee (2012a, b). For the empirical application of the test, we follow Enders and Lee (2012b): (i) We estimate the Fourier ADF unit root test equation for the disequilibrium series without intercept and linear trend, as both become statistically insignificant and are thus excluded. (ii) We include three lags of the dependent variable, i.e., the first difference of the disequilibrium series, in the test equation, but it turns out that only one lag is sufficient to remove autocorrelation/serial correlation from the residuals of the equation. (iii) Finally, we estimate the test equation with the frequency of the trigonometric functions of sine and cosine, *f* ranging from one to five. It is found that the test equation with *f=1* has the smallest sum of squared residuals among the five equations, and we test whether the sine and cosine in this equation are jointly statistically significant. The sample value of the F-statistic from the Wald test gets 2.19, which is even well below the critical value of 6.35 at the 10% significance level from Enders and Lee (2012b), indicating that the trigonometric pair should be excluded from the test equation and the standard ADF test equation should be used for the test. The statistical insignificance of the trigonometric pair indicates that the disequilibrium series does not exhibit nonlinearity, which, in turn, means that there is no statistically significant evidence of structural breaks in the series. Applying the standard ADF test equation (i.e., without intercept and trend and one lag of the dependent variable) yields a t-statistic value of -2.95 with the probability of 0.0053. This value is even larger than the critical value at the 1% significance level from MacKinnon (1996), which means that the null hypothesis of a unit root process can be rejected in favor of a stationary process for the disequilibrium series, confirming our observation from Figure A2.1 about the stationarity of the series.

Thus, the graphical representation and the number of tests used indicate the stationarity of the disequilibrium from the long run relationship of the private sector output. This means that the disequilibrium series, and consequently the long run relationship, is not subject to structural breaks. Looking at the recent studies for Saudi Arabia, the same conclusion was reached by Hasanov et al. (2022) in their analysis of non-oil output. The finding that the long-run relationship is stable does not necessarily mean that major events have not caused structural breaks in private sector output and the explanatory variables. Figure 1 clearly shows the breaks in the variables. However, these structural breaks in the variables have not caused instability in the long-run relationship. This is because both private sector output and its determinants exhibit co-breaking (again, see Figure 1), i.e., the same events are reflected in both the dependent and explanatory variable(s) and therefore cancel each other out, so that their linear combination does not show the effects of these events. For example, Figure 1 shows that private sector output rose sharply from the mid-1970s to the mid-1980s. During the same period, oil revenues rose sharply, and the exchange rate appreciated considerably. Moreover, both private sector output (i.e., the dependent variable) and oil income (i.e., the explanatory variable) experienced an upward break in their development trend after 2003, and their development trend has flattened since 2015. Furthermore, COVID-19 caused a significant decline in both the dependent and explanatory variables in 2020.

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