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King Abdullah Petroleum Studies and Research Center

Impacts of Higher Energy Efficiency on Growth and Welfare Across Generations in Saudi Arabia

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC’s mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Key Points

Energy policies in the oil-rich countries of the Gulf Cooperation Council (GCC) region influence their domestic growth in the long run. Accordingly, they also redistribute income across generations over long periods. In this paper, we use MEGIR-SA to assess the aggregate effects of higher energy efficiency in Saudi Arabia.

The model MEGIR-SA – Model with Energy, Growth and Intergenerational Redistribution-Saudi Arabia – is designed to assess the quantitative effects on growth and welfare across generations of different energy policies in Saudi Arabia – e.g., increasing end-use energy prices, fostering alternative energy mixes, bolstering energy efficiency and defining different levels of oil production over time while developing a sovereign wealth fund.

An annual increase of 4 percent in future energy efficiency would result by 2030 in 1 million barrels per day (bbl/d) of avoided domestic energy consumption and thus enable additional oil exports. Saudi oil income could increase by 50 billion Saudi Arabian Riyals (SAR) to 100 billion SAR per annum by 2030, depending on market conditions. If fully recycled through public current spending or investments, the upward effect on growth could be between 0.3 and 0.6 percent per year by 2030. Under pessimistic oil market and domestic oil production assumptions, our model suggests there would be a benefit in recycling additional oil revenues into public investments in infrastructures.

Most of the economic benefits of higher energy efficiency gains would accrue to individuals born after 1990 – who now account for more than half of the current Saudi population – or to future generations. The welfare effect is limited for those Saudis who are already adults.

Executive Summary

Energy policies in oil-rich countries of the Gulf Cooperation Council (GCC) region influence their domestic growth in the long run. Accordingly, they also redistribute income across generations over long periods.

KAPSARC developed MEGIR-SA (Model with Energy, Growth and Intergenerational Redistribution — Saudi Arabia) to assess the quantitative effects on growth and welfare across generations of different energy policies in the Kingdom — such as increasing end-user energy prices, fostering alternative energy mixes, bolstering energy efficiency and defining different levels of oil production over time while developing a sovereign wealth fund. A particular strength of MEGIR-SA is its capacity to compare the welfare effects of energy policies across age groups, current or future, and to compute simultaneously the aggregate impact of these policies in a unified setting.

This paper uses MEGIR-SA to assess the aggregate effects of higher energy efficiency in Saudi Arabia. Increasing energy efficiency can be significantly achieved through tighter efficiency regulations rather than by additional direct government spending — especially in Saudi Arabia. In MEGIR-SA, an increase in energy efficiency affects the economy through three main channels: a) Substitution effect — which lowers energy consumption for a given level of output and which is partially offset by an income effect resulting from higher available income and leading higher levels of activity and energy consumption; b) Oil income effect — where the lower domestic energy consumption stemming from improved energy efficiency accounts for higher Saudi oil exports and public income; c) Recycling effect — where the additional public oil income is recycled in the Saudi economy through higher current public spending or higher public investments.

Results suggest that an annual increase of 4 percent in future energy efficiency would result by 2030 in 1 million bbl/d of avoided domestic energy consumption and thus enable additional oil exports. Saudi oil income could increase by 50 billion SAR to 100 billion SAR per annum by 2030, depending on oil market conditions. If fully recycled through public current spending or investments, the upward effect on growth could be between 0.3 and 0.6 percent per year by 2030. Under pessimistic oil market and domestic oil production assumptions, our model suggests there would be a significant benefit in recycling additional oil revenues into public investments in infrastructures.

Most of the economic benefits of higher energy efficiency gains would accrue to individuals born after 1990 — who now account for more than half of the current Saudi population — or to future generations. The welfare effect is limited for those Saudis who are already adults.

Higher Energy Efficiency in SA: The Impact on Growth and Welfare Across Generations

The Kingdom's recently announced Vision 2030 established an ambitious set of targets and timelines for modifying the Saudi economic growth model so that it depends less on oil while still enhances welfare.

KAPSARC developed the model MEGIR-SA to assess the quantitative effects on growth and welfare across generations of different energy policies in Saudi Arabia – e.g., increasing end-use energy prices, fostering alternative energy mixes, bolstering energy efficiency and defining different levels of oil production over time while developing a sovereign wealth fund. (See Gonand, 2016 for a full technical description). In this paper, we use MEGIR-SA to assess the aggregate effects of higher energy efficiency in Saudi Arabia.

MEGIR-SA is the first general equilibrium model with overlapping generations to be developed and applied for energy policy analysis in the GCC region. Its particular strength is its capacity to compare the welfare effects of energy policies across age groups, current or future, and to compute simultaneously the impact of these policies on growth in a unified setting.

This paper provides insights into the magnitude of the possible benefits at the aggregate scale from increasing energy efficiency at the microeconomic level. In doing so, we ran different simulations relying on a particular setup for key variables, such as oil production, oil prices, government spending, energy mix, economic structure and a baseline for the background level of energy efficiency in the economy. We checked that the policy implications of the model are robust to most of its parameters and investigated the consequences of different assumptions as to the oil price and volume of oil production.

The setup focuses attention on the main policy options that directly influence the aggregate effects of a rise in energy efficiency. Clearly, with the current plans for economic transformation, other energy policies could indirectly influence energy productivity at the aggregate level — including potential changes to the energy mix, domestic energy prices, diversification initiatives and various capital spending and saving plans, all of which can be taken into account in our MEGIR-SA model. It is not our intention to model the full complexity of all the substantial policy changes underway that would be likely to affect the Saudi economy. These are, of course, important areas of study in their own right, but here we wish only to single out the potential impact that raising energy efficiency might have on the economy.

Increasing energy efficiency can be achieved through tighter efficiency regulations rather than by additional direct government spending. Regulatory changes have the potential to significantly affect energy efficiency in KSA. It has been estimated that introducing measures such as regulating air conditioners in KSA could reduce power demand by as much as 25 percent or 10 GW (Matar, 2015).

In MEGIR-SA, an increase in energy efficiency affects the economy through three main channels:

> A substitution effect lowers energy consumption for a given level of output. It is partially offset by an income effect which, resulting from higher available income, leads to higher levels of activity and greater energy consumption.

An oil income effect where the lower domestic energy consumption stemming from improved energy efficiency accounts for higher Saudi oil exports and public income.

A recycling effect where the additional public oil income is recycled in the Saudi economy, whether through higher current public spending or higher public investments.

In this paper, we illustrate the case where all the avoided energy consumption from higher energy efficiency is exported, rather than consumed domestically or kept in the ground. We consider this a good base case to provide policymakers with an indication of the orders of magnitude that increasing energy efficiency has on key variables.

Setup for the analysis

This section describes the main technical assumptions used in this paper. A more detailed technical description of the MEGIR-SA model is included in an accompanying KAPSARC methodology paper (Gonand, 2016).

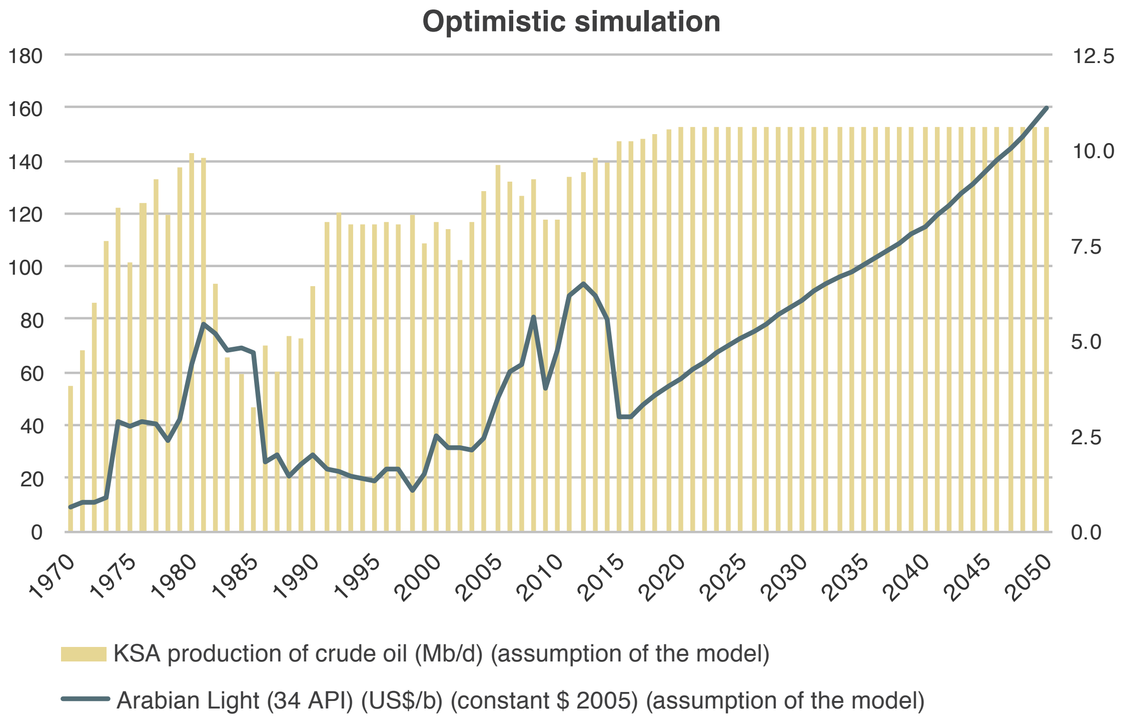
It is not our intention to model likely oil market outcomes, but rather to provide just an upper and lower bound for our analysis. We use an optimistic set of assumptions with high oil prices and production and a more pessimistic assumption set with lower oil prices and declining production.

1. Optimistic assumption: Increasing oil prices and a high and stable level of oil production. We use the Oxford Economics oil price forecasts, under which future crude oil prices keep increasing up to $154/bbl in 2050 in constant terms. Such a level of oil price in constant terms is two times higher than the peak level of oil observed, in real terms, in 2008. Beyond 2050, the price of oil is assumed to continue increasing at a moderate pace, by +0.5 percent per year in real terms. We also assume a high, stable level of production after 2020, around 11 million bbl/d. Prior to 2020, we follow the Oxford Economics forecast of increasing levels of Saudi crude oil production.

2. Pessimistic assumption: Future real price of oil remaining at levels seen in the first half of 2016 and declining production of 1 percent per year from 2020 onwards. It would be possible to construct a more pessimistic scenario, based on the marginal cost of producing Arab Light crude, but this probably would not reveal any unexpected economic insights beyond recording the extreme economic stress this would place on the Kingdom.

These assumptions are illustrated in Figure 1. In both cases, we assume that the world price for oil is set by the market, rather than supported by cutting Saudi production. This is in line with Huppmann and Holz (2012), and also with most data over the last 20 years. However, the model does include some linkage between the oil price and Saudi exports.

Precisely estimating the energy efficiency index of a whole economy is a difficult task, as energy efficiency is observed only at the microeconomic level. In MEGIR-SA, energy productivity can be measured at the aggregate level as the ratio of GDP to energy demand, but it does not change in a strictly parallel manner with energy efficiency. This is because energy productivity at the macroeconomic level is also influenced by general equilibrium feedback effects such as the oil income ('rebound') effect.



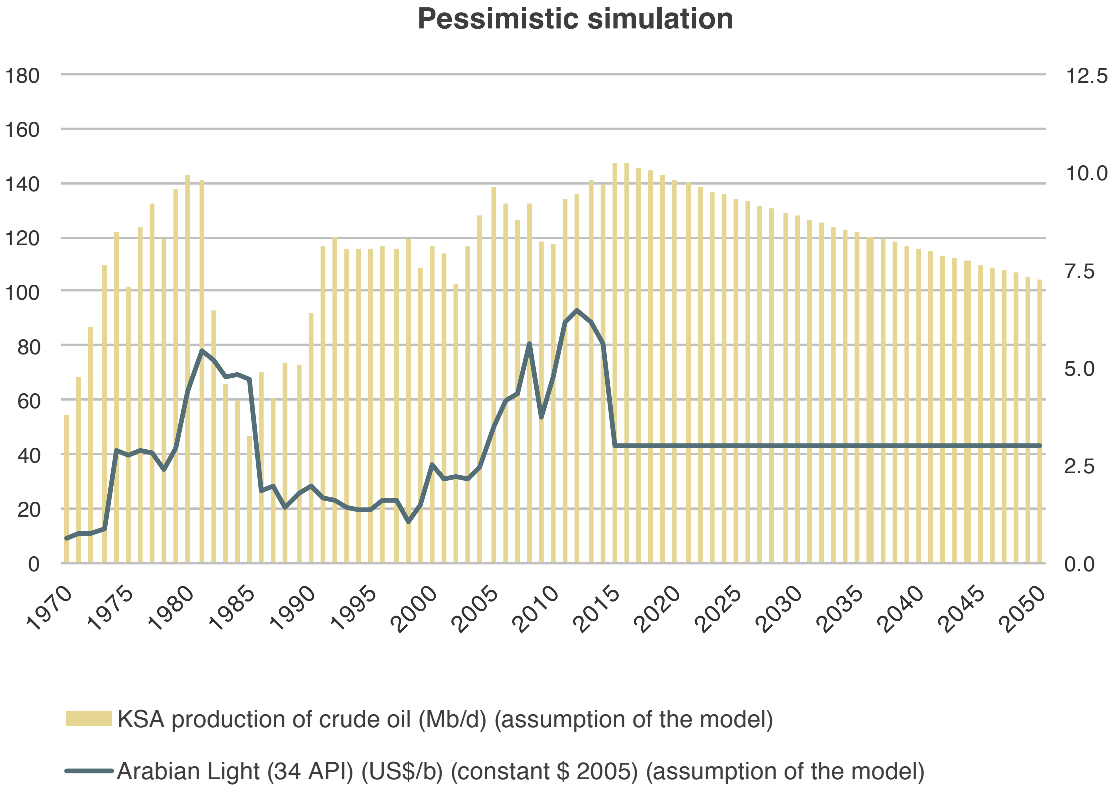


Figure 1. Two possible extreme cases for the future price of oil and KSA production.

Source: KAPSARC.

For Saudi Arabia, KAPSARC research has shown that energy productivity has, on average, been stable over the last two decades (Galeotti, Howarth and Lanza, 2016). Accordingly, we assume a baseline of no energy efficiency improvement, based on what we observe in available historical data.

All scenarios assume that the Saudi Government budget remains balanced over the next decades. However, future research using MEGIR-SA might include modeling a sovereign wealth fund and simulating its changing size over time.

The MEGIR-SA model assumes three key trends in the future dynamics of the Saudi population:

- A slowdown in population growth.
- A shift from a very young population toward an aging population.
- A progressive Saudization of the labor force.

In terms of intergenerational welfare, the model assumes aging may be significantly observed from the middle of the 2020s onwards, with a rapid increase in the proportion of the population aged more than 60, from 4 percent in 2016 to 22 percent in 2050. Demographic aging and Saudization both reinforce capital deepening, the former because savings increase for older working households and the latter because Saudis, by contrast with expatriates, are assumed to invest their savings in the domestic economy.

On the supply side of the economy, we use a standard production function, with labor – Saudi and expatriates – private capital, public capital and energy. On the demand side, we model the consumption and labor behaviors of around 60 age cohorts.

Results of the analysis

Our baseline Scenario A has no energy efficiency gains.

Scenario B: Higher Energy Efficiency and Higher Oil Income Reinvested Into Public Infrastructure

By contrast, the reform scenarios – described below as Scenario B1 and B2 – incorporate an increase in energy efficiency of 4 percent per year up to 2050. Higher energy efficiency lowers energy demand which, all else being equal, leads to higher net income for private agents. This, in turn, triggers a rebound effect on the demand for energy. The net effect is still lower domestic energy demand than in the baseline scenario, which results in avoided energy consumption, which we model as being allocated to higher volumes of crude oil to be exported.

In the reform scenarios, Saudi domestic demand would be reduced by around 1 million bbl/d in 2030 and 2.5 million bbl/d in 2050 (Figure 2). Depending on the assumptions as to the future price and production of oil, future annual Saudi oil income would be bolstered by between SAR2005 50 billion and SAR2005 100 billion in 2030 in the pessimistic and optimistic simulations, respectively, and between SAR2005 150 billion and SAR2005 600 billion in 2050.

In the reform scenarios, the increase in public oil income is recycled through higher public capital expenditure up to 2050, with current public spending remaining unchanged from the level in the no reform scenario.

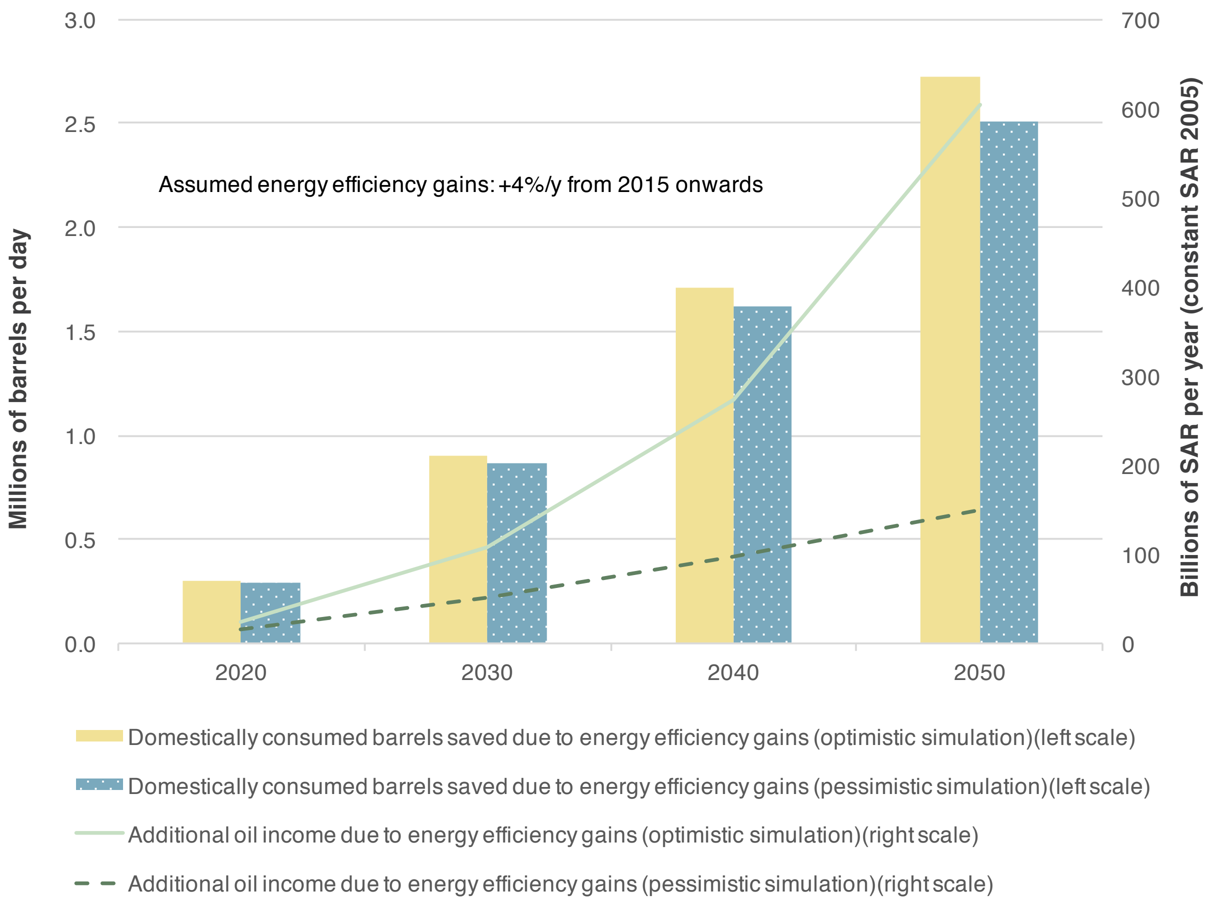


Figure 2. Impact of the simulated higher energy efficiency gains on domestic consumption of oil and public income from additional oil exports.

Source: KAPSARC.

Higher public capital investments trigger two macroeconomic mechanisms: they enhance the marginal productivity of labor and private capital over decades, and they redistribute some income to Saudi agents in the short run. Indeed, public investment typically finances the purchases of intermediate consumption that is used to build infrastructure, thus raising the income of Saudi shareholders and employees, as well as that of non-Saudi workers.

Accordingly, the amount of income benefiting Saudi GNP in the short run when public infrastructure is built depends on:

- The proportion of Saudis among the total employed population.
- The amount of intermediate consumption that is produced domestically.

The former is exogenous in the model. The latter mirrors the level of diversification of the Saudi economy: the more KSA provides the intermediate consumption needed to build its own infrastructure, the more Saudi agents benefit from the government's recycling energy efficiency gains through public investments.

To perform a sensitivity analysis, we distinguish between two empirical versions of Scenario B, depending on the future oil price and the level of Saudi oil production, and with the two possible cases introduced above – relating to the degree of diversification of the economy in the future.

Table 4. Empirical versions of Scenario B (i.e., higher energy efficiency gains, higher oil income, higher public investments).

	Diversified Saudi economy	Non diversified Saudi economy
Optimistic simulation (future rising oil price, high Saudi production of oil)	Scenario B1	
Pessimistic simulation (future stable oil price, decreasing Saudi production of oil)		Scenario B2

Source: KAPSARC.

This degree of diversification is measured by the level of KSA intermediate consumption, expressed as a percentage of the value of the infrastructure. In the no diversification case, this fraction is set at 0 percent in the future. In the diversification case, it shows a linear increase to 50 percent in 2050. The figure of 50 percent was chosen because intermediate consumption typically represents 50-60 percent of total construction sector turnover.

In Figure 3 the two groups of columns on the left represent the results obtained using Scenario B1. This configuration is especially favorable for the magnitude of the impact on growth of higher energy efficiency gains. In this context, exports of crude oil would stabilize around 7 million bbl/d until the 2050s. Oil income would increase significantly up to 2050, as shown in Figure 4, in the columns on the left.

Public finances would improve as a result of higher oil income (Figure 5, left). Saudi GNP would be 23 percent higher in 2050 than in a no reform scenario, corresponding to an increase in annual GNP growth of 0.65 percent on average over the period 2020-2049.

In Figure 3 the two groups of columns on the right show the results obtained with Scenario B2. This configuration corresponds to an especially adverse case for future KSA oil exports and, consequently, for oil income (Figure 4, columns on the right). Public finances would not improve significantly (Figure 5, right). The level of Saudi GNP would be 11 percent higher in 2050 than in the no reform scenario, corresponding to an average annual increase of 0.31 percent on average over the period 2020-2049.

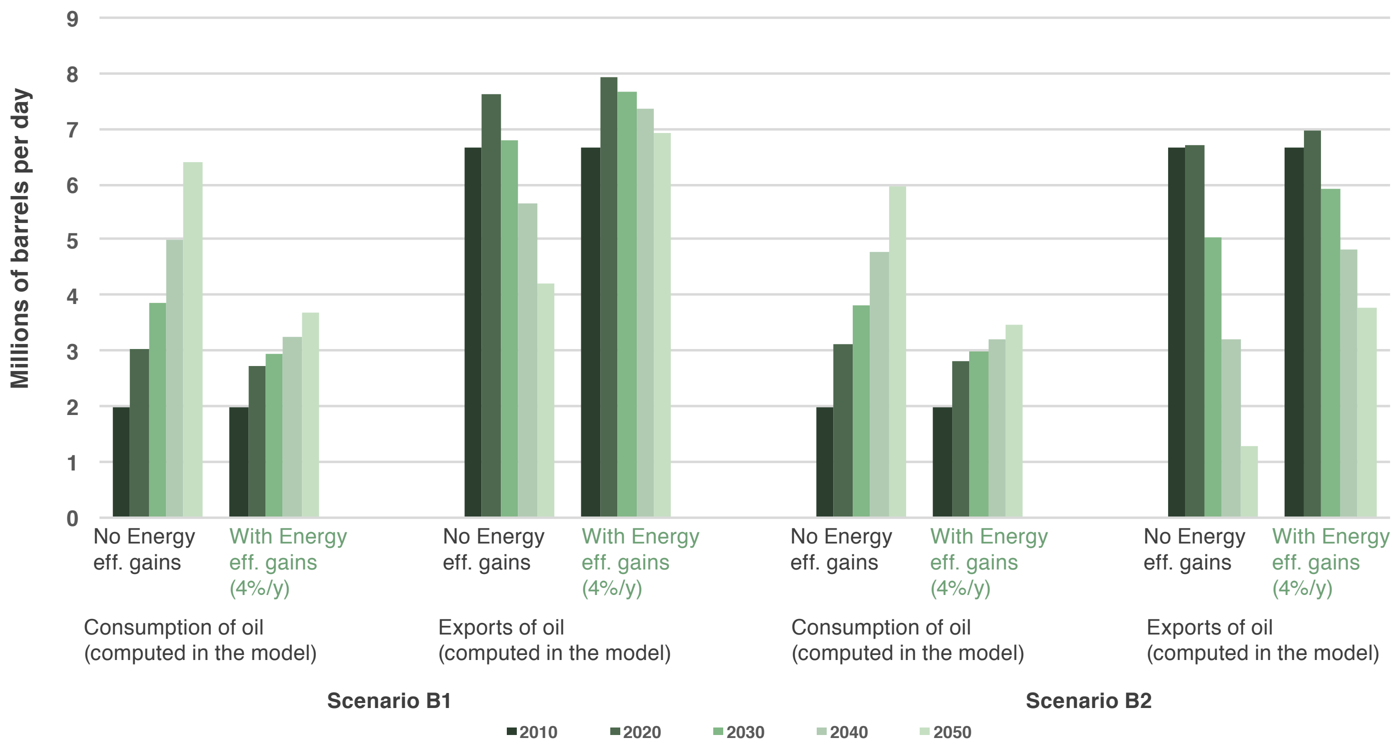


Figure 3. Impact of higher energy efficiency on simulated oil consumption, production and exports (Scenario B).

Source: KAPSARC.

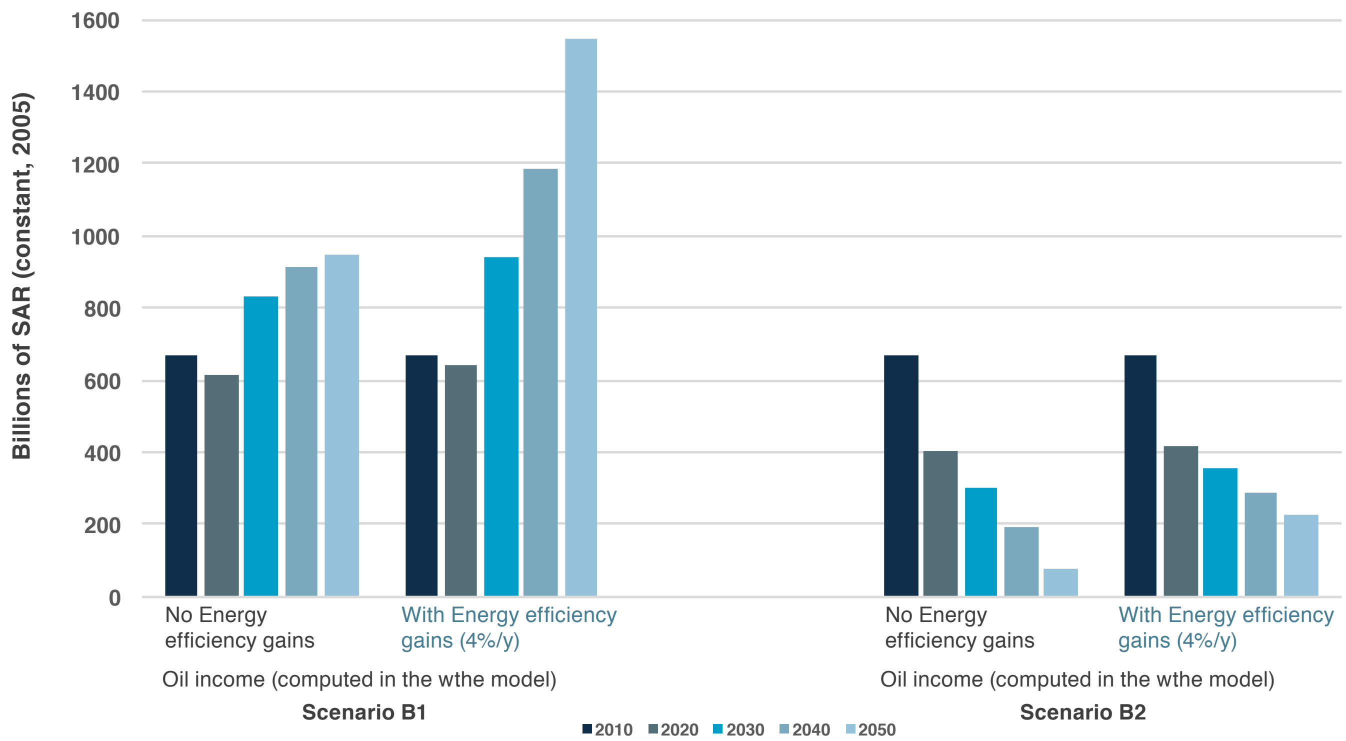


Figure 4. Impact of higher energy efficiency on simulated oil revenues (Scenario B).

Source: KAPSARC.

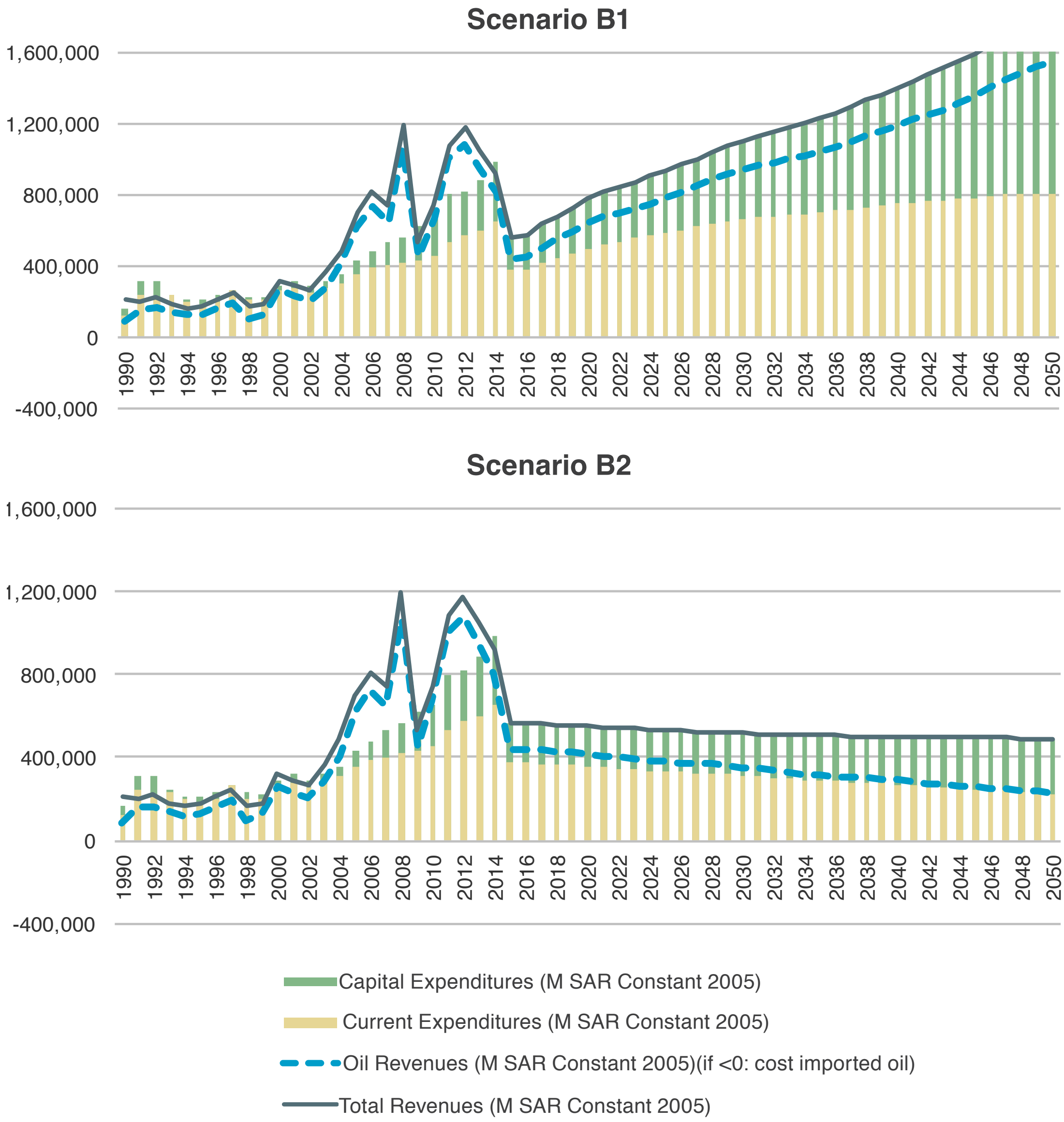


Figure 5. Saudi public finances (reform scenarios).

Note: All these variables are computed by the model for future periods (they are endogenous).

Source: KAPSARC.

These assumptions about the degree of diversification of the Saudi economy in the future significantly influence the impact on growth of higher public investment. It is perhaps noteworthy that, in the optimistic simulation (not shown here) on oil prices and volumes which includes no diversification of the Saudi economy in the future, GNP would be enhanced only by 0.46 percent per year, as against 0.65 percent in Scenario B1.

Scenario C: Higher Energy Efficiency and Higher Oil Income Recycled Through Current Public Spending

In Scenario C, the higher oil income resulting from greater energy efficiency gains is fully and immediately recycled into larger current public spending in a lump sum manner, with public capital expenditure remaining as in the no reform scenario.

In both the optimistic and pessimistic simulations, the impacts of higher energy efficiency gains on domestic demand for oil, exports of crude oil and oil income are close to those observed for Scenario B. For simplicity, these are not shown here.

However, by contrast to Scenario B, Saudi public finances would, by assumption, be characterized by a steep rise in public current expenditure, directly and positively increasing the income of the population Figure 6.

To quantify this, in the optimistic simulation, GNP would be 22 percent higher in 2050 than in a no reform scenario, corresponding to an average positive impact on GNP of 0.61 percent per year over 2020-2049. In the pessimistic simulation, GNP would be 9 percent higher in 2050 than in a no reform scenario, corresponding to an average increase of 0.28 percent per year over 2020-2049.

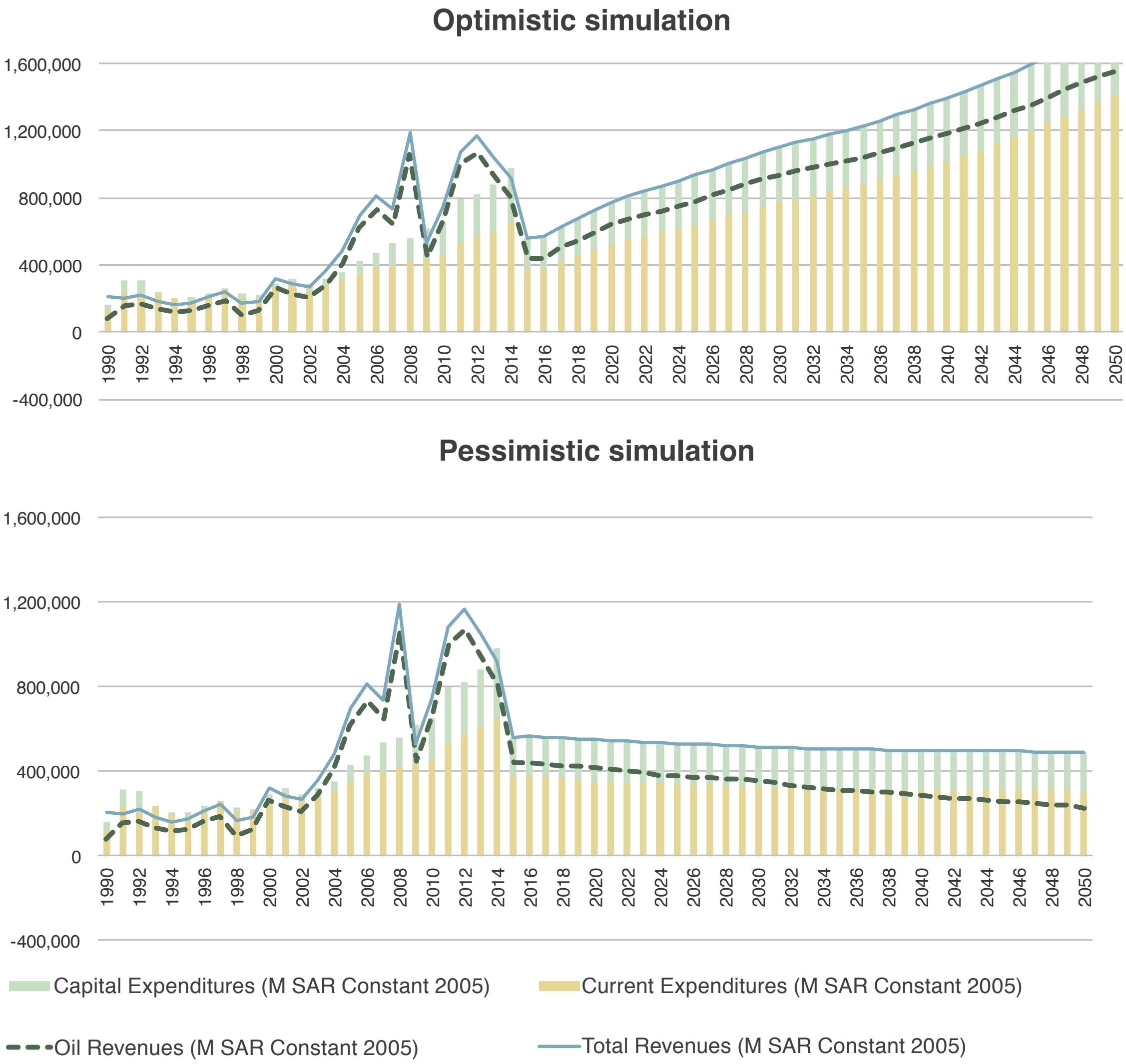


Figure 6. Saudi public finances (Scenario C).

Note: All these variables are computed by the model for future periods (they are endogenous).

Source: KAPSARC.

Prioritizing public investment or current spending: comparing the impacts on growth

In this section we compare the results from scenarios B and C. In the pessimistic simulation with future oil income lower than may currently be anticipated, Scenario B, with higher public investment, fosters more Saudi GNP than Scenario C, which has higher public spending. This holds true whatever the level of diversification of the Saudi economy (Figure 7a).

In the optimistic simulation, where future KSA oil income remains high, investing in infrastructure would only foster GNP more than current spending in the long run, provided that KSA diversifies its economy (Figure 7b).

These results correspond to how private agents may be expected to adapt when they anticipate that future oil income in KSA will be less favorable than they expected only a few years ago. Revised expectations increase the private saving rate, in order to smooth the impact of lower oil income on the consumption profile in the future.

Private capital accelerates. Since higher public investment bolsters the productivity of private capital and labor, the prospects for KSA oil income in the future are less favorable and public investments will bolster GNP further, as compared with current expenditure, all else being equal. This holds true all the more as diminishing future oil income reduces the increase in the amount of oil income flowing from higher energy efficiency and thus affects the growth of the associated higher current spending. By contrast, recycling a relatively high energy efficiency dividend in the next few years through public investments will benefit growth, as long as this recycling is used for infrastructure.

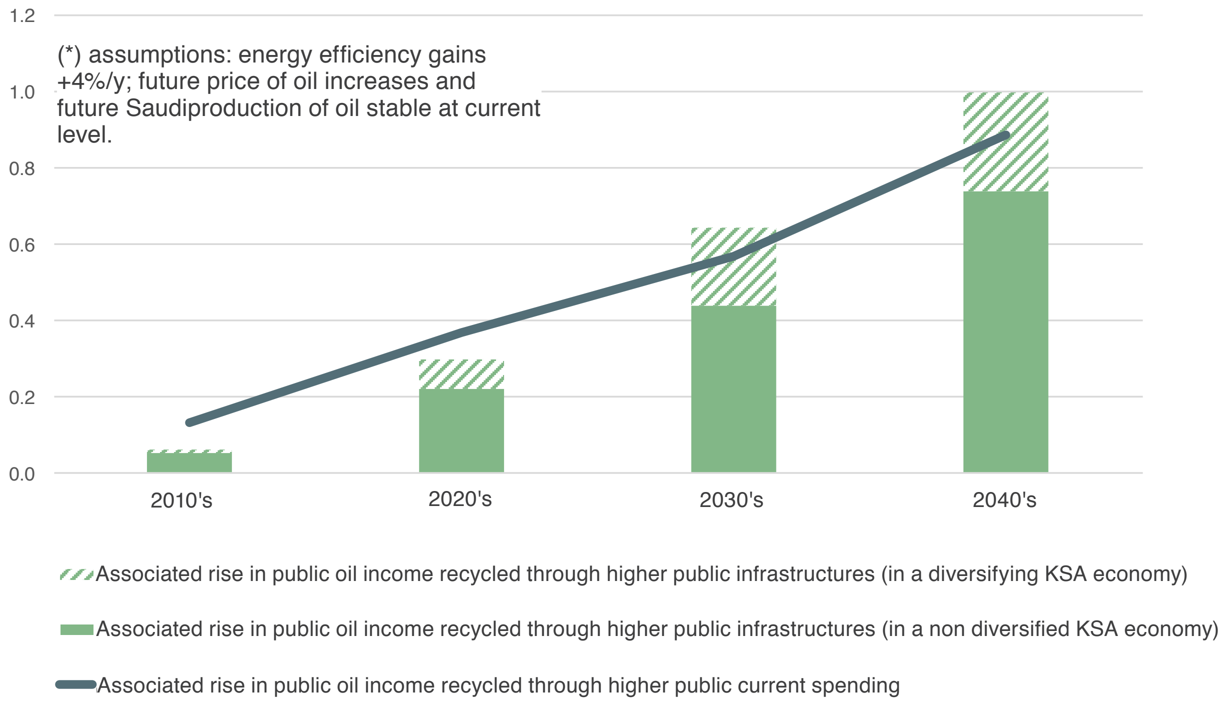


Figure 7a. Impact of higher energy efficiency gains on the GNP growth rate (optimistic simulation).Effect on the average annual growth rate of the Saudi GNP of a rise in energy efficiency from 2015 on (in %)(MEGIR-SA model)(*).

Source: KAPSARC.

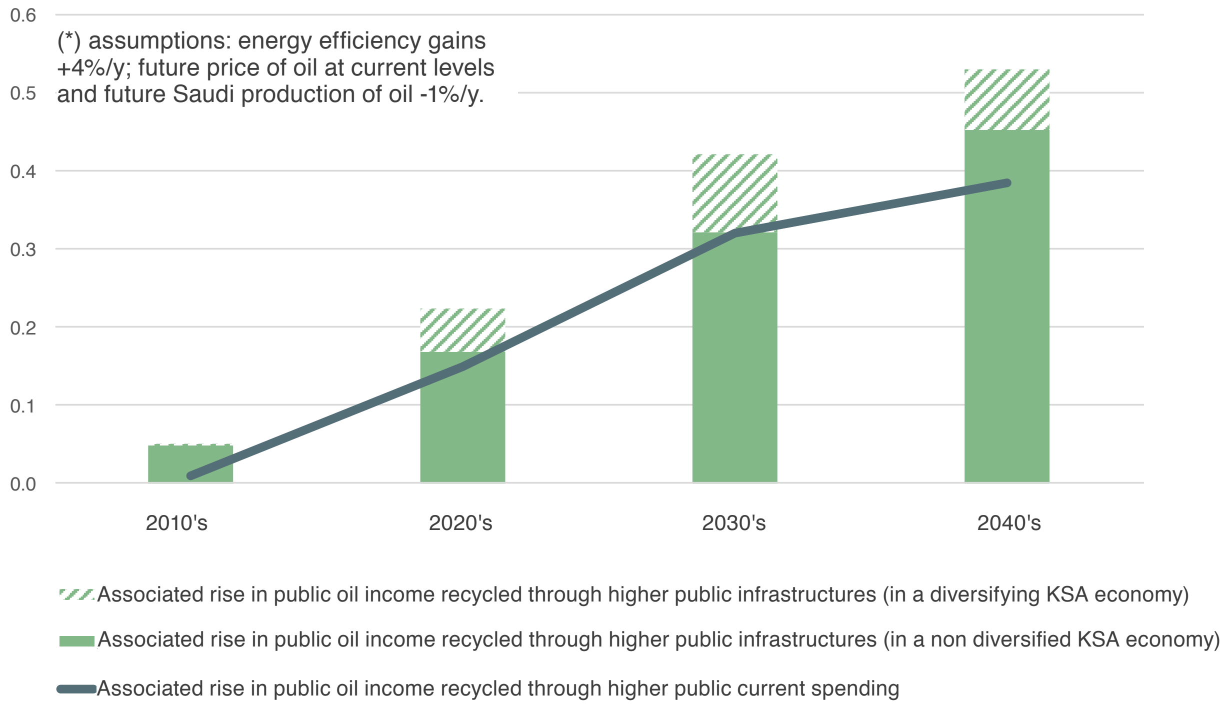


Figure 7b. Impact of higher energy efficiency gains on the GNP growth rate (pessimistic simulation).Effect on the average annual growth rate of the Saudi GNP of a rise in energy efficiency from 2015 on (in %)(MEGIR-SA model)(*).

Source: KAPSARC.

Distribution of the potential gains from enhanced energy productivity between age groups

With more than 75 percent of the population of Saudi Arabia under 40, it is relevant for policymakers to consider the intergenerational dimension of energy policy choices. This dimension can be assessed with MEGIR-SA by using its overlapping generations framework through an assessment of intertemporal welfare by age cohort. Intertemporal welfare is the discounted level of utility of the levels of consumption and leisure over the whole life span of a cohort, all born in the same year. It is a global well-being indicator of a generation over its life. Comparing the intertemporal welfare of each cohort in different scenarios allows for measuring the intergenerational redistributive effects of a policy.

Figures 8a and 8b display the impact of higher future energy efficiency gains on the intertemporal welfare of an average Saudi individual, depending on his/her age, and on future oil prices and production. Several significant results emerge:

> In all cases, most of the economic benefits of higher energy efficiency gains accrue to individuals currently under 30. The welfare effect is much less for those over 30.

> Under our pessimistic oil market and production scenario, the welfare benefit is higher when the larger oil income is reinvested in public capital spending. This holds true all the more under conditions of greater economic diversification.

> Under our more optimistic oil market and production assumptions, the gains from investment in capital and diversification are relatively close to those obtained with increasing annual public spending.

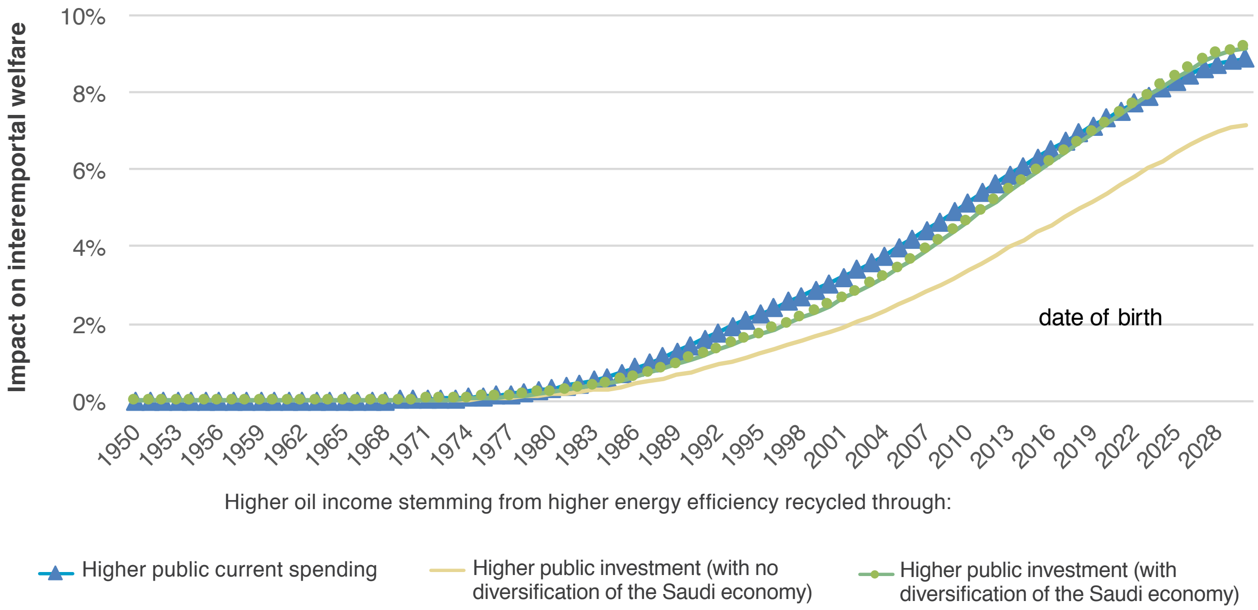


Figure 8a. Impact on households' welfare of higher energy efficiency gains. Optimistic simulation with ever increasing oil prices and stable, high Saudi production of oil.

Source: KAPSARC.

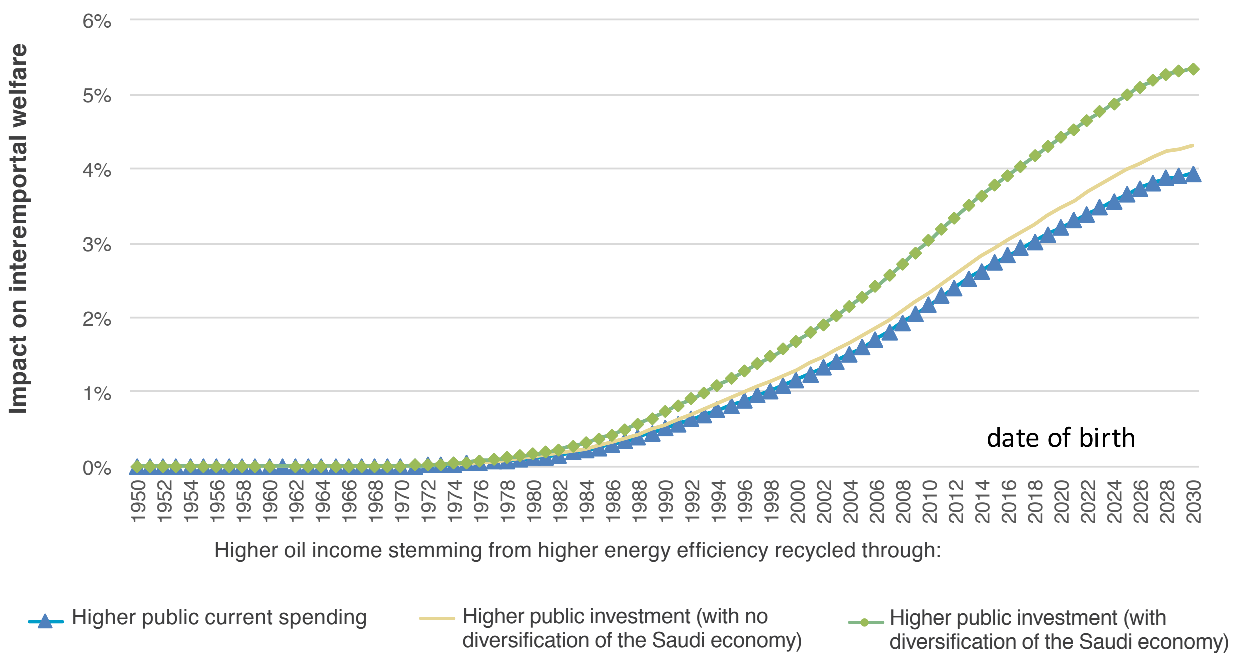


Figure 8b. Impact on households' welfare of higher energy efficiency gains. Pessimistic simulation with stable, low future oil prices and a slightly decreasing level of KSA oil production (-1%/y).

Source: KAPSARC.

Conclusion

Overall, this paper suggests that higher energy efficiency in KSA could potentially deliver significant benefits to long-run growth and fiscal sustainability. Even under pessimistic oil market and oil production conditions, the model suggests there is a benefit to recycling any extra oil revenues from avoided energy consumption into public investments that can help diversify the economy.

References

Galeotti Marzio, Nicholas Howarth and Alessandro Lanza, “Energy productivity in the GCC: Evidence from an international Kuznets curve analysis,” KAPSARC Discussion Paper, 2016.

Gonand Frédéric and Pierre-André Jouvet, ‘‘The "second dividend" and the demographic structure,’’ Journal of Environmental Economics and Management, v.72, 2015, pp.71-97.

Gonand Frédéric, “Macroeconomic and welfare effects of energy policies in Gulf countries: introducing the MEGIR-SA model for Saudi Arabia,” KAPSARC Discussion Paper, 2016.

Huppmann Daniel and Franziska Holz, “Crude oil market power – a shift in recent years ?” The Energy Journal, v.33(4), 2012.

Kilian Lutz, “Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market,” American Economic Review, v.99, 2009, pp.1053–1069.

Matar Walid, “Beyond the end-consumer: how would improvements in residential energy efficiency affect the power sector in Saudi Arabia?’’ Energy Efficiency, 2015, DOI 10.1007/s12053-015-9392-9.

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About the Project

Increasing energy productivity holds some of the greatest possibilities for enhancing the welfare countries get out of their energy systems. It also recasts energy efficiency in terms of boosting competitiveness and wealth, more powerfully conveying its profound benefits to society.

KAPSARC and UNESCWA have initiated this project to explore the energy productivity potential of the Arab region, starting with the six GCC countries and later extending to other countries.

Aimed at policymakers, this project highlights the social gains from energy productivity investments, where countries are currently at, and pathways to achieving improved performance in this area.

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