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Examination of the Electricity Pricing Change and the Development in Lao PDR: The GTAP-E Model Approach

Soukvisan Khinsamone

Business School of Hohai, Hohai University, Nanjing, China

E-mail: khinsamone@yahoo.com

Zhang Yang

Business School of Hohai, Hohai University, Nanjing, China

E-mail: zyang@hhu.edu.can

Visansack Khamphengvong

Department of Economic and Business Management,

National University of Laos, Lao PDR

E-mail: v.khamphengvong@nuol.edu.la

Sisabay Chanthasombath (Corresponding author)

Department of Energy Management, Ministry of Energy and Mines, Lao PDR

E-mail: sisabay1@gmail.com

Phongsili Soukchalern

Department of Economic and Business Management,

National University of Laos, Lao PDR

E-mail: phong.soukchalern@gmail.com

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Abstract

This study examines the impact of electricity price changes on the economic structure of Lao PDR, utilizing a disaggregated sectoral approach based on the GTAP-E model framework. The research aims to contribute insights into how variations in electricity pricing affect the country's economic development, trade, and welfare. We assess two scenarios: a baseline and a policy simulation, to achieve this. The baseline scenario subjects macroeconomic variables to exogenous shocks projected through 2030 using the Gdyn-E model. We set the policy simulation scenario for 2025 to 2028, which assumes an increase in electricity prices in line with the Lao government's announced policies. These scenarios provide a comprehensive understanding of the anticipated outcomes of electricity price adjustments.

Keywords: Electricity price, the development, the GTAP-E Model

1. Introduction

The energy sector in Lao PDR has been a key driver of the country's economic growth, with hydropower significantly contributing to an average GDP growth rate of 7% over the past decade. Although an estimated $11.4 billion in infrastructure investment is projected over the next ten years, this represents a promising opportunity to strengthen the nation's energy infrastructure and accelerate economic development (OECD, 2017). These initiatives highlight the critical role of sustainable energy development in shaping the nation's long-term prosperity (Macroeconomics, Trade and Investment Global Practice, 2022). To achieve sustainable development goals, the Lao government has prioritized expanding the share of renewable energy in its energy portfolio (United Nations Economic and Social Commission for Asia and the Pacific, 2023). Economic projections highlight the significance of developing robust regulatory frameworks to promote stability and prosperity, particularly in the energy industry. The country aims to have 50% of its renewable energy capacity by the year 2030 (Lao People's Democratic Republic Energy Sector Assessment, Strategy, and Road Map, 2019). Stakeholder engagement is often seen as critical to the success of energy projects (Asian Development Bank, 2021). Within the area of economic literature, a significant amount of attention has been paid to the complex relationship that exists between the development of energy and the expansion of the economy. This theory emphasizes the essential role that technological change plays in pushing economic progress. This change is driven by expenditures in human capital, creativity, and knowledge. It is impossible to separate these components from the process of energy production (Endogenous Technological Change on JSTOR, n.d.). Empirical data from various developing countries indicate that a 1% increase in energy infrastructure investment can lead to a 0.5% rise in GDP growth, underscoring the criticality of energy development in economic progression. Stern (2011) examines energy as an

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essential component in economic growth, showing its major role in manufacturing due to its integration in production processes, which influences economic output. The results indicate that energy availability and energetics are crucial for economic growth, especially in developing nations. Enhancements in energy efficiency have been associated with over 5% annual economic growth in certain regions of Sub-Saharan Africa. This underscores the necessity for developing nations to address their energy sectors to maintain economic growth. The effective utilization of substantial hydroelectric resources has been essential in the developmental path of Lao PDR (Goichot et al., 2023). Furthermore, the finding from empirical recent research in the Lao PDR underscores the importance of hydropower projects as drivers for sustainable development. Through infrastructure construction and electric access. Hydropower underscores the significance of renewable energy in fostering social and environmental advancement, thereby accelerating and sustaining inclusive development. The corrective work represented a novel and inventive scope of work, aimed at rectifying development projects that facilitated rural electrification and infrastructure enhancement. Hydropower, with the primary benefit of poverty reduction, is an important part of the long-term development strategy for Lao PDR. Despite such geopolitical challenges, hydropower remains a centerpiece in bringing together communities and enabling conducive development across the country through many important reforms and policies focused on environmental issues (Deed - Attribution 3.0 IGO - Creative Commons, n.d.).

2. Literature Review

Numerous studies have been carried out on the subject of fluctuations in the cost of electricity, which has helped shed light on the complexity of energy market reforms in a variety of different situations. Studies in other regions, such as by Yin et al. (2019) and Hao et al. (2024) conducted a noteworthy study that explores the consequences of electricity market reform, focusing enhanced efficiency and the possible effects on consumer welfare. Research from Borenstein (2013) indicated the pricing strategy has the potential to enhance the efficiency of the electricity supply system and promote increased investment in cleaner energy technologies. It is crucial for pricing strategies and subsidies to align effectively; insufficient subsidies may hinder investments in renewable energy. (Lobel & Perakis, 2011). Lin, B. Q. (2006) provided a comprehensive study of the effects of rising electricity prices, the results suggested that manufacturing companies are especially exposed to variations in electricity prices, given that energy expenditures form a large share of their operational costs. Additionally, the overall effect on society's total price level stayed largely unchanged. The results demonstrate the complex relationship between changes to energy prices and how they affect commodities markets and economic stability (Taghizadeh-Hesary, 2024). The paper by Song (2011) examined the correlation between power costs and the general price level in China utilizing an input-output table. The research indicated that slight escalations in power costs had minimal influence on inflation, implying that the economy can accommodate minor price alterations without considerable disturbances.

The electricity price policy in Lao PDR has had multiple modifications in recent years as the government aims to achieve a balance between economic development, energy sustainability, and social equality. The nation's power sector has historically depended on subsidies to maintain low prices for residential consumers and industries. The changes in electricity pricing strategy have an impact on several spheres of society. Attempts to set tiered pricing or subsidies for domestic users aim to guarantee cheap energy access while keeping export income. Through cross-border trade, particularly with Thailand and Vietnam, the hydroelectric sector which dominates energy generation in Laos helps to boost GDP. Still, domestic electricity rates remain among Southeast Asia's lowest, creating a disparity between local economic stimulus and export-driven income. Pricing policies also impact programs for rural electrification as well as energy-intensive businesses. Rising energy prices could boost cash sources for infrastructure construction but make energy less affordable for low-income homes. As stated in the strategic energy and development plans of the nation, these dynamics are crucial for reaching the objective of sustainable economic growth and correcting welfare inequalities (World Bank, 2023). Recent policy revisions have underlined the move from subsidized tariffs to cost-reflective pricing. This shift aims to better match electricity pricing with the expenses of energy generation, including hydropower resource costs and environmental effects (ADB Annual Report 2019, 2020). The Lao government has looked at tiered pricing systems, which let low-income households get subsidized rates while those with more use pay market-based rates. This change is judged necessary to solve budgetary problems and promote sustainable development in the energy sector (Milattanapheng et al., 2010). The implementation of elevated rates poses a problem to household energy affordability, especially for low-income people. To shield economically disadvantaged populations from the complete effects of price increases, the use of tiered pricing systems and targeted subsidies has been proposed (Burniaux & Truong, 2002).

The simulation scenario identifies both positive and negative policy effects and analyzes their possible consequences on economic parameters. Competitive electricity costs could boost Laos's worldwide commercial appeal. Manufacturing and other power-dependent firms are price-sensitive. Competitive power pricing may help Laos attract foreign investment, ensuring capital and skills. This might boost production and exports, boosting the Lao economy and international trade. High power prices may diminish Lao products' global competitiveness, limiting exports and economic growth. A policy simulation scenario includes policy tweaks or external shocks to examine their economic impact. This study examines how power pricing policy changes affect Lao PDR's economy, trade, and welfare. The energy sector shapes a nation's economic development, therefore changes in domestic electricity pricing can affect economic performance, trade dynamics, and social welfare. Computable general equilibrium (CGE) modeling and dynamic pricing strategy analysis provide comprehensive insights. This strategy helps identify appropriate power sector growth pathways, balances sustainability, improves market efficiency, and assesses socioeconomic implications. Laos has made major energy infrastructure changes. Policymakers must grasp these complicated relationships to design frameworks that promote sustainable national growth and economic resilience.

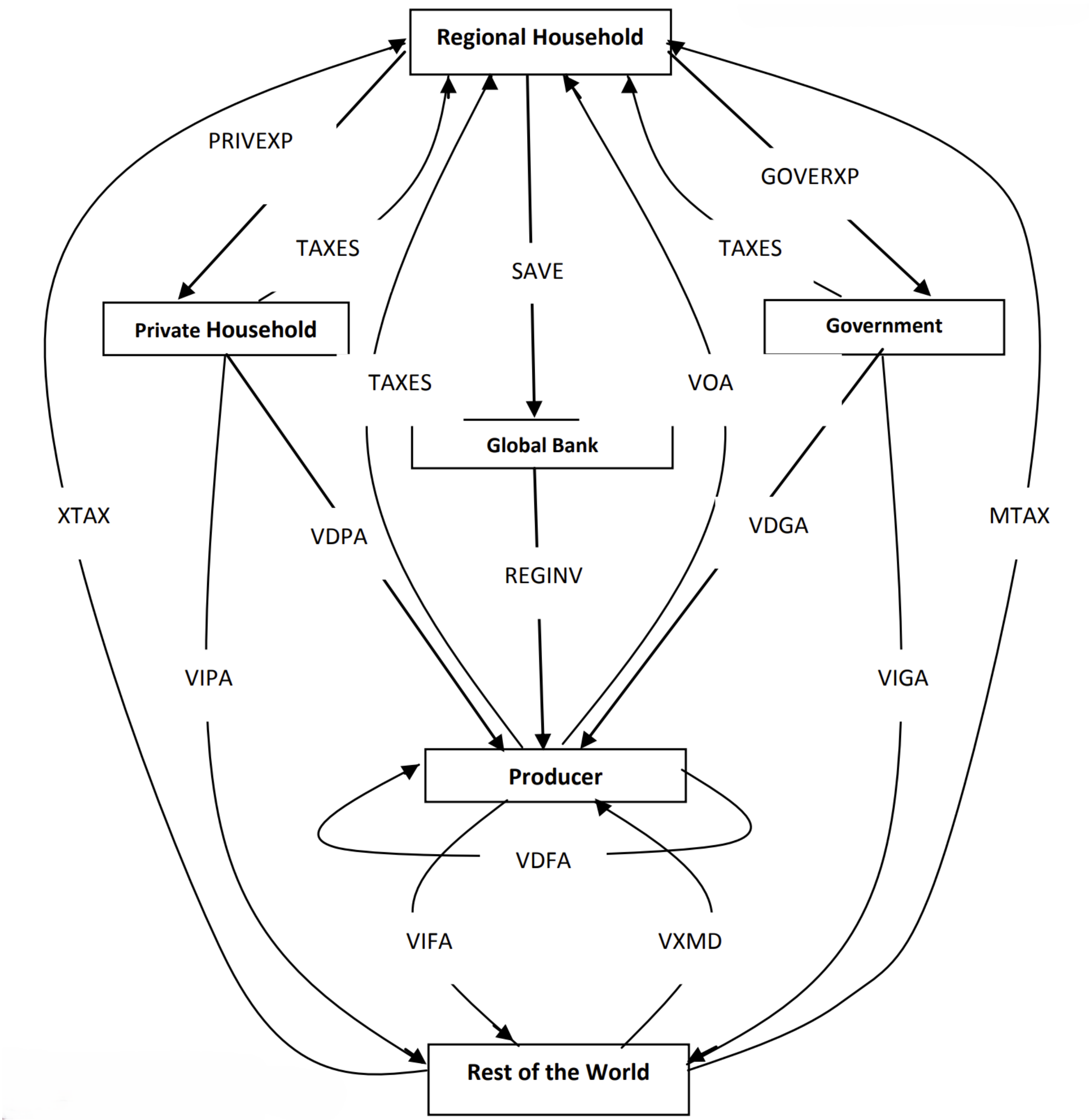
3. Method and Data

3.1 Model Description

This study examines the medium-term impact of electricity price policy on each macroeconomic, including economic growth, trade, and welfare. We applied the environmental version of the dynamic GTAP model, called "Gdyn-E". The dynamic GTAP-E (Gdyn-E) is combined between dynamic GTAP, developed by Ianchovichina and McDougall (2001) and GTAP-E model, proposed by Burniaux and Truong (2002) and McDougall and Golub (2007).

In addition to maintaining all of the standard features of the GTAP model, such as perfect competition, Armington trade flows, disaggregated import usage by activity, non-homothetic consumer demands, and explicit modeling of international trade and transport, the Dynamic GTAP (GTAP-Dyn) is a recursive-dynamic extension of the standard GTAP (Hertel, 1997) that improves the investment theory by incorporating international capital mobility and ownership (Ianchovichina & McDougall, 2012). The activity patterns of an open economy in the dynamic GTAP model are depicted in figure 1.

A disequilibrium approach to modeling endogenously transnational capital mobility is introduced by an adaptive expectations theory of investments. Because time is a variable rather than an index, it facilitates a recursive solution process and makes it simple to include the dynamic into the traditional GTAP model with only minor modifications. The GTAP-Dyn model tracks international capital movement and foreign wealth using the regular GTAP data base, which is enhanced with foreign income data from IMF Balance of Payments statistics and a new parameters file required for the dynamic theory (Antimiani et al., 2013).

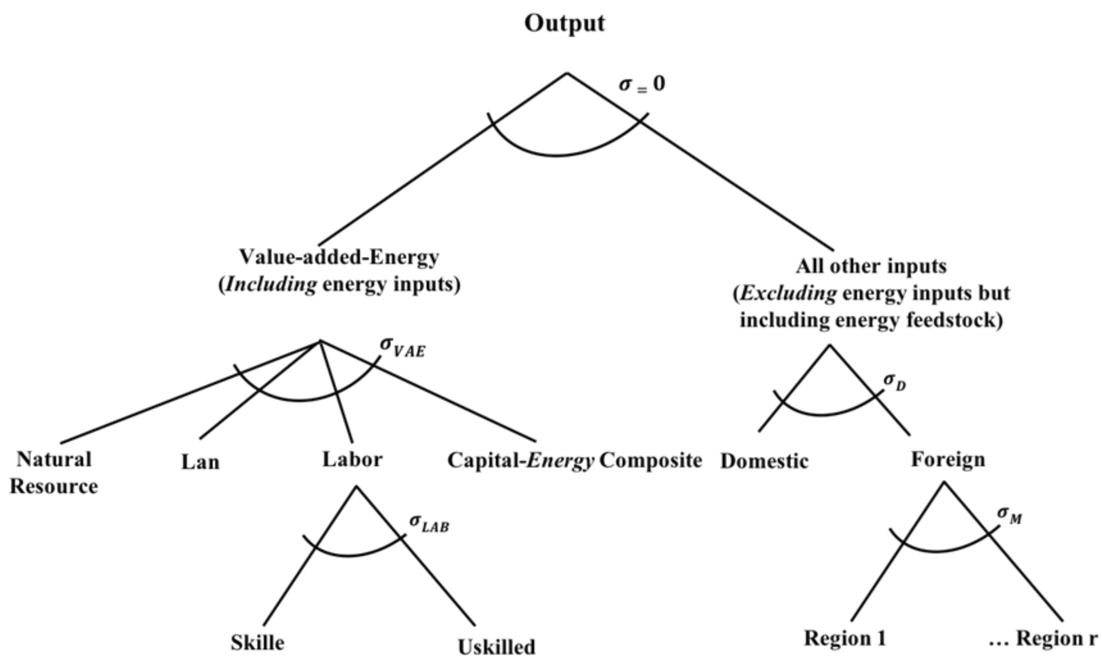


Source: Brockmeier, 1996.

Figure 1. Multi region open economy

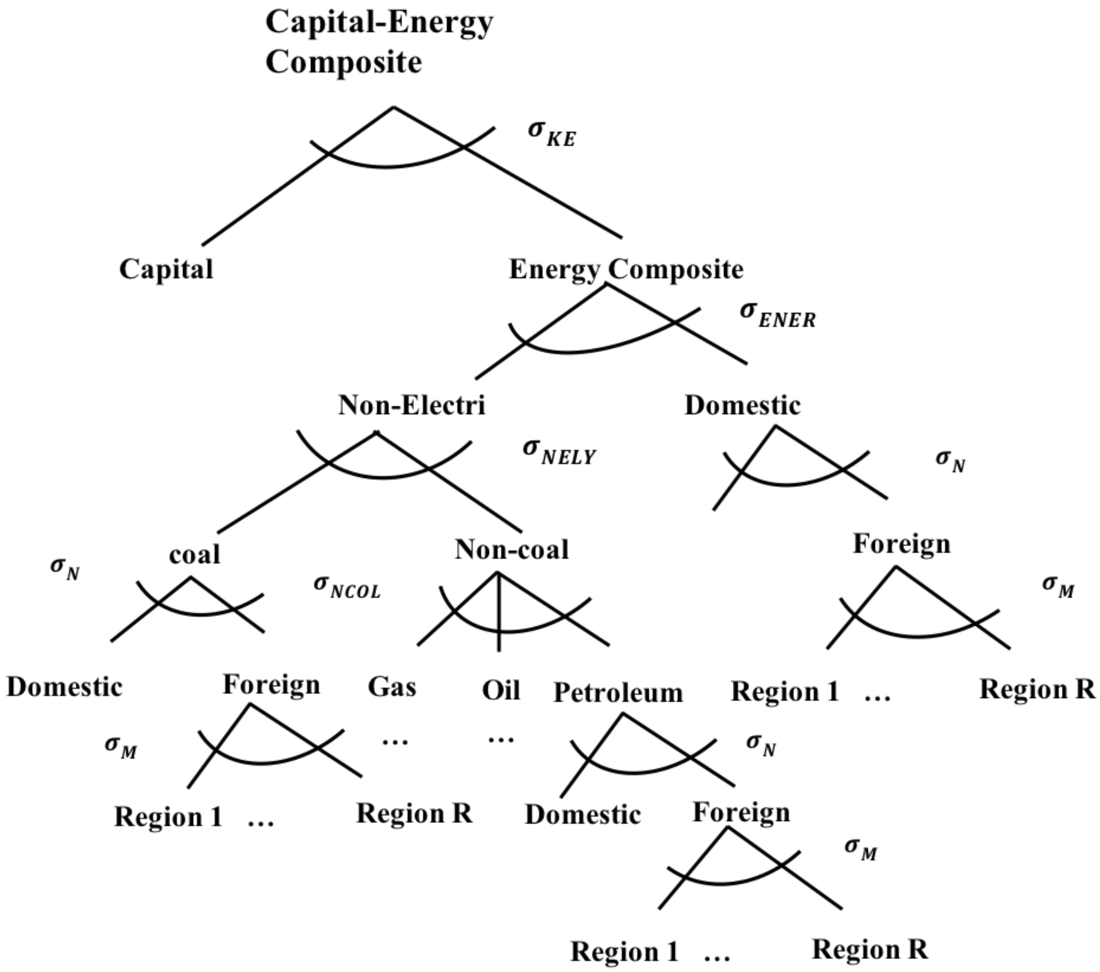
However, an energy-environmental variant of the classic GTAP model is the computable general equilibrium GTAP-E model (Burniaux & Truong, 2002; McDougall & Golub, 2007). It covers energy demand explicitly as well as the potential for inter-factor and inter-fuel substitution. The GTAP-E model also differs from the former in that energy commodities are taken out of the intermediate input nest and added to the value-added nest, whereas the former does not account for the substitution structure between intermediate goods and primary factors (Higashi et al., 2022).

The GTAP-E model divides energy commodities into two categories: electricity and nonelectricity. Coal and noncoal groupings are further subdivided from the nonelectricity group. Oil, gas, and petroleum products are examples of noncoal groups. Figure 2 displays the GTAP-E model's production structures, while Figure 3 provides a more thorough explanation of the Capital-Energy Composite.



Source: Burniaux and Truong, 2002.

Figure 2. Production structure of the GTAP-E model



Source: Burniaux and Truong, 2002.

Figure 3. Capital-energy composite structure of GTAP-E model.

3.1 Regional and Sectoral Aggregation

The GTAP database version 9 can use to analyze the regions up to 140 regions and 57 sectors. Since this study focuses on the impact of the electricity price policy of the government of Laos on the economy, the regional aggregation is mainly focused on Laos, and the 139 remaining regions are categorized into a group, namely "Rest of the World". As far as sectoral aggregation is concerned, in addition to the energy sectors such as coal, crude oil, gas, refined oil products, and electricity, we use the default sectors as they single out agriculture, energy-intensive industries, and other industries and services.

Table 1. Regional and sectoral aggregation

Regions	Sectors
Lao PDR	Coal
Rest of the World	Crude oil
	Gas
	refined oil products
	electricity
	Agriculture
	Energy intensive industries
	Other industries and services

Source: Authors.

3.2 Scenario Development

In order to examine the impact of electricity price policy on the economy, trade, and welfare. We develop two scenarios, namely baseline and policy simulation. In the baseline scenario, we shock the exogenous variables up to 2030, which is the key macroeconomic variables important for the Gdyn-E model. While in the policy simulation scenario, we assume the consumer to consume the higher electricity price from 2025 to 2028 by 7.05% annually. This assumption is made upon the announced policy of the government of Laos and the Ministry of Energy and Mines (MEM) since 2011. As mentioned, if we look at the supply side of electricity, Laos relies on the hydropower projects for producing electricity. Most of the projects are joint ventures between the government of Laos and foreign investors. Since the COVID-19 pandemic ended in late 2022, Lao economic development has faced a lot of challenges, especially the pressure from the high inflation rate, which results in the high cost of business operations. The government of Laos and the Ministry of Energy and Mines (MEM) announce the policy in early 2024, aiming to increase the domestic electricity price for the consumer. So, this policy simulation scenario objective is to assess the impact of this announced policy on the Lao economy, trade, and community's welfare. The key assumptions of the scenarios are summarized in Table 2.

Table 2. Scenario's assumption

Scenario	Key assumption
Baseline	This scenario considers as business as usual scenario. We update the exogenous variables such as real GDP growth rate, Population, labor force (skilled and unskilled labor) up to 2030.
Policy simulation	This scenario investigates the policy shock of electricity price by assuming the increase in the electricity price 7.05% annually during the period of 2025 to 2028[1].

Source: Authors' summation.

3.3 Data

This study using the GTAP 9.0 database, which base year is 2011. We employed the data from different sources for developing the baseline scenario, such as World Bank, International Monetary Fund, and United Nation database. The obtained data, such as real GDP growth, Population, labor force (skilled and unskilled labor) are used to update the reference up to 2023, and its projection until 2030. The reasons we deploy the projection period ending at 2030 are first is to ensure the validity of the data due to most of international organization such as World Bank and International Monetary Fund project economic growth of each country until 2030. Second is due to this study aim to assess the impact of electricity pricing policy in short and medium-term, and third is due to the uncertainty of the electricity pricing policy of the government of Laos.

4. Results

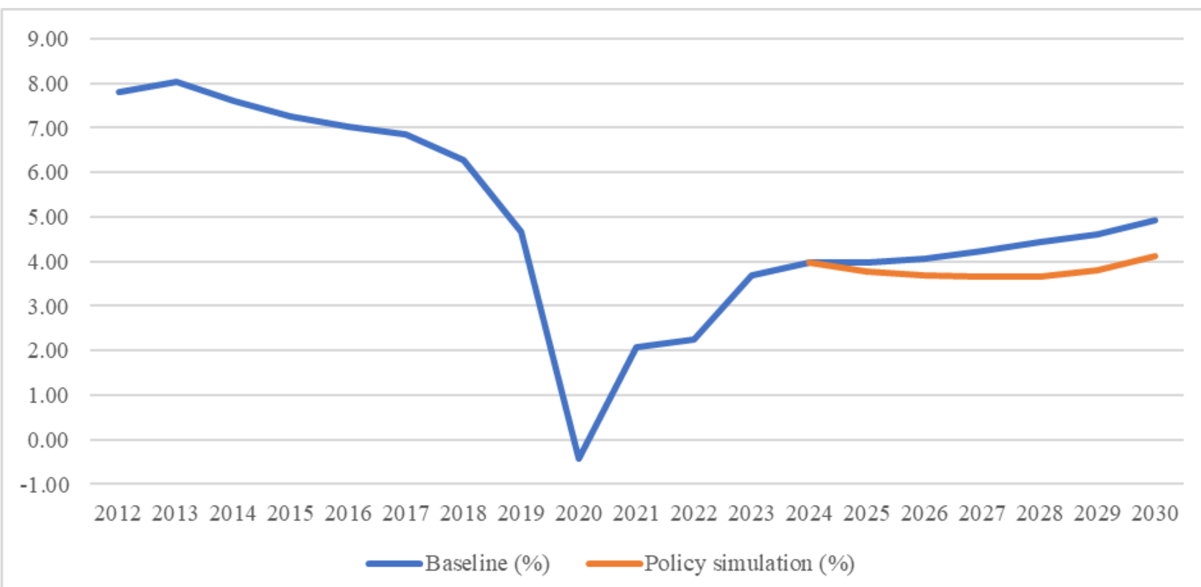
4.1 The Impact on Economy

According to figure 4, it reports the results of assessing the impact of implementing electricity price policy on economic growth of Lao PDR. In the baseline scenario, the GDP growth rate depicts a steady decline from 2012 to 2020, and a negative growth rate (-0.43%) is occurred in 2020 due to it is hit by the COVID-19 pandemic. In post 2020, the economy of the country is in the recovery period, and its growth rate rebound to 3.69% in 2023. Furthermore, from 2024

[1] This electricity price is calculated by the authors based on the electricity price policy of government of Laos.

onward, it is the projected period, and the GDP growth rate is estimated to be 4.93% in 2030.

On the other hand, the policy simulation scenario, introduce the shock of increasing electricity price, which is the government plan to implement during the period of 2025 to 2028. The findings reveal the negative impact on economic growth relative to the baseline scenario. In 2025, the economic growth rate in the policy simulation is estimated to be 3.77% lower than 3.97% in the baseline scenario, and the gap between both scenarios is 0.2%. in addition, the impact is estimated to increase to 0.81% in 2030. This suggesting that an increasing in electricity price can lead to hurt the economic growth, and its effects can last in the long term. Furthermore, energy is a critical input for all sector of the country, and an increase in electricity prices not only raises production costs but also reduces disposable income for households, hitting domestic consumption and investment. This result in line with the study of D. Stern I. et al. (2019), Takentsi et al. (2022), Abbasi et al. (2021), Jamil and Ahmad (2010), and Sato and Dechezleprêtre (2015).



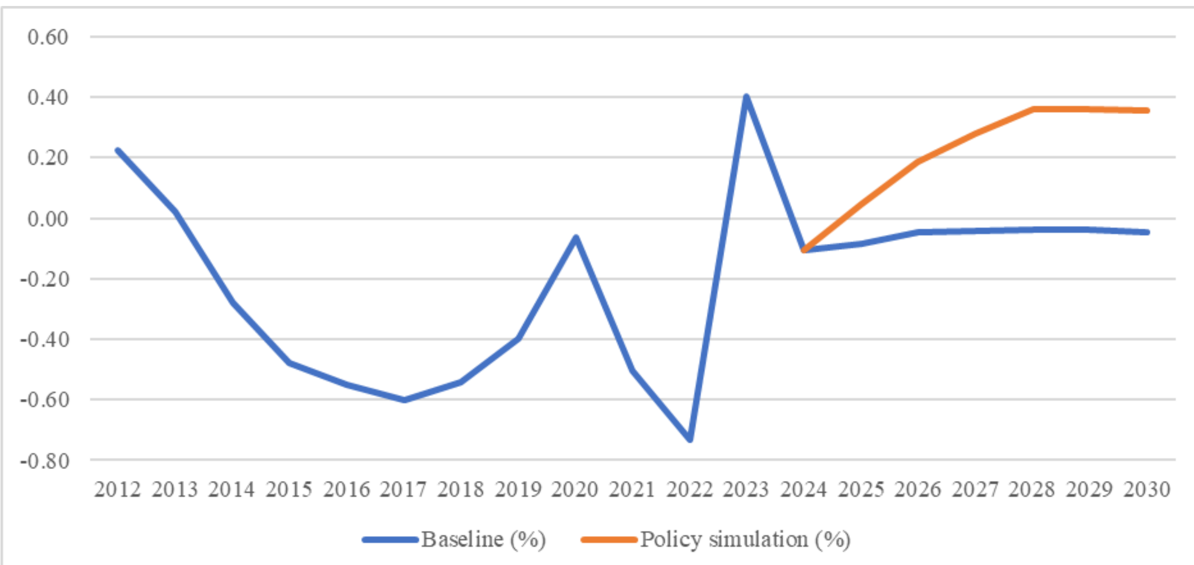
Notes: Author’s estimates.

Figure 4. Economic impacts from electric price shock

4.2 The Impact on Trade

We further estimate the impact of electricity price shock on the term of trade. The findings are depicted in figure 5. According to the figure, we found that there is a gradual decreasing in the trade of Lao PDR from 2012 to 2022, and it is reaching -0.73% in 2023. Notably, the baseline shows the substantial recover in 2023 to be 0.40% compared to 2022. However, a significant decline is also found in 2024, resulting 0.51% decreasing in the growth of trade. Moreover, the baseline projects the term of trade to growth by -0.05% in 2030.

In the policy simulation scenario, where the electricity price policy is introduced. The results depict an increasing trend in the growth of trade, indicating a positive impact on the term of trade. In 2025, the growth rate of the term of trade is projected to be 0.05, and it is continually increasing to reach 0.35% in 2030. This may due to Laos's export is mainly driven by the electricity of hydropower sector. So, an increasing in electricity price can push the electricity export's potential of the country. This finding support by the work of He et al. (2010), and Wang and Lin (2021).



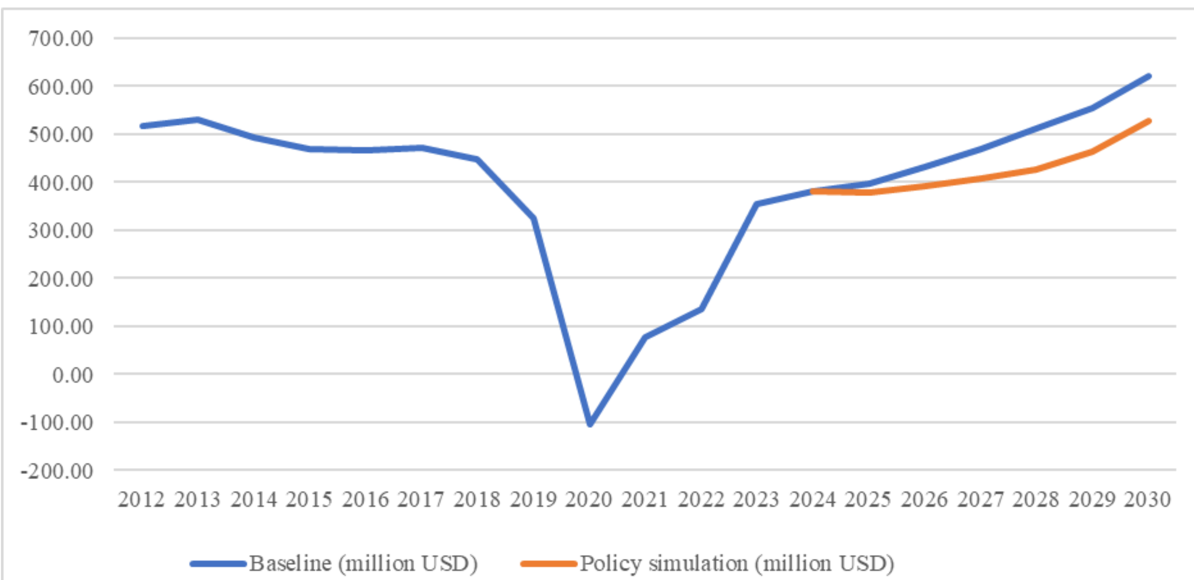
Note: author's estimates.

Figure 5. Trade impacts from electric price shock

4.3 The Impact on Welfare

Figure 6 reports the results of impact of electricity price increase on welfare in Lao PDR, measured in millions of USD. In the baseline scenario, the welfare in the country experiences a steady decline, decreasing from 517.77 million USD in 2012 to 323.89 million USD in 2019. In addition, there is a significant falling of welfare in 2020 due to the COVID-19 pandemic, reaching -105.52 million USD. After 2020, the welfare recovers significantly, reaching 353.73 million USD in 2023, and continue on an upward trend. Moreover, the baseline is projected to reach 621.78 million USD in 2030.

However, when an increasing electricity price is introduced during 2025 to 2028 in the policy simulation scenario, the findings indicate the declining in the welfare relative to the baseline scenario. In 2025, the welfare is 379.17 million USD, lower than the baseline by 19.02 million USD. Furthermore, the gap between both scenarios continues increasing, and in 2030, the welfare decreasing from 621.78 million USD in the baseline to 527.62 million USD in the policy simulation scenario, which the impact is estimated to be 94.16 million USD approximately. In conclude, the results indicating the negative impact on welfare of the country when the planned electricity price policy of the government of Laos is employed. The findings suggests that higher electricity prices may reduce household’s income, increase costs of production for firms, and constrain overall consumption, which leads to a reduction in welfare. Furthermore, its impact can reduce economic activities and efficiency, especially for energy-intensive industries. This results in line with the work of Qeqe et al. (2022), Pacudan and Hamdan (2019), Maboshe et al. (2018), and E. Ianchovichina and McDougall (2000).



Note: author’s estimates.

Figure 6. Welfare impacts from electric price shock

5. Conclusion and Discussion

This study examines how power pricing policy changes affect Lao PDR’s economy, trade, and welfare. We applied an environmental version of dynamic GTAP model. The study develops the policy scenario by composing the electric price policy issued by the Ministry of Energy and Mine. The findings indicate that rising power costs have a negative influence on economic expansion, as demonstrated by the large decline in GDP when compared to the condition that existed before the effects of the rising power costs were observed. In a similar, the policy simulation scenario leads to a significant loss in welfare. This is because rising power costs result in a decrease in household income and an increase in living expenses, which in turn has an effect on people with low incomes and enterprises that rely heavily on energy. On the other hand, the policy simulation suggested that there was an increase in trade within the country. The rise in the cost of energy has the effect of enhancing the export potential of hydropower, which is the primary factor that drives trade in the Lao People's Democratic Republic. Despite the fact that increased electricity costs have a negative impact on the local economy, increased export earnings from power adds to the improvement of the nation's trade balance.

To address this, the policymakers should consider adopting a balanced approach in order to address this issue. It is possible that this could involve the implementation of targeted subsidies for households who are susceptible, in addition to measures that encourage energy efficiency and reduce reliance on expensive electricity during periods that are not characterized by a pandemic. The negative effects on welfare would be mitigated as a result of this, while the good contributions that the policy makes to commerce and government finances would be preserved.

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