Projecting Saudi Arabia's CO_2 Dynamic Baselines To 2060: A Multivariate Approach

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As a party to the Paris Agreement, which aims to limit the global average temperature rise to below 2 degrees Celsius and as close as possible to 1.5 degrees Celsius, Saudi Arabia has submitted a nationally determined contribution (NDC). NDCs are essentially climate action plans encompassing a party's climate target and the initiatives or policies it plans to implement to achieve that target. NDCs lie at the heart of the Paris Agreement and are submitted in 5-year intervals, with each successive NDC (either referred to as a new or updated NDC) reflecting higher ambition. Saudi Arabia has so far participated in two successive rounds of NDC submissions. In its most recent updated NDC, submitted in 2021, Saudi Arabia announced its new pledge to reduce greenhouse gas (GHG) emissions by 278 million tonnes (Mt) of carbon dioxide (CO_2) equivalent (eq) annually by 2030.

Saudi Arabia's NDC emission target is expressed as a reduction below a baseline or business-as-usual emissions growth scenario. A country's baseline is a counterfactual scenario showing how emissions would evolve, assuming that no mitigation policies or measures would be implemented beyond those already in force and/or planned to be adopted. Although Saudi Arabia did not publicly disclose a quantitative baseline in its NDC at the time of writing, it provided qualitative details on its baseline, which it refers to as 'dynamic baselines.' Saudi Arabia's dynamic baselines depend on the level of economic development and the extent of economic diversification that occurs in the country over the coming years. Specifically, Saudi Arabia has envisioned two distinct but possible baseline scenarios. The first, taken as the default scenario, Saudi Arabia achieves economic diversification, driven by its oil exports, with oil export revenues directed into investment in high-value-added sectors like financial services and tourism. In the second scenario, oil resources are utilized domestically to expand Saudi Arabia's energy-intensive industrial base, with increasing contributions to the national economy from industries such as petrochemicals, cement, mining, and metal production.

Focusing only on CO_2 emissions, which account for around 80-90% of total GHG emissions in Saudi Arabia, this paper contributes to understanding how they might evolve in Saudi Arabia through 2030 and up to 2060 by producing various dynamic emissions scenarios. To achieve this, we estimate equations using both Autometrics and the Structural Time Series Model (STSM), two methods that can explain the emissions data through a combination of trends, interventions, and right-hand side variables like GDP and energy prices – but in different ways. Using both methods, we estimate multiple equations with different sets of explanatory variables (drivers). The econometric results reveal that the coefficients on variables such as gross domestic product (GDP) and the real

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energy price are consistent across the estimated equations, which points to the coefficients' robustness. From the estimation, to generate CO_2 emissions projections across the different scenarios, we settle on a preferred specification that passes all diagnostic tests and outperforms all other models and specifications. Furthermore, the specification has the advantage of including the useful drivers that can influence CO_2 emissions projections when producing several scenarios under different policies or levers– the drivers being GDP, the real energy price, the service value-added share, and an underlying emissions trend (UET) that captures the combined effect of exogenous factors such as consumer behavior and energy efficiency.

Given the preferred specification, several scenarios were constructed before generating the CO2 emissions projections, reflecting the different assumptions on the drivers of CO_2 emissions, GDP, the real energy price, economic structure, and the UET. We, therefore, build a number of scenarios, starting with a baseline scenario that acts as a reference, showing how CO_2 emissions might evolve in Saudi Arabia without any additional policy efforts, assuming the underlying drivers continue to evolve in the future as they did in the past (by utilizing the baseline assumptions on the evolution of the drivers in the preferred econometric model. The baseline scenarios suggest that Saudi CO_2 emissions would rise from 540 Mt in 2019 to 621 Mt in 2030 and 878 Mt in 2060.

The various CO_2 emissions scenarios around the baseline projection highlight how different factors might affect CO_2 emissions in Saudi Arabia up to 2060. The gap between the highest and lowest projections underscores how much emissions could evolve differently depending on the underlying drivers. In the highest scenario, in which GDP grows fastest, the economy becomes more heavily industrialized, energy prices decline in real terms, and the UET grows at a constant rate, CO_2 emissions would grow to 666 Mt in 2030 and 1,391 Mt by 2060. On the other hand, in the lowest scenario, in which GDP grows slowest, energy prices are reformed, the economy diversifies, and the UET declines at a constant rate, CO_2 emissions would decline to 516 Mt in 2030 and 465 Mt by 2060.

Additionally, we emphasize the significant impact of economic structure and GDP growth on CO_2 emissions, and our findings align with Saudi Arabia's NDC priorities. In a scenario highlighting heavy industrialization, emissions are projected to reach 646 Mt in 2030 and 1,096 Mt in 2060. Conversely, an emphasis on economic diversification with high service shares forecasts emissions of 602 Mt in 2030 and 769 Mt in 2060. The 46 Mt difference by 2030 and 327 Mt by 2060 between these scenarios underscores the pivotal role of GDP composition in emission trajectories. Additionally, in a high GDP growth scenario, emissions are estimated to reach 635 Mt in 2030 and 985 Mt in 2060, while a low GDP growth scenario projects emissions of 607 Mt in 2030 and 781 Mt in 2060. These insights provide context for the strategic focus of the Saudi government on these variables in its updated NDC.

To conclude, our paper generates several key insights for policymakers. First, it highlights how different variables, such as GDP and energy prices, influence CO_2 emissions projections. Second, it reveals the critical role the economy's structure can play, especially in a country like Saudi Arabia undergoing rapid economic transformations. Third, it demonstrates that even in the lowest emissions scenario, further efforts are needed to achieve net zero by 2060. These efforts could encompass policies such as carbon pricing and investment in carbon removal technologies such as direct air capture. These additional efforts will be necessary for the Kingdom of Saudi Arabia to achieve its goals of net zero and a sustainable future.