Impact of energy investment on sectoral growth in Algeria. An empirical approach using the Social Accounting Matrix (SAM) multiplier model.

تأثير الاستثمار الطاقوي على النمو القطاعي في الجزائر. منهج تجريبي باستخدام نموذج مضاعفات مصفوفة المحاسبة الاجتماعية

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Abstract:

This article aims to assess the impact of energy investments on the Algerian economy by analyzing the intersectoral changes induced by variations in investments in this sector. Using the multipliers of the Social Accounting Matrix (SAM 2021), our study reveals that investments in the energy sector have a slightly positive effect on the country's economic growth. Increased public investments in this sector generally result in positive effects on all sectors of activity, production factors, and institutional sectors, although these effects are relatively modest. Our results indicate that this effect is more pronounced for the energy, agriculture, Food processing industries, ISMMEE, hydrocarbons, construction, transportation, communication, hospitality, and restaurant sectors. Furthermore, the distributive impact is more significant on capital remuneration through business income.

Keys words: Energy investment, Intersectoral, Economic growth, SAM Multipliers.

JEL classification codes: O13, D24, O40, C67.

ملخص:

تهدف هذه المقالة إلى تقييم تأثير الاستثمارات الطاقوية على الاقتصاد الجزائري من خلال تحليل التغيرات بين القطاعات الناتجة عن التباينات في الاستثمارات في هذا القطاع. باستخدام مضاعفات المصفوفة الاجتماعية للحسابات 2021، تكشف دراستنا أن الاستثمارات في قطاع الطاقة لها تأثير إيجابي بشكل طفيف على نمو الاقتصاد في البلاد. تؤدي الاستثمارات العامة المتزايدة في هذا القطاع عمومًا إلى آثار إيجابية على جميع قطاعات النشاط، وعوامل الإنتاج، والقطاعات المؤسسية، على الرغم من أن هذه الآثار متواضعة نسبيًا. تشير نتائجنا إلى أن هذا التأثير أكثر وضوحًا في القطاعات التالية: الطاقة، والزراعة، صناعات تصنيع المواد الغذائية، المحروقات، البناء، النقل، الاتصالات، الضيافة والمطاعم. علاوة على ذلك، فإن التأثير التوزيعي أكبر على مكافأة رأس المال من خلال دخل الأعمال المؤسسات.

الكلمات المفتاحية: استثمار الطاقة، بين القطاعات، النمو الاقتصادي، مضاعفات SAM

تصنيف JEL: O13, D24, O40, C67.

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1-Introduction

Energy plays a crucial role in the development process of any nation, becoming an essential necessity for all activities of economic agents, including their daily needs. The availability of a sufficient quantity and quality of electrical energy, according to Hounkpatin (2013), promotes the comfort and well-being of households, while stimulating the development of craftsmanship, industries, small and medium-sized enterprises, as well as administrative services, information technology, and communication. The experience of developed countries highlights the paramount role of energy in economic development, both as a primary input in industrial development and as a key factor in improving the quality of life of populations (Ndiaye O. H., 2018).

Thus, energy economics has garnered increasing interest in economic research, notably due to the severity of energy crises (1973, 1979, 1986, 1985, and 2006), the persistence of the importance of energy resources in production, and especially in the current context of the crisis in Ukraine, where energy has become a formidable weapon. Algeria, aware of the importance of energy in its economy, has since its independence opted for the development of the energy sector, as part of a national policy aiming to improve electrical and gas infrastructure and to guarantee the population's access to electricity and natural gas, considered an absolute priority for improving the standard of living and the economic situation of the country.

However, the energy sector in Algeria is still characterized by limited access to modern energy services, insufficient infrastructure, low purchasing power, reduced investments, and excessive dependence on traditional biomass. In the early 2000s, Algeria recognized the need for increased efficiency in the water and electricity industries, with ongoing reforms to achieve this. This period also saw a growing awareness of environmental issues, which motivated these reforms.

In this context, this article aims to study the impact of energy investment on the Algerian economy by quantifying the intersectoral changes induced by a variation in the quantity of energy. To do so, we adopt an empirical approach based on the Social Accounting Matrix (SAM) multiplier model for the year 2021. The choice of this approach is justified by the fact that SAM multiplier models provide a comprehensive macroeconomic analysis by providing a detailed structure of the economy with all its sectors, and by taking into account the direct, indirect, feedback, and spillover effects of a sector on the rest of the economy through the interdependence of SAM accounts.

This article is structured in two parts. The first provides a review of theoretical and empirical literature on the role of energy in economic growth, presenting the main relevant theories and empirical studies. The second part focuses on empirical analysis, starting with an introduction of the SAM and multiplier model, followed by the methodology for developing the disaggregated SAM (2021) for Algeria and deriving the multipliers. Then, we present the empirical simulation and key results. Finally, a conclusion summarizes the main findings and provides recommendations.

2. Literature review on the role of energy in economic growth

Understanding the links between investment in the energy sector and economic growth requires a thorough analysis of the existing literature, covering various theories and empirical works on the subject. This literature review is essential for grasping the evolution of ideas in this specific field, which will enable us to select the appropriate methodology to achieve the objectives of this article.

2.1. Review of Economic Theories

The issue of the relationship between economic growth and electrical energy traces its origins back to the late 18th century with the Industrial Revolution. This period, characterized by the increasing use of new energy sources and energy-intensive machinery, sparked the interest of classical and neoclassical authors in the role of energy in the economy, although they did not directly integrate energy as a factor of production into their models. Adam Smith, in his theory of value, notably emphasized that the value of a good depends solely on the amount of labor required for its production, which led to an implicit underestimation of the role of energy during this period of industrial revolution. Despite attempts by thinkers like Jean Baptiste Say and Ricardo to examine productivity gains resulting from the use of machinery, no convincing conclusion was drawn at that time.

However, it was from the pioneering work of Stanley Jevons in 1865, which highlighted the impact of coal availability on industrial development in the United Kingdom, that energy was explicitly introduced into economic analysis. Despite this warning about the importance of energy for economic growth, classical and neoclassical theory did not always consider energy as a determining factor of national production, preferring to focus on labor, capital, and land (later integrated into the capital factor).

With the emergence of new theories of economic growth, the role of energy in the production process was often overlooked. Theorists of endogenous growth, such as Solow, Barro, Becker, and Romer, explained the performance of nations based on other endogenous factors, such as technological progress, innovation, public expenditure, human capital, and learning by doing. This trend persisted until the advent of the oil crisis in 1973. It was only from the 1960s, with the first explicit works on the economic analysis of energy that energy began to be seriously considered as a production factor. The oil crises of the 1970s reinforced this interest in energy as a production factor, leading to the emergence of new production functions integrating energy and raw materials. Concurrently, research on climate change and the depletion of natural resources contributed to exploring possibilities for economic growth with less energy and the development of alternative energy resources. This theoretical evolution was accompanied by numerous empirical studies aimed at understanding the interdependencies between energy and economic growth.

2.2. Empirical studies on the relationship between energy and economic growth

The examination of the interrelationships between investment in the energy sector and economic growth has been the subject of few empirical studies. Upon reviewing relevant literature on energy, we identified only three studies. Two of them, using an econometric approach, focused on the case of Benin (Houangni MRMC., 2017 and Sinsin LM, 2017), while a third study examined the application of input-output modeling and its extensions in Southern countries (Bentaleb N, 2002).

The most addressed issue in these studies concerns the analysis of the correlation and causality between electricity consumption and economic growth. Establishing a relationship between these two variables is a crucial criterion for understanding the importance of increasing investments in the energy sector, especially the impact of public investments on energy demand, often reflected by consumption. If energy consumption and economic growth are linked, any change in one of these variables will have long-term repercussions on the other, thus justifying our study.

Since the pioneering works of Kraft and Kraft (1978), Sims (1972, 1980), Granger et al. (1981, 1983), followed by Granger and Engle (1987), and Johansen (1991), interest has been drawn to studying the relationship between energy consumption and economic growth. Consequently, several studies, primarily focused on developed countries rather than developing ones, have been conducted in the literature, employing various approaches for different periods. Some adopted a correlation approach, others a causality approach, sometimes both. However, empirically, the relationship between these variables typically boils down to the question of causality direction, and the conclusions lead to divergent results. This often leads to unidirectional or bidirectional causality, or even a complete absence of causality, meaning that to date, there is no consensus in research on this issue.

This abundant and controversial literature concerning the relationship between energy, electricity, and the economy has been reviewed by numerous authors (Méhrara M, 2007; Bettaib H, 2015; Ndiaye O. H, 2018; Larbi K et Braik L, 2019, among others). We will review some of these studies, with a focus on those concerning Algeria. Méhrara M (2007) identifies four generations of methodological approaches for empirical studies on the link between energy consumption and economic growth. The first generation consists of studies based on the VAR (Vector Auto Regression) method, applying Sims' test and Granger's causality test, assuming that the series are stationary. The second generation adopts a bivariate approach and simply examines the direction of causality between GDP and energy, applying unit root and cointegration tests on individual time series without considering non-stationarity. The third generation adopts a multivariate approach, based on the maximum likelihood method and applies cointegration tests. Finally, the fourth generation applies unit root and cointegration testing procedures based on panel data. The results obtained after using these econometric methods show diverse perspectives due to the utilization of different methods and the heterogeneity of the countries considered.

Some more recent studies have focused on analyzing the link between economic growth and energy production, energy demand, and/or renewable energies. Lim HJ. and Yoo SH. (2012) studied the short and long-term causality between natural gas consumption and economic growth in Korea, for quarterly data covering the period 1991-2008. Isah W. (2017) analyzed the relationship between per capita energy production and economic growth in Saudi Arabia from 1971 to 2013. Alam M.J. et al. (2017) explored the causality between energy demand and economic growth in Bangladesh from 1980 to 2011. Shakouri et al. (2017) examined the relationship between economic growth, total energy consumption, renewable energy consumption, fixed capital formation, and trade openness in South Africa from 1971 to 2015. These studies yielded diverse results, highlighting the importance of renewable energies for economic growth and the interdependence between energy consumption and growth.

Regarding Algeria, few studies exist and mainly apply an econometric approach. Abderrahmani F. and Blaid F. (2013) examined the short and long-term relationship between electricity consumption, oil prices, and economic growth in Algeria from 1971 to 2010, considering structural changes. Yaiche E. and Chetioui L. (2016) studied the long and short-term causality between energy consumption and economic growth in Algeria for the period 1980-2014. Fethi

A. (2017) investigated the relationship between renewable and non-renewable energies and GDP in Algeria from 1980 to 2012. Larbi K. and Braik L. (2019) explored the link between electricity consumption and economic growth in Algeria from 1970 to 2018. These studies have produced varied results, shedding light on the different relationships between energy consumption and economic growth in the Algerian context.

Regarding empirical studies on the analysis of existing relationships between investments in the energy sector and economic growth, the results are similar. Sinsin LM (2017) studied the impact of international investments on energy demand in Benin by applying an instrumental variable regression model for the period 1990-2013. Bentaleb N (2002) attempted to demonstrate the utility of adopting methodological tools provided by input-output modeling and its extensions in Southern countries. These studies have provided significant insights into the links between investments in the energy sector and economic growth in these specific contexts.

3. Empirical approach: assessing the effects of energy investment on sectoral growth

In our methodological approach, we utilize the Social Accounting Matrix (SAM) multiplier model to assess the effects of energy investment on sectoral growth in Algeria. The choice of this model is justified by its ability to provide a comprehensive structure of the economy by integrating all sectors, as well as by its consideration of the direct and indirect effects of a sector on the entire economy through the interdependence of SAM accounts. This approach is particularly well-suited to our problem statement, as highlighted by Bentaleb N. (2002), because it allows for the consideration of interactions among households, sectors of activity, and an energy investment. Indeed, while numerous indicators are available to assess human or sociological development, it is not always straightforward to integrate them into a common methodological framework to analyze the impacts of an energy investment on the economy as a whole.

3.1 Presentation of the Social Accounting Matrix and multiplier model (SAM)

To develop a multiplier model, we must first construct a Social Accounting Matrix (SAM). This matrix serves as the foundation for the multiplier model, as it represents in detail the economic exchanges between different sectors of a given economy. In this section, we will begin by presenting the social accounting matrix, then we will discuss the multiplier model (SAM). Next, we will outline the methodology used to construct the 2021 SAM specific to the Algerian economy, as well as the multiplier model derived from this SAM. Finally, we will examine the results of the empirical simulation and the main conclusions that follow from it.

3.1.1 The Social Accounting Matrix (SAM)

The Social Accounting Matrix (SAM) is a synthetic accounting tool that summarizes and schematizes all flows of production, income, demand, and exchanges among various economic actors for a given year, at a specific level of detail. It provides an overview of the economy at a particular moment, enabling in-depth analysis of economic policies. Its usefulness lies in three main objectives: firstly, it exhaustively organizes data related to the economy for policy analysis, covering macroeconomic, mesoeconomic, and microeconomic aspects. Secondly, it illustrates the links and income flows between factors of production, production, goods, and economic agents. Thirdly, it serves as a reference for modeling fixed-price multipliers and input-output models, where relative prices are essential (Round, 2003). A SAM for an open economy typically includes five types of aggregated accounts: the production account, the products account, the factors of production account, the accounts of domestic institutions (households, businesses, government), and foreign institutions (rest of the world), as well as a combined savings-investment account for all institutions.

3.1.2 The Multiplier Model

The analysis of multipliers within the framework of the SAM examines how an injection (or leakage) from one sector of the economy influences other sectors due to interdependencies among economic actors. The multiplier model based on the SAM extends Leontief's input-output model by integrating the links between production, income generation, and its use, thereby accounting for both the direct and indirect effects of any exogenous injection or induced policy change. Unlike the input-output model, the SAM multiplier model takes into account value-added and incomes of corporations and households, thus generating multiplier effects in the economy. It is a static short-term forecasting model that assumes prices and technical coefficients remain fixed, and supply is elastic, unconstrained, and can adjust according to demand. Economic agents' responses to a marginal shock are represented by fixed marginal propensities to spend, assumed to be equal to average propensities.

Thus, the SAM multiplier model is widely used to assess the effects of exogenous injections into a specific account on the entire economy. SAM multipliers measure the impact of additional demand from one sector on the entire economy, taking into account intersectoral exchanges, income distribution, household expenditure behavior, and transfers between institutions. In this type of analysis, shocks (injections or leaks) are introduced into the model from exogenous accounts and affect the economy through interactions among endogenous accounts. The flows at the level of endogenous accounts unfold as follows: production generates factor costs, which are then paid out to institutions as income. These institutions then spend their resources on consumption for production activities and savings. And the process repeats.

3.2 Development of the disaggregated SAM for Algeria and deduction of multipliers

Our multiplier model (SAM) relies on data from the SAM of the Algerian economy established for the year 2021. The construction of this SAM required the use of two main national accounts tables: the estimated input-output table (IOT) and the overall economic table (OET) published by the National Office of Statistics (ONS) for the year 2021. Information regarding production, exchange, consumption of goods and services, as well as the distribution of factor incomes, was primarily extracted from the IOT. Inter-institutional transfers and savings are recorded in the OET. The methodology adopted for developing the sub-matrix of inter-institutional transfers is that proposed by Fofana (2007). For the general structure and construction steps of our matrix, refer to the article by Zerkak S. and Achouche M. (2016). The constructed SAM (2021) thus comprises 46 accounts divided into 19 production activity accounts, 19 corresponding product accounts, 2 aggregated production factors (capital and labor), 4 institutional accounts (households and individual businesses, financial and non-financial corporations, government, rest of the world), 1 account for trade margins, and finally 1 account for savings-investment.

Based on this SAM (2021) for the Algerian economy, SAM multipliers were derived in accordance with the methodology followed by Defourny and Thorbecke (1984), Breisinger, Thomas, and Thurlow (2009). The process unfolded as follows:

- Distribution of the SAM into endogenous and exogenous accounts (The commonly used rule to distinguish between endogenous and exogenous accounts is as follows: an account is endogenous if changes in its expenditures are strongly related to a change in income level; conversely, an account is exogenous if its level of expenditures is assumed to be independent of income). Accounts such as government, rest of the world, and accumulation were considered exogenous. Thus, the SAM comprising 46 accounts was restructured into 41 endogenous accounts, consisting of 3 groups (activities/products 37, factors 2, institutions 2), and 1 exogenous account.

- Transformation of the endogenous accounts matrix into a matrix of average expenditure propensities (A) of size 41x41. This was achieved by dividing each element of the matrix by the total of the corresponding column of the SAM of order 46x46. The obtained technical coefficients are structural coefficients, generally non-negative and less than unity. The matrix of technical coefficients (A) indicates the proportion of expenditures from each column account to the row account, thus revealing the expenditure (use) structure of all endogenous accounts in the column. Thus, each total endogenous income xn is expressed as follows:

$$\underset{(kx1)}{X} = \underset{(kxk)}{A}\ \underset{(kx1)}{X} + \underset{(kx1)}{E} \quad \ldots\ldots\ (1)$$

X is a matrix of endogenous income and E is a matrix of exogenous accounts. The multiplier matrix M is derived from equation (1).

$$X = (I - A)^{-1}E = MX \quad \ldots\ldots\ldots\ (2)$$

with I : the identity matrix

The total multiplier matrix details the repercussions of changes in one or more exogenous accounts on each of the 41 endogenous accounts. This matrix takes into consideration the interrelations between different production sectors, factors, and institutions in the Algerian economy. Essentially, it allows visualizing how exogenous expenditures influence the entire economic system through an iterative process of multiplying impacts, which follows a circuit of production, distribution, and utilization of income.

3.3 Simulation and summary of results

The evaluation of the impact of an energy investment on the endogenous accounts of the SAM relies on the analysis of the impact vector, which results from the multiplication of the multiplier matrix by the injection vector. To express the variation of the injection, represented in our case by a unit increase in public investment in the energy sector, we assigned a value of 0 to all elements of the shock vector, except for the element representing the energy-water product. This latter encompasses non-hydrocarbon energy activities (such as electricity, gas, and water), including water-related expenses associated with these activities. It includes elements such as electricity from gas turbines, steam turbines, combined cycles, as well as diesel, hydroelectricity, and retail gas supply. Then, we multiplied this shock vector by the transpose of the total multiplier matrix M, calculated using Matlab software, to obtain the impact vector. Examining the impact vector allows detecting the effects of sectoral production in the rows corresponding to sectors and income effects in the rows corresponding to factors, households, and enterprises. Thus, the first 19 rows show the effect of increasing investment in the energy sector on the production of each sector, while the next 19 rows measure the effect on sectoral output. As for the last rows of this vector, they indicate the effect of increasing energy investment on the incomes of production factors and institutional sectors. The results of these effects are successively illustrated in the tables below:

Table 1: Effects of unit increase in energy investment on sectoral production

Code	Sector of Activity	Effect on Production
1	Agriculture, forestry, fishing	0,1562
2	Water and Energy	1,1474
3	Hydrocarbons	0,1498
4	Services and Public Oil Works	0,0013
5	Mining and quarries	0,0006
6	ISMMEE	0,0419
7	Construction Materials	0,0031
8	Building and Public Works	0,0104
9	Chemicals, Plastics, Rubber	0,0199
10	Food Processing Industries	0,1211
11	Textiles, clothing, knitwear	0,0260
12	Leather and Shoes	0,0083
13	Wood, Paper, and Cork	0,0110
14	Various Industries	0,0082
15	Transport and Communications	0,0665
16	Commerce	0
17	Hotels - cafes - restaurants	0,0271
18	Business Services	0,0153
19	Household Services	0,0184
	Total	1,8326

Source: Compiled by the authors based on our simulations using Matlab software.

Analysis of Table No. 1, concerning SAM-type production multipliers, highlights that a unit increase in energy investment has a significant impact on national production, albeit relatively modest, amounting to approximately 1.8326 monetary units only. This implies that an investment of 1 million dinars in the energy sector leads to an increase of about 2 million dinars in national production. The results reveal that the production of all sectors is affected, but some sectors such as agriculture, hydrocarbons, food processing industries, ISMMEE, textiles, clothing, knitwear, hospitality, construction, and services provides to businesses and households are more strongly impacted.

Table 2: Effects of unit increase in energy investment on sectoral output

Code	Sector	Effet on Product
P_1	Agriculture, forestry, fishing	0,1971
P_2	Water and Energy	1,1986
P_3	Hydrocarbons	0,1637
P_4	Services and Public Oil Works	0,0013
P_5	Mining and quarries	0,0012
P_6	ISMMEE	0,1723
P_7	Construction Materials	0,0053
P_8	Building and Public Works	0,0106
P_9	Chemicals, Plastics, Rubber	0,0535
P_{10}	Food Processing Industries	0,1941
P_{11}	Textiles, clothing, knitwear	0,0640
P_{12}	Leather and Shoes	0,0171
P_{13}	Wood, Paper, and Cork	0,0242
P_{14}	Various Industries	0,0153
P_{15}	Transport and Communications	0,0689
P_{17}	Hotels - cafes - restaurants	0,0482
P_{18}	Business Services	0,0236
P_{19}	Household Services	0,0184
	Total	2,2771

Source: Compiled by the authors based on our simulations using Matlab software.

In Table No. 2, it is observed that the increase in energy investment stimulates the national output by approximately 2.2771 monetary units. However, the results reveal that goods have a more pronounced impact than services. More specifically, this effect is more marked for the energy product itself, agricultural produce, Food processing industries, ISMMEE, hydrocarbons, textiles, clothing, knitwear, BTPH, transportation and communications, as well as hospitality and catering sectors.

Table 3: Effects of a Unit Increase in Energy Investment on Factor and Economic Agent Income

Production Factor and Institutional Sector	Income Effect
Labor	0,5167
Capital	0,6201
Enterprise (SME and Financial Institutions)	0,9042

Household	0,2936

Source: Compiled by the authors based on our simulations using Matlab software.

The increase in energy investment has generated a modest increase in factor and economic agent income, totaling approximately 2.3346 monetary units. Upon closer examination, it is observed that this distributive effect is more pronounced for enterprise income, with an increase of approximately 0.9042 monetary units, as well as for capital remuneration compared to labor, with an increase of approximately 0.5167 monetary units, and household income, with an increase of approximately 0.2936 monetary units. This trend is explained by the intensive use of capital compared to labor in the production process of this sector, resulting in less significant increases in household and enterprise incomes. These results reveal that wage levels for employees in this sector remain low in Algeria.

A comprehensive analysis of the results regarding the effects of energy investment on activity sectors, production factors, and institutional sectors indicates a weak correlation between energy investment and economic growth in Algeria. In other words, energy demand, whether it be an increase in investment or final consumption, does not seem to be a determining factor for economic growth in Algeria. These conclusions corroborate those of previous studies conducted by Fethi A (2017), Larbi K and Braik L (2019), which applied econometric approaches for Algeria, as well as those of Mehrara M (2007), Arfaoui L (2016). and Ferid O. (2017), who utilized panel data including Algeria. These results suggest that energy conservation constitutes a reasonable policy without adverse effects on economic growth in Algeria. In terms of policy implications, Algerian policymakers should therefore consider increasing the share of renewable energies while controlling that of non-renewable energies. Ultimately, Algeria must prepare for a transition to an energy model based on renewable energies.

4.Conclusion

In conclusion, the SAM multiplier approach has allowed us to understand the effects of energy investment on the national economy and to quantify the intersectoral changes induced by variations in energy quantity.

The analysis of SAM multipliers for 2021 indicates overall that investment in the energy sector slightly promotes economic growth in Algeria.

Although the increase in public investment in this sector produces a generally positive effect on all activity sectors, production factors, and institutional sectors, this effect remains relatively weak and limited. Furthermore, the results reveal that certain sectors, such as agriculture, Food processing industries, ISMMEE, hydrocarbons, construction, transportation and communications, as well as hospitality and catering, are relatively more impacted.

Moreover, the results highlight a weak but significant distributive effect, with a greater impact on capital remuneration through enterprise income than on employee remuneration. These conclusions suggest a weak correlation between energy investment and economic growth in Algeria. In this context, energy conservation emerges as a reasonable policy without adverse effects on economic growth. Thus, it is recommended that Algerian policymakers consider increasing the share of renewable energies while controlling that of non-renewable energies. Ultimately, Algeria must prepare for a transition to an energy model based on renewable energies to ensure sustainable economic growth and address future environmental challenges.

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