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Economic and Geographical Impact of Development Poles in the Countries of the South: Industrial and Commercial Transformations of the Forestry Sector in Gabon

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Abstract: Gabon's decision to stop exports of forestry raw materials and to develop an industrialization strategy made it possible to apply certain theories of regional growth. The creation of the Nkok Special Economic Zone in 2012 (considered a homogeneous space unlike the external zone of the SEZ, considered heterogeneous) and the improvement of infrastructure illustrate the use of Rosenstein-Rodan's "Big push" theories and the Douglass North export base). These investments have fostered a process of unbalanced economic polarization, as theorists such as François Perroux have studied. Thanks to the use of the "Bias-Corrected Estimation of linear dynamic panel data" model, the analysis of industrial and commercial relationships and mechanisms during the period 2014-2022 show that the homogeneous space has positively influenced the heterogeneous space and the macroenvironment. This led to an increase in industrial income linked to exports, except for forestry products due to the ban on the export of raw materials. Export revenues boosted industrial production, while an increase in industrial revenues led to a decline in raw material exports, favoring domestic processing. The study makes it possible, using data from short and unbalanced panels, to carry out suitable estimation methods by establishing a decision-making process which results in an optimal model to be used for modeling spatial imbalance. This polarization process needs to be further studied to understand long-term economic and geographic imbalances in developing countries.

Keywords: Pole theories; SEZ; geographical; economic impact; homogeneous; heterogeneous spaces; Decision-making processes; Panel Bias-Corrected Estimation

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Introduction

Traditional regional development theories seek to understand why some regions experience economic growth while others stagnate or decline Perroux (1955) [1]. Myrdal (1957) [2]. Hirschman (1958) [3]. They provide different perspectives on regional development and have influenced the creation of development strategies in various countries, tailored to specific geographic and economic contexts. However, these theories have strengths and weaknesses, depending on the economic and social particularities of the regions concerned, particularly in underdeveloped and developing regions, such as in sub-Saharan Africa Myrdal (1957) [2]. Milton (1974) [4]., Misra, 1978 [5]. Inspired by the success of growth poles in Asia and South America in the 1970s and 1980s, African states and their partners adopted growth poles as industrialization strategies. After a pilot project in Madagascar in 2005, several centers were launched between 2008 and 2012 in Tanzania, Mozambique, Burkina Faso, Gabon and Nigeria, then extended to other African countries. However, this approach is not unanimous with many small business, farmer and civil society organizations criticizing these strategies. In sub-Saharan Africa, it remains difficult to adapt these theoretical models and measure their positive or negative effects, despite the traditional and modern theoretical contributions of regional development theorists. Who have influenced the evolution of theories in contexts of underdevelopment Milton, 1974[4]., Misra, 1978[5]. These regional development theories and approaches are generally little known and little exploited by actors in the centers of underdeveloped regions of the continent. Traditional theories of regional development, for example, remain for the most part forgotten, not only by political actors but also by researchers on the continent.

Concerning the decision-making processes for the choice of optimal models, **Thombs, Ryan P. (**2022) [22] proposed a tool for large panels after having carried out numerous estimates, then obtained an optimal model to use and suggested the use of this type of process. Others studies concern the many studies that show the positive effects of development hubs, including SEZs. The paper by Frick, Rodríguez-Pose, and Wong (2019) [19] examines through an empirical approach the factors that influence the economic dynamism of special economic zones (SEZs) in emerging countries, filling a notable gap in quantitative research. Using innovative methodologies in monitoring data such as performance indicators to measure SEZ performance, the study highlights several key findings. Larger SEZs generally have better growth prospects due to economies of scale and broader infrastructure. Location matters, meaning that both geographic and economic contexts play a significant role in the success of SEZs. Areas close to major cities and markets, as well as in already industrialized areas, perform better. Cheap labor remains an attractive feature, but proximity to demand centers is equally crucial. Another study, Lotta Moberg's (2015) [20] paper, "The Political Economy of Special Economic Zones," examines the effectiveness of special economic zones (SEZs) in stimulating economic development through a robust political economy framework. This framework focuses on two major challenges: the knowledge problem (insufficient information for effective economic planning) and negative incentives (risk of rent-seeking behavior by firms and government officials). The paper by Tangtipongkul et al. (2021) [21] focuses on local economic development (LED) strategies designed to maximize opportunities and mitigate challenges presented by special economic zones (SEZs) along the Southern Economic Corridor of the Greater Mekong Subregion (GMS). Using Kanchanaburi and Trat provinces in Thailand as case studies, the research highlights how infrastructure development, trade facilitation, and local economic activities interact with regional and international economic dynamics. Key findings focus on economic opportunities and integration by stipulating that SEZs in these provinces have played a critical role in enhancing cross-border trade, attracting investment, and improving local infrastructure. Furthermore, the study reveals the challenges and strategic approaches and highlights the importance of addressing economic leakages, such as the outflow of profits to non-local stakeholders. The use of frameworks such as the BCG matrix helps to prioritize economic variables according to their current and future importance, allowing for targeted interventions. In view of these few advances in governance and informed initiatives in the development poles of some Asian countries, most developing countries present greater challenges on these issues. But still, the absence of sufficient data and research in sub-Saharan Africa, particularly in Gabon, makes governance and strategic planning difficult.

Thus, in the context of this study, a return to the fundamentals of the old theoretical framework seems necessary, especially since several of these theories were developed and applied in a context of underdevelopment in certain European regions, from West to East Asia, from South and in most of South America including those presenting notable advances in Asia. For the case of sub-Saharan Africa, in the context of this study, particular attention is paid to the Special Economic Zone (SEZ) of Nkok, in Gabon. Considered by certain political actors and development support organizations as a model of industrial transformation in Africa. This study makes it possible to show the positive effects of polarization (economies of agglomeration, diffusion, capital accumulation and inter-industrial connections). More specifically, it attempts to show the effects of polarization in the forestry sector of Gabon using an innovative quantitative approach (short partial dynamic panel with correction of estimation bias). The objective is to show the industrial and commercial impact of the Nkok Special Economic Zone (SEZ) in Gabon, using spatial and temporal data from the local timber industry.

Indeed, by using panel data estimation methods with relatively short N and T, the objective is to establish an overall industrial and commercial assessment of the timber industry since the creation of the Special Economic Zone in 2009. Based on the recording of industrial and commercial performances from 2014 to 2022, the study also highlights the relationships between the variables of interest according to geographical areas. But even more, to show how the Nkok Special Economic Zone generates polarization effects identified and analyzed in the last part of the study.

I. Literature Review

I.1. Theoretical Foundations of Polarization and Associated Phenomena

The development of regional economic theories really took off between the 1950s and 1970s, in response to growing economic problems around the world. It was during this period that the concept of regional convergence emerged, with an emphasis on growth and development of regional economic policies. Theories of balanced growth, inspired by broader economic theories, are based on economists such as Rosenstein-Rodan (1943, 1944) [6,7] and Nurkse (1961) [8]. They postulate that the free movement of capital, labor and technology could balance regional economies.

As part of this study, it is appropriate to review the work of the authors of the theory of regional development from the 1950s to the 1970s. It is in this period of history that the foundations of the theory of regional development have been established, laying the foundations for understanding how economic growth can be achieved through localized strategies and the engagement of private and public actors. Indeed, certain authors like Isard, Walter (1956) [9] often considered as one of the pioneers of spatial analysis and regional science, developed models which link location choices with market structures and 'urbanization.

I.1.1. Theories of Balanced Regional Growth

Growth theories seek to understand the mechanisms by which regional disparities can be mitigated and how to promote uniform economic growth. Several economists and theorists have proposed different approaches to explain balanced regional growth. Theories of balanced regional growth are diverse and attempt to resolve the issue of economic disparities between regions. Rosenstein-Rodan (1943) [6,7] and Nurkse (1961) [8]. However, the application of these theories depends on factors specific to each region, such as infrastructure, access to resources and education…etc.

As part of this study, some relevant theories on balanced regional growth are presented, representing the theoretical basis for understanding and analyzing the determinants of polarization of the economic and geographical spaces studied.

I.1.1.1. The Big Push Theory

The “Big Push” theory developed by Rosenstein-Rodan in 1943 highlights the need for massive investments in infrastructure and industry to stimulate economic growth, particularly in underdeveloped regions. It emphasizes the importance of strategic coordination to create a self-sustaining development cycle, where initial investments lead to increased productivity and, ultimately, improved living conditions.

In his article entitled "The Problems of Industrialization in Eastern and South-Eastern Europe", Rosenstein-Rodan argues that industrialization is an essential condition for helping developing countries overcome poverty. He argues that capital accumulation is a central pillar of economic progress and that isolated investments have only limited impact. To succeed, large-scale, simultaneous investments in diverse industry sectors are necessary to create a network of interdependent markets.

This theory emphasizes the benefits of economies of scale, explaining that only large investments can produce social benefits that exceed the associated costs. It highlights the importance of strategic planning and government intervention to develop infrastructure and promote industrialization. This model is not limited to economic growth, but also aims to reduce social inequalities by guaranteeing equitable distribution of the benefits of development to the entire population. (Rosenstein-Rodan, 1943) [6,7]

I.1.1.2. "Export Base" Theories

The export base theory was introduced by American economist Douglass North (1990) [10]. According to him, the main flaws of closed economy models are their failure to recognize the potential of trade as a catalyst for economic growth, suggesting that the export base model serves to fill this gap. The rationale for this theory encompasses the integration of foreign trade considerations into rigorous comparative statistical analyses. This theoretical framework posits that the economic progress of a given region depends on the expansion of its export activities, because escalating external demand will catalyze growth in that region. Furthermore, this theory asserts that as each region directs its efforts toward maximizing its inherent advantages, free trade dynamics will gradually balance the factors of production (capital and labor) as well as price structures (profits and wages) between regions, thus leading to a lasting reduction in interregional disparities. This process not only promotes economic convergence, but also encourages innovation and competitiveness, as regions strive to improve their productivity and adapt to changing market conditions (Douglass-North, 1990) [10].

I.1.2. The Theory of Unbalanced Regional Growth

Being based on theoretical hypotheses, and adapted for centralized economies, theories of balanced regional economic development have forgotten a very important factor of economic growth, temporal distance, in other words, the evolution of disparity and regional development is dynamic. Thus, a number of economists, against this theory of balanced economic growth, have put forward theories of unbalanced regional growth. Among the authors of this school there are Perroux (1955) [1], Myrdal (1957) [2] and Hirschman (1958) [3] who present the work relevant to this study.

I.1.2.1. The Theory of Growth Poles

The theory of growth poles is a theory of economic growth whose precursor is the French economist, Perroux (1955) [1]. According to him, *"growth does not appear everywhere at once, but it manifests itself in the form of points or poles of growth with variable intensities, it spreads through various channels and with variable terminal effects for the entire economy.* And Jandir (2005) [11], postulates that: *"The driving unit can be ordinary or complex, composed of various companies and industries. It can be a combination exerting an effect of attraction (domination) on the other units related to it" (Jandir F.L, 2005) [11].*

Perroux defines the growth pole in an economic space and not in a geometric or geographical space. The economic space is made up of economic relations. It classifies economic spaces into three types, namely: "plan economic space, force field economic space and homogeneous economic space". It is by focusing on economic spaces as fields of force and homogeneous economic spaces that Perroux (1955) [1] developed his growth pole theory. He postulates that the growth pole is a point which generates a field composed of two forces, one "centrifugal" and the other "centripetal". The "centripetal" force causes a flow shift of the so-called "parasitic" or "propelled" units or industries towards the pole or "driving unit"; in this case we can speak of an upstream effect. In practice, these propelled units can be primary sector units (agriculture, livestock, forestry, fishing, etc.). In sectors such as Agriculture, the upstream effect can manifest itself in such a way that the powered units which may be agricultural operators (agricultural businesses and family-type agriculture) produce primary agricultural goods and sell them to the driving units, which will be responsible for processing or marketing them on a larger scale.

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In theory, this "centripetal" force can also cause a movement of propelled productive units (businesses, family farms) towards the driving unit, this is the "agglomeration" phenomenon. Opposite to the "centripetal" force, the "motor" units generate activities and there follows a movement of flow towards the "propelled" units, this is the downstream effect. The force responsible for this effect is called "Centrifugal" Force. The "centrifugal" force also generates beneficial effects which emanate from the pole or "motor" unit towards the "propelled" units and towards other territorial entities (surrounding population, local administration, research and training centers, etc.). Perroux's theory (1955, 1961) [1] particularly influenced industrialization strategies in sub-Saharan Africa, particularly in Gabon.

I.1.2.2. The Theory of Cumulative Circular Causation

In 1957, Myrdal introduced the theory of the dual geographic economy in his work "Economic Theory and Underdeveloped Regions", explaining the effects of developed regions on underdeveloped regions through the mechanisms of "sprawl effects" and "backflow effects". He emphasizes that regional development exacerbates disparities, with interactions between regions amplifying inequalities. Myrdal (1957) [2] proposes targeted interventions to leverage the advantages of developed regions while supporting the progress of underdeveloped areas. It recommends an asymmetric development strategy at the start, with investment in regions with high potential, but calls for policies aimed at reducing disparities once a certain development threshold is reached. He said this approach would create a more balanced economic landscape, promoting sustainable growth that would benefit all regions in the long term.

I.1.2.3. Hirschman's Theories of Unbalanced Growth

In 1958, Hirschman proposed a theory of unbalanced growth. According to him, economic growth cannot occur everywhere at the same time, but is concentrated around growth poles. He distinguished two effects: "trickling-down" contagion effects and polarization effects. Initially, polarization effects predominate, increasing regional disparities, but in the long run, contagion effects reduce these gaps. Hirschman (1958) [3] also highlighted the importance of investments with contagion effects and linkages between industries to maximize profits.

I.2. Contextual Frameworks of the Economic and Geographical Spaces Studied

I.2.1. Presentation of the Nkok Special Economic Zone

In 2009, the Gabonese government decided to put in place a strategic plan whose main objective is to diversify the Gabonese economy (production and export). It is with this in mind that the government created Special Economic Zones (SEZs) in order to promote the local processing of raw materials, attract Foreign Direct Investment (FDI) and develop public and private partnerships (PPP).

I.2.1.1. Creation of the Nkok Special Economic Zone

The Nkok Special Economic Zone (SEZ) is a Free Zone, which is located 27 km from Libreville, the capital of Gabon. It was created by decree 461/PR/MPITPHTAT (Journal O. RP. G, 2011) [12] of October 10, 2012 and was built on an area of 1,390 hectares, it is divided into three zones: Industrial, Commercial and Residential. During its year of creation, the Gabonese government wanted a center of excellence for its industrialization strategy and made infrastructural investments with an international private partner by creating a public and private capital company (60% of assets for the private Multinational Firm and 40% of the capital for the Gabonese government. The company carries out missions assigned to it for a period of 45 years. In addition to this, the government creates a tax regime to attract Direct Investment. Foreigners (IDE).

I.2.1.2. Attractive Tax Regime for Multinational Firms

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The tax regime of the Nkok SEZ was established based on law "No. 10/2011 of July 18, 2011" which provides for a certain number of facilities for firms established in the zone, some of which are:

- *"Investors, companies affiliated to the Nkok SEZ and their subcontractors are exempt from obtaining the necessary permits and authorizations for the constructions and installations that they carry out in application of their investment program if the latter has been expressly approved by the planning and management body and endorsed by the administrative authority".*
- *"The products manufactured and services provided by companies admitted to the Nkok SEZ regime are intended, for at least 75%, for export".*
- *"The products manufactured and services provided by admitted companies may be sold on the national market, up to a maximum of 25% of their total production and/or services".*
- *"The exemption from withholding tax, valid when at the end of twenty-five years following the first sale of the company, concerns in particular the 10% withholding on payments for the benefit of non-resident service providers and permanent establishments established in Gabon and belonging to a capital company whose head office is abroad". (Journal O. RP. G, 2011) [12].*

The developed tax regime makes it possible to give the Nkok SEZ a good level of attractiveness for domestic firms and multinational firms (MNCs). This attractiveness allows, in accordance with the theories of balance and imbalance of regional growth, to generate polarization effects (diffusion, localization, connection and training in the different polarized and homogeneous economic spaces).

The establishment of the Nkok Special Economic Zone has created two distinct economic and geographical spaces across the country. Namely: the Special Economic Zone which is the "In Free Zone" space, benefiting from a privileged regime (tax, administrative, logistics and infrastructure, industrial developments, etc.). Then the "Out Free Zone" space which constitutes the territories in which the forestry sector operates across the country.

II.2. Production Volume and Industrial Income in Polarized Spaces

In Gabon, the period 2014 to 2022 corresponds to a strong expansion of industrial income (figure 1) from the forestry sector and varies depending on the geographical space considered. The macroenvironment revenue values represent the sum of revenues from the "In Free Zone" space and the "Out Free Zone" space.

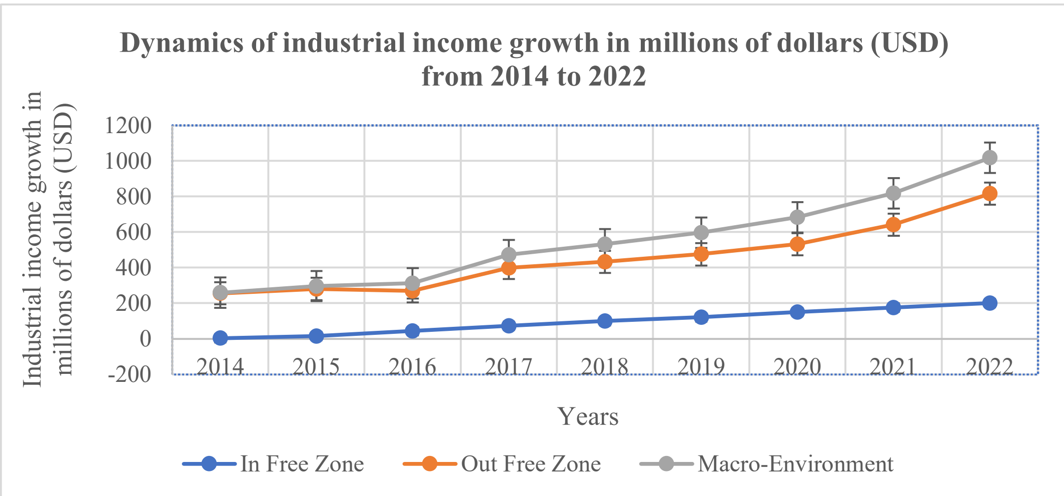

Figure 1. Presents the dynamics of industrial income growth in millions of dollars (USD) according to economic and geographic spaces. ***Source:*** *Authors based on the Gabon Economy Dashboard and the FAOSTAT database.*

In the Free Zone space, industrial revenue started in 2014 with a value of $4 million (USD). This is the year in which the Nkok Special Economic Zone begins to generate revenue. Then, there was

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strong annual growth until reaching approximately 202 million dollars in 2022. Although the "In Free Zone" space, was created in 2012, representing the first Special Economic Zone (SEZ) of the country, it constitutes from the point of view of Perroux's theory, a "homogeneous" space capable of generating a field of force which extends over several administered territories. The force field created by the Nkok SEZ ended up creating economic and geographical changes which are nothing other than the polarization process in its initial phase. These modifications concern industrial and geographical dynamism and the creation of a "heterogeneous" region in relation to the Nkok SEZ (homogeneous space). The dynamics of these two types of spaces show accelerations in the growth of industrial revenues in the "Out Free Zone" space. It is entirely natural that in this geographical space, industrial revenues (256 million USD in 2014 to 816 million USD in 2022) are higher than the homogeneous space (In Free Zone) created in 2012.

The dynamics of industrial production in volume in the three geographic spaces from 2014 to 2022 (figure 2) makes it possible to highlight the different flows of industrial production and consumption goods in cubic meters (m^3). In the homogeneous space (In Free Zone), the period 2014 to 2022 is marked by an increase of almost one hundred (100) in industrial production goods. Going from 6798.346 m^3 in 2014 to 608,000 m^3 in 2022. While during the same period, the growth of production in the heterogeneous space (In Free Zone), did not carried out at the same pace. Although industrial production in homogeneous space still represents approximately a quarter (1/4) of industrial production in heterogeneous space in 2022.

Thus, the flows of consumer goods necessary for the industrial and non-industrial processing activity of the Special Economic Zone (SEZ) of Nkok, come from the periphery, which is located in the heterogeneous economic and geographical space (Out Free Zone). The peripheral zone is made up of forestry sites, particularly community forests. Numerous "driving" industries with forest resources extraction capacities make it possible to intensify industrial production in heterogeneous space while supplying homogeneous space.

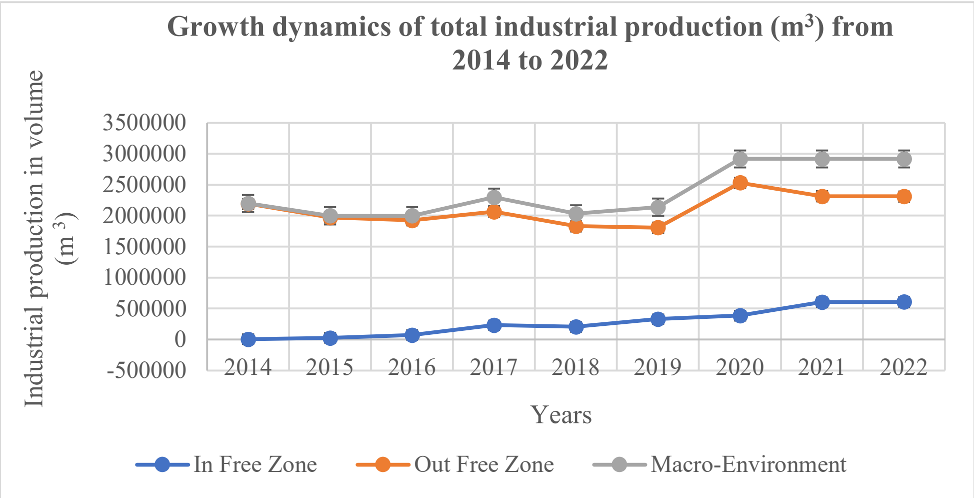

Figure 2. Presents the growth dynamics of industrial production in volume (m^3) according to economic and geographical spaces. ***Source:*** *Authors based on the Gabon Economy Dashboard and the FAOSTAT database.*

During the creation phase of the Nkok Special Economic Zone, numerous investments were made to facilitate the movement of production and consumption goods between polarized spaces within the country. However, most of the infrastructure is concentrated in homogeneous space. The creation of two new ports, the construction of the Special Economic Zone around the railway line to the new ports, the location of SEZ 27 km from the capital Libreville, which is the most populated city in the country, give the Nkok SEZ a strong "push" capacity. Indeed, the "Big Push" theorized by Rosenstein-Rodan (1943) [7] and applied to the Nkok SEZ, makes it possible to stimulate not only the

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effects of polarization, but also the dynamics of exports (figures 3) in volume (m^3) generated by homogeneous and heterogeneous economic spaces.

In the homogeneous space (In Free Zone), during the period 2014 to 2022, exports in volume of production goods in cubic meters (m^3) were multiplied practically by a hundred (100), parallel to the industrial production. Industrial production ($Ind\_P\_T_{m3}$) in the Nkok Special Economic Zone is essentially export-oriented (figures 3). Its industrial potential generates not only “Big Push” effects but also polarization effects in all economic and geographical spaces of the polarized region of the interior of the country (in homogeneous and heterogeneous spaces).

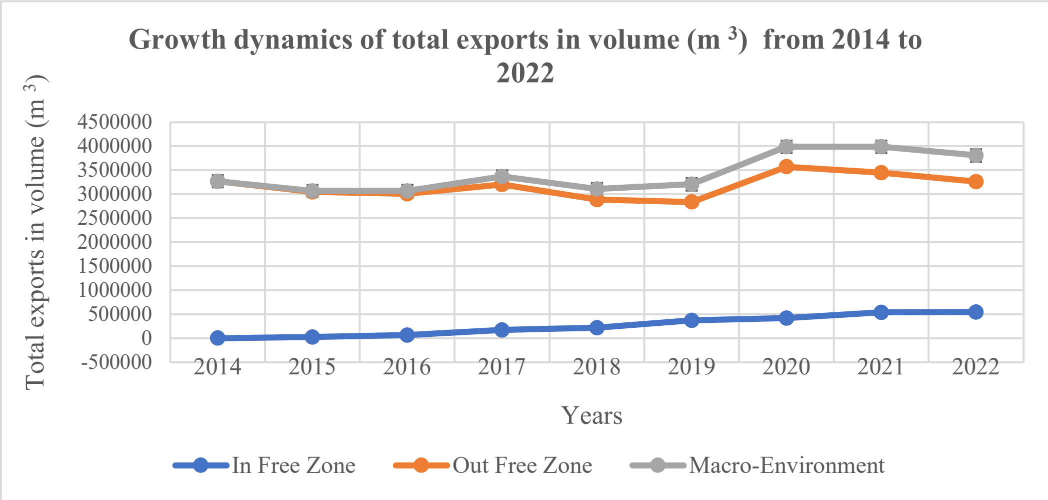

Figure 3. Presents the growth dynamics of total exports in volume (m^3) according to geographic economic spaces. ***Source:*** *Authors based on the Gabon Economy Dashboard and the FAOSTAT database.*

But still, the strategy of Myrdal (1957) [2], which proposes "targeted interventions to take advantage of the advantages of developed regions" thanks to investments made in the homogeneous space, at the location close to the population basin of the capital and the strategic infrastructures located there make it possible to bring together the conditions for “Big Push”. The “asymmetric development” initially proposed by Myrdal (1957) [2], with “investment in regions with high potential” as achieved for the Nkok Special Economic Zone (In Free Zone), manifested itself during the period 2014 to 2022 throughout the economic and geographical space considered by the study. However, particular attention should be paid to strategic monitoring and studies of temporal and spatial dynamics, in order to prevent the undesired effects presented by certain unbalanced growth theories. In particular the “peripheral center” effects of Hirschman (1958) [3] and those presented by Myrdal (1957) [2]. As for the growth dynamics of export revenues (figure 4), in the homogeneous space, it underwent dazzling growth over the period 2014-2022, which made it possible to achieve the export revenues of the space heterogeneous. Although the descriptive analysis of the overall context of the forestry sector in Gabon reveals numerous effects resulting from theories of balanced and unbalanced regional development. The in-depth study of the effects through econometric modeling and analyzes of trends in growth dynamics in different geographic spaces makes it possible to provide a quantitative empirical dimension in order to obtain more complete insight and achieve the objectives of the study.

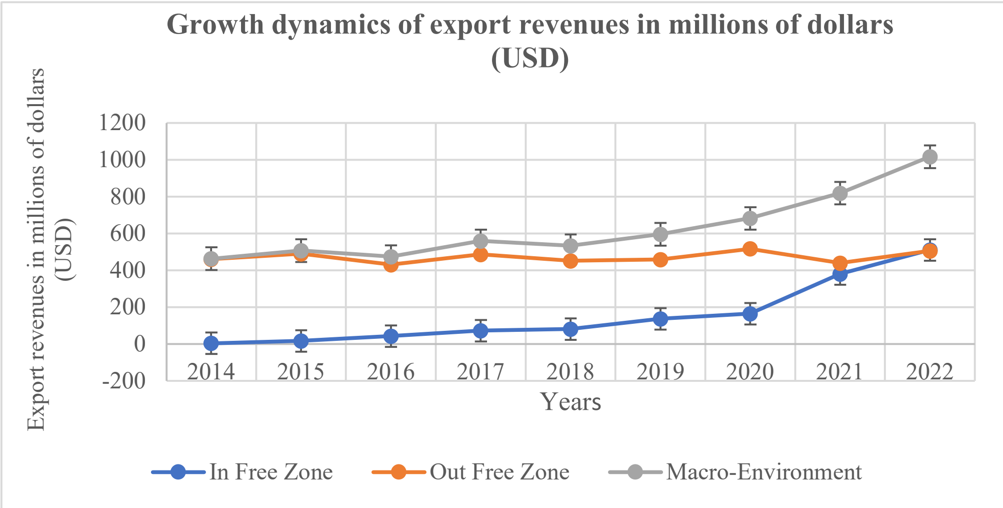

Figure 4. Presents the growth dynamics of export revenues in millions of dollars (USD) according to geographic economic spaces. ***Source:*** *Authors based on the Gabon Economy Dashboard and the FAOSTAT database.*

The second part of the study, devoted to the methodology of the quantitative empirical study, is divided into three (3) parts. The first part presents the data sources by identifying the variables of interest. The second part describes the relationships between deterministic macroeconomic variables and the choice of variables to study. Finally, the last part is devoted to the presentation of stochastic models, as well as the description of the process of managing estimation biases and the description of the optimal model chosen.

II. Methodology

II.1. Data Sources

The software used to carry out the estimates and descriptive statistics is Stata 18, R and Excel. To carry out this study, four (4) macroeconomic variables were selected to establish the industrial balance sheet (Table 1). The variables are described as follows:

Table 1. Description of variables.

Variable	Stand points	Units	Describe
Ind_P_TUSD (Industrial Income)	Variable Dependent	Millions of dollars (USD)	Total industrial production in value (million USD), represents the total sum of industrial revenues of companies in the woody forestry sector on the territory of Gabon. Noted : Ind_P_TUSD.
Exp_TUSD (Export Income)	Independent variable	Millions of dollars (USD)	Total exports in millions of USD dollars, represents the export income of Gabon's woody forest products. Noted : Exp_TUSD.

Exp_T_{m3} (Forestry Exports)	Independent variable	Cubic meter (m^3)	Total exports in m^3, which represents the national volume of exports of wood forest products from Gabon. Noted: Exp_T_{m3}.
$Ind\_P\_T_{m3}$ (Industrial Forestry Production)	Independent variable	Cubic meter (m^3)	Total industrial production in m^3, represents the total sum of industrial production (processed and unprocessed) of companies in the woody forestry sector in Gabon. Noted: $Ind\_P\_T_{m3}$.
Source 1 : **FAOSTAT :** *https://www.fao.org/faostat/en/#data/FO* Source 2: **Dashboard of the economy of Gabon:** *http://www.dgepf.ga/23-publications/25-table-de-bord-de-l-economie/169-table-de-bord-de-l-economie//*			

The data series used for the homogeneous space (In free Zone) were obtained from secondary documentary sources from the Ministry of the Economy of Gabon (Dashboard of the economy of Gabon from 2014 to 2022). The dashboards contain annual statistics on the economic performances of the timber sector in general and the Nkok Special Economic Zone (In Free Zone) in particular. The data series used for the "Macroenvironment" space were obtained from the FAOSTAT database which contains the aggregated macroeconomic variables of the forestry sectors of the countries of the world, particularly Gabon. For wood forest products, the main source is the International Tropical Timber Organization (ITTO) database. Concerning the data from the "Out Free Zones" space, they were obtained by deduction by subtracting the data from the "In free Zone" space with those from the "Macroenvironment" space. Econometric panel modeling with N =2 and T=9 could be carried out for the "Out Free Zones" and "In Free Zone" spaces. While for the "Macroenvironment" space, an N=3 and T=9 panel modeling was carried out by combining the three (3) types of geographical spaces.

Thus, the study makes it possible to carry out three models in three types of geographical spaces which are as follows:

1. The first model makes it possible to carry out static and dynamic panel estimates with N =2 and T=9. The results of these estimations make it possible to study the effects of the "In Free Zone" space on the "Macroenvironment" space;
2. The second model makes it possible to carry out static and dynamic panel estimates with N =2 and T=9. The results of these estimations make it possible to study the effects of the "Out Free Zones" space on the "Macroenvironment" space;
3. The third model makes it possible to carry out static and dynamic panel estimates with N =3 and T=9. The results of these estimations make it possible to study the simultaneous effects of "In Free Zone" and "Out Free Zones" spaces on the "Macroenvironment" space.

II.2. Deterministic Macroeconomic Functions

From the main aggregates used in this study, an assessment of the deterministic equations can be developed in order to understand the stochastic models and to establish a forestry and industrial assessment.

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- The total industrial income in values is obtained by subtracting the total income from the non-industrial income. That's to say :

$$P\_T_{USD} = Ind\_P\_T_{USD} + No\_Ind\_P\_T_{USD} \quad (1)$$

In Equations (1), total income (P_T_{USD}) is equal to industrial income ($Ind\_P\_T_{USD}$) added to non-industrial production ($No\_Ind\_P\_T_{USD}$).

$$Ind\_P\_T_{USD} = P\_T_{USD} - No\_Ind\_P\_T_{USD} \quad (2)$$

Equation (2) makes it possible to obtain the total industrial income in value (million USD) corresponding to the first variable of interest for the stochastic model.

- Regarding production in volume, we obtain:

$$P\_T_{m3} = Ind\_P\_T_{m3} + No\_Ind\_P\_T_{m3} \quad (3)$$

In Equation (3), total forest production (P_T_{m3}) is equal to industrial production ($Ind\_P\_T_{m3}$) added to non-industrial production ($No\_Ind\_P\_T_{m3}$)

Equation (4) allows us to obtain the total industrial production in volume (m^3). This is the second variable of interest for the stochastic model.

$$Ind\_P\_T_{USD} = P\_T_{USD} - No\_Ind\_P\_T_{USD} \quad (4)$$

II.3. Stochastic Modeling

Equation (5) with is the general model with k predictors allowing estimates to be made in panel data econometrics. This equation requiring transformations for practical applications leads us to Equation (6) which is a detailed version of Equation (5) with specific predictors: x_1, x_2, x_3. This equation thus makes it possible to name the variables used for the final stochastic model (7). Equation (7) is a logarithmic transformation model, used for the analysis of log-linear regressions in the study. The general equations are:

$$y_{it} = \sum_{k=1}^{K} \binom{K}{k} \beta_{ki}\, x_{kit} + \omega_{it} \quad (5)$$

$$y_{it} = \beta_0 + \beta_1 x_{1(it)} + \beta_2 x_{2(it)} + \beta_3 x_{3(it)} + \omega_{(it)} \quad (6)$$

$$LogInd\_P\_T_{USD\ (it)} = \beta_0 + \beta_1 * LogExp\_T_{USD\ (it)} + \beta_2 * LogExp\_T_{m3\,(it)} + \beta_3 * LogInd\_P\_T_{m3\,(it)} + \omega_{(it)} \quad (7)$$

The equations used for classical modeling in econometrics of panel data, which are also the most widespread, are classical or traditional models, namely Fixed Effect (FE) models, Random Effects (RE) models and OLS models. However, these models can present estimation biases when the temporal dimension of the series is short Nickell (1981) [13]. But also, when the cross-sectional dimension is short and the estimates are carried out using parametric models which are based on stricter assumptions and require a fairly large number N of cross-sectional units. Unlike non-parametric modeling, which is less powerful but more robust than parametric models. As part of this study, an estimation bias management process is proposed in order to produce good quality estimates. But also, to show researchers our decision-making process which shows the biases generated by classic models and how to correct them using more adapted models. In particular certain generalized moment models (Dhaene and Jochmans, 2016) [14] and other more recent ones such as the Corrected Bias method of moments estimators (Breitung, Kripfganz and Hayakawa, 2021) [15].

II.3.1. Managing the Problem of Estimation Bias

The models used in this study use very short (N=2) and relatively short (T=9) panels. As said previously, these approaches generate estimation biases with traditional estimation methods, namely Fixed Effects (FE), Random Effects (RE) and OLS models. However, more recent estimation methods capable of eliminating estimation biases linked to the small sizes of the temporal and individual dimensions provide solutions. Namely:

- Low sample N estimation methods, which are non-parametric and robust estimation methods but have low power compared to parametric estimation methods, help to correct the biases linked to the size N;
- Estimation methods to resolve biases linked to the weakness of the temporal dimension are presented for the first time by Nickell (1981) [13]. And since then, methods such as GMM methods have made it possible to solve these problems. As part of this study, new estimation methods to resolve estimation biases will be used. Methods such as Arellano-Brover & Blundell-Bond, One-step system GMM and FE-Bias-Corrected Estimation.
- Finally, the use of numerous estimates to understand and apprehend estimation biases is of great use for this study. However, a decision-making process for choosing the optimal model must be used for the study of each geographical space in order to obtain guidelines for public and private policies at the scale of the sector and at the macroeconomic level.

As part of the search for the optimal model, the equations used in panel data including individual and temporal dimensions will allow in this study to carry out partial static and dynamic estimates using the dependent variables as lagged variables.

Although the decision-making process for choosing the optimal model is presented, it is necessary to describe the final optimal model chosen for estimations in the three (3) types of spaces (In Free Zone, Out Free Zone and Macroenvironment). The decision-making process is divided into four (4) stages, namely:

Step 1: Estimates of assumed parametric models

This is the estimation step of classic models, namely Fixed Effect (FE) models, Random Effects (RE) models and OLS models. This preliminary modeling step makes it possible to make an initial assessment of the estimates, to obtain the appropriate parametric specification, to isolate the residuals of the appropriate models in parametric conditions and to verify their validity through the tests of steps 2 and 3.

Step 2: Specification Testing

These are "Hausman (Sigmaure) and Breusch and Pagan Lagrangian multiplier test for random effects". This is the step which first makes it possible to obtain the appropriate supposedly parametric model among the classic models (RE, FE and OLS). Then to isolate residuals from the classical model assumed to be optimal in parametric conditions in order to verify the validity of the latter in Step 3.

Step 3: Model validity testing

After isolation of the residuals, of the model assumed to be optimal in parametric conditions, three validity tests are carried out. These are:

- Normality tests (Jarque-Bera normality test),
- Homoscedasticity tests (Breusch–Pagan/Cook–Weisberg test for heteroskedasticity (White))
- Autocorrelation tests (Wooldridge test for autocorrelation)

Step 4: Model estimates for correction of estimation biases in robust form

This involves carrying out estimates from GMM models and Bias Corrected (BC) moments, as well as associated validity tests such as the "Sargan test of overid_chi2" and "Hansen test of overid _chi2" tests. », for the validation of the instrumental variables of the GMM models. Then the "Arellano-Bond" test for the autocorrelation of the residuals at first order and second order.

Step 5: Description of the decision-making process and choice of the optimal model

The description of the decision-making process is carried out using a diagram which describes the steps and which shows how we arrive at the optimal model to be estimated. Which is a non-

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parametric and dynamic model. As part of this study, it is necessary to describe and present the "Bias-Corrected Estimation of linear dynamic panel data models", which are the most appropriate for this study.

II.3.2. Correct Estimation of Biased Linear Dynamic Panel Data Model

The "Bias-Corrected Estimation of linear dynamic panel data models" method is a new estimation method making it possible to correct estimation biases known as Nickell (1981) [13]. It is a bias-corrected (BC) method of moments estimator of Breitung, Kripfganz, and Hayakawa (2021) [15] for linear dynamic panel data models with unobserved group-specific effects. In the latter, all independent variables are strictly exogenous with respect to the idiosyncratic error component. The Fixed Effects (FE) version of the estimator is equivalent to the fitted profile likelihood estimator of Dhaene and Jochmans (2016) [14]. It is practical for models with a single shift of the dependent variable, using the bias-corrected iterative estimator of Bun and Carree (2005) [16].

In the presence of unobserved group-specific heterogeneity, traditional Fixed Effects (FE) and Random Effects (RE) estimators for linear panel data models with a lagged dependent variable are biased in most cases when the horizon temporal (T) is short (Nickell, 1981) [13]. Existing solutions include generalized method of moments estimators abbreviated GMM (Kripfganz, 2016, 2019) [17] [18]. GMM estimators can flexibly adapt to predetermined or endogenous repressors using appropriate instrumental variables.

The Bias Corrected (BC) Estimator presented by Breitung, Kripfganz, and Hayakawa (2021) [15] has finite sample properties and makes it possible to correct estimation biases linked to the weakness of the size of the temporal dimension (T) of the model. The BC estimator also allows correction directly at the source by adjusting the respective moment conditions. The low variance of the estimators of classic models such as the Fixed Effect (FE) and Random (RE) models is preserved.

Higher order autoregressive models can be supported with this tool. The BC estimator is a method of moments estimator with a known asymptotic distribution. Therefore, standard errors can be easily calculated. Standard errors can be adjusted to be robust to cross-sectional dependence. The Bias Corrected (BC) Estimator also uses an error correction vector, of which there are several. As part of this study, standard error correction vector (vcetype) is used. The vcetype specifies the type of standard error reported, which includes types derived from asymptotic (conventional) theory and which are robust to certain types of misspecifications. The standard error correction vector (vcetype) in its robust version, noted: "vce (robust)" is more suitable for carrying out non-parametric estimates. That is to say with samples of reduced size N.

II.3.1.1. General Form of Linear Dynamic Panel Data Model

The general form of the "Bias-Corrected Estimation of linear dynamic panel data models" model is as follows:

$$y_{it} = \sum_{j=1}^{p} \binom{P}{j} \lambda_j \, y_i, t - j + X'_{it}\beta + \alpha_i + u_{it}, \qquad i = 1, 2, \dots, N, \ t = 1,2 \dots, T \tag{8}$$

The basic model assumptions are as follows:

- The minimum individual and temporal dimensions are N=2 and T=2, they can extend to infinity (Breitung, Kripfganz, and Hayakawa, 2021) [15].

i = 1,2,...,N, t = 1,2,...,T

- The autoregressive (higher order) model with P lags of the dependent variable and only minimal regularity conditions on the initial observations;
- Strictly exogenous x_{it} repressors with respect to the idiosyncratic error term are:

E [x_{it} u_{it}] = 0 for all t and s; (9)

- For Fixed Effects specific and random to unobserved groups,

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E [$x_{it}\,\alpha_i$]≠0, or "random effects" E [$x_{it}\,\alpha_i$] = 0; (10)

- Serially Uncorrelated Idiosyncratic Errors are as follows:

E [$u_{it}u_{is}$] = 0 for all tets and E [u_{it}^2] = σ_i^2. (11)

For simplicity, let p = 1 and define θ = (λ_1, β′) ′. The Fixed Effect Bias Corrected (FE-BC) estimator that has just been identified solves:

$$\hat{\theta} = \boldsymbol{arg\ min}\ (\textstyle\sum_{i=1}^{N} m_i(\theta))'(\sum_{i=1}^{N} m_i(\theta)) \quad (12)$$

With the moment of the function which is calculated as follows:

$$m_i(\theta) = \frac{\mathbf{1}}{\boldsymbol{T}}\sum_{\boldsymbol{t=1}}^{\boldsymbol{T}}[\begin{pmatrix} y_{i,t-1}-\bar{y}_{-1,i} \\ X_{it}-\bar{X_i} \end{pmatrix} \begin{pmatrix} \frac{T}{T-1}\ b(\lambda_1)\,(e_{it}-\bar{e}_i) \\ 0 \end{pmatrix}]\ e_{it} \quad (13)$$

$$\bar{X_i} = \frac{1}{T}\sum_{t=1}^{T} X_{it} \quad \text{and} \quad b(\lambda_1) - \frac{1}{T^2}\sum_{t=0}^{T-2} X_{it}\sum_{s=0}^{t} X_{it}\ \lambda_1^s \quad (14)$$

With, E [m_i (θ)] =0 (15)

(Breitung, Kripfganz and Hayakawa, 2021) [15].

III. Results and Discussions

III.1. Descriptive Statistics

The growth dynamic within the homogeneous space (figure 5) is very strong (the slopes have very strong increasing trends) for all variables of interest. The average export revenues (306.161 million USD) are higher than the average industrial revenue (229.271 million USD) (Table 2).

Table 2. Descriptive statistics of free zone (homogeneous space).

Variables	Parameters	Mean	STD. Dev.	Min	Max
Ind_P_TUSD	Amount to	229.271	225.1.344	4	1018
	between		108.209	98.454	251.485
	inside		218.476	-8.810	995.785
Exp_TUSD	Amount to	306.161	274.364	4	1036.298
	between		123.591	156.749	331.5338
	inside		267.250	6.828	1010.926
Exp_Tm3	Amount to	2245464	1260365	5807.998	4570000
	between		1640283	262484.9	2582196
	inside		953855.2	798267.8	4233268
Ind_P_Tm3	Amount to	1801760	885762.3	6798.346	3500000
	between		1262967	274927.7	2061033
	inside		618238	875726.6	3240727

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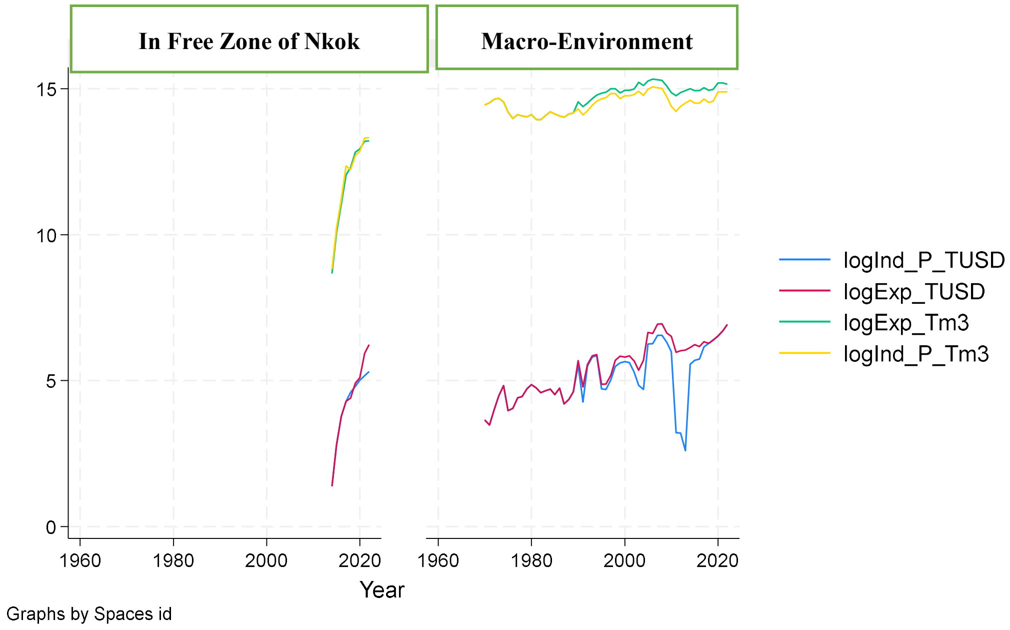

Figure 5. Presents the growth dynamics of variables in homogeneous economic and geographical spaces (In Free Zone of Nkok) and the macroenvironment.

The variability between geographical spaces (between) for the variables; exports and industrial production in volume (m^3) are higher than the internal variabilities. While for those of the variable's income from exports and industrial income ($Ind\_P\_T_{USD}$ and Exp_T_{USD}), the internal variabilities (within the homogeneous space) are higher than the variabilities between spaces. While for production and consumer goods, exports (2,245,464 m^3 in volume are higher than the average industrial production (1,801,760 m^3). In the heterogeneous economic and geographical space (figure 6), average income from exports and industrial income keeps the same trends as in the homogeneous space with slightly reduced differences (table 3).

Table 3. Descriptive statistics outside the free zone (heterogeneous space).

Variables	Parameters	Mean	STD. Dev.	Min	Max
$Ind\_P\_T_{USD}$	Amount to	281.171	238.654	13.404	1018
	between		144.606	251.485	455.9899
	inside		227.334	43.901	1047.686
Exp_T_{USD}	Amount to	351.803	264.561	32.2	1036.298
	between		987.367	331.533	471.1686
	inside		259.872	52.469	1056.568
Exp_T_{m3}	Amount to	2667292	977331.6	1135000	4570000
	between		414520	2582196	3168416
	inside		954900.1	1220096	4655096
$Ind\_P\_T_{m3}$	Amount to	2067567	619458.5	1135000	3500000
	between		31828.28	2061033	2106045
	inside		619252.2	1141534	3506534

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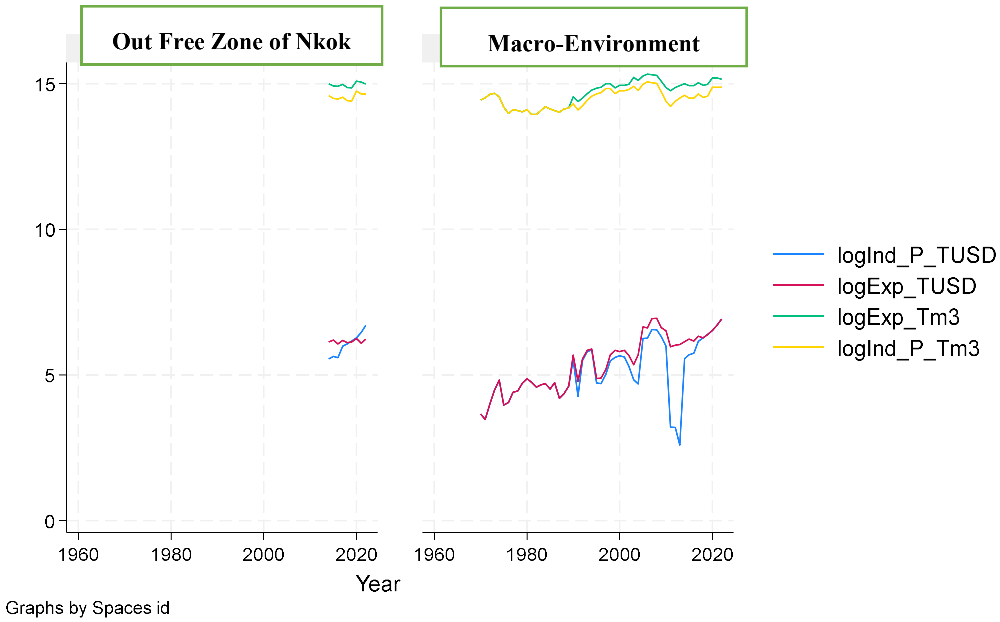

Figure 6. Presents the growth dynamics of variables in heterogeneous economic and geographical spaces (outside Free Zone of Nkok) and the macroenvironment.

As for industrial production and exports in volume, the differences are very small (with 2,067,567 m ^{3} for industrial production and 2,667,292 m ^{3} for exports). The growth dynamics within the heterogeneous space for the export and production volume variables are very weak (the slopes have weak increasing trends for these two variables of interest).

At the macroenvironment level, which contains the series from 1970 to 2022 show increasing trends for export income and industrial income (Table 4 and figure 7).

Table 4. Descriptive macroenvironment statistics.

Variables	Parameters	Mean	STD. Dev.	Min	Max
Ind_P_TUSD	Amount to	258.01	232.255	4	1018
	between		179.384	98.454	455.989
	inside		213.536	19.928	1024.525
Exp_TUSD	Amount to	327.078	262.216	4	1036.298
	between		157.536	156.7495	471.168
	inside		249.685	27.744	1031.842
Exp_Tm3	Amount to	2362457	1219393	5807.998	4570000
	between		1536725	262484.9	3168416
	inside		894348.8	915261.7	4350262
Ind_P_Tm3	Amount to	1840331	837329.9	6798.346	3500000
	between		1044445	274927.7	2106045
	inside		583181.9	914298	3279298

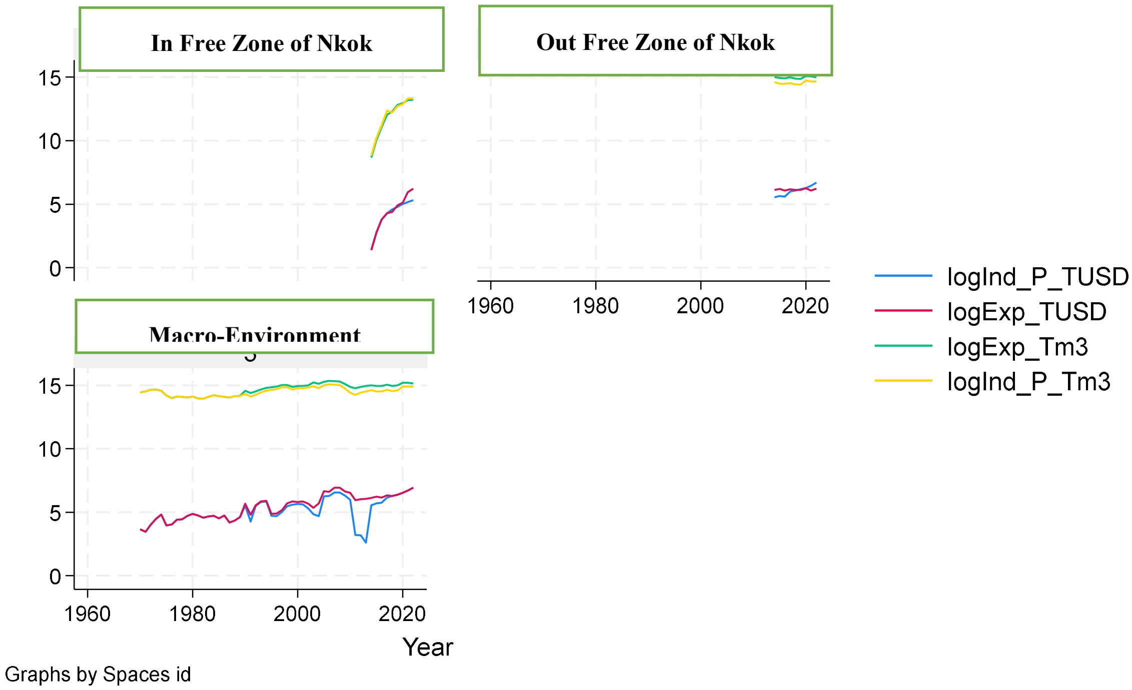

Figure 7. Presents the growth dynamics of the variables in the three types of economic and geographical spaces combined (homogeneous, heterogeneous and the macroenvironment).

Whereas for the production and export volume variables, the trends are not clearly identified. The estimates made in tables 5, 10, 11 and 12 make it possible to make in-depth observations and analyze commercial and industrial dynamics depending on the spaces.

III.2. Classic Estimations

Classic models make it possible to make an initial assessment of the relationships between the industrial income variable and the explanatory variables of interest.

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Table 5. Classic estimations based on economic and geographic spaces (OLS, RE and FE).

Scheme 0. ** $p<0.05$, * $p<0.1$.

	(1)	(2)	(3)
Variables (In Free Zone)	**OLS**	**Random Effect**	**Fixed Effect**
	LogInd_P_T_{USD}		
LogExp_T_{USD}	0.99***	0.99***	1.12***
	(0.12)	(0.12)	(0.16)
LogExp_T_{m3}	-2.11***	-2.11***	-2.55***
	(0.60)	(0.60)	(0.71)
LogInd_P_T_{m3}	2.24***	2.24***	2.49***
	(0.62)	(0.62)	(0.65)
Constant	-1.80	-1.80	0.37
	(1.11)	(1.11)	(2.14)
(N/T)	2/62	2/62	2/62
Statistics	51.87	155.60	45.69
Test > f	0.0000	0.0000	0.0000
Corr (u_i, X or Xb)		0	0.1475
On R-squared	0.7285	0.7285	0.7285
	(1)	**(2)**	**(3)**
Variables (Out Free Zone)	**OLS**	**Random Effect**	**Fixed Effect**
	LogInd_P_T_{USD}		
LogExp_T_{USD}	1.27***	1.27***	1.33***
	(0.17)	(0.17)	(0.15)
LogExp_T_{m3}	-3.01***	-3.01***	-4.12***
	(0.77)	(0.77)	(0.74)
LogInd_P_T_{m3}	3.17***	3.17***	4.38***
	(0.78)	(0.78)	(0.76)
Constant	-3.51	-3.51	-4.96
	(4.27)	(4.27)	(3.81)
(N/T)	2/62	2/62	2/62
Statistics	39.21	117.64	46.42
Test > f	0.0000	0.0000	0.0000
Corr (u_i, X or Xb)		0	0.0434
On R-squared	0.6698	0.6698	0.6484
	(1)	**(2)**	**(3)**
Variables (Macro-Environment)	**OLS**	**Random Effect**	**Fixed Effect**
	LogInd_P_T_{USD}		
LogExp_T_{USD}	0.98***	0.98***	1.12***
	(0.12)	(0.12)	(0.15)
LogExp_T_{m3}	-1.47**	-1.47***	-2.59***
	(0.56)	(0.56)	(0.67)

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$LogInd\_P\_T_{m3}$	1.58***	1.58***	2.52***
	(0.58)	(0.58)	(0.62)
Constant	-1.37	-1.37	0.45
	(1.12)	(1.12)	(2.05)
(N/T)	3/71	3/71	3/71
Statistics	56.15	168.46	49.96
Test > f	0.0000	0.0000	0.0000
Corr (u_i, X or Xb)		0	0.1861
On R-squared	0.7155	0.7155	0.6686

Indeed, in the three types of economic and geographical spaces (homogeneous, heterogeneous and macroenvironment), all the independent variables are significantly correlated with the dependent variable ($Ind\_P\_T_{USD}$). And the export volume variable (Exp_T_{m3}) is always negatively correlated with the dependent variable.

III.3. Classic Specification and Validity test (OLS, RE and FE)

- ***Classic Spécification test***

The specification tests (Table 6) indicate that for the homogeneous economic and geographical space, the Random Effect (RE) model is preferable for carrying out the estimates. Which automatically leads to carrying out the "Breusch and Pagan Lagrangian multiplier test for random effects" which indicates that the OLS model is more appropriate. Therefore, to carry out estimates within the homogeneous space in parametric conditions, the random effect model is the most appropriate. In heterogeneous economic spaces and the macroenvironment, the Hausman specification test indicates that the fixed effect model is the most appropriate for carrying out estimations in parametric conditions.

- ***Heteroskedasticity test***

The heteroskedasticity tests (Table 7) indicate that all the residuals are homoscedastic in the three types of economic and geographical spaces. Whereas in the parametric condition, there would be no validity problem linked to homoscedasticity.

- ***Normality test***

The Jarque-Bera normality test (Table 8) indicates that in the three spaces, the residuals do not follow a normal law. This normality problem linked to the low sample size of the temporal and individual dimensions indicates that the conditions of validity in a parametric situation are not respected. Thus, the classic models (RE, FE and OLS) cannot be used to make estimates in the three types of spaces (homogeneous, heterogeneous and macroenvironment).

- ***Wooldridge autocorrélations test***

Concerning the autocorrelation tests (Table 9), p. values indicate that there is first-order autocorrelation when estimates are made with the classic models (RE, FE and OLS). That is to say when the estimates are carried out in parametric conditions.

Ultimately, there are only homoscedasticity tests which respect the validity conditions for the three spaces. Unlike normality and autocorrelation tests which invalidate the use of classic models (RE, FE and OLS) under parametric conditions. Which leads us to use estimation methods to correct the estimation biases obtained by parametric methods. Regarding the decision-making process and the choice of the optimal model (figure 8), we note that the "One-step system GMM_Robust" and "FE-Bias-Corrected Estimation (Robust)" models provide the best results. Regarding the "One-step system GMM_Robust" model, the "Sargan test of overid_chi2" tests are not significant in the three spaces.

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Table 6. Classic specification test.

Spaces	Statistics	p.value	Remark
Housman test (Sigmaure)			
In Fee Zone	1.4	0.237	Random Effect is appropriate
Out Free Zone	13.02	0.0003	Fixed Effect is appropriate.
Macro-Environment	10	0.0067	Fixed Effect is appropriate.
Breusch and Pagan Lagrangian multiply test			
Song title: In Fee Zone	0.00	1.00	Pooled Model is Adaptive pool model is suitable.

For the Hausman test (Sigmaure) test (White), hypotheses H_0: Random effect is appropriate. For the Breusch and Pagan Lagrangian multiplier, hypotheses H_0: Pooled Model is appropriate.

Table 7. Heterogeneity test.

Breusch – Pagan/Book – Weisberg heterogeneity test (white)			
Spaces	**Statistics**	**p.value**	**Remark**
In Fee Zone	2.03	0.1538	Constant variance (Homoscedastic Residuals)
Out Free Zone	2.39	0.1538	Constant variance (Homoscedastic Residuals)
Macro-Environment	1.05	0.3066	Constant variance (Homoscedastic Residuals)

For the Breusch–Pagan/Cook–Weisberg test (White), hypotheses H_0: the Residuals Homoscedastic.

Table 8. Normality test.

Jarque-Bera normality test			
Spaces	**Statistics**	**p.value**	**Remark**
In Fee Zone	120	8.60E-27	Residue does not follow normal distribution
Out Free Zone	70.4	5.20E-16	Residue does not follow normal distribution
Macro-Environment	92	1.10E-20	Residue does not follow normal distribution

For the Jarque-Bera normality test, the hypothesis H_0: the residuals follow a normal distribution.

Table 9. Autocorrelation test.

Wooldridge autocorrelation test			
Spaces	**Statistics**	**p.value**	**Remark**
In Fee Zone	353.966	0.0338	First order autocorrelation
Out Free Zone	2613.494	0.0125	First order autocorrelation
Macro-Environment	271.794	0.0037	First order autocorrelation

For the Wooldridge test for autocorrelation, the hypothesis H_0: there is no first order autocorrelation.

III.4. Decision-Making Processes and Choice of the Optimal Model

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Figure 8 presents the decision diagram, which illustrates the decision-making process used to make choices of the optimal model to estimate in each economic and geographic spaces.

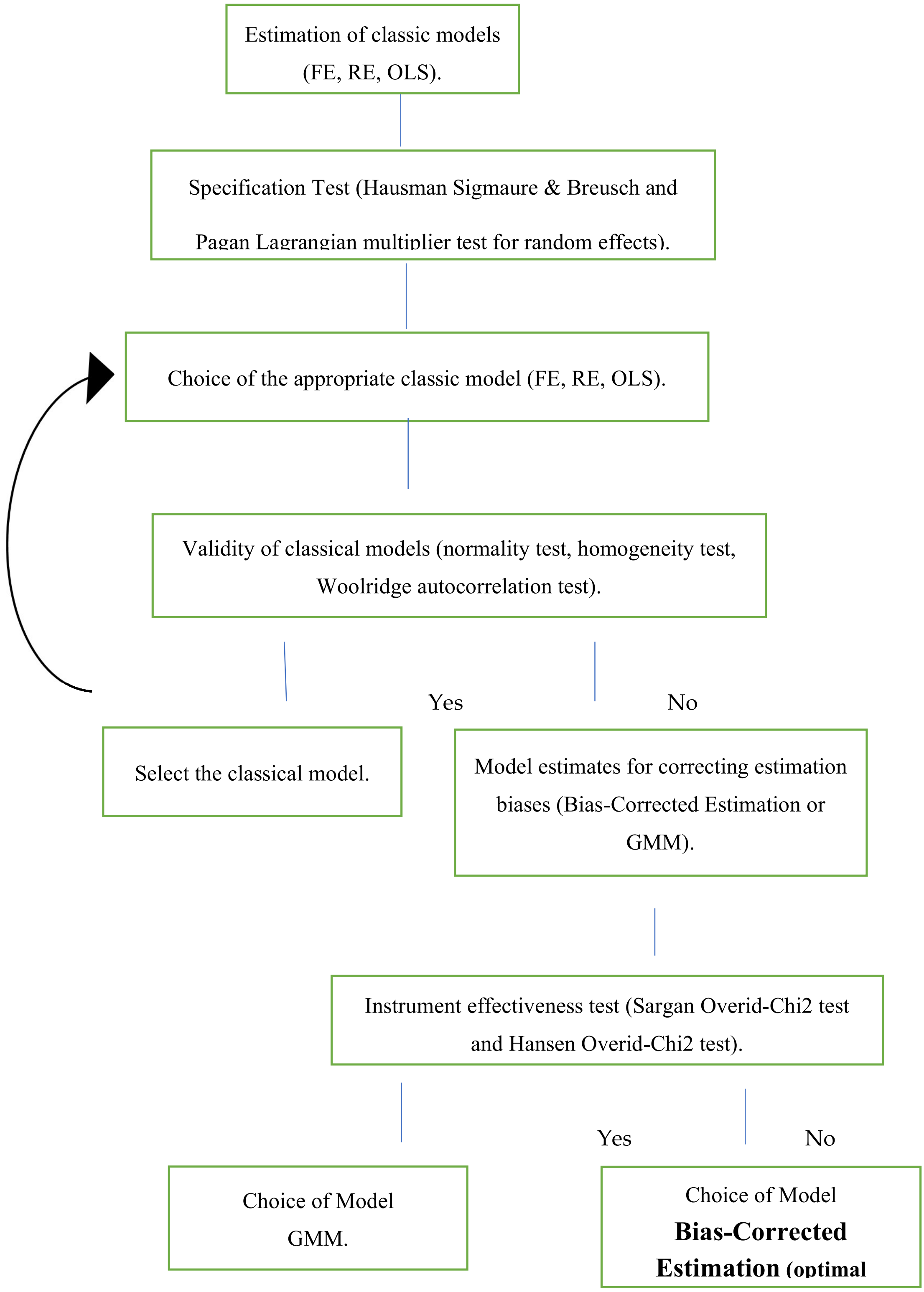

Figure 8. Presents the decision diagram, which illustrates the decision-making process used to make the choices of the optimal model to estimate in each economic and geographical space. ***Source:*** *Authors.*

Although the "Hansen test of overid_chi2" tests are significant, we cannot conclude that the instruments are valid in any of the panels. Thus the "FE-Bias-Corrected Estimation (Robust)" model

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will be retained as the optimal model for estimations in the three spaces (homogeneous, heterogeneous and macroenvironment). However, the "Arellano-Brover/Blundell-Bond" and "One-step system GMM" models make it possible to enrich the analysis and appreciation of the relationships between the dependent variable and the independent variables from static and dynamic angles.

III.5. Estimates With Error Corrected

The selected model "FE-Bias-Corrected Estimation (Robust)" presents a better estimation guarantee. The biases observed in classic models have been corrected and the estimates are carried out in non-parametric conditions, correcting normality problems. The residuals are all homoscedastic in the three economic and geographical spaces (homogeneous, heterogeneous and macroenvironment) observed during the validity tests in parametric conditions. Autocorrelation problems and those linked to the weakness of the temporal dimension have been corrected. Thus, estimates can be made in the three types of spaces (table 10, 11 and 12).

III.5.1. Effects of the Nkok Special Economic Zone on the Macroenvironment

In the homogeneous space, the first order (p. value =0.2667) and second order (p. value =0.3004) post-estimate autocorrelation tests indicate that there are no autocorrelations. The dynamic part of the model indicates that the lagged autoregressive dependent variable has a slope of 40%. Indeed, an increase in the industrial income of a unit for a given year (n) leads to its increase by 40% the following year (n+1). From a static point of view, export revenues have a significantly positive relationship with the dependent variable, unlike industrial export volumes which are negatively correlated with the dependent variable ($LogInd\_P\_T_{USD}$). Indeed, an increase in export revenues (Table 10 and Figure 9) of 83% leads to an increase in industrial revenues of 100%. While an increase in industrial income of 100% leads to a drop in industrial exports in volume (m^3) of 224% in the homogeneous space (In Free Zone). The industrial and commercial relations observed are explained by the theories of balanced and unbalanced regional growth. Indeed, export revenues are explained by the export base theory of Douglass-North (1990) [10], which postulates that: "the economic progress of a given region depends on the expansion of its export activities as escalating external demand will catalyze growth in this region. " . The beneficial effects that could result in the short, medium and long term are valid not only for the growth of export revenues, but also for the growth of industrial revenues. Some advantages are the progressive balance of production factors (capital and labor), transformation of price structures allowing economies of scale to be achieved, including significant reductions in the prices of production and consumer goods and improvements in wages.

Table 10. Optimal estimates of the effect of homogeneous space (In Free Zone).

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variables	(1) Alejano Brover Brendel Bond	(2) GMM one-step system	(3) One step system GMM- (robust)	**(4) FE-Bias-Corrected Estimation (robust)**
		LogInd_P_T_{USD}		
Δ*LogInd_P_T_{USD}	0.35***	0.37***	0.37***	0.40***
	(0.06)	(0.08)	(0.03)	(0.05)
LogExp_T_{USD}	0.79***	0.74***	0.74***	0.83***
	(0.09)	(0.11)	(0.27)	(0.21)
LogExp_T_{m3}	-2.18***	-1.91***	-1.91	-2.24*
	(0.37)	(0.48)	(1.40)	(1.17)
LogInd_P_T_{m3}	2.16***	1.96***	1.96	2.06
	(0.38)	(0.51)	(1.47)	(1.32)
Constant	-0.16	-1.07	-1.07	1.52
	(1.14)	(1.12)	(2.12)	(2.70)
Sargan test of overid-chi2		80.80 (0.013)	80.80 (0.013)	
Hansen test of overid-chi2			0.00 (1.000)	
Autocorrelation order 1				-1.1106 (0.2667)
Autocorrelation order 2				1.0356 (0.3004)
(N/T)	60/2	60/2	60/2	60/2
Ward Chi 2 (4)	330.66	8196.39	302.07	
p. value	0.0000	0.000	0.000	

Standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1 For the Sargan test of overid_chi2 and Hansen test of overid _chi2, p. values are in parentheses and chi-square statistics are outside the parentheses. The assumption of the Arellano-Bond test for the autocorrelation of the residuals in first order and second difference are: "H_0: no autocorrelation of order 1 or 2". The p. values are in parentheses and Z statistics are outside parentheses.

Concerning the effects of the drop in industrial exports in volume of homogeneous space on the macroenvironment, they could be explained by the decision of the Gabonese government to prohibit the export of woody forest resources without having first undergone a first transformation industrial at a minimum. In addition, it could be explained by the process of structural transformation of the forestry sector driven by the homogeneous economic space which generates "Big Push" effects theorized by Rosenstein-Rodan (1943) [6,7].

III.5.2. Effects of the Region Outside the Nkok SEZ on the Macroenvironment

In the heterogeneous space, the first order (p. value =0.2667) and second order (p. value =0.3004) post-estimation autocorrelation tests indicate, as for the homogeneous space, that there is no autocorrelation. The autoregressive dynamic dependent variable of the model has a slope of 36% which is lower than that of the homogeneous space. From a static point of view, export revenues have a significant positive relationship with the dependent variable, unlike industrial exports in volume which are negatively correlated with exports in value. Indeed, an increase in export revenues (Table

11 and Figure 9) of 102% leads to an increase in industrial revenues of 100% driven by the heterogeneous space on the macroenvironment. While an increase in industrial revenues of 100% leads to a drop in industrial exports in volume of 355% driven by the heterogeneous space. Concerning industrial production in volume, an increase in industrial revenues of 100% leads to an increase in industrial production in volume of 377% driven by the heterogeneous space.

Table 11. Optimal estimates of the effect of heterogeneous space (Out Free Zone).

Variables	(1) Alejano Brover Brendel Bond	(2) GMM one-step system	(3) One step system GMM-(robust)	**(4) FE-Bias-Corrected Estimation (robust)**
		LogInd_P_T_{USD}		
Δ*LogInd_P_T_{USD}	0.39***	0.43***	0.43***	0.36***
	(0.05)	(0.07)	(0.09)	(0.02)
LogExp_T_{USD}	0.99***	0.92***	0.92***	1.02***
	(0.11)	(0.14)	(0.12)	(0.02)
LogExp_T_{m3}	-3.19***	-2.65***	-2.65***	-3.55***
	(0.42)	(0.56)	(0.86)	(0.09)
LogInd_P_T_{m3}	3.40***	2.80***	2.80***	3.77***
	(0.42)	(0.56)	(0.93)	(0.11)
Constant	-4.51**	-3.62	-3.62***	-4.77***
	(2.23)	(3.06)	(1.14)	(0.33)
Sargan test of overid-chi2		83.05 (0.009)	83.05 (0.009)	
Hansen test of overid-chi2			0.00 (1.000)	
Autocorrelation order 1				-1.0636 (0.2875)
Autocorrelation order 2				1.0356 (0.3030)
(N/T)	60/2	60/2	60/2	60/2
Ward Chi 2 (4)	453.99	9885.60	10.04	
p. value	0.0000	0.000	0.040	

Standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1. For the Sargan test of overid_chi2 and Hansen test of overid _chi2, p. values are in parentheses and chi-square statistics are outside the parentheses. The assumption of the Arellano-Bond test for the autocorrelation of the residuals in first order and second difference are: "H_0: no autocorrelation of order 1 or 2". The p. values are in parentheses and Z statistics are outside parentheses.

The significant increase in production volume driven by heterogeneous space finds its explanation in unbalanced regional growth theories. In particular the theories: "peripheral center" of Hirschman (1958) [3] and the explanations of Perroux (1955) [1] on the transformation of industrial relations between the center and the periphery. The fact that the homogeneous space strongly specializes in industrial transformation with strategic competitive advantages compared to the heterogeneous space. In particular the agglomeration economies and infrastructures which force many firms to locate in the peripheral regions of the heterogeneous space, in order to extract woody

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forest resources and supply them in the homogeneous spaces. This reorganization of the Gabonese forest industrial matrix is demonstrated by the relationships observed from estimates in heterogeneous space, showing an accelerated polarization process.

III.5.3. Effects of Industrial Income on Macro-Environmental Variables

Finally, concerning the macroenvironment (Table 12 and Appendix), the hypotheses of non-autocorrelations are also verified as for homogeneous and heterogeneous spaces. From a static point of view, the relationships between variables are the same as in homogeneous space. The dynamic behavior of the autoregressive dependent variable is also the same when compared to that of the homogeneous or heterogeneous space.

Table 12. Optimal Estimates in the Macroenvironment.

Variables	(1) Alejano Brover Brendel Bond	(2) GMM one-step system	(3) One step system GMM--(robust)	**(4) FE-Bias-Corrected Estimation (robust)**
		LogInd_P_T$_{USD}$		
Δ*LogInd_P_T$_{USD}$	0.37***	0.44***	0.44***	0.412***
	(0.06)	(0.08)	(0.07)	(0.064)
LogExp_T$_{USD}$	0.81***	0.68***	0.68***	0.824***
	(0.08)	(0.11)	(0.26)	(0.216)
LogExp_T$_{m3}$	-2.12***	-1.39***	-1.39	-2.244**
	(0.34)	(0.44)	(1.39)	(1.134)
LogInd_P_T$_{m3}$	2.05***	1.38***	1.38	2.065
	(0.35)	(0.46)	(1.47)	(1.285)
Constant	0.21	-0.40	-0.40	1.579
	(1.10)	(1.08)	(2.06)	(2.752)
Sargan test of overid-chi2		92.58 (0.009)	92.58 (0.009)	
Hansen test of overid-chi2			0.00 (1.000)	
Autocorrelation order 1				-1.1420 (0.2534) 1.0467 (0.2952)
Autocorrelation order 2				
(N/T)	60/2	60/2	60/2	60/2
Ward Chi 2 (4)	366.66	9920.87	176.21	
p. value	0.0000	0.000	0.000	

Standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1, For the Sargan test of overid_chi2 and Hansen test of overid _chi2, p. values are in parentheses and chi-square statistics are outside the parentheses. The assumption of the Arellano-Bond test for the autocorrelation of the residuals in first order and second difference are: "H_0: no autocorrelation of order 1 or 2". The p. values are in parentheses and Z statistics are outside parentheses.

It is fair to note that from a static point of view, the slope variations are different but similar to those of homogeneous space. Thus, over the period 2014 to 2022, the dynamics of the

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macroenvironment tended to be more sensitive to the industrial dynamics of the homogeneous space compared to those of the heterogeneous space. This situation shows that homogeneous space plays the role of a driving industry on the scale of the macroenvironment, thus verifying the theory of Perroux (1955) [1] on the role of driving industries in growth poles. The analysis of industrial and commercial relations based on Granger causality tests (Table 13 and Figure 9) makes it possible to understand the mechanisms generated by the process of polarization of the economic and geographical spaces of the timber forestry sector in Gabon.

III.6. Causality Tests

The industrial and commercial relationships between the dependent variable and the independent variables show from Granger causality tests (Table 13 and Figure 9) that the growth dynamics of export revenues associated with investments and the strategic location of the homogeneous space brings together the conditions to generate polarization effects (agglomeration, diffusion and connections, creation of central regions and peripheral regions).

Table 13. Dumitrescu and Hurlin (2012) Granger non causal test results.

Granger causality Tests					
Causality	**Z-bar**	**p-value**	**Z-bar tilde**	**p-value**	**Remarks**
Ind_P_T_{USD}- Exp_T_{USD}	17,541	0.1360	13,450	0.0794	Exp_T_{USD} does Granger-cause Ind_P_T_{USD} for at least one panel
Exp_T_{USD}-Ind_P_T_{USD}	15,807	0.6479	0.4636	0.1140	
Ind_P_T_{USD}-Exp_T_{m3}	0.9619	0.3361	0.8538	0.3932	Ind_P_T_{USD} does Granger-cause Exp_T_{m3} for at least one panel
Exp_T_{m3}-Ind_P_T_{USD}	25,485	0.0108	23,273	0.0199	
Ind_P_T_{USD}-Ind_P_T_{m3}	0.8259	0.4089	0.7275	0.4669	Ind_P_T_{USD} does Granger-cause Ind_P_T_{m3} for at least one panel
Ind_P_T_{m3}-Ind_P_T_{USD}	48,121	0.0000	44,296	0.0000	

For the Granger causality Tests, the hypothesis H_0: variable X_1 does not Granger-cause. Variable X_2 for at least one panel.

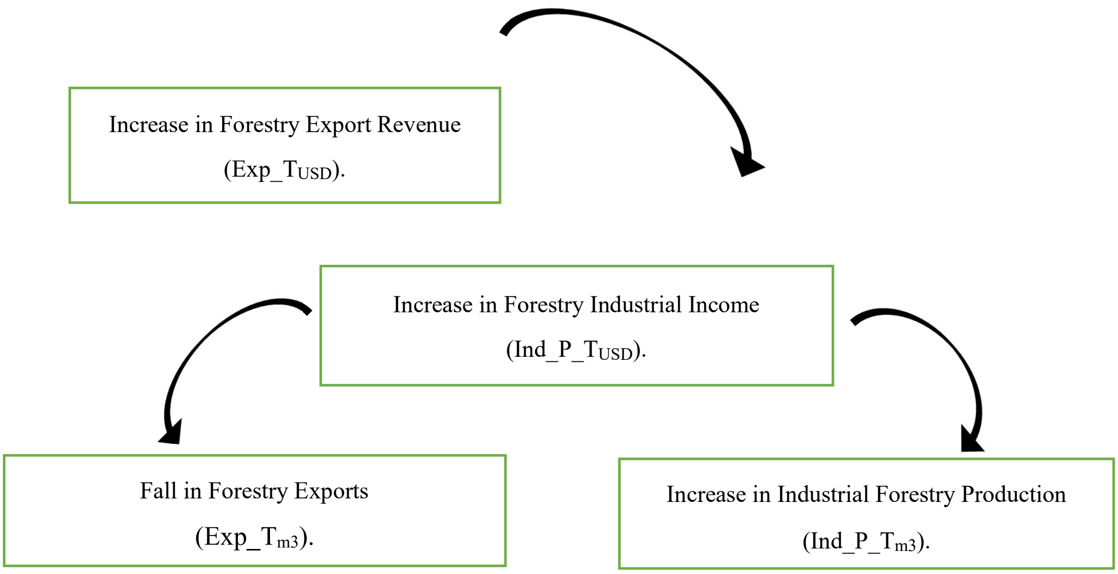

Figure 9. Causal diagram that illustrates industrial and commercial relationships in the polarized economic and geographic spaces of Gabon's forestry sector.

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The conditions met also generate a process of transformation of the industrial matrix by differentiating and specializing activities according to the space considered. The homogeneous region, more oriented towards exports, represents a real strong driving industry for downstream and upstream activities. While the heterogeneous region brings together secondary and primary driving activities (less strong than those of the homogeneous region), providing raw materials to the homogeneous space which has more of an industrialization and export function.

Policies and recommendations:

The study made it possible to demonstrate, thanks to a quantitative approach for Gabon's forestry sector, that growth poles, in particular special economic zones (SEZs), can generate numerous beneficial regional effects in developing countries by concentrating investments and infrastructure in specific areas, to the detriment of other regions. However, unbalanced regional growth can create economic and social disparities driven by development poles in many regions. Here are recommendations and policies to minimize these disparities while promoting the benefits of regional unbalanced growth:

1. Develop a network of hubs in several regions of the same country

Problem: In developing countries, clusters (mainly special economic zones) are often located in already developed areas such as peri-urban areas, leaving rural or remote regions on the margins.

Recommendation and policies:

- Create a network of SEZs spread across several strategic regions, including rural or less developed areas.
- Develop SEZs focused on local resources (e.g. agro-industry in agricultural regions).
- Connect SEZs through transport infrastructure to promote regional economic integration.

Example: India has set up SEZs in less developed areas like Uttar Pradesh to boost regional development.

2. Strengthen infrastructure in peripheral regions

Problem: Areas outside SEZs often lack basic infrastructure, which hinders their development.

Recommendation and policies:

- Use revenues generated by SEZs to finance infrastructure in surrounding regions.
- Build roads, electricity networks and sanitation facilities connecting rural areas to SEZs.
- Promote integrated development programs to connect urban and rural areas.

3.Integrate local SMEs into SEZ value chains

Problem: SEZs often favor large foreign companies to the detriment of local SMEs.

Recommendation and policies:

- Encourage businesses located in SEZs to source from local suppliers.
- Provide incentives for SMEs to participate in the value chains of industries present in SEZs.
- Train and finance local businesses so that they can meet the required quality standards.

Example: In Ethiopia, the Hawassa industrial park promotes local employment and the integration of local suppliers.

4. Redistribute the fiscal and financial benefits of SEZs

Problem: SEZs benefit from tax privileges, which reduces the income redistributed to the rest of the country.

Recommendation and policies:

- Establish a mechanism for redistributing income generated by SEZs to less developed regions.
- Create regional development funds funded by part of the taxes or profits generated by the SEZs.

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- Establish quotas or Investment obligations in local infrastructure.

5. Train local populations to expand employment opportunities

Problem: Jobs created in SEZs often benefit skilled workers from other regions or countries.

Recommendation and policies:

- Establish vocational training centers near SEZs to train the local workforce.
- Include specific training programs for women and young people, who are often excluded from opportunities.
- Establish local hiring quotas in SEZs.

Example: Bangladesh trains thousands of local workers in the textile sector around its SEZs.

6. Encourage co-development policies

Problem: SEZs often function as economic enclaves, unconnected to the rest of the national economy.

Recommendation and policies:

- Develop links between SEZs and regional economies (e.g. local agriculture to supply food industries).
- Create economic corridors connecting SEZs to peripheral regions to stimulate economic activity along these corridors.
- Promote co-development projects where several regions benefit from the same investment.

7. Improve governance and transparency in SEZ policies

Problem: Resources and investments in SEZs are sometimes poorly managed, worsening disparities.

Recommendation and policies:

- Ensure equitable regional planning to distribute resources and investments.
- Strengthen transparency in the award of contracts, management of funds and assessment of the impacts of SEZs.
- Establish regional institutions to monitor the impact of SEZs on local communities.

8. Develop inclusive and sustainable SEZs

Problem: SEZs can create environmental and social imbalances.

Recommendation and policies:

- Integrate ecological practices in SEZs to protect the local environment.
- Implement social responsibility programs to support surrounding communities.
- Ensure public consultation with local populations before the implementation of new projects.

Example: The SEZs of Kigali (Rwanda) integrate principles of sustainability and inclusive development.

9. Encourage public-private partnerships (PPP)

Problem: Limited public resources often prevent investments in peripheral regions.

Recommendation and policies:

- Involve the private sector in the development of infrastructure outside SEZs.
- Promote PPPs to finance educational, health or economic projects in underdeveloped areas.

10. Regularly evaluate and adjust SEZ policies

Problem: The lack of monitoring prevents the negative effects of SEZs from being corrected on regional disparities.

Recommendation and policies:

- Establish monitoring indicators to measure the economic, social and environmental impacts of SEZs.
- Readjust policies based on results to better meet regional needs.
- Involve local stakeholders in planning and evaluation processes.

To resolve regional disparities, the clusters, particularly the SEZs of developing countries, must be integrated into a balanced national development strategy. This means distributing resources equitably, strengthening peripheral regions and ensuring that the benefits of the hubs flow across the country. An inclusive and sustainable approach is essential for clusters to become engines of equitable development.

Conclusions

Ultimately, the decision to stop exports of forestry raw materials and the development of a strategy for the industrialization of this sector in Gabon made it possible to apply a certain number of traditional theories of regional growth. The Nkok Special Economic Zone created in 2012, as well as its strategic location and the construction of infrastructure to boost exports are the materialization of the application of the traditional theories of regional growth of Rosenstein-Rodan (1943) [6] [7] via the "Big push" theory and Douglass-North (1990) [10] through the "export base" theory. These infrastructural and industrial investments made it possible to trigger a process of polarization already studied by numerous authors of theories of unbalanced regional growth, the main architect of which is Perroux (1955) [1].

The review of these theories made it possible to understand and explain the results, which constitute the empirical part of the study whose objective was to initially measure the impact of the homogeneous region (Special Economic Zone) on the heterogeneous region and the macroenvironment. And secondly, to explain the mechanisms around industrial and commercial activities, as well as the relationships between economic and geographical spaces engaged in an accelerated polarization process (agglomeration economies, diffusion of technologies, creation of connections and reorganization of the space in "central-peripheral" regions) theorized by Hirschman (1958)) [3].

During the period 2014-2022, the homogeneous space of the entire polarized region led to the heterogeneous space and the macroenvironment space by developing strong positive relationships between industrial income and the independent variables of the model which are income. exports and industrial production. With the exception of the relationship between industrial income and exports in volume of woody forest products which is negative because of the ban on the export of raw materials and their domestic transformations. The mechanisms surrounding commercial and industrial activities have shown that income from exports leads to an increase in industrial production volume and its revenues. While the gradual increase in industrial income leads to a drop in exports of raw materials due to the gradual increase in product transformations and the creation of new processed woody forest products (new types of furniture, transformation of veneer sheets into new products secondary processing…etc.).

The polarization process generated should be considered as a phase of economic and geographical imbalances whose long-term issues should be studied and predetermined further by researchers on the question of the poles of southern countries in underdeveloped environments.

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Conflicts of interest: The authors declare no conflicts of interest.

Appendix: Point Clouds in the Macroenvironment

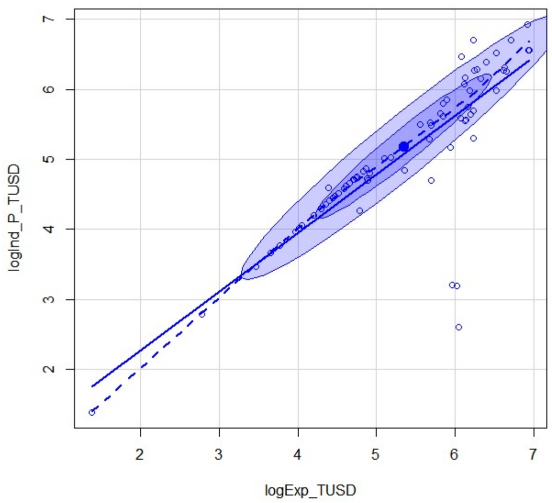

Figure A. Regression of industrial income production

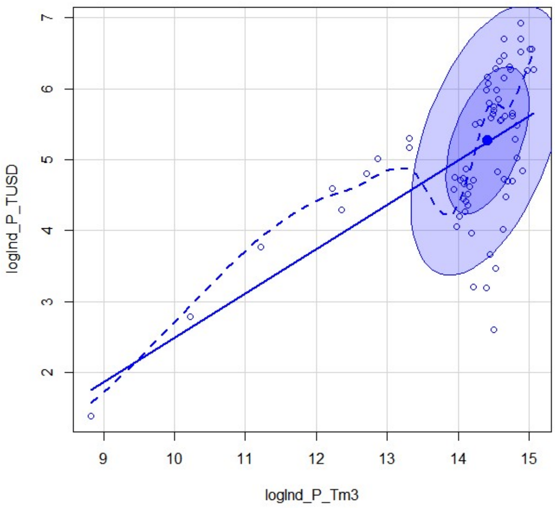

Figure B. Regression of industrial forestry

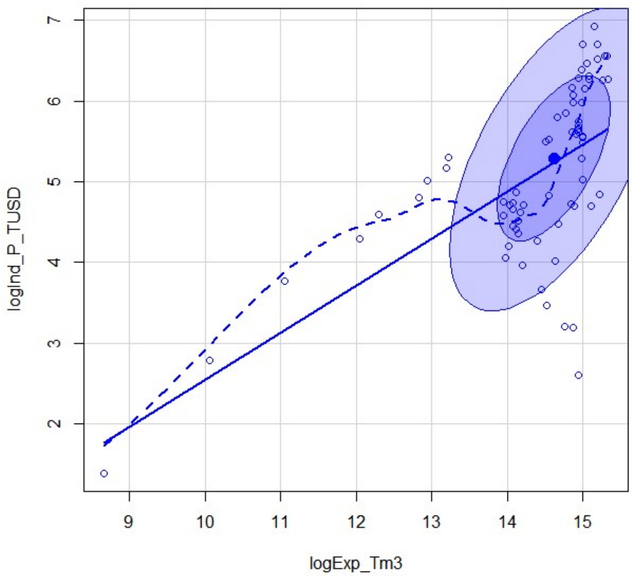

Figure.C. Regression of Forestry exports

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