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Estimating the Impact of the COVID-19 Pandemic on Saudi GDP

An estimate of the impact of the COVID-19 pandemic on Saudi Arabia's gross domestic product, based on an input-output framework, scenario analyses and nightlight images

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Instant Insight

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Introduction

The COVID-19 pandemic has interrupted economic and social activity globally at an unprecedented pace. The international movement of goods has been limited to the necessary minimum, often solely for deliveries of protective and healthcare equipment. Many governments have imposed strict international travel bans to limit the risk of importing the virus, or at least to sharply reduce the inflow of infected persons. Many countries have implemented severe domestic restrictions not seen since the Second World War, including domestic travel bans, partial or full movement restrictions, and the closure of schools, factories, shops and services. The globalized world has entered the largest, fastest and most serious shock in modern history, posing economic, healthcare, social, moral, cooperative and leadership challenges to societies.

This Instant Insight focuses solely on the economic impact of the COVID-19 pandemic on Saudi Arabia's gross domestic product (GDP). Two different approaches are used to estimate GDP deviations from a baseline scenario. The first estimation is carried out within the input-output framework, using the Saudi Vision 2030 Input-Output Table (IOT) (V2030 IOT) for the year 2020 to design and evaluate three scenarios which differ in their assumptions of the severity, sectoral composition and the duration of the economic shock. The second approach relies on nighttime light (NTL) satellite images to infer changes in overall economic activity in Saudi Arabia, taking into account the latest available observations. The advantage of having these two different methods side-by-side lies in their complementarity. Despite being different in essence and using different sets of information, the outcomes of both are generally consistent.

The V2030 IOT scenario analysis shows that the negative impact of the COVID-19 economic lockdown on overall GDP ranges from -4.6% to -9.5% compared with the baseline level. This negative impact is partially offset by the government's fiscal countermeasures, resulting in a positive counter effect of some 2.6% in real GDP. Assuming a hypothetical economic expansion of 2% in a world in which COVID-19 did not occur, the estimated annual decline in overall GDP ranges from -0.4% to -5.4% in 2020. The NTL approach allows us to estimate an immediate annual decline in overall economic activity of -7.9%, regardless of the government's countermeasures. This outcome is in line with the expected negative impact of the IOT scenario's analysis. The NTL analysis also provides a disaggregated estimate for individual regions in Saudi Arabia.

Scenario designs and sectoral shocks

In the early stages of the COVID-19 lockdown, only limited hard economic data, if any, related to the event was available, as it is usually published with some lag. Higher-frequency data such as inflation may have a lag of one month. For quarterly data such as GDP, the lag may extend up to two quarters. Moreover, most data are subject to further revisions, particularly at a time of large adjustments and uncertainty. Given these circumstances, assumptions based on expert judgment and anecdotal evidence are key to economic simulations and estimates.

Given the high level of uncertainty around COVID-19, we have designed three different impact scenarios – medium, moderate and severe. These differ (i) in the severity of the overall initial shock – an assumption of how much final demand was affected at the peak of the crisis; (ii) in the distribution of the initial shock among economic sectors – an assumption of the exposure of individual economic sectors to the lockdown,

with some sectors affected more than others, and (iii) in the time needed for economic activity to recover – an assumption of how long the economic lockdown might take.

In this simulation exercise, we exploit the advantage of the sectoral granularity of the V2030 IOT (Havrlant 2020) using 50 sectors. However, there are many ways to introduce a shock to such a detailed IOT. Therefore, we have limited these options and have defined a set of six initial shocks used in each of the three impact scenarios. These initial shocks are then distributed across economic sectors within the IOT. We believe that such a limitation enhances the clarity of the initial shock to final demand and facilitates comparisons across the scenarios.

It is generally assumed that individual sectors of the economy are exposed to the COVID-19 crisis in varying degrees. In this respect, the healthcare sector is likely to be affected to a different extent than the retail sector, and the oil sector is likely to be exposed in a different way than the transportation sector. It needs to be emphasized that the initial shock represents the expected decline in final demand in the second quarter (Q2) of 2020, which is expected to be the most negatively affected quarter of the year. The six types of initial shocks vary in severity, as shown in Table 1. As such, a highly exposed sector such as air transport may be assigned a severe initial shock of -80%, while a less affected sector such as water transport may be assigned a significantly milder initial shock of -10%.

Table 1. Six initial shocks in Q2 2020 for the three impact scenarios.

Shock type	Medium scenario (in %)	Moderate scenario (in %)	Severe scenario (in %)
0	0	0	0
1	-10	-10	-15
2	-20	-20	-25
3	-40	-40	-45
4	-60	-60	-65
5	-80	-80	-85

The V2030 IOT is based on yearly data. Thus, each sectoral shock must eventually be recorded as an annual adjustment to final demand. At the same time, we would like to introduce a time aspect into the simulation, so that the duration of the economic lockdown may be taken into account. This is achieved by a variation in the quarterly profile of the negative shock, as follows.

It is assumed that the main negative impact is recorded in Q2 2020, which shows the most pronounced deviation from the baseline. Meanwhile, the economy is expected to start recovering in the following quarter, Q3 2020. The extent to which sectoral activity has recovered from the initial shock will then bring the time dimension into the simulation. The initial shock is expected to be reduced to 1/2 in Q3 2020 in the medium scenario, to only 1/3 in the moderate scenario and to remain at 2/3 in the severe scenario. The link between the quarterly deviations from the baseline and the annual adjustment to final demand is illustrated in Table 2 for the initial shock of -10%, recorded in Q2 2020, resulting in an annual decline in final demand of -3.8%.

Table 2. Quarterly profile of the negative shock resulting in an annual adjustment.

Date	Deviation from baseline (in %)	Level	Quarterly change (QoQ in %)	Annual direct shock (YoY in %)
Q1 2020	0.0	100.0	0.0	
Q2 2020	-10.0	90.0	-10.0	
Q3 2020	-5.0	95.0	5.6	
Q4 2020	0.0	100.0	5.3	-3.8

Note: YoY = year-on-year; QoQ = quarter-on-quarter.

The initial shock in the **medium impact scenario** is defined as a -10% deviation from the baseline in Q2 2020, resulting in a 10% decline in quarterly final demand. The second quarter is assumed to represent the peak of the economic lockdown. In the subsequent quarter, Q3 Q2020, the deviation from the baseline is reduced to 1/2 of the initial shock or -5%, recovering somewhat from the peak of the economic downturn. Finally, sectoral activity is expected to fully recover to the baseline level in the last quarter of the year. These quarterly deviations from the baseline are translated into an annual direct shock to final demand of -3.8%. This figure forms part of the IOT impact calculation.

In the **moderate impact scenario**, the economic recovery is assumed to be faster, with the expected decline in final demand in Q3 2020 only 1/3 that of the initial shock. We also apply a limited adjustment to the distribution of the shocks. The oil and gas sector is given a milder initial shock by one degree, compared with the other scenarios. This adjustment reflects a higher degree of complexity and uncertainty as to the channels impacting the oil and gas sector domestically and internationally. The main impact channels of all other sectors are more straightforward to determine, as they are clearly dominated by the massive reduction in final demand.

The forces currently impacting the international oil and gas market are more complex than the sectors mentioned above. Despite a drastic reduction in global demand for oil due to the COVID-19 economic downturn, Saudi Arabia's oil exports may show some resilience, predominantly linked to it gaining market share. This may partially outweigh the fall in demand in the short term, leaving the contribution of the oil and gas sector to real GDP growth almost unchanged. However, the sector's performance in the medium term could be affected by other factors such as a reduction in corporate income due to the low oil price or limited investment expenditure due to a subdued global economic outlook. The domestic oil industry's supporting and limiting factors are assumed to be almost balanced in the moderate scenario. We believe that the elevated uncertainty regarding the strength and timing of the various transmission channels related to the oil and gas industry provides a good reason to alternate the distribution of the initial shocks.

In the **severe impact scenario**, the distribution of initial shocks among sectors is identical to that of the medium scenario, keeping the structure of the overall COVID-19 economic downturn unchanged. Increased market share for the domestic oil and gas sector is expected to be outweighed by the medium-term reduction in corporate income and subdued global demand for oil in a low-price environment. As discussed above, the exposition of the domestic oil and gas industry, which accounts for a substantial contribution to Saudi GDP, is subject to considerable uncertainty at this stage.

In addition, a steeper initial decline is assumed across the whole economy, resulting in a sharper fall in final demand in Q2 2020 for all sectors with non-zero initial shock. The expected quarterly deviation from the baseline in Q2 2020 is reinforced by an additional 5 percentage points for each type of predefined shock, except the zero-impact shock. The recovery in economic activity is expected to proceed at a more gradual pace, with the consecutive quarter's deviation from the baseline final demand accounting for 2/3 of the initial shock. This naturally leads to a more severe annual direct shock to final demand used in the V2030 IOT computation. Table 3 summarizes the major differences among all three scenarios.

Table 3. Main differences among impact scenarios.

	Medium scenario	**Moderate scenario**	**Severe scenario**
Initial magnitude	Zero-impact shock and other shocks ranging from -10% to -80%	Zero-impact shock and other shocks ranging from -10% to -80%	Zero-impact shock and other shocks ranging from -15% to -85%
Sectoral distribution	Oil and gas sector: supportive channel outweighed by limiting channels	Oil and gas sector: supportive channel almost on par with limiting channels	Oil and gas sector: supportive channel outweighed by limiting channels
Recovery time	Medium recovery, Q3 2020 deviation from baseline at 1/2 of the initial shock	Faster recovery, Q3 2020 deviation from baseline at 1/3 of the initial shock	More gradual recovery, Q3 2020 deviation from baseline at 2/3 of the initial shock

The negative impact on headline and sectoral GDP

The three scenarios, medium, moderate and severe, enter the simulation as adjustments to the final demand for all sectors, with the negative impact of COVID-19 calculated according to sectoral GDP and based on the V2030 IOT multipliers (Miller 2009). The addition of all sectoral adjustments results in the deviation of headline GDP from the baseline level. The calculated deviations are not sensitive to the assumed baseline, which is discussed later. Table 4 shows the overall negative impact of the COVID-19 economic lockdown on Saudi GDP. It is important to note that this does not yet represent an estimate of the annual GDP growth rate; it accounts solely for the negative impact on economic activity. The countermeasures taken by the Saudi government that imply a positive economic effect and hypothetical economic growth are introduced in the following section.

Table 4. The negative impact of various impact scenarios on overall GDP.

	Medium scenario	Moderate scenario	Severe scenario
COVID-19 negative impact to GDP (deviation from bl. in %)	-7.0	-4.6	-9.5

Note: bl. = baseline.

The negative shock of the COVID-19 economic lockdown, distributed among the IOT sectors with varying intensity, results in an overall GDP deviation from the baseline of -7.0% in the medium scenario. This scenario is considered the most likely at this stage. A total deviation in GDP of -4.6% is estimated for the moderate impact scenario, with the oil and gas sector being exposed to less of the initial shock and experiencing a faster economic recovery. Finally, considering the steeper initial economic decline in Q2 2020 for all sectors, along with a more gradual pace of economic recovery, the overall deviation of headline GDP from the baseline is -9.5% in the severe scenario.

It is obvious that the estimated impact of COVID-19, including the magnitude of the initial decline, the sectoral distribution of the shocks and the time needed for the economy to recover, rely heavily on assumptions and expert judgment. Some assumptions are likely to prove correct as the situation evolves and the economic data arrives, some less so. This is common in any projection or simulation exercise. However, the range provided by the three scenarios can shed light on the extent of the uncertainty surrounding the overall economic impact of COVID-19.

There is an additional layer of uncertainty about how the COVID-19 pandemic could develop and its medium- and long-term consequences. For example, will there be another wave of the infection or a prolonged economic depression on a global scale? If these unfavorable events were to unfold, the estimate would require a more adverse set of assumptions, introducing more severe shocks for more sectors along with the longer timeframes needed for the economy to fully recover. We have considered a more aggravated scenario in our simulation that results in an overall GDP deviation from the baseline of almost -12% in 2020, with the potential for this to spill over to the following year. However, we do not discuss it in detail at this stage, as there are no clear signals indicating that this outcome may eventuate.

Applying the V2030 IOT framework allows us to have sectoral GDP impacts at our disposal. Table 5 shows the sectors most and least impacted under the medium scenario.

Table 5. Most and least affected sectors in the medium scenario.

COVID-19 sectoral impact	Shock type	Initial shock in Q2 2020 (in %)	Annual direct shock to final demand (in %)	Impact on sectoral GDP contribution (in %)
Recreational, cultural and sporting activities	5.0	-80.0	-30.0	-22.3
Air transport	5.0	-80.0	-30.0	-21.2
Motor vehicles, trailers and semi-trailers	3.0	-40.0	-15.0	-14.8
Road transport	3.0	-40.0	-15.0	-12.3
Wholesale retail trade	3.0	-40.0	-15.0	-11.6
Crude oil and natural gas	2.0	-20.0	-7.5	-7.8
…	…	…	…	…
Agriculture	0.0	0.0	0.0	-1.8
Health and social work	0.0	0.0	0.0	-1.7
Food products, beverages and tobacco	0.0	0.0	0.0	-0.5
Public administration and defence; compulsory social security	0.0	0.0	0.0	-0.2

Understandably, the most severe impact on GDP is recorded in sectors with the steepest initial shocks to final demand, such as recreational activities, air and road transport and retail trade. At the same time, even sectors with assumed zero direct shocks in Q2 2020, such as agriculture, healthcare or public administration are affected through their links with the rest of the economy. The translation of the shock to sectoral GDP impacts is also shaped by the import intensity of a given economic activity. This is one of the advantages of the input-output framework: a direct shock to one sector can be transmitted to other sectors, depending on the strength of their external and inter-industry linkages.

Countermeasures of the Saudi government

Governments worldwide have implemented a wide range of policy initiatives to combat COVID-19, such as social distancing, prohibitions on group gatherings and crowds, and travel restrictions. Over 100 countries have implemented travel restrictions. The International Monetary Fund (IMF) has compiled a list of the critical economic responses of 193 economies aimed at limiting the spread of COVID-19, along with the subsequent economic fallout.

The Saudi government has responded boldly and swiftly to the COVID-19 pandemic and has been very active in communicating with the public through social media awareness campaigns. It has set up various support systems, including call centers and medical care for all affected, regardless of their residency status. As a result, people have dramatically adjusted their daily routines, with most activities, and hence the spread of the virus, substantially reduced. Saudi Arabia has taken strict measures to contain the spread of COVID-19 and has implemented the following.

- A nighttime curfew for 21 days in most cities
- A 24/7 curfew for Mecca and Medina
- Domestic and international travel restrictions
- Suspending prayers at mosques
- The closure of all schools and universities
- The closure of shopping malls, except for groceries and pharmacies
- Suspending government and private employees' attendance at workplaces
- Covering expenses for COVID-19-related medical treatment for all in the country

It is obvious that the challenge presented by the pandemic is twofold. On the one hand, there is a clear imperative to protect lives and prevent an extreme overload of the medical system. A lockdown buys time to stockpile medical and protective equipment. On the other hand, any reduction in social and economic activity has economic costs, with many factories not producing goods, most shops closed, and services discontinued. This is the direct economic impact, which opens up potential second-round challenges

associated with adverse impacts on the labor market and other economic areas. Undoubtedly the world faces one of the most severe economic crises in its recent history, the economic consequences of which could reach beyond a steep downturn in GDP.

In this unique environment, the Saudi government has decided to protect and support its economy through various measures. These include monetary, social, health and labor support measures. In this simulation exercise, we focus solely on fiscal support measures that can partially offset the short-term direct economic impact of COVID-19 and are relatively straightforward to implement in the input-output framework. The Saudi government has announced a 70 billion Saudi riyal (SAR) ($18.7 billion) private sector support package.

This fiscal support package is allocated among various sectors in the V2030 IOT according to the following guidelines: (i) six types of positive shocks are applied on an annual basis, including a zero direct support, ranging from 6% to 30% of sectoral final demand; (ii) sectors with the largest negative exposure to the COVID-19 crisis receive more funding within the fiscal support program, while sectors that are expected to not be directly affected receive less fiscal support; (iii) essential sectors such as healthcare receive more fiscal stimulus compared to non-essential activities.

The distribution of fiscal stimulus among sectors and the magnitude of the predefined positive shocks are kept unchanged across the scenarios. We do not apply any variation in terms of quarterly timing across scenarios, as the fiscal support is expected to be delivered with the utmost urgency regardless of the lagged economic data. The positive effect of the fiscal stimulus on GDP in percentage terms, as a deviation from the baseline level, is similar in all three scenarios, ranging from 2.4% to 2.6%. A slight variation arises according to the difference in the comparative base case for each scenario, with calculations being processed at GDP levels to maintain precision and the summability of sectoral GDP contributions.

The upper segment of Table 6 gives an overview of the negative impact of COVID-19 on GDP and the positive effect of the fiscal countermeasures. It should be noted that these are deviations from a baseline level. Annual growth estimates are discussed in the next paragraph. Looking at the medium scenario, considered to be the most likely at this stage, the negative impact on GDP of the COVID-19 economic lockdown falls to -7.0% from the baseline. In contrast, the positive effect of the government's fiscal countermeasures offsets this by 2.5%, resulting in a total deviation of -4.7% from the baseline.

Table 6. Negative, positive and overall impacts on GDP and expected growth in 2020.

	Medium scenario (in %)	Moderate scenario (in %)	Severe scenario (in %)
COVID-19 negative impact (dev. from bl.)	-7.0	-4.6	-9.5
Fiscal countermeasures (dev. from bl.)	2.5	2.4	2.6
Total (deviation from baseline)	-4.7	-2.3	-7.2
Hypothetical GDP growth (YoY)	2.0	2.0	2.0
All impacts included GDP growth (YoY)	-2.8	-0.4	-5.4

Note: dev. = deviation; bl. = baseline; YoY = year-on-year.

We assume a hypothetical 2% GDP growth rate between 2019 and 2020 in a hypothetical world without COVID-19. This is an assumed baseline economic growth rate and a starting point for incorporating the negative impact of COVID-19 and the positive effects of government countermeasures. Under such an assumption, overall GDP in the medium scenario is estimated to decline by 2.8% in 2020 year-on-year. The lower part of Table 6 shows the growth rate estimates.

For the remaining scenarios, the negative impact of COVID-19 on GDP ranges from -4.6% in the moderate scenario to -9.5% in the severe scenario. Taking the positive effects of fiscal countermeasures into account, along with the assumption of a hypothetical 2% economic expansion, headline GDP is estimated to decline between -0.4% and -5.4% annually in 2020. As discussed, the moderate scenario assumes a less severe initial shock to the oil and gas industry and a faster economic recovery, while the severe scenario introduces a steeper initial decline in Q2 2020 across all exposed sectors, followed by a more gradual economic recovery.

Nighttime light satellite images

In this section, we estimate the impact of COVID-19 containment measures on economic activity in Saudi Arabia using nighttime light (NTL) satellite images. This provides us with an early view of the economic ramifications of the shutdown.

A few cities account for the majority of Saudi Arabia's economic growth and house most of its population. They can also be observed through the use of satellite imagery. Indeed, they are dominant hotspots of activity in Saudi Arabia, with high concentrations of light observed at night. While cities are critical economic hubs, they are also sources of risk during a pandemic. Their high concentration provides a fertile environment for the spread of disease, unless countermeasures are imposed.

We analyze satellite images of NTL for two days, aggregated to the provincial level, to estimate the impact of COVID-19 on the Saudi economy. Each pixel in the NTL images represents a geographic area of 500 square meters and is assigned a digital number (DN). The DN records the intensity of light emitted from a specific area for each of the two days, and the DNs can be aggregated by provinces or other units. As such, NTL values at the provincial level can be constructed by grouping adjacent pixels that fall within different Saudi provinces together, summing up their DNs to arrive at the total amount of light emitted from each province.

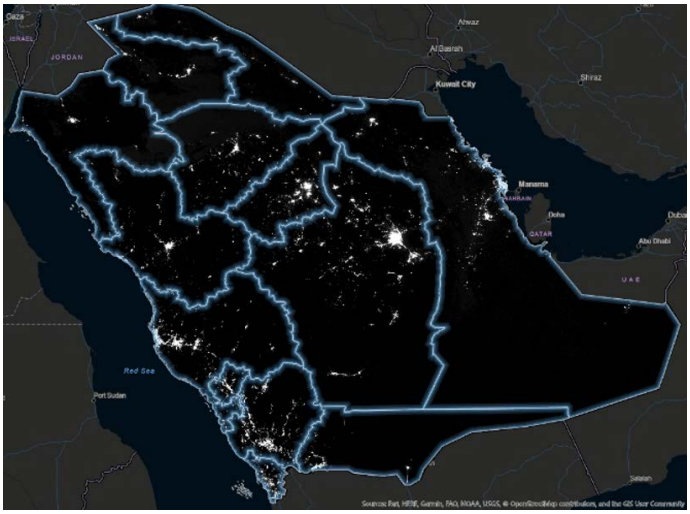
We collected two days of nightlight images on March 5 and March 26 (three days after curfew measures were implemented), using one of NASA's Black Marble products, "Daily Gridded Day Night Band 500m Linear Lat Lon Grid Night," (VNP46A1) (Román et al. 2018). VNP46A1 is a daily raw NTL product that provides top-of-atmosphere, at-sensor nighttime radiance at a 500-meter spatial resolution.

VNP46A1 is derived from the Visible Infrared Imaging Radiometer Suite (VIIRS), one of five instruments mounted on the Suomi National Polar-Orbiting Partnership (SNPP) satellite platform. The day-night band (DNB), produced by the VIIRS sensor, captures measurements of visible and near-infrared light reflected from the Earth's surface. The VIIRS DNB sensor is very sensitive to levels of low light.

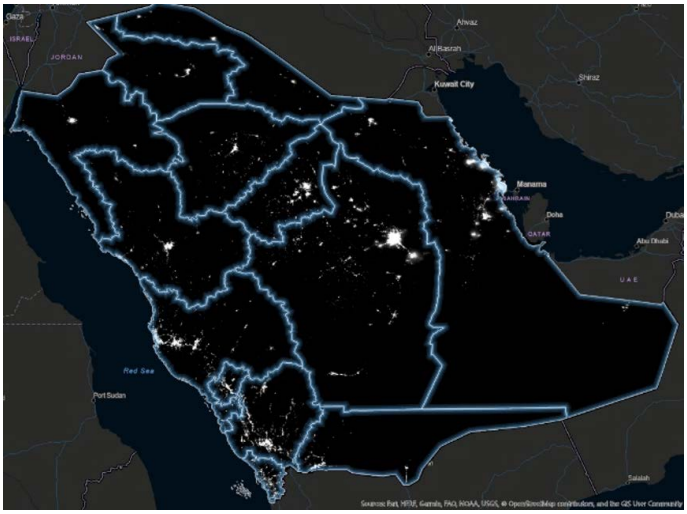
Not only does it capture artificial lights on the Earth's surface due to human activity, but it also detects light reflected from the moon. Ideally, moonlight should be filtered out to allow for a more accurate measurement, but this was not feasible for this analysis. As a result, the figures generated are conservative and represent an estimate of the upper bound, as the data did not control for the effects of lunar illumination and cloud cover.

VNP46A1 utilizes a specific tiling system to organize the daily NTL images. Each day, a little less than 600 tiles are generated to cover the whole globe. Saudi Arabia is covered by nine of those tiles. Thus, we extracted 18 tiles (nine images per day) from NASA's Earth Data portal. The tiles are stitched together to create one unified nighttime image for Saudi Arabia for March 5 and March 26. Finally, we use the ArcGIS suite of products to compute the total amount of light reflected from each province for each day (Figure 1).

Figure 1. Regional NTL images for Saudi Arabia.



Regional nighttime intensity on March 5

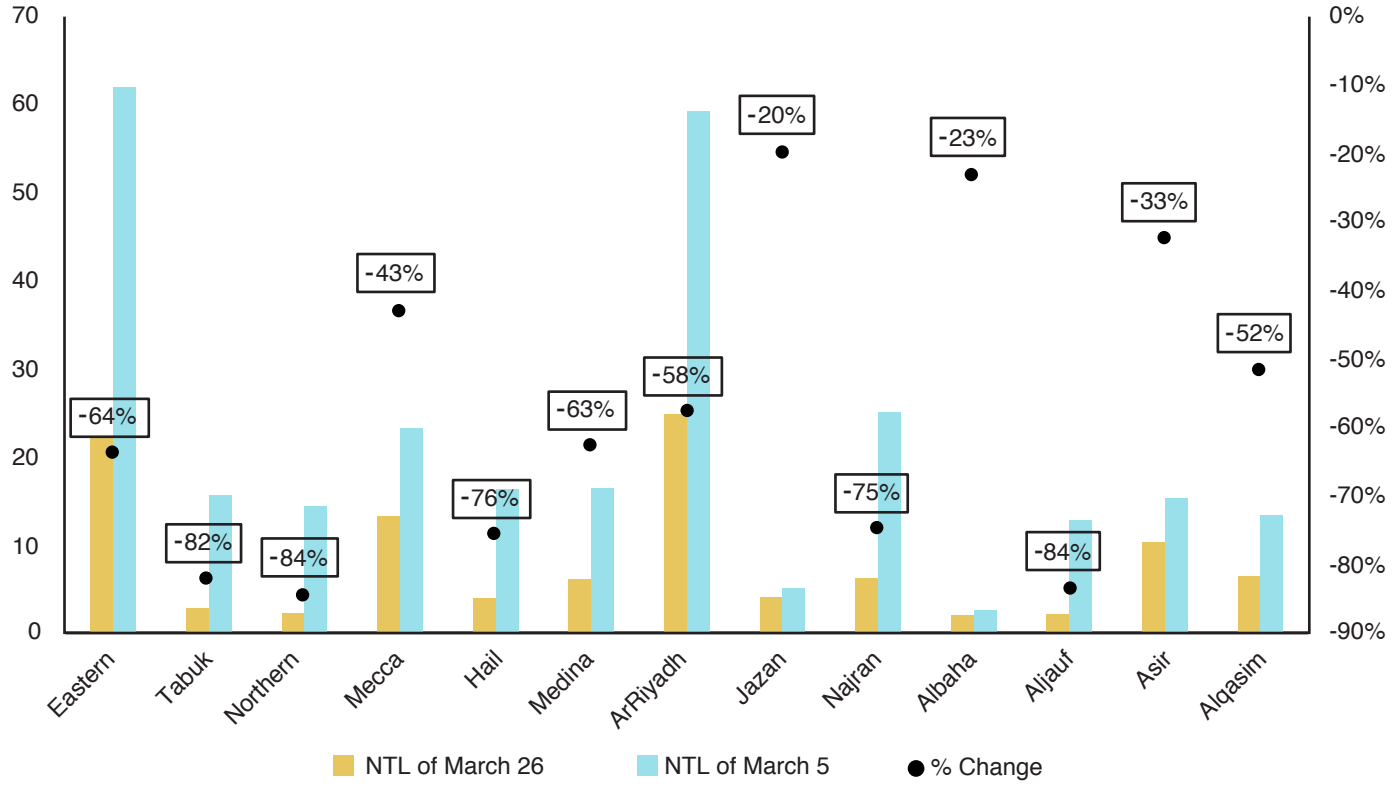


Regional nighttime intensity on March 26

Figure 2 shows the change in NTL values between March 5 and March 26 for Saudi Arabia's 13 provinces. It clearly illustrates the difference the measures taken to combat the spread of COVID-19 had on NTL values. The figure also shows that the percentage change in NTL varies between regions. The most significant drop is seen in the Eastern Province, followed by the Riyadh region, whereas Albaha and Jazan regions experienced the smallest declines in NTL values. In total, Saudi Arabia's NTL images show a 62% reduction in total illumination between March 5 and March 26.

Using NTL captured by satellites as a proxy measure for economic activity is well established in the economic literature (Elvidge et al. 1997, 2012; Pinkovskiy 2016). NTL images have been used to study human and economic activity for almost 30 years. Economists have used NTL to proxy economic growth because of the robust correlation between NTL and economic activity. We follow the strategies used by Lopez et al. (2019), who developed an empirical approach to estimating the relationship between NTL and GDP in Saudi Arabia.

Figure 2. Millions of NTL between March 5 and March 26 (left axis), percentage change.

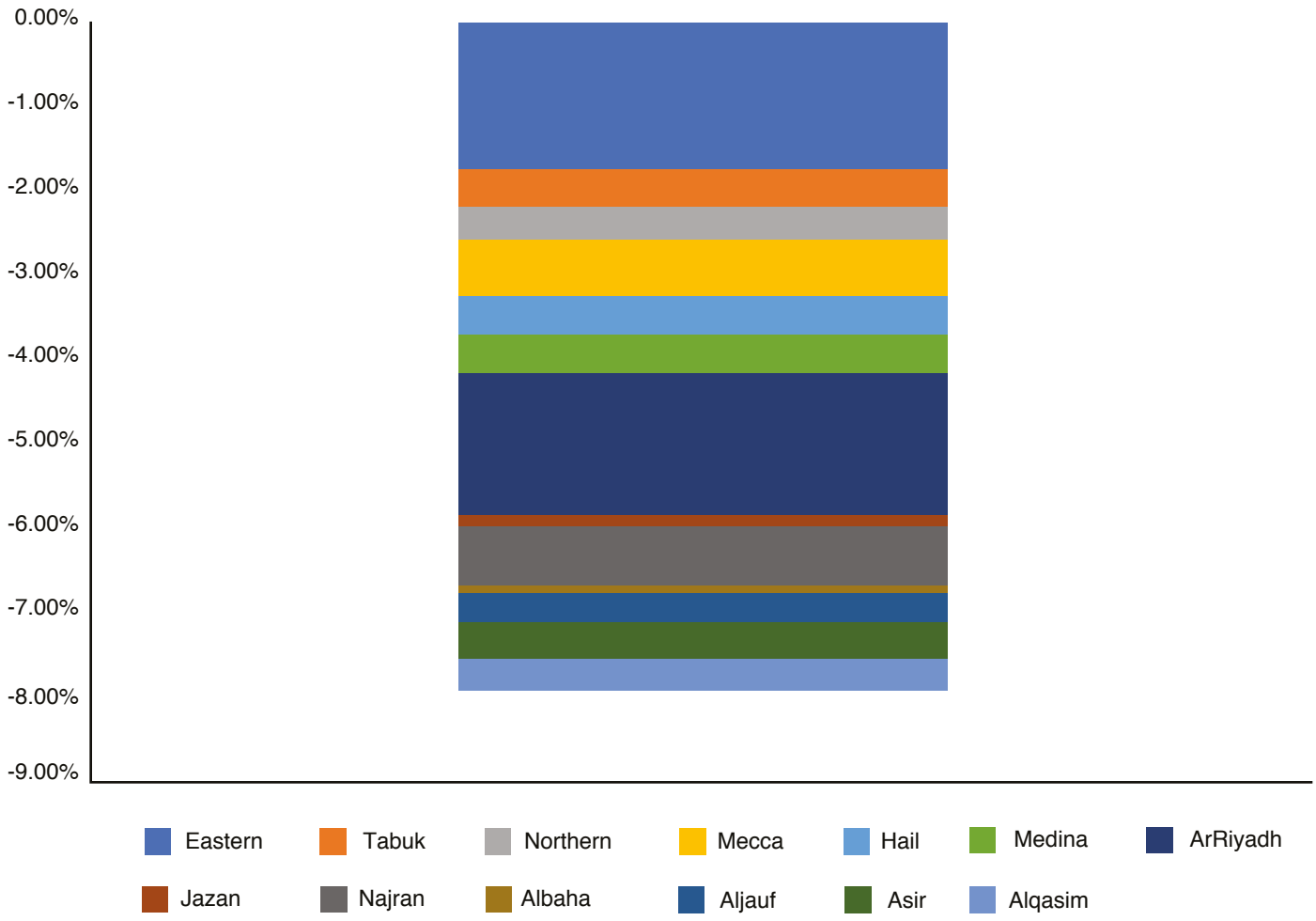


Using the change in NTL for Saudi Arabia, we estimate that COVID-19 containment measures would result in a 7.9% reduction in Saudi Arabia's GDP growth for 2020. This is a direct result of the reduction in mobility, transactions, and, hence, economic activity. However, this estimate does not take into account any fiscal countermeasures taken by the Saudi government. It also assumes that the current Saudi countermeasures are in place for the remainder of 2020. Thus, the NTL approach may be interpreted as an upper bound for the economic impact of the coronavirus containment measures.

Figure 3 details the provincial shares of this decline in GDP growth. This could provide policymakers with an indication of how provinces are differentially impacted. The economic impacts are proportional to each province's change in NTL, and the changes in NTL across provinces are quite different. These differences are primarily driven by the economic sectoral decomposition of each province.

As mentioned previously, the estimated reduction in GDP growth does not account for the fiscal countermeasures already implemented to help cushion the impact of the COVID-19 response. The Saudi government also issued a wave of monetary and macro-financial policies to mitigate the impact of the COVID-19 containment measures. In March, the Saudi Arabian Monetary Authority (SAMA) reduced the country's interest rate twice, provided a support package to the private sector, deferred payments on existing loans for small- and medium-sized enterprises (SMEs), and covered private enterprise fees for point-of-sale and e-commerce transactions. A 70 billion SAR private sector support package was also announced, along with an increase in health sector spending. A royal decree was issued by H.R.H. King Salman and authorized by the government to cover 60% of the salaries of those in the private sector through unemployment insurance (SANED). Future research will be able to assess the effectiveness of these fiscal interventions through the use of NTL images.

Figure 3. The impact of COVID-19 on GDP segmented by province (in % and percentage points).



In general, the Kingdom witnessed a 62% drop in total illumination between March 5 and March 26. This change in NTL can be directly used as a proxy measure for the change in economic activity, particularly GDP. Our analysis finds that COVID-19 containment measures at the upper bound could result in a 7.9% reduction in GDP growth in Saudi Arabia. Further, the containment measures have had different impacts across provinces. NTL analysis may enable policymakers to direct fiscal countermeasures where they are needed most.

Conclusion

The input-output framework has been applied to estimate the impact of the COVID-19 pandemic on Saudi GDP at a time when no, or limited, hard economic data related to the event are available. The estimation thus relies on expert judgment and assumptions about the decline of final demand in individual sectors. For the sake of clarity and comparability, six types of predefined shocks were considered with various degrees of severity. Given the strength and speed of this unique economic shock, we designed three different scenarios to address the elevated uncertainty surrounding future developments. These scenarios vary in the distribution of the predefined shocks among sectors, in the severity of the initial decline in final demand

in Q2 2020 and in the time needed for the economy to fully recover. The V2030 IOT has been used to translate the set of shocks into sectoral and headline GDP impacts.

The medium scenario is considered the most likely at this stage. In this scenario, the negative impact of the COVID-19 economic lockdown results in a -7.0% real GDP deviation from the baseline level. The Saudi government's fiscal countermeasures to protect the economy and mitigate the negative impact of COVID-19 are also addressed in the simulation. The direct fiscal support, which is mainly targeted at the private sector, is distributed among the economic sectors of the V2030 IOT, resulting in a positive increase of 2.5% in real GDP. Assuming a hypothetical economic expansion of 2% between 2019 and 2020 in a world where the COVID-19 crisis did not occur, year-on-year real GDP would be expected to decline by 2.8% in 2020. Looking at the remaining scenarios, overall GDP is estimated to decline by -0.4% to -5.4% this year, depending on the assumed severity of the initial shock, the channels affecting the oil and gas sector and the time needed for the economy to fully recover.

NTL satellite image analysis was also used to assess the change in Saudi Arabia's economic activity before and after the COVID-19 lockdown. The analysis of two NTL images indicates an overall impact on economic activity of -7.9% on an annual basis, which is in line with the estimated negative impact in the medium IOT simulation scenario. The NTL approach also provides disaggregated information for individual provinces. We are aware that the nature, severity and geographic scope of the COVID-19 economic lockdown are extraordinary. As such, our estimates are subject to further global, regional and national developments.

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