Modelling the relationship between
DEMOGRAPHY, PEACE AND SECURITY

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ABSTRACT

In this work, we present a multidimensional analysis of peace and security and its determinants (military expenditure, schooling for young people, demographic dependency, etc.). We then analyse the sociodemographic factors that foster insecurity in the Sahel. Lastly, we determine the explanatory factors behind the level of peace and security in Africa, taking spatial correlation into account. The results show that the level of peace and security is positively correlated with the secondary school enrolment rate, the urbanization rate and the agricultural performance of a country. Furthermore, the level of peace and security is negatively correlated with the demographic dependency ratio, the level of economic inequality and the unemployment rate among young people. A country classification produced three groups of countries. The first group comprises countries with a high level of security, mostly Western countries. The second group of countries has a medium level of security. There are no West African countries in this group. The third and final group of countries have a low level of security. These countries have a higher demographic dependency ratio (75 per cent compared with a general average of 47 per cent) and a youth unemployment rate that is 10 points higher than the general average (27.71 per cent compared with 17.86 per cent). Finally, their secondary school enrolment rate is half the general average (36.94 per cent compared with 72.18 per cent). The results of the modelling for the Sahel countries show that youth unemployment (especially among young men), migration and the youthfulness of the population had an impact on the increase in insecurity in the Sahel. On the other hand, increasing the share of gross domestic product (GDP) allocated to health expenditure leads to a decrease in insecurity in the Sahel.

Spatial modelling of peace and security in Africa shows that the spatial autoregressive coefficient has a significance threshold of 5 per cent. All other things being equal, an increase in the level of peace and security in one country thus has a positive effect on the level of peace and security in the countries with which it shares common borders, through the contagion effect. The other determinants of peace and security in Africa are: the demographic dependency ratio, forest cover, the agricultural performance of a country, the level of democracy, the secondary school enrolment rate and access to the sea.

Keywords: insecurity, peace, demography, Africa, Sahel, Panel, Spatial

JEL classification code: A13, C02

GENERAL INTRODUCTION

Recent human history is marked by a 20th century defined, especially in its first half, by international conflicts with disastrous social, economic and human consequences. Humanity embarked on the third millennium with a series of conflicts, albeit on a smaller scale; these involved fewer states, were internal in origin and generally had a combination of political, economic and social roots. These new kinds of conflict are fed by state weakness, contribute to their own deconstruction and also cause a great deal of human distress. Africa is a continent scarred by the atrocities of this new type of conflict and receives significant international interest from political science researchers. Nevertheless, few researchers have attempted to provide a response based on quantitative elements to highlight the factors behind these conflicts.

Although the immediate causes that are generally cited for most of these crises are youth unemployment, the shortage of resources, high levels of social inequality and poor governance, the demographic factor is increasingly mentioned in the literature (Goldstone, 2002). In most cases, these conflicts develop in a social context marked by very slow demographic transition, fuelled by relatively high levels of mortality and fertility, and by population structures dominated by young people under 30 years of age.

The decline in child mortality observed in most African countries in recent years has not yet led to a significant decline in fertility, as expected in the classic pattern of demographic transition. In many African countries, the average number of children per woman is still high, at around five children per woman, and has not yet reduced significantly.

In many cases, poor living conditions and a lack of employment opportunities make these young people vulnerable to the manipulation and false promises of extremists and to human trafficking. While some choose to venture abroad in search of better economic opportunities, often with unpredictable consequences, most have no choice but to express their dissatisfaction on the streets. In doing so, they create an easy market for the big crime lords, including international terrorists.

As indicated in the theoretical framework below, security and demographic issues seem to be closely linked. An analysis of this relationship requires a holistic approach and consideration of several control variables focused on socioeconomic, cultural and political aspects. This study was undertaken to provide information for the analysis of demographic and economic challenges in the Sahel, linked to the security crisis and armed conflicts observed in the West and Central Africa region. It aims to provide an evidence base for the development and implementation of projects that will ensure stability and development in the region. Using examples from selected countries around the world, the study is based on the hypothesis that the emergence of armed conflicts or security crises is linked to uncontrolled population dynamics, which have not been sufficiently taken into account in national development policies and programmes.

The overall objective of this work is to analyse the interrelationships between peace, security and demography around the world, and particularly in Africa and the Sahel. To do this, the following specific objectives have been identified:

- Conduct a multidimensional analysis of the determinants of peace and security in relation to demographics around the world.

- Analyse the determinants of peace and security in Africa, taking into account spatial correlation and the dynamic aspect.
- Analyse the sociodemographic factors that foster insecurity in the Sahel.

We thus make the following assumptions in this report:

- Taking spatial dimensions into account significantly improves the way in which peace and security are measured.
- There is a causal relationship between demographic dependency and peace and security.
- The countries of the Sahel have specific characteristics in terms of peace and security.

To achieve the overall objective cited above and to confirm or refute our assumptions, we have divided the document into three chapters. The first is a multidimensional analysis of the determinants of peace and security in relation to demographics. After outlining the different definitions and measurements of peace and security, we review the various existing peace and security indices before proposing a multidimensional analysis of the selected index to examine its correlation with other factors and its scores in the different continents and subregional blocs. The second chapter presents an analysis of the explanatory factors of peace and security in Africa, taking into account the spatial and dynamic aspect. The last chapter identifies the sociodemographic factors that contribute to insecurity in the Sahel.

CHAPTER I
MULTIDIMENSIONAL ANALYSIS OF PEACE AND SECURITY

Abstract

This chapter provides a multidimensional analysis of the explanatory factors of peace and security, highlighting the specific role of demographics. Principal component analysis (PCA) and classification are used to analyse similarities between countries. The analysis includes a set of 11 variables determining the level of security, and 163 countries spread over five continents.

The results show that the Global Peace Index (GPI) in a country is positively related to certain factors, such as the level of education (measured by the secondary school enrolment rate), the rate of urbanization and the level of development of the country, as measured by agricultural performance. Furthermore, the level of security of a country is negatively related to other factors, such as demographic dynamism (measured by the demographic dependency ratio), the level of economic inequality and youth unemployment. A country classification produced three groups of countries. The first group comprises countries with a high level of security, mostly Western countries. The second group is made up of countries with a medium level of security. No West African country is included in this group. The third and final group of countries have a low level of security. These countries have a higher demographic dependency ratio (75 per cent compared with a general average of 47 per cent) and a youth unemployment rate that is 10 points higher than the general average (27.71 per cent compared with 17.86 per cent). Finally, their secondary school enrolment rate is half the general average (36.94 per cent compared with 72.18 per cent).

Keywords: insecurity, demography, peace, multidimensional, classification

JEL codes: A13, C02

I. Definition of concepts and literature review

This section presents an overview of recent theoretical and empirical literature on demography, peace and security, particularly in the African context. We firstly outline and define the basic concepts of the topic. Next, we present different theoretical approaches to violence and insecurity, including economic, social and demographic approaches. Finally, in the third part we review empirical work on the explanatory factors of security.

I.1. Definition of basic concepts on security and peace

A. Demography

From the ancient Greek, (*demos*: people and *graphein*: to write), demography is defined by the United Nations Multilingual Dictionary as the scientific study of human populations primarily with respect to their size, their structure and their development; it takes into account some of their general characteristics. Today, the demographic question is at the heart of all major contemporary societal issues. Each area of the world is affected differently by population changes. While Africa is yet to complete its demographic transition, Europe is seeing its population stagnate, tending towards a reduction by 2050. Meanwhile, population dynamics in Asia are diverse: with Japan in demographic decline and India booming.

Nevertheless, the general trend is towards an increase in world population, raising many questions about migration flows and human capacities to ensure peaceful coexistence at the local, regional and intercontinental levels.

B. Peace

The concept of peace has undergone changing definitions as humanity has advanced and moral values have evolved. Derived from the Latin *pax*, in its original meaning, peace designates a state of tranquillity, serenity, harmony and calm. It has an important cultural dimension and varies according to context.

Among the Maya, the concept of peace is linked to well-being, i.e. to the idea of a perfect balance between the different spheres of life.

In the Eastern tradition, peace is more an inner state (peace of mind and heart) in the original sense, whereas in the Western world, the notion of peace is external to the individual (the absence of war or violent conflict). Among the cultures of India, peace is called *shanti*, which means "perfect spiritual order" or "peace of mind". Moreover, Gandhi based his philosophy and strategy on the concept of *Ahimsa*, meaning "non-violence" and therefore abstention from all harmful acts. For Gandhi's followers, there is no such thing as an enemy.

Among Christians, peace is presented as a gift but, above all, it is the consequence of a desire and the reality of a relationship, firstly with God and then with one's loved ones and anyone else.

In Muslim culture, peace is an attribute of God (Allah) and is called *Assalam*. As underlined by Abdelmalki (2016), Qutb (1974) refocuses the concept of peace on the individual dimension of each person's consciousness and family environment, then within society and, finally, in international relations, between countries and peoples. He distinguishes positive peace, which tends to value and exalt life, from negative peace, which fosters resignation and being left frustrated, rejecting principles and values in favour of vice and corruption.

This distinction was also made by Johan Galtung, one of the founders of modern irenology,[1] who considers positive peace to be a state of cooperation, economic growth and development, equality and justice, pluralism, and dynamism, where violence is reduced but not eliminated: a life free from fear, need and exploitation.

The 2000s represented a new stage, marked by new concepts of a "Culture of Peace", which establishes the global, collective and individual dimensions of peace (Daniel, 2011) as an extension of Galtung's thinking. The Luarca Convention (2006), which set out the contours of the human right to peace, states "*the positive concept of peace goes beyond the strict absence of armed conflict and is linked to the economic, social and cultural development of peoples as a condition for satisfying the basic needs of human beings, to the elimination of all kinds of violence and to the effective respect for all human rights*".

At the global level, peace is understood as peaceful international relations between countries and peoples, and stems from each person's way of acting in their everyday relationships.

Peace therefore seems to be a multidimensional, abstract concept and remains a work in progress. In the common sense of the term, peace is defined in opposition to war, and in the context of this study it will be considered as the absence of armed conflict.

C. Security

Like peace, security is an abstract and very relative concept. In this respect, Zabadi (2005) considers security to be not only polysemic and cross-cutting but also multidimensional in nature, suffering from a lack of consensus on a general definition. The Larousse Dictionary of the French language defines security as a situation in which someone or something is not exposed to any danger, with no particular risk of physical aggression, accident, theft or deterioration. In other words, it corresponds to the absence of conditions that may cause physical, psychological or material damage, so as to preserve the health and well-being of individuals. It is an essential, valuable and indispensable good for community well-being, both for daily life and for achieving medium- and long-term aspirations.

In this respect, special attention must be paid to achieving and permanently maintaining optimal security, which is the primary ambition of any developing community. For this to happen, all sectors of society, citizens, communities, governments and all stakeholders must work together to help achieve this optimal security situation.

I.2. Review of the theoretical literature

The explanatory factors of conflict are certainly numerous and suggest that several aspects should be taken into account, particularly psychological aspects (frustration/aggression theories of conflict); sociological aspects (violent action by the masses, propaganda); or aspects characterized by political antagonism between rival powers: the interplay of reified representations and identities and economic interests. All of these factors involve or are related to demographics. In most theories, violence and insecurity are analysed using three approaches: economic, social and demographic. These three viewpoints are not exclusive, however, and can be mutually complementary.

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1   From the Greek "eirene" meaning peace, irenology aims to understand the origins of armed conflicts and thus moderate, prevent or resolve them.

The economic approach: The economics of conflict

Economic factors are one of the main causes cited in the search for the determinants of conflict in Africa. Economics, identity, the legacy of the (colonial) past and soaring population growth remain the most visible factors and those most commonly put forward to explain conflict in Africa (Gazibo, 2006).

According to the literature, there are three main economic analyses to consider (Hugon, 2001):

- A utilitarian analysis, which concerns agents' economic rationality.
- An analysis based on the interplay between economic and power interests; from this perspective, conflicts may be caused by a failure to meet Hobbes' conditions,[2] to some extent. Hobbes' theory involves building a state that is strong enough to ensure security and avoid internal wars because, for Hobbes, strong and impartial authority is essential for peacekeeping (Dockès, 1999). The interplay between economic interests and weakened power, however, makes it impossible to respect the social contract as defined by Hobbes in *Leviathan* (1650) and Locke[3] in his *Second Treatise on Civil Government (1690).*
- An analysis that considers war as a systemic risk; this draws on the concepts of Keynes and Freud with regard to depressive representations and irrational behaviour linked to radical uncertainty. This view sees conflict as a consequence of a lack of trust in the system or an uncertain future.

The social approach

Although similar, the social approach differs from the economic one, as it focuses on societal behaviour. Some researchers, such as Huntington (2000), attribute conflict to cultural and civilizational factors. Africa is not often the victim of civilizational factors, however; rather, confrontations have ethnic, community, tribal or clan-based overtones that indicate multiple rationales (Hugon, 2001; Gazibo, 2010).

Geertz (1963), taken up in Gazibo's (2006) analysis of conflicts in Africa, reminds us that ethnicity is the explanatory variable most commonly put forward. The predominance given to the identity factor is linked to a tendency among Africanists to favour cultural approaches to the detriment of others, whether proactive, historical or institutional.

The demographic approach

Numerous theories link demography and the origin of certain conflicts. Malthus[4] was among the first to challenge ideologies that legitimized large populations. In the analysis of demography as a predictor of conflict, "The dominant neo-Malthusian ideology regards the demographic factor as the main, if not the only factor responsible for the ills afflicting the planet in general, and Africa in particular" (Gendreau, 1996).

The literature indicates that many theorists approach demographic influence over the occurrence and recurrence of conflict by considering intermediate variables, including social, economic and cultural

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2   Thomas Hobbes (1588–1679), an English philosopher and precursor of thinking on the "contractual social order", outlined his concept of the social contract in his work, Leviathan (1650).

3   John Locke (1632–1704), Hobbes and Rousseau were the first theorists of the contractual social order. In his three Essays on Civil Government (1690), Locke sets out a more liberal and less absolutist version of the contractual doctrine of state than that developed by Hobbes.

4   Robert Malthus (1766–1834), British economist of the classical school.

characteristics, and access to education and health. The consideration of multiple interacting factors only makes analysing the influence of demographic factors more complex (Coquery-Vidrovitch, 1987). History (the French Revolution of 1789 or the Russian Revolution of 1917) provides information on the abundant causes of conflict but always suggests the presence of demographic characteristics. What's more, demographic information alone can contribute to plunging a country into chaos. One example is the Biafran war, largely caused by the distribution of wealth from oil and the catalyst for which was the result of the 1963 census, which revealed the distribution of the population, and in particular of ethnic groups, by region.

There is also a discourse that refutes the influence of demographic characteristics over the occurrence of conflict. The work of Collier and Hoeffler (1998), however, introduced a new perspective, showing that the probability of conflict increased with the number of ethnic groups, due to the multiplication of alliances.

I.3. Review of the empirical literature

Going beyond theoretical concepts, some works have used econometric methods to examine whether there is a causality between the recurrence of conflict and population levels in Africa. A recent study (Demographic changes, migration and security in the Sahel: assessments, prospects and policies, UNFPA WCARO, April 2019) showed a negative correlation between the GPI and population growth. The linear regression model used in this study revealed sociodemographic determinants of insecurity in the world in general, and in the Sahel region in particular. The study concludes that the democracy index, the youth demographic dependency ratio, the proportion of young people not in education or employment, economic growth, the Gini index (which measures income inequality), and the net secondary school enrolment rate are all determinants of insecurity – which is increasing in countries with high youth dependency ratios, reflecting the delayed demographic transition.

In proposing an explanatory model of civil wars, Collier and Hoeffler (2000) show that the benefits of inciting rebellion depend on:

- the expected revenues in the event of victory
- the probability of winning the war, which is a decreasing function of government military expenditure.

Collier and Hoeffler (2000) add a coordination effect, as rebels do not behave as a unitary agent. Coordination costs increase in accordance with the ethnic fragmentation and population size of the country.

When applied to rebellion, the "*utility function*" is broken down into a post-victory earnings function according to a probability (either) and a wartime cost function (or, , both functions being affected by the duration of the war and the Grossman discount rate $(1 + r)^t$. The *utility function of rebellion is written:*

- *P* (T) is the rebellion's probability of victory, which is a function of state fiscal capacity (T).
- G (T, P) are the gains of the war, conditional upon victory, a function of T and P, the population size.
- Y is the per capita income and C is the coordination costs.
- D is the duration of the war.

By treating the decision as a randomly determined (stochastic) process, Collier and Hoeffler break down two joint functions under the hypothesis of full information rational expectations:

1. probability of going to war (dichotomous variable): increasing function of p (T). T and P and decreasing function of D, Y and C

2. maximum expected duration of war (continuous variable): increasing function of p (T). T and P and decreasing function of Y and C.

Moreover, Collier and Hoeffler (1998) highlighted five main catalysts of conflict:

- primary commodity dependence
- poor governmental ability to finance defence expenditure
- diaspora funding
- poor employment opportunities for out-of-school youth
- population dispersion in uncontrolled territories.

Hugon (2003) uses Collier and Hoeffler's (2000) explanatory model of civil war and, with the help of econometric tests, concludes that four major determinants increase the probability of the occurrence and the duration of African conflicts:

- low levels of income
- natural resources that do not evolve rapidly and increase the risk of conflict up to a certain level, before contributing to conflict reduction
- the size of the population
- the ethnolinguistic division, which is not a strictly monotonic function.

Demographic results concern population size and ethnic diversity (which is also linked to demography).

II. Methodology and data source

II.1. Description of variables

To analyse the relationship between demographic change and the security crisis from a Sahelian perspective, we used three kinds of variable. In addition to the demographic structure of the country (in this analysis measured by the youth demographic dependency ratio and the population growth rate), other variables relate to openness to democracy, as measured by the Democracy Index, which is often cited in the literature as a factor of conflict or source of insecurity in African countries (Weinstock, 2003).

The Democracy Index was created in 2006 by the British press group The Economist Group. It assesses the level of democracy in 167 countries, including 166 sovereign states and 165 United Nations members. The calculation is based on 60 criteria, grouped into five categories: electoral process and pluralism; civil liberties; the functioning of government; political participation; and political culture. Countries are rated on a scale of 0 to 10, and then classified according to four regime types:[5] full democracy; flawed democracy; hybrid regime; or authoritarian regime.

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5   In this classification system, the index classifies most Sahelian countries as hybrid or authoritarian regimes.

The youth demographic dependency ratio refers to the ratio between the number of people who are considered to "depend" on others in their daily lives – young people under the age of 15 – and the number of people (aged 15 to 64 years) who are capable of assuming responsibility for dependents. The higher the fertility rate of a country, the higher the youth demographic dependency ratio. The same applies to economic dependency, since those assumed to be economically active are responsible for a much higher number of dependents, mainly adolescents, children and the elderly.

In the Sahel, this ratio is around 85.2 per cent, with huge disparities noted. It stands at 97 per cent in Chad and Mali and 106 per cent in Niger. It also appears that, in these countries, particularly those around Lake Chad, the level of security is low compared to the scores recorded in the GPI. On the other hand, the top 10 countries in terms of peace and security all have dependency ratios of less than 33 per cent.

These variables are also used to monitor the effect of environmental factors on insecurity, which may be manifested in a lack of arable land. The agricultural sector is one of the sectors most affected by climate change worldwide. Ensuring its sustainable management is the top priority for the coming decades, which will be marked by ever-increasing global demand in a context of a scarcity of high-quality agricultural land. The percentage of arable land helps to understand the effect of climate change on arable land (e.g. degradation of coastal ecosystems due to rising sea levels, salinization, desertification, flooding, etc.). This indicator also makes it possible to assess the effect of housing needs on arable land, in correlation with population growth.

In the Sahel, the area of arable land is declining, primarily due to the effects of climate change but also to sustained population growth. This situation leads to both urban and international migration. It is also a source of tension between farmers or between farmers and herders whose livelihoods generally revolve around the same cultivation areas which, in many cases, are also used for grazing. The alternative solution, which involves deforestation to make more arable land available where possible, has significant adverse effects. It poses a threat to the environment in the context of climate change and also contributes to reducing already limited pastoral areas.

The economic growth rate is an annual performance indicator. Positive growth can be a means of stimulating the economy through the creation of infrastructure and jobs. In the Sahel region – which is undergoing a demographic transition marked by a predominance of young people – positive and shared economic growth is crucial to meet the high social demand which, if left unmet, is often a source of frustration. This is exactly what can be seen in most of these countries, where the economy is not equipped to respond adequately to the demands of the masses. This results in increased poverty, which has a real impact on national and cross-border security.

Since our hypotheses assume that the effect of demographic variables on the security situation is manifested through unmet social demand, we have used the school enrolment rate and the percentage of young people not in education, employment or training as control variables. These two variables facilitate an understanding of the difficulties that countries encounter in meeting the high demand for social integration from young people, through schooling and inclusion in the labour market. In the Sahel region, around 30 per cent of young people are not in education or employment, while this figure barely reaches 5 per cent in countries such as Australia, Iceland, and Portugal, which have the best peace and security rankings in the world according to the 2018 index. This lack of social integration among young people in the Sahel makes them economically and socially vulnerable to the manipulation and false promises of extremists and to human trafficking. A study undertaken by the Centre for Applied Economic and Financial Research at the

University of Thies, Senegal, on the sociodemographic profile of most Sahelian countries, confirms this reality, showing that on average, young people remain economically dependent until the age of 28 years.

The net secondary school enrolment rate is the quotient of the population enrolled in secondary education at the official age in relation to the population of the same age eligible for enrolment. It highlights the impact of education for children aged above or below the normal school age. It also serves as an indicator of the quality of education over time, by measuring drop-out rates. As regards the relationship between education and insecurity, it seems that relevant and good quality education can create conditions that hinder the propagation of violent extremist ideologies and acts. More specifically, education policies can ensure that places of learning are not fertile ground for violent extremism. Instead, they can ensure that the content and pedagogical methods taught and used strengthen students' resilience to violent extremism. The role of education is to create conditions that enable learners to strengthen their resilience to violent extremism and to reaffirm their commitment to peace and non-violence.

Another variable that demonstrates inequality in wealth distribution, and whose influence on security or peace is widely cited in the specialized literature, is the Gini index (or coefficient). The Gini index is an overall indicator of inequality in living standards. It varies between 0 and 1 (or between 0 and 100 per cent). Zero represents a situation of perfect equality, where all wages, incomes, living standards, etc. are equal. At the other extreme, 1 represents the most unequal situation possible, where all people but one have no salary, income, standard of living, etc. The most egalitarian countries have a coefficient of about 0.2 (i.e. 20 per cent). Comparing this index across countries reveals those with the highest levels of income inequality. In the Sahel region, the Gini index is estimated at around 53 per cent, indicating that most of the wealth is concentrated among a small minority. In particular, most of these countries are also characterized by very high levels of insecurity. The opposite is true of the top 10 countries in the world in terms of peace and security (according to 2018 figures), for which the Gini index is around 25 per cent.

II.2. Factorial analysis methods

Factorial analysis methods make it possible to process several variables at the same time. The main advantage of these methods is that they make it possible to represent the data on axes (factors), which enables the information contained in large tables to be summarized.

II.2.1. Principle

Factorial analysis seeks to explore the structure of the individuals described by a set of data so as to identify a typology. The data cover a large number of individuals, described by several variables. The principle of factorial methods involves looking for subspaces in the projection, allowing for maximum spread. Factorial analysis is used to summarize the information from the projection axes. In other words, it looks for the axes or the factorial design that will maximize data projection. Depending on the nature of the data, there are several methods of factorial analysis.

II.2.2. Principal component analysis

PCA applies to tables in which a set of individuals is described by a set of quantitative variables. It provides a map of the individuals according to their proximity and a map of variables according to their correlation. We can use PCA to construct a peace and security index, if desired, given that the macroeconomic variables characterizing peace and security are almost all quantitative.

To assess the quality of the representation, we will use:

• **Cosine squared (CO2)**: this provides information on how well the element is represented on the axis in question. It measures the angle between an element and an axis. The higher the angle, the better the element is represented on this axis, i.e. this axis shows the originality of the element.

• **Contribution (CTR)**: is the share of information an element contributes to axis formation.

• **Distance to the centre of gravity**: this measures the position of an individual in relation to the centre, thus allowing atypical individuals to be detected.

II.2.3. Application of the multidimensional analysis

This section presents a multidimensional analysis of the explanatory factors of security. First, we present the countries considered in this study. The correlations between the variables are then presented. Lastly, we establish country groups according to the level of security and characterize these groupings.

The individuals: In this study, the individuals are different countries around the world, including those in sub-Saharan Africa.

The table below gives the names and descriptions of the continuous variables.

TABLE 1.1: Economic dimension variables

Name of the economic dimension variable	Description of variables
Population ages 0-14 of total	Population of children aged 0-14 years out of the country's total population
Sec_school	Net secondary school enrolment ratio. The net school enrolment ratio is the ratio between children of official school age who are enrolled in school and the corresponding population of official school age. Secondary education complements basic educational provision (which begins at the primary level and aims to lay the foundations for lifelong learning and human development) by providing more subject- or skills-based education and using more specialized teachers.
Youth_unemp	The unemployment rate for young people not in training. The share of young people not in education, employment or training (NEET) is the proportion of young people not in education, employment or training in relation to the population of the corresponding age group: young people (15–24 years); people aged 15–29 years; or both age groups.
Arable land of land area	Arable land. Arable land includes land defined by the FAO as land under temporary crops (areas under double cropping are counted once); temporary grasslands for mowing or grazing; land under market and kitchen gardens; and land that is temporarily lying fallow. Land abandoned as a result of shifting cultivation is excluded.

Name of the economic dimension variable	Description of variables
Crop production index 2004-2006	The agricultural production index shows the agricultural production for each year in relation to the 2004–2006 base period. It includes all crops except fodder crops. The regional and income group aggregates for FAO production indices are calculated using the underlying values in international dollars, normalized for the 2004–2006 base period.
Urban population of total	Urban population refers to people living in urban areas, as defined by national statistical offices. The data are collected and smoothed by the United Nations Population Division.
GDP growth annual	Annual percentage of GDP growth at market prices, on a constant local currency basis. Aggregates are based on constant 2010 United States dollars. GDP is the sum of the gross added value of all resident producers in the economy, plus taxes on product and subsidies not included in the value of products. It is calculated without making deductions for the depreciation of manufactured assets or for the depletion and degradation of natural resources.
Gini	The Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. A Gini index of 0 thus represents perfect equality, while an index of 100 implies perfect inequality.
Age dependency ratio young	The youth dependency ratio is the ratio of the number of young people dependent on one person. For the calculation, the population aged under 15 years is compared to the working-age population (i.e. people aged 15 to 64 years). The data are presented as the proportion of dependents per 100 working-age people.
Forest area of land area	Forest area is land under natural or planted stands of trees of at least 5 metres in situ, whether productive or not, and excludes stands of trees in agricultural production systems (e.g. in fruit plantations and agroforestry systems) and trees in urban parks and gardens.
Military_ expenditure	Military expenditure as a percentage of GDP.
Additional variables:	
Level of security	The level of security in the country (five levels in total)
WCAR_Region	Belonging to the West African region
GPI	Global Peace Index

Source: United Nations Population Fund (UNFPA), World Development Indicators (WDI)

TABLE 1.2: List of the 163 countries according to geographic position

Africa	Europe	America	Asia	Oceania
Burkina Faso	Austria	Canada	Australia	New Zealand
Cameroon	Czech Republic	Argentina	Singapore	Papua New Guinea
Central African Republic	Denmark	Chile	Bhutan	
Chad	Iceland	Costa Rica	Indonesia	
Côte d'Ivoire	Ireland	Ecuador	Kazakhstan	
Gambia, The	Portugal	Nicaragua	Korea, Republic of	
Guinea	Slovenia	Panama	Kuwait	
Mali	Switzerland	Paraguay	Lao People's Democratic Republic	
Mauritania	Belgium	Peru	Latvia	
Niger	Bulgaria	Uruguay	Malaysia	
Nigeria	Croatia	Bolivia	Mongolia	
Senegal	Cyprus	Brazil	Oman	
Benin	Estonia	Cambodia	Qatar	
Botswana	Finland	Cuba	Sri Lanka	
Equatorial Guinea	France	Dominican Republic	Timor-Leste	
Ghana	Germany	El Salvador	United Arab Emirates	
Liberia	Hungary	Guatemala	Vietnam	
Madagascar	Italy	Haiti	Taiwan	
Malawi	Lithuania	Jamaica	Bangladesh	
Mauritius	Netherlands	United States	China	
Morocco	Albania	Colombia	Honduras	
Namibia	Moldova	Mexico City	Jordan	
Sierra Leone	Norway	Venezuela, Bolivarian Republic of	Nepal	
Tanzania	Romania	Guyana	Tajikistan	
Zambia	Serbia	Trinidad and Tobago	Thailand	
Tunisia	Spain		Turkmenistan	
Algeria	Sweden		Uzbekistan	
Angola	United Kingdom		Azerbaijan	
Djibouti	Eswatini		Bahrain	
Gabon	Armenia		India	
Guinea-Bissau	Belarus		Iran, Islamic Republic of	
Rwanda	Bosnia and Herzegovina		Philippines	
Togo	Georgia		Saudi Arabia	
Mozambique	Greece		Afghanistan	
Uganda	Kosovo		Iraq	
Burundi	Lesotho		Korea, Democratic People's Republic of	
Congo, Republic of the	Macedonia, Former Yugoslav Republic of		Pakistan	
Egypt, Arab Republic of	Ukraine		Syrian Arab Republic	
Eritrea	Russian Federation		Turkey	
Ethiopia			Yemen, Republic of	
Kenya			Japan	
South Africa			Kyrgyz Republic	
Zimbabwe			Israel	
Congo, Democratic Republic of the			Lebanon	
Libya			Myanmar	
Somalia			Palestine	
South Sudan				
Sudan				

Source: Created by the authors

Modelling the relationship between demography, peace and security

The variables: We have 11 active continuous variables and two additional qualitative variables, as follows:

- level of security (with five modalities)
- West Africa region (with two yes or no modalities for whether the country belongs to the West African region).

III. Results of the multidimensional analysis

The variables used in the PCA are recorded in Table 1. There are significant levels of correlation between certain variables (see Appendices 1 and 2) such as: the GPI, which is positively and significantly correlated with the demographic dependency ratio and the youth unemployment rate; the secondary school enrolment rate, which is positively and significantly correlated with the Human Development Index; and the total population living in urban areas. We performed the Bartlett test: the probability obtained (p-value) is 1.451899e-156, well below 5 per cent. We reject the null hypothesis that PCA does not apply to our data.

III.1. Implementation of PCA for the security level analysis

PCA was performed on all the determinant variables of security; we added the following supplementary variables: GPI, security level and membership of the West Africa region. These variables were therefore not taken into account during the construction of the factorial axes. However, their positions make it possible to better interpret the axes. The eigenvalues histogram shows that the first two axes retrieve 49 per cent of the information and we observe a drop between the second and third axes.

FIGURE 1.1: Eigenvalues histogram
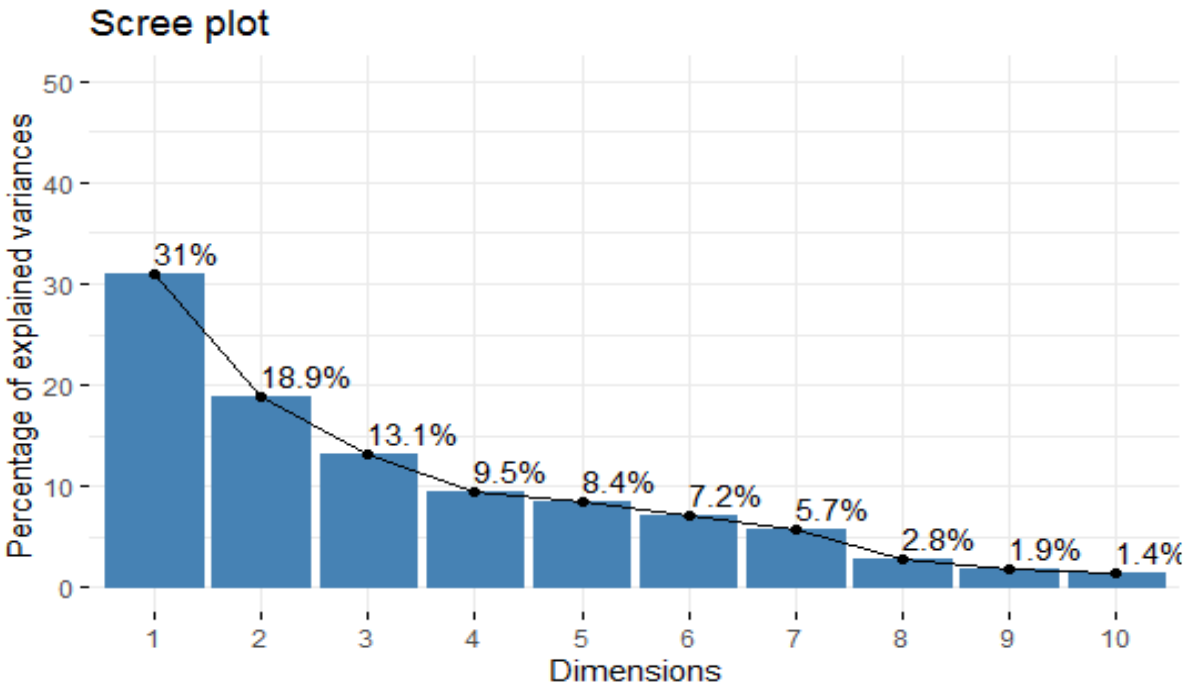
Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, authors' calculations

The first axis retrieves 31 per cent of the continuous information in the data table on the determinants of the security level of a country. The following variables are responsible for the positioning of this axis: the youth demographic dependency ratio; the total population living in urban areas; the secondary school enrolment rate; and the overall democracy index. All these variables reflect the development of a country.
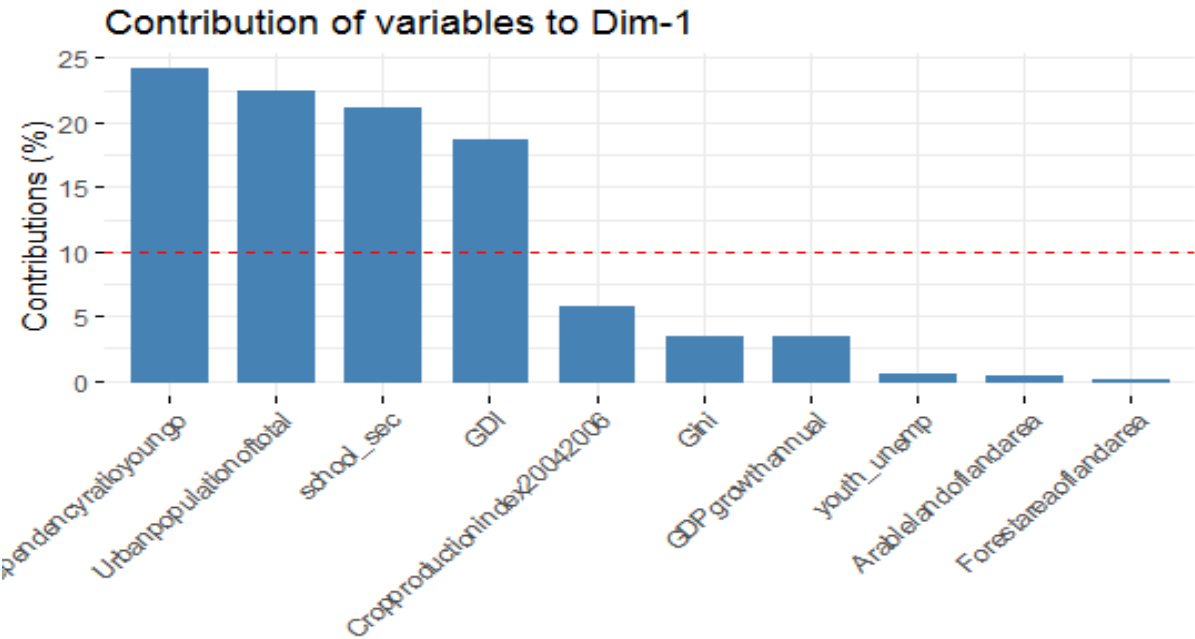
Contribution of variables to Dim-1

Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, author's calculations

Most of our variables are well represented on the first axis (cos2>0.5); some are positively correlated and some are negatively correlated with this axis. The first factorial axis reflects an opposition of the variables (demographic dependency ratio, Gini index and youth unemployment rate) to the right of the axis with a correlation of 0.87, 0.62 and 0.59 respectively. On the same side, the GPI variable is positively correlated with axis 1, with a correlation level of 0.54. It should be recalled that a high value for this index reflects a high level of insecurity for the country. Along this axis we can therefore say that the variables reflecting the level of security in the country are all to the left of axis 1 and are negatively correlated with this axis. This means that when a country has a high value for one of these variables, it is likely to have high values for the other variables, as well as having a high value for the level of peace and security. To the left of the first axis we have a second group of variables opposed to the first group, including secondary school enrolment rate, urbanization rate and the global democracy index. The first axis represents demographic dependency, social inequality and youth unemployment, all of which are associated with insecurity.

FIGURE 1.3: Projection of variables on the first factorial design

Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, author's calculations

The variable that is positively correlated to axis 2 is the forest area. It is opposed to the share of military expenditure as a percentage of GDP.

**FIGURE 1.4:** Quality of representation of variables on the first factorial design
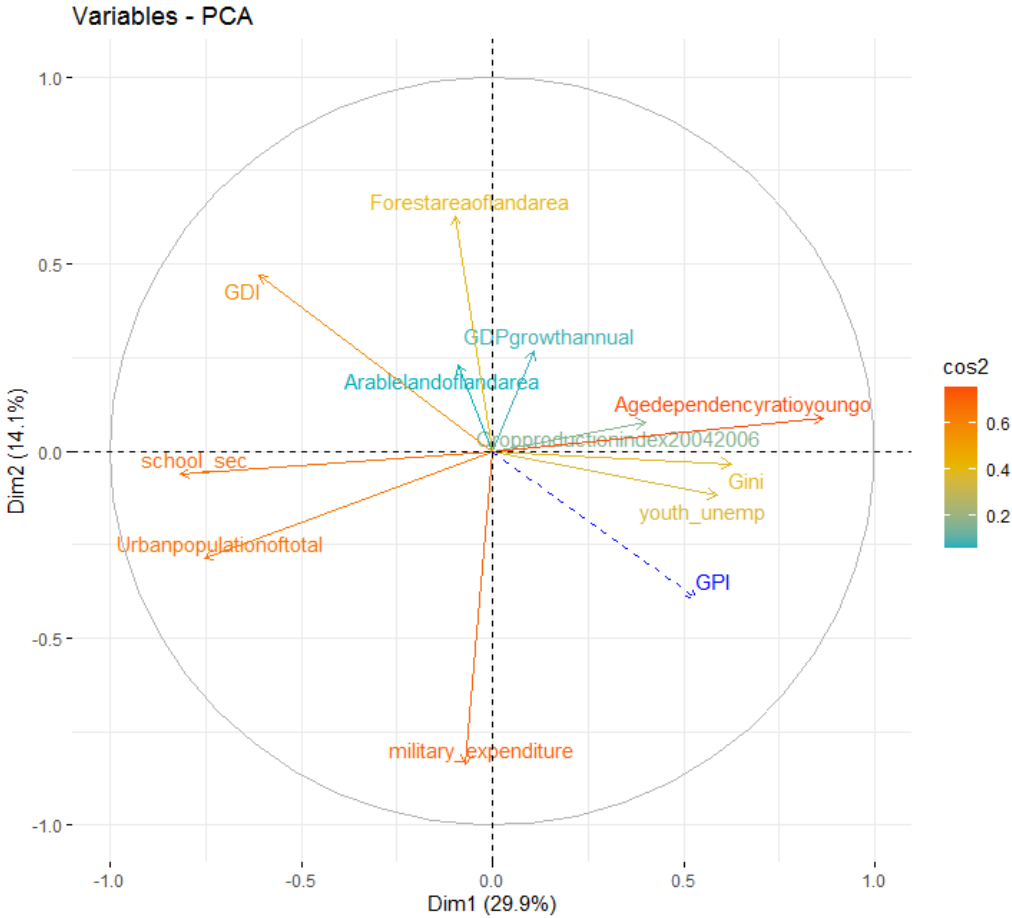

Contribution of variables to Dim-2

Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, author's calculations

The variables determining the security level make it possible to make a clear distinction for sub-Saharan African countries with regard to the level of security. Indeed, these countries generally have a very low level of security (see Figure 6).

Axis 1 therefore reflects the opposition of two groups of countries. Those with a high or very high security level (Australia, Finland, Iceland, Japan, Norway, Sweden, etc.) and those with a low or even very low security level, mostly West African countries (Chad, Niger, Mali, South Sudan, etc.).

III.2. Division of countries into groups

We applied ascending hierarchical classification to our sample countries to obtain homogeneous groups of countries. The best division of our sample of 163 countries is into three groups. The first group contains 40 countries, the second contains 70 countries and the third contains 53 countries.

- **First group: Countries with a high level of security, mostly Western countries**

The group is characterized by high and very high security levels. In fact, all countries with a high level of security belong to this group.

FIGURE 1.5: Search for best distribution and histogram of indices

```
PARTITION PAR COUPURE D'UN ARBRE HIERARCHIQUE
RECHERCHE DES MEILLEURES PARTITIONS
RECHERCHE DES PALIERS
+-------------+----------+-------------------------------------------------+
|   PALIER    | VALEUR DU |                                                 |
|   ENTRE     |  PALIER   |                                                 |
+-------------+----------+-------------------------------------------------+
|   71--   72|  -625.28 | ************************************************* |
|   67--   68|  -127.87 | ***********                                      |
|   68--   69|   -78.69 | *******                                          |
+-------------+----------+-------------------------------------------------+
LISTE DES   3 MEILLEURE(S) PARTITION(S) ENTRE 2 ET 10 CLASSES
  1 - PARTITION EN   3 CLASSES
  2 - PARTITION EN   7 CLASSES
  3 - PARTITION EN   6 CLASSES
```

Source: Authors' calculations

In addition, the sample includes 15.95 per cent and 26.38 per cent of countries with low and medium security levels respectively. In the first group, these proportions are much lower at 2.33 per cent and 9.30 per cent respectively. These countries have a higher rate of secondary school enrolment (93.03 per cent compared with 72 per cent for the general average of the countries).
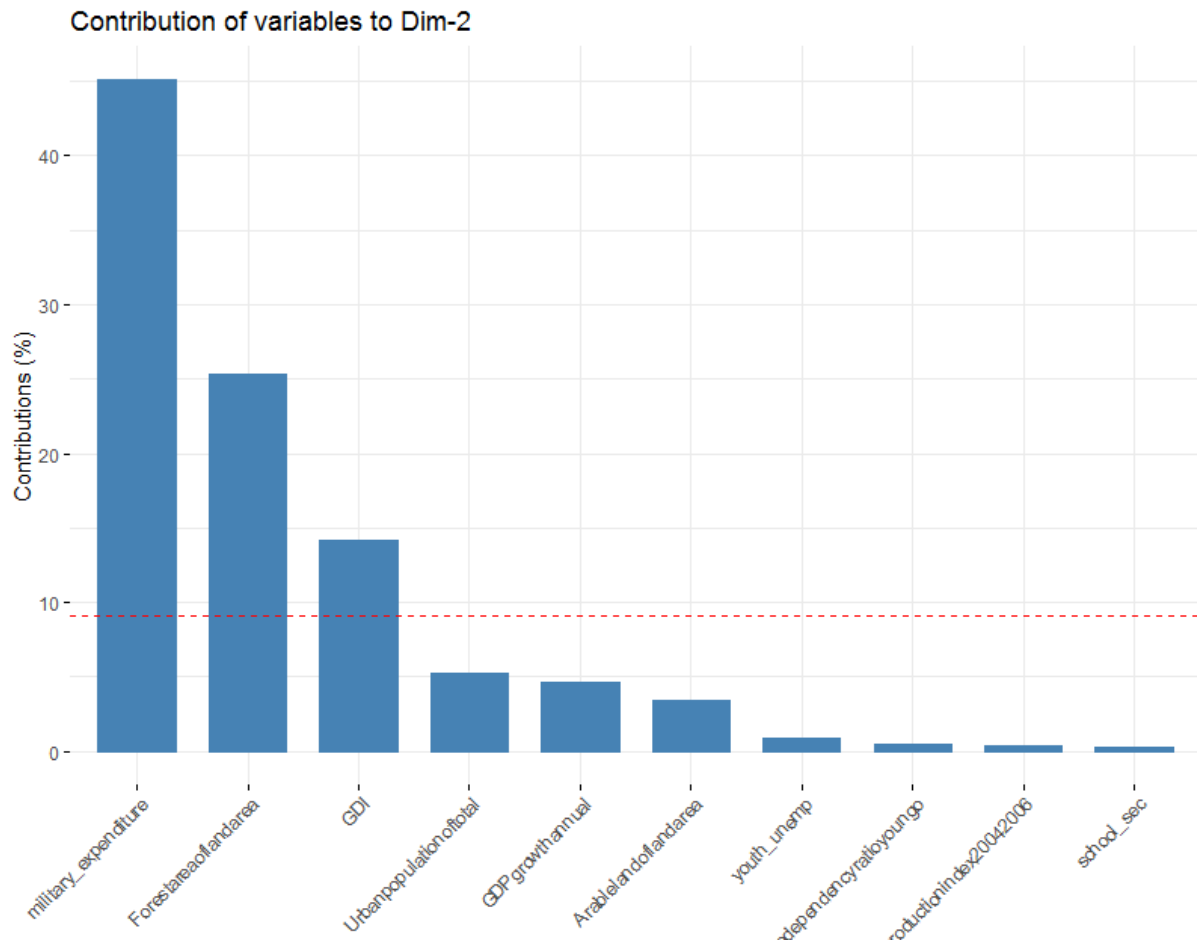
FIGURE 1.6: Cloud of countries in the first factorial design
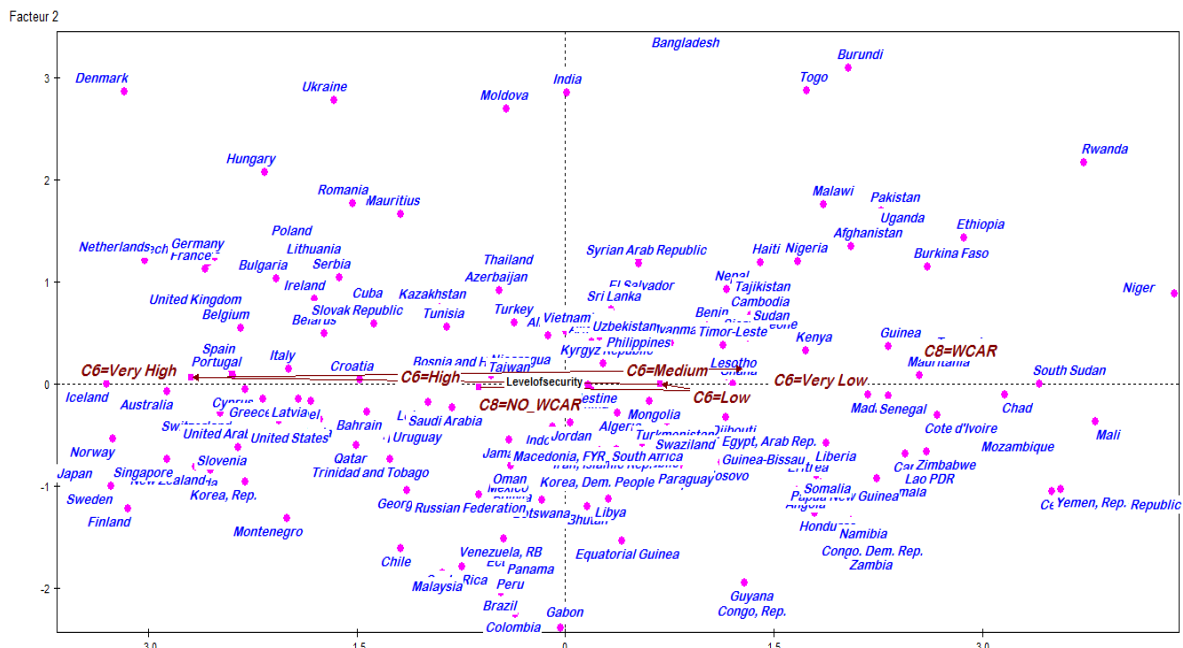
Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, author's calculations

- **Second group: Countries with a medium level of security (the majority group)**

The second group comprises countries with a medium level of security. No country with a very high level of security and no West African country is included in this group. Countries such as Albania, Algeria, Armenia

and Taiwan are included in this group. These countries have a higher level of urbanization and inequality than the general average.

FIGURE 1.7: Classification of the economic dimension variables into three groups
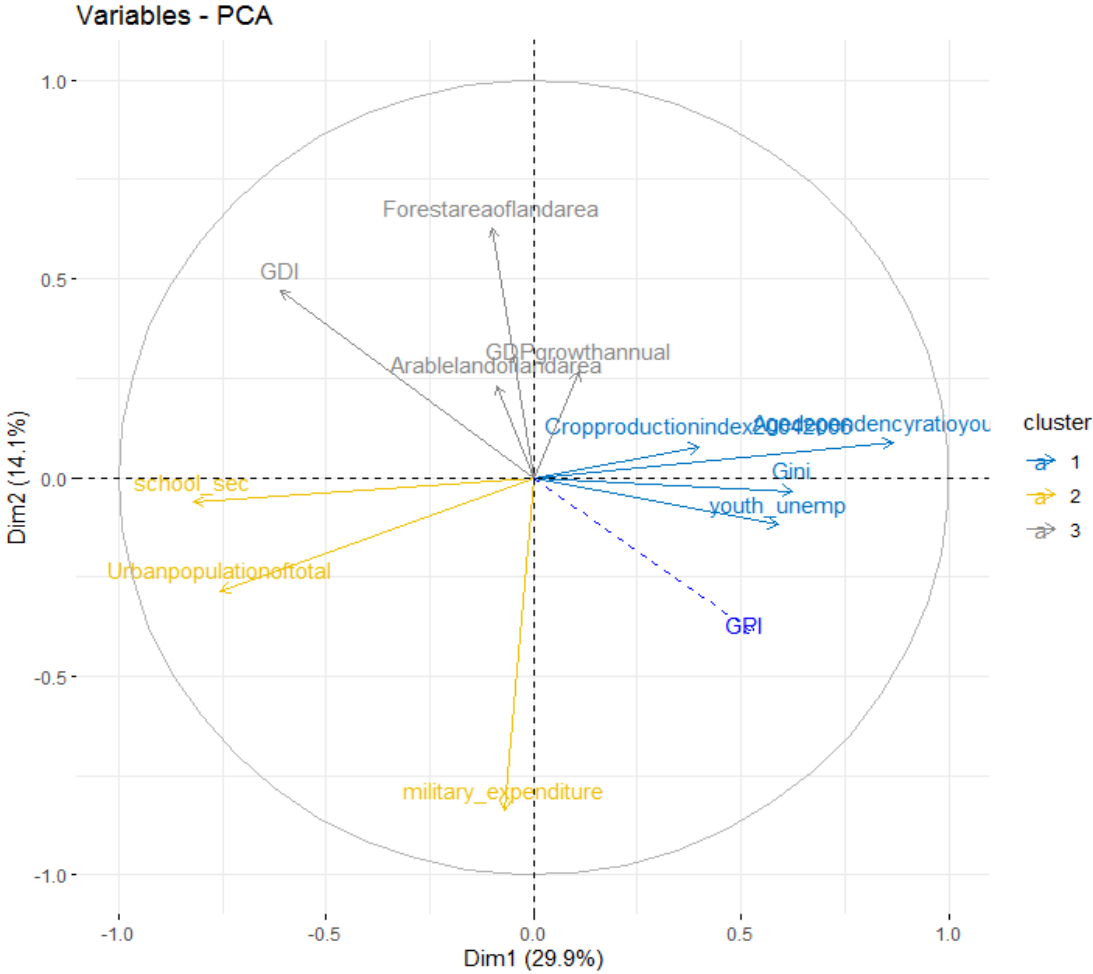
Source: United Nations Conference on Trade and Development (UNCTAD) and the World Bank World Development Indicators (WDI) data, author's calculations

- <u>**Third group: Countries with a low level of security**</u>

The third group comprises countries with a low level of security. It is dominated by the West Africa region: 100 per cent of the countries in this region fall within this group. No country in this group has a very high level of security, while only 20 per cent have a high level of security compared to 40 per cent for the general average. These countries have a higher demographic dependency ratio (75 per cent compared with 47 per cent for the overall average). Their youth unemployment rate is 10 points higher than the general average (27.71 per cent compared with 17.86 per cent). Their rate of urbanization is lower than the general average (35.05 per cent compared with 58.31 per cent). Finally, their secondary school enrolment rate is half the general average (36.94 per cent compared with 72.18 per cent). This group includes countries such as Chad, Niger and Mali.

Modelling the relationship between demography, peace and security

I. Conclusion and recommendations

In this study, we analysed the correlation between the security levels of the countries and certain explanatory factors. We then classified the countries in our sample according to their level of peace and security and the main explanatory factors. We obtained a positive link between the GPI and the youth demographic dependency ratio, the Gini inequality index and the youth unemployment rate. In other words, countries with high demographic dependency and youth unemployment, and glaring income inequalities, are generally the most affected by insecurity.

On the other hand, secondary school enrolment, urbanization and agricultural performance are associated with improved peace and security. In other words, countries with a high level of secondary school enrolment, a high urbanization rate and good agricultural performance generally experience a high level of security.

Applying classification techniques to the 163 countries in our sample revealed three groups of countries overall:

- Countries with a high level of security, mostly comprising Western countries: these countries are mainly characterized by a very high level of secondary school enrolment.
- Countries with a medium level of security: these countries are mainly characterized by a high level of urbanization and strong social inequalities. No West African countries are included in this list.
- Countries with a low level of security: this group includes all the countries of West Africa. These countries have a demographic dependency level 160 per cent higher than the general average. They are further characterized by very high youth unemployment, low urbanization and low secondary school enrolment.

Socioeconomic and demographic policy recommendations

In light of these results, the problem of peace and security has been proved to be significant in West African countries.

These countries, which are characterized by a high level of insecurity, should pursue policies to control demographic dependency; their demographic dependency ratio is well above the average. This is coupled with a very high unemployment rate among young people.

Countries in a situation of insecurity, especially those in West Africa, should support the urbanization process of cities and establish an education policy to keep children in the education system and thus increase the secondary school enrolment rate.

Limitations and prospects for further research

The main limitation of this study is its purely descriptive nature; the results obtained need to be supported by confirmatory statistical techniques. Moreover, the study only covers 2018; taking a dynamic evolution (a panel) into account would produce more robust results.

CHAPTER II
MODELLING OF DETERMINANTS OF INSECURITY IN AFRICA

Abstract

The objective of this chapter is to analyse the determinants of security in Africa using spatial panel modelling. Panel modelling is appropriate because the security problems of a country could have consequences for situations of insecurity in bordering countries. The results show that the spatial autoregressive coefficient has a significance threshold of 5 per cent. All other things being equal, an increase in the level of peace and security in one country therefore has a positive effect on the peace and security level in its bordering countries, through the contagion effect.

The other principal determinants of peace and security in Africa highlighted by the study include the population dependency ratio, forest cover, the agricultural performance of a country, democracy, the secondary school enrolment rate and access to the sea.

Key words: Africa, security, peace, spatial panel, demography

I. Introduction

Peacebuilding and security remain the main challenge for many African countries, and are key to the success of any development action. Despite the socioeconomic policy measures taken at the country level, security in Africa remains far below the expected level.[6] This study therefore seeks to explore the dynamics of insecurity and peace in Africa. It aims to:

- find variables that could explain changes in the level of peace and security in Africa
- take into account the spatial interaction between the countries included in this analysis of peace and security changes in Africa.

The research hypotheses are as follows:

- Sharing a common border influences the level of peace and security.
- Countries with high levels of demographic dependency are more insecure.

To answer this problem and achieve the research objectives, the document is structured around four points. The first section considers the approach found in the literature together with the different determinants of peace and security. The second section explores the methodology adopted and the data used. The third section presents the changes in peace and security indicators and their potential determinants. The fourth section presents the results of the modelling of peace and security determinants in Africa.

II. Definition of concepts and literature review

This section presents an overview of recent theoretical and empirical literature on demography, peace and security, particularly in the African context. We firstly outline and define the basic concepts of the topic. Next, we present different theoretical approaches to violence and insecurity, including economic, social and demographic approaches. Finally, in the third part we review empirical work on the explanatory factors of security.

II.1. Definition of basic concepts on security and peace

- **Demography**

The Larousse encyclopaedia defines demography as the study of human populations, their state, their movement and the factors (biological, sociocultural, etc.) that affect these characteristics. The **demographic question** is at the **heart of all major contemporary societal issues** today. Each area of the world is affected differently by population changes. While Africa is yet to complete its demographic transition, Europe is seeing its population stagnate, tending towards a reduction by 2050. Meanwhile, population dynamics in Asia are diverse: with Japan in demographic decline and India booming.

Nevertheless, the general trend is towards an increase in world population, raising many questions about migration flows and human capacities to ensure peaceful coexistence at the local, regional and intercontinental levels.

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6   According to the Institute for Economics & Peace, insecurity in sub-Saharan Africa in 2019 was 135 per cent higher than in Europe and 107 per cent higher than in Latin America.

- **Peace**

The concept of **peace** has undergone changing definitions as humanity has advanced and moral values have evolved. Derived from the Latin pax, in its original meaning, peace designates a state of tranquillity, serenity, harmony and calm. It has an important cultural dimension and varies according to context.

Among the Maya, the concept of peace is linked to well-being, i.e. to the idea of a perfect balance between the different spheres of life.

In the Eastern tradition, peace is more an inner state (peace of mind and heart) in the original sense, whereas in the Western world, the notion of peace is external to the individual (the absence of war or violent conflict). Among the cultures of India, peace is called *shanti*, which means "perfect spiritual order" or "peace of mind". Moreover, Gandhi based his philosophy and strategy on the concept of *Ahimsa*, meaning "non-violence" and therefore abstention from all harmful acts. For Gandhi's followers, there is no such thing as an enemy.

Among Christians, peace is presented as a gift but, above all, it is the consequence of a desire and the reality of a relationship, firstly with God and then with one's loved ones and anyone else.

In Muslim culture, peace is an attribute of God (Allah) and is called *Assalam*. As underlined by Abdelmalki (2016), Qutb (1974) refocuses the concept of peace on the individual dimension of each person's consciousness and family environment, then within society and, finally, in international relations, between countries and peoples. He distinguishes positive peace, which tends to value and exalt life, from negative peace, which fosters resignation and being left frustrated, rejecting principles and values in favour of vice and corruption.

This distinction was also made by Johan Galtung, one of the founders of modern irenology,[7] who considers positive peace to be a state of cooperation, economic growth and development, equality and justice, pluralism, and dynamism, where violence is reduced but not eliminated: a life free from fear, need and exploitation.

The 2000s represented a new stage, marked by new concepts of a "Culture of Peace", which establishes the global, collective and individual dimensions of peace (Daniel, 2011) as an extension of Galtung's thinking. The Luarca Convention (2006), which set out the contours of the human right to peace, states "The positive concept of peace goes beyond the strict absence of armed conflict and is *linked to the economic, social and cultural development of peoples as a condition for satisfying the basic needs of human beings, to the elimination of all kinds of violence and to the effective respect for all human rights*".

At the global level, peace is understood as peaceful international relations between countries and peoples, and stems from each person's way of acting in their everyday relationships.

Peace therefore seems to be a multidimensional, abstract concept and remains a work in progress. In the common sense of the term, peace is defined in opposition to war, and in the context of this study it will be considered as the absence of armed conflict.

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7   From the Greek "eirene" meaning peace, irenology aims to understand the origins of armed conflicts and thus moderate, prevent or resolve them.

- <u>**Security**</u>

Like peace, security is an abstract and very relative concept. In this respect, Zabadi (2005) considers security to be not only polysemic and cross-cutting but also multidimensional in nature, suffering from a lack of consensus on a general definition. The Larousse Dictionary of the French language defines security as a situation in which someone or something is not exposed to any danger, with no particular risk of physical aggression, accident, theft or deterioration. In other words, it corresponds to the absence of conditions that may cause physical, psychological or material damage, so as to preserve the health and well-being of individuals. It is an essential, valuable and indispensable good for community well-being, both for daily life and for achieving medium- and long-term aspirations.

In this respect, special attention must be paid to achieving and permanently maintaining optimal security, which is the primary ambition of any developing community. For this to happen, all sectors of society, citizens, communities, governments and all stakeholders must work together to help achieve this optimal security situation.

II.2. Review of the theoretical literature

The explanatory factors of conflict are certainly numerous and suggest that several aspects should be taken into account, particularly psychological aspects (frustration/aggression theories of conflict); sociological aspects (violent action by the masses, propaganda); or aspects characterized by political antagonism between rival powers: the interplay of reified representations and identities and economic interests. All of these factors involve or are related to demographics. In most theories, violence and insecurity are analysed using three approaches: economic, social and demographic. These three viewpoints are not exclusive, however, and can be mutually complementary.

The economic approach: The economics of conflict

Economic factors are one of the main causes cited in the search for the determinants of conflict in Africa. Economics, identity, the legacy of the (colonial) past and soaring population growth remain the most visible factors and those most commonly put forward to explain conflict in Africa (Gazibo, 2006).

According to the literature, there are three main economic analyses to consider (Hugon, 2001):

- A utilitarian analysis, which concerns agents' economic rationality.
- An analysis based on the interplay of economic and power interests; from this perspective, conflicts may be caused by a failure to meet Hobbes' conditions,[8] to some extent. Hobbes' theory involves building a state that is strong enough to ensure security and avoid internal wars because, for Hobbes, strong and impartial authority is essential for peacekeeping (Dockès, 1999). The interplay between economic interests and weakened power, however, makes it impossible to respect the social contract as defined by Hobbes in *Leviathan* (1650) and Locke[9] in his *Second Treatise on Civil Government (1690).*

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8   Thomas Hobbes (1588–1679), an English philosopher and precursor of thinking on the "contractual social order", outlined his concept of the social contract in his work Leviathan (1650).

9   John Locke (1632–1704), Hobbes and Rousseau were the first theorists of the contractual social order. In his three Essays on Civil Government (1690), Locke sets out a more liberal and less absolutist version of the contractual doctrine of state than that developed by Hobbes.

- An analysis that considers war as a systemic risk; this draws on the concepts of Keynes and Freud with regard to depressive representations and irrational behaviour linked to radical uncertainty. This view sees conflict as a consequence of a lack of trust in the system or an uncertain future.

The social approach

Although similar, the social approach differs from the economic one, as it focuses on societal behaviour. Some researchers, such as Huntington (2000), attribute conflict to cultural and civilizational factors. Africa is not often the victim of civilizational factors, however; rather, confrontations have ethnic, community, tribal or clan-based overtones that indicate multiple rationales (Hugon, 2001; Gazibo, 2010).

Geertz (1963), taken up in Gazibo's (2006) analysis of conflicts in Africa, reminds us that ethnicity is the explanatory variable most commonly put forward. The predominance given to the identity factor is linked to a tendency among Africanists to favour cultural approaches to the detriment of others, whether proactive, historical or institutional.

The demographic approach

Numerous theories link demography and the origin of certain conflicts. Malthus[10] was among the first to challenge ideologies that legitimized large populations. In the analysis of demography as a predictor of conflict, "The dominant neo-Malthusian ideology regards the demographic factor as the main, if not the only factor responsible for the ills afflicting the planet in general, and Africa in particular" (Gendreau, 1996).

The literature indicates that many theorists approach demographic influence over the occurrence and recurrence of conflict by considering intermediate variables, including social, economic and cultural characteristics, and access to education and health. The consideration of multiple interacting factors only makes analysing the influence of demographic factors more complex (Coquery-Vidrovitch, 1987). History (the French Revolution of 1789 or the Russian Revolution of 1917) provides information on the abundant causes of conflict but always suggests the presence of demographic characteristics. What's more, demographic information alone can contribute to plunging a country into chaos. One example is the Biafran war, largely caused by the distribution of wealth from oil and the catalyst for which was the result of the 1963 census, which revealed the distribution of the population, and in particular of ethnic groups, by region.

There is also a discourse that refutes the influence of demographic characteristics over the occurrence of conflict. Nevertheless, the work of Collier and Hoeffler (1998) introduced a new perspective, showing that the probability of conflict increased with the number of ethnic groups, due to the multiplication of alliances.

II.3. Review of the empirical literature

Going beyond theoretical concepts, some works have used econometric methods to examine whether there is a causality between the recurrence of conflict and population levels in Africa. A recent study (Demographic changes, migration and security in the Sahel: assessments, prospects and policies, UNFPA WCARO, April 2019) showed a negative correlation between the GPI and population growth. The linear regression model used in this study revealed sociodemographic determinants of insecurity in the world in general, and in the Sahel region in particular. The study concludes that the democracy index, the youth

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10   Robert Malthus (1766–1834), British economist of the classical school.

demographic dependency ratio, the proportion of young people not in education or employment, economic growth, the Gini index (which measures income inequality), and the net secondary school enrolment rate are all determinants of insecurity – which is increasing in countries with high youth dependency ratios, reflecting the delayed demographic transition.

In proposing an explanatory model of civil wars, Collier and Hoeffler (2000) show that the benefits of inciting rebellion depend on:

- the expected revenues in the event of victory
- the probability of winning the war, which is a decreasing function of government military expenditure.

Collier and Hoeffler (2000) add a coordination effect, as rebels do not behave as a unitary agent. Coordination costs increase in accordance with the ethnic fragmentation and population size of the country.

When applied to rebellion, the "*utility function*" is broken down into a post-victory earnings function according to a probability (either) and a wartime cost function (or, , both functions being affected by the duration of the war and the Grossman discount rate $(1 + r)^t$. The *utility function of rebellion is written:*

- *P* (T) is the rebellion's probability of victory, which is a function of state fiscal capacity (T).
- G (T, P) are the gains of the war, conditional upon victory, a function of T and P, the population size.
- Y is the per capita income and C is the coordination costs.
- D is the duration of the war.

By treating the decision as a randomly determined (stochastic) process, Collier and Hoeffler break down two joint functions under the hypothesis of full information rational expectations:

1. probability of going to war (dichotomous variable): increasing function of *p* (T*)*. T and P and decreasing function of D, Y and C

2. maximum expected duration of war (continuous variable): increasing function of *p* (T). T and P and decreasing function of Y and C.

Moreover, Collier and Hoeffler (1998) highlighted five main catalysts of conflict:

- primary commodity dependence
- poor governmental ability to finance defence expenditure
- diaspora funding
- poor employment opportunities for out-of-school youth
- population dispersion in uncontrolled territories.

Hugon (2003) uses Collier and Hoeffler's (2000) explanatory model of civil war and, with the help of econometric tests, concludes that four major determinants increase the probability of the occurrence and the duration of African conflicts:

- low levels of income

- natural resources that do not evolve rapidly and increase the risk of conflict up to a certain level, before contributing to conflict reduction
- the size of the population
- the ethnolinguistic division, which is not a strictly monotonic function.

Demographic results concern population size and ethnic diversity (which is also linked to demography).

III. Methodology

III.1. Estimation method

Spatial panel models are still quite recent in the literature. The three main models found differ according to whether the spatial lag of the dependent variable is taken into account in the explanation and/or a spatial autoregressive distribution.

The first model, proposed by Baltagi et al. (2003), only considers the spatial autoregressive distribution. The two models developed by El Horst (2003, 2007) likewise only take a single aspect into account: the first (2003) only considers the spatial lag and the second (2009) only considers the spatial autoregressive distribution. Kappor et al. (2007) also developed a similar model to Baltagi et al. (2003). The difference between the two models is the specification of error terms. Mult and Pfaffermayr (2011) later improved the model developed by Baltagi et al., by simultaneously including spatial lag and spatial autoregressive distribution. The estimation method differs depending on whether a fixed effects or a random effects model is used. The ordinary least squares method is not appropriate because the assumption of no autocorrelation of error terms is not met. A maximum likelihood estimation method was used to estimate the model (Millo and Piras, 2012).

III.2. Specification of the model

In this study, we seek to explain the peace and security level in African countries by using the demographic dependency ratio, the agricultural performance index, schooling, democracy, the forested surface area of a country and its access to the sea.

The basic equation is as follows:

$$(Global\_Peace\_Index)_{it}$$

$$= \lambda \sum_{j}^{\square} w_{ij} (Global\_Peace\_Index)_{jt} + \alpha_1 Age\_dependency\_ratio_{it}$$

$$+ \alpha_2 Share\_youth\_education_{it} + \alpha_3 GDP\_growth_{it} + \alpha_4 GINI\_index_{it} + \alpha_5 Encl_i$$

$$+ \alpha_6 Crop\_production\_index_{it} + \alpha_7 Arable\_landx_{it} + \alpha_8 Secondary\_school\_enrolment_{it}$$

$$+ \alpha_9 Democraty\_index_{it} + \beta_i + \varepsilon_{it}$$

With

$(Global\_Peace\_Index)_{it}: Global\ peace\ and\ security\ index\ in\ country\ i\ in\ year\ t$

$Age\_dependency\_ratio_{it}:\ Age\ dependency\ ratio\ in\ country\ i$

$Share\_youth\_education_{it}: percentage\ of\ young\ people\ in\ the\ education\ system$

$GDP\_growth_{it}: demographic\ growth\ in\ country\ i\ in\ year\ t$

$GINI\_index_{it}: GINI\ inequality\ index\ in\ country\ i\ in\ year\ t$

$Landl_i: an\ indicator\ variable\ that\ takes\ 1\ if\ country\ i\ is\ landlocked, 0\ if\ not$

$Arable\_landx_{it}: percentage\ of\ arable\ land\ in\ country\ \ i\ in\ year\ t$

$Democracy\_index_{it}: Democracy\ index\ in\ country\ i\ in\ year\ t$

IV. Description of study variables

IV.1. Changes in the GPI in Africa

Analysis of the GPI average value shows that Africa has a very high score, remaining above 2.1 throughout the 2008–2016 period, which indicates that the continent continued to be affected by a high level of insecurity during this period. Analysis of changing trends shows that the security situation steadily deteriorated over the 2008–2015 period, before showing a small improvement in 2016; however, the score remained above 2.2. By comparison, the average index value for South America was 2.101 in 2018, compared with 2.252 for sub-Saharan Africa – well above the European average score of 1.666 (Global Peace Index 2019).

Source: Institute for Economics & Peace, Author's calculation

IV.2. Structure of the GPI for Africa (2016)

Figure 2.2. shows the GPI scores for Africa in 2016. We established five groups according to the index score; the more insecure the country is, the darker the colour. African countries in a situation of insecurity include: Central African Republic, Libya, Nigeria, Somalia and Sudan. On the other hand, countries with the highest level of security include: Ghana, Morocco, Namibia, Senegal, Tunisia and Zambia.

Sharing a common border had a strong influence on the security of African countries in 2016. In fact, some countries, such as Central African Republic, Libya and Sudan, which share common borders, are all in a very high state of insecurity. However, this is not the only factor: Tunisia is ranked among the safest countries, despite sharing part of its border with Libya (a highly insecure country).

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FIGURE 2.2: Map of the Global Peace Index for Africa in 2016
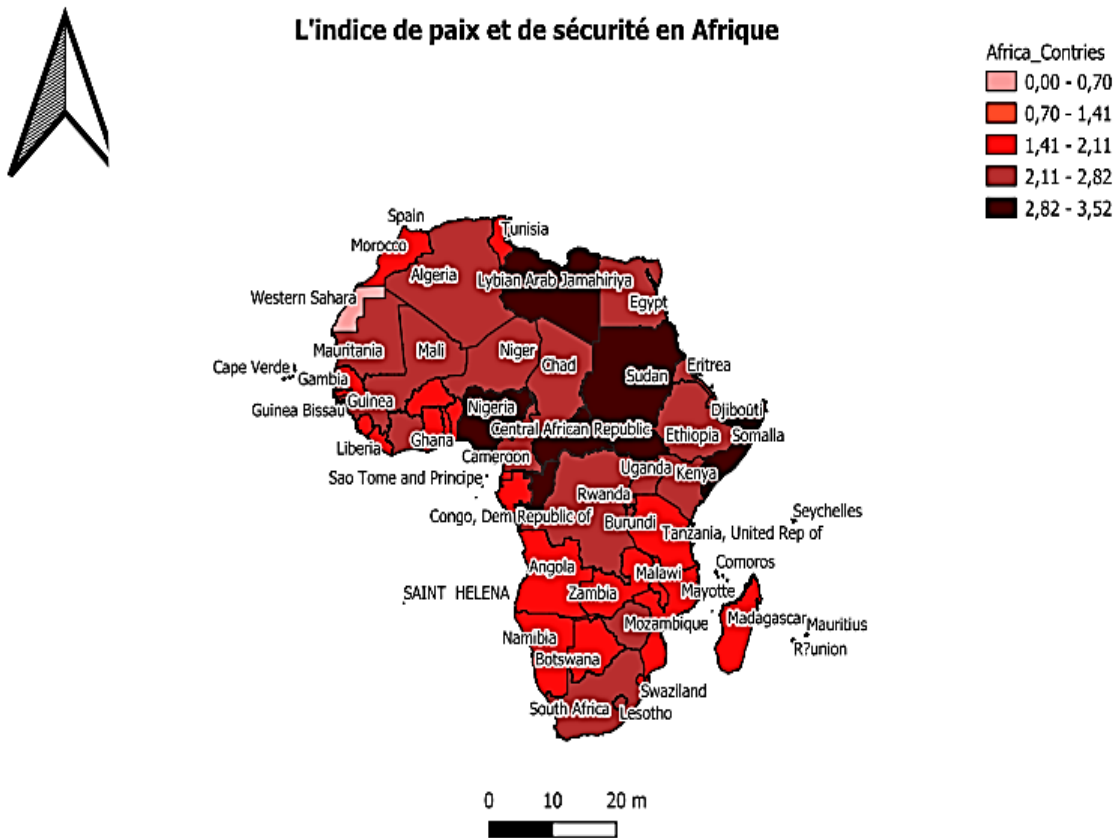
Source: Institute for Economics & Peace, Author's calculation

IV.3. Structure of the demographic dependency ratio in Africa

The map below shows the demographic dependency ratios in 2016. This year was chosen due to the availability of data. The structure of the demographic dependency ratio for African countries is almost identical to that of the overall GPI, with a few differences.

North African countries (Algeria, Egypt, Libya, Morocco and Tunisia) have the lowest dependency ratio on the continent. On the other hand, sub-Saharan countries (Burkina Faso, Central African Republic, Chad, Democratic Republic of the Congo, Mali and Niger) have the highest level of demographic dependency. In addition, some southern African countries (Botswana, Namibia, South Africa and Zimbabwe) have average levels of demographic dependency. A non-parametric test confirmed the link between the position of countries according to the demographic dependency ratio and their ranking in the GPI.

FIGURE 2.3: Map of the demographic dependency ratio of African countries

Ratio de l'âge de dépendance demographique
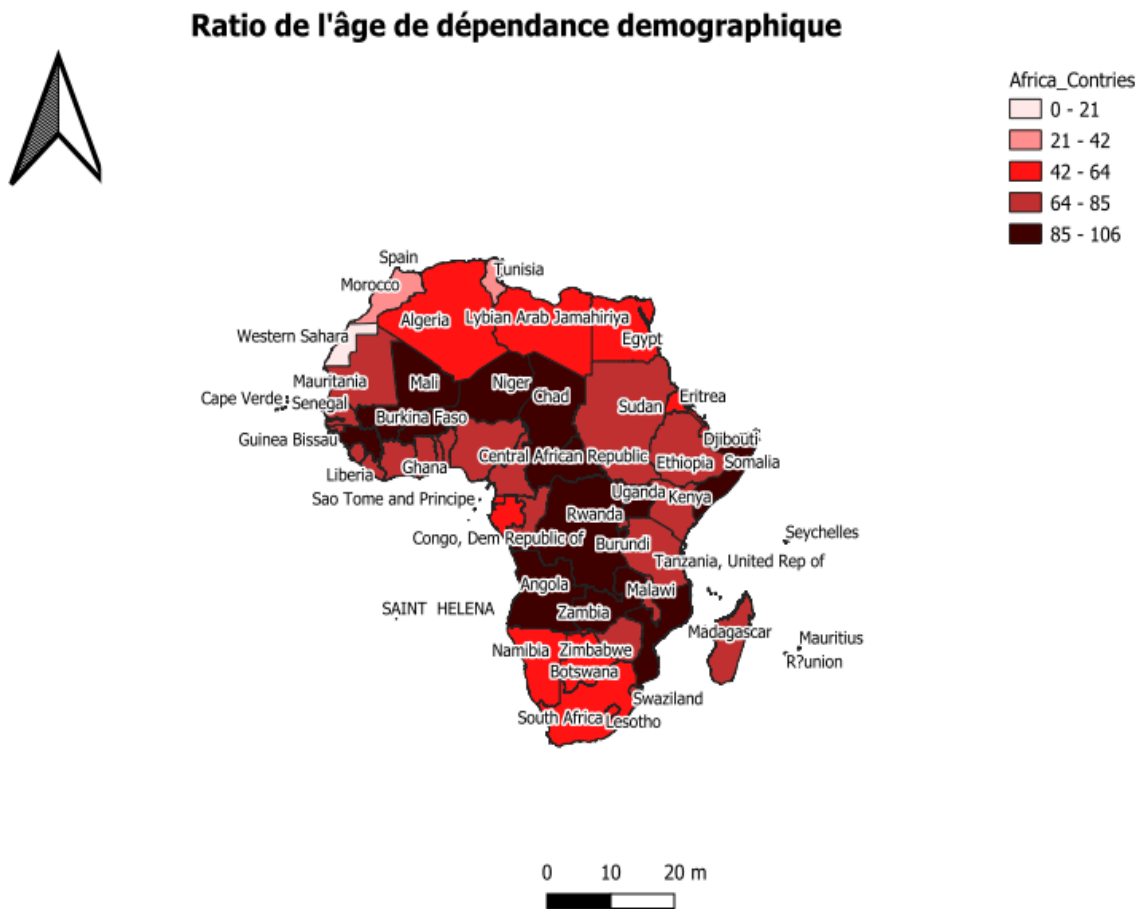
Source: Author's calculation

The demographic dependency levels of the countries did not change significantly over the 2008–2016 period (see the 2008 map, annexed). The countries with the highest levels of demographic dependency in Africa in 2016 were, in order, Niger, Mali, Chad, Uganda, Somalia and Angola. In 2008, the list of countries was practically identical (Niger, Chad, Uganda, Somalia and Mali).

IV.4. Share of the population living in urban areas in African countries

An analysis of Figure 2.4 shows that the most urbanized African countries are in North Africa (Algeria, Libya, Morocco, and Tunisia) and southern Africa (Botswana, South Africa and Zimbabwe). On the other hand, some countries in West and Central Africa have relatively low urbanization rates (Chad, Niger, etc.).
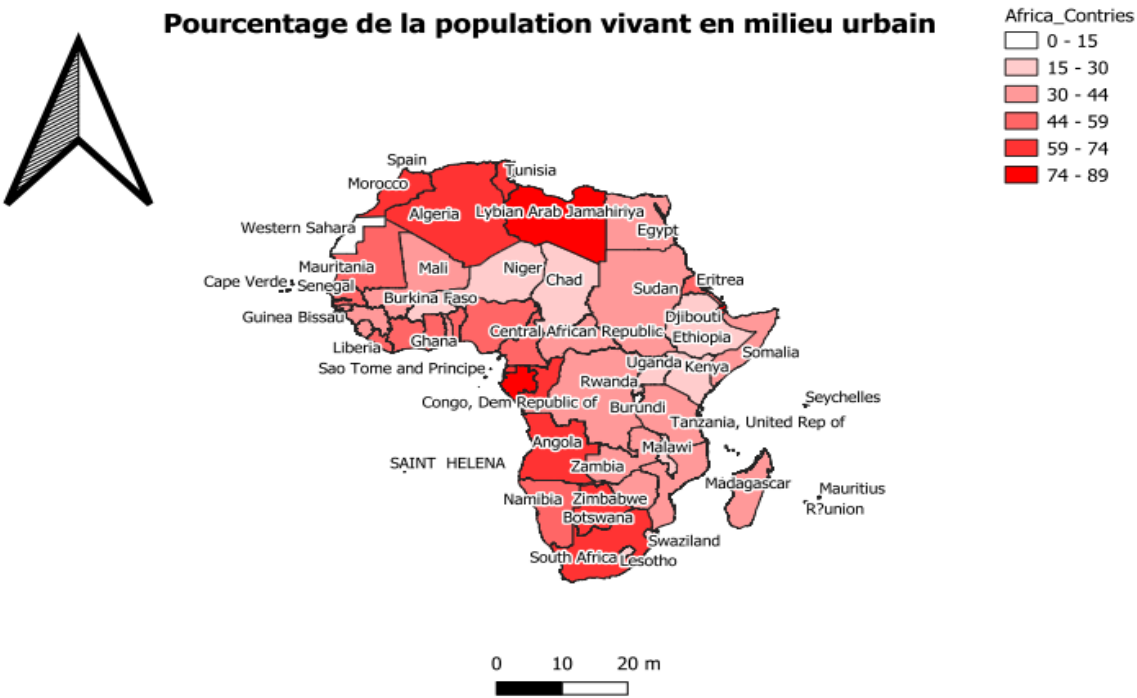
Source: Author's calculation

The least urbanized countries are those with security problems.

IV.5. Structure of secondary school enrolment of young people in Africa in 2016

Just as for urbanization rates, the countries of North Africa (Algeria, Libya, Morocco and Tunisia) and southern Africa (Namibia, South Africa and Zimbabwe) have the highest secondary school enrolment rates in Africa.
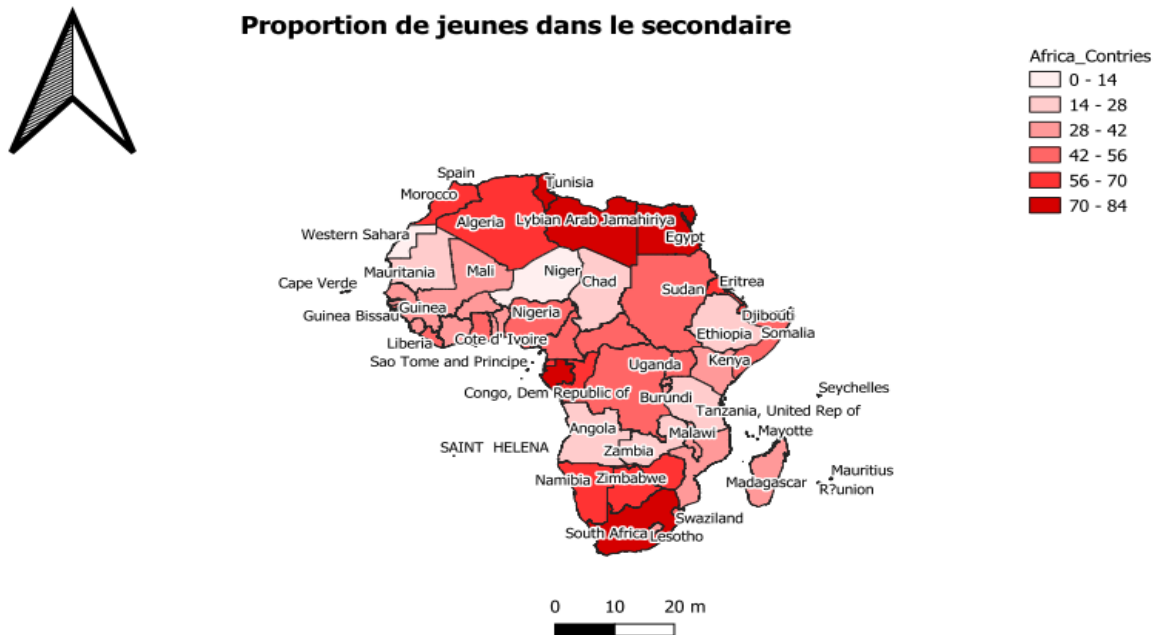
Source: Author's calculation

V. Results of the modelling

- **Results with the border matrix**

The results obtained are consistent with the assumptions made. The spatial lag is significant, as are the variables relating to the demographic dependency age ratio and the economic growth, forest area, democracy index, and secondary school enrolment rate of the country. However, variables relating to the urbanization rate, GDP growth, inequality index and the percentage of young people not in education or employment are not significant.

The spatial autoregressive coefficient has a significance threshold of 5 per cent and is equal to 0.0235. This means that if the GPI score of any country increases by one unit, the score for neighbouring countries that share a common border rises by almost 0.024. Here, we see the effect that proximity between countries (measured across shared borders) has on peace and security. This is because such countries are historically linked and the same groups of people are often found on both sides of the border. This is the case, for example, in Niger and Mali.

An increase in the level of demographic dependency of a country (as measured by the average number of dependents per person of working age) fosters insecurity. All other things being equal, a one percentage point increase in the ratio leads to an increase in the GPI score of 0.010 units for the country. This level is almost identical albeit slightly lower than the level found in studies that did not take the spatial dimension into account in the modelling (Ngom et al., 2019), (almost 1 per cent).

The forest area variable is negative and significant. The larger the forest area of a country, the safer it therefore is. This is hardly surprising given that it is the countries of the Sahel that are facing the greatest problems of insecurity (war, terrorism, trafficking etc.). A similar result is obtained with the agricultural

performance variable. This refers to the agricultural production for each year in relation to the 2004–2006 base period. The better the agricultural performance of a country, the less insecure it will be.

Moreover, the results of the modelling have shown that democracy contributes to improved security situations. In an African context marked by problems of governance and democracy, this result could contribute to better implementation of policies and programmes.

Another important result is the positive and significant influence of a country being landlocked on its level of security and peace. This result is not very surprising as coastal countries often have access to natural resources, and these are a source of conflict and insecurity in Africa. Moreover, these coastal countries are often victims of maritime piracy.

TABLE 2.1: Estimation of the random effects model with the border matrix

	Coefficients	Standard error deviation	t-stat	Proba. Value
λ	0.0235390	0.0029782	7.9039	2.703e-15 ***
Constant	1.70167462	0.20667816	8.2335	< 2.2e-16 ***
Age dependency ratio (young)	0.01058946	0.00128173	8.2618	< 2.2e-16 ***
Share of young people not in education, employment or training	-0.00083952	0.00218912	-0.3835	0.7014
% of urban population	-0.00077908	0.00124051	-0.6280	0.5300
GDP annual growth rate	-0.275670	0.209707	-1.3145	0.18866
Gini index	-0.00028519	0.00255750	-0.1115	0.9112
Forest area (% of land area)	0.00628934	0.00075633	-8.3156	< 2.2e-16 ***
Crop production index	-0.00281243	0.00053150	-5.2915	1.213e-07 ***
Arable land (% of land area)	-0.00165256	0.00115712	-1.4282	0.1532
Secondary school enrolment (net %)	0.01006430	0.00146725	6.8593	6.921e-12 ***
Democracy index	-0.06773962	0.00885199	-7.6525	1.972e-14 ***
Continental country	-1.0152e-01	3.6496e-02	-2.7817	0.005407 **

Signif. of codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: World Bank, Institute for Economics & Peace (IEP), Authors' calculations

VI. Conclusion

Within the framework of the border matrix as a spatial weight matrix, the main determinants of peace and security in Africa are the population dependency ratio, democracy, access to secondary education, agricultural performance, forest cover and access to the sea. Contagion effects were an interesting finding. A high level of insecurity in one African country increases the level of insecurity in bordering countries. A decrease of one unit in the demographic dependency ratio improves the country's security level (by 0.0105 on the GPI). However, access to the sea negatively impacts the level of security when a border matrix is used as a weight matrix.

It would be interesting, with the availability of data, to extend the analysis to 2020 with a view to taking the effects of COVID-19 into account. Moreover, spatial analysis (using the distances between capitals as a weight matrix) could be a relevant basis for studies to complement this border matrix study.

CHAPTER III
SOCIODEMOGRAPHIC FACTORS THAT FOSTER INSECURITY IN THE SAHEL

Abstract

The main objective of this chapter is to identify the sociodemographic factors that contribute to insecurity in the Sahel. To do this, a fixed effects Spatial Durbin Model (SDM) was applied to a sample of 11 Sahelian countries monitored over 12 years (2008 to 2019). The GPI index was used to capture the level of insecurity in a country. The literature has identified a number of factors likely to foster insecurity; the objective of the modelling is to verify whether these factors have indeed been responsible for the insecurity prevailing in the Sahel by calculating their effects on the GPI.

The results showed that youth unemployment (especially among young men), literacy, migration and the youthfulness of the population foster insecurity in the Sahel. In addition, an increase in the share of GDP allocated to health expenditure led to a decrease in insecurity in the Sahelian region.

I. Introduction

Over the past 25 years, the Sahel has faced many ecological, socioeconomic and security challenges. In addition to climate change – including drought, famine and desertification, and their impact on poverty – this region of Africa is experiencing security problems such as the intensification of organized crime and the growing number of radical armed groups. Recent events in Burkina Faso, Cameroon, Chad, Niger, Nigeria, and Mali have placed the West and Central Africa region at the heart of international research and policy concerns aimed at eradicating this phenomenon and setting these African countries on the road to economic growth.

The multiple causes of these crises in the region include: youth unemployment; scarcity of resources; high levels of social inequality; poor governance; and high population growth, which will see the population of these countries double over the next two decades. Population growth is increasingly mentioned in the literature (Goldstone, 2002) as one of the main causes of insecurity in the area. In most cases, this insecurity is developing in a social context in which these countries are all lagging behind in their demographic transition. The decline in child mortality observed in recent years in this region, as in most countries across the world, has not yet led to a substantial decline in fertility, as predicted in the classic pattern of demographic transition. The average number of children per woman is still high, at close to or exceeding five children per woman, and has not yet fallen significantly. Demographic structures are dominated by young people below 30 years of age.

There is evidence that countries with rapidly growing populations – and where more than 60 per cent of the total population is under 30 years of age – are more likely to experience civil conflict or security crises due to pressures on education systems, socialization, unemployment and underemployment, along with a propensity for crime (Leahy et al. 2007). Low demographic pressure on resources does not, however, necessarily mean less conflict. In fact, if good governance is not enforced and resources are not fairly distributed, there can be explosive situations, just as in the case of strong demographic pressure.

The issue of population growth was considered at the Conference on Population and Development (ICPD) held in Cairo in 1994. One of the main recommendations to emerge was that population issues should be integrated into sectoral and national development policies to prevent populations from becoming demographic time bombs, with implications for peace and security.

The Sahel has grown ceaselessly and impressively from 1950 to the present day. In fact, estimated at just over 60 million in 1950, the population increased more than fivefold between 1950 and 2018, and the United Nations now estimates it at 320 million. The Sahel encompasses the four countries surrounding the Lake Chad Basin. Of these, Nigeria is the demographic giant, with a current population estimated at 196 million, i.e. 60 per cent of the Sahelian population. Demographic projections anticipate that the population of the Sahel will continue its upward trend and it is expected to surpass that of South-East Asia by 2090, if current trends continue.

The average population growth rate in this region therefore remains one of the highest in the world and stood at between 2 and 4 per cent during the two periods under consideration. The lowest growth rates are currently observed in Cameroon (2.5 per cent per year) and Nigeria (2.7 per cent per year), as compared with Chad and Niger, which recorded record annual growth rates of 3.3 per cent and 3.8 per cent respectively for 2018. This rapid population growth is the result of a high fertility rate that has remained unchanged over time. The total fertility rate, which measures the average number of children per woman, was 6.57 children per woman in the 1950s and now stands at 5.57 (2018), a decline of only 1 point in half a century.

The determining factors of fertility levels in Sahelian countries include child marriage, unplanned pregnancies and prenatal attitudes, with strong cultural and religious beliefs being a contributing factor in men and women not subscribing to family planning services. For example, the median age for first marriages is estimated at 17.1 years in the Sahel, reflecting the significance of child marriage. The same is true for adolescent fertility, which stands at 132 births per 1,000 girls, compared with 105 for sub-Saharan African countries.

These African countries face a significant deficit in the health sector, particularly in access to sexual and reproductive health services, including family planning services. Contraceptive prevalence is 12.3 per cent, compared with 27 per cent for sub-Saharan Africa.

The changing age structure of the population that has accompanied this population explosion has resulted in a very young population, in which three out of four people are under 35 years of age. In terms of employment, some young people seek better education and employment opportunities abroad to escape unemployment, insecure employment situations, or to avoid becoming part of the working poor. This irregular migration often leads to a situation of insecurity, both on the migration routes and in transit or host countries.

Faced with this demographic explosion, combined with poor living conditions and a lack of employment opportunities, young people are increasingly vulnerable to the manipulation and false promises of extremists and to human trafficking. While some choose to venture abroad in search of better economic opportunities, often with unpredictable consequences, most have no choice but to express their dissatisfaction on the streets. In doing so, they create an easy market for the big crime lords, including international terrorists.

The objective of this study is therefore to determine the sociodemographic and economic factors that influence the risk of crisis in the Sahel.

More specifically, it aims to:

        O1: describe the security situation in the Sahel region

        O2: identify the explanatory factors of insecurity in the area

        O3: make recommendations for eradicating or preventing the phenomenon in the area.

To achieve these different objectives, the document is structured in 3 sections. The first part outlines the conceptual framework and reviews the literature on the subject; the second presents the methodology and a description of the data used; and the third presents the results and the various implications of the study.

II. Literature review

This section aims to highlight the pioneering empirical work related to the topic of this study.

In 2016, the United Nations Economic Commission for Africa conducted a study addressing the development consequences of conflicts in the Sahel, and the roots and causes of insecurity and violence in the Sahel region, which are multiple and varied. The study distinguishes two types of factors in this phenomenon: structural and immediate factors. Structural factors are a broader process that pushes some individuals to commit violence and sow insecurity. Immediate factors are the personal motivations that attract potential supporters, and the arguments that can be used to legitimize the use of violence.

The study lists the following structural causes:

- **Environmental stress** due to the geographic location of the countries in the area. This stress exposes countries to natural disasters such as drought, desertification and even floods. All of this leads to a multitude of problems, such as internal tensions, refugee flows, youth migration, intercommunity violence, political instability and the revival of irredentism.
- **Historical grievances**, which complicate intergroup relations, political dynamics and mechanisms for establishing the rule of law in many Sahelian countries.
- **The youth demographic explosion**: with more than 60 per cent of the population composed of young people under the age of 25 years, this demographic architecture undoubtedly has negative repercussions, such as unemployment, environmental stress, social and economic exclusion, and political instability.

The immediate causes highlighted by the study are:

- **Migration**: the displacement of pastoralists and their livestock from their areas increases the risks of confrontation and therefore of insecurity.
- **Food insecurity**: affecting an estimated total of 19.8 million people, of whom at least 2.6 million have already crossed the emergency threshold and are in need of immediate food assistance in the Sahel. This situation is often a cause of insecurity and social imbalance.
- **Politically motivated coups**: these occur frequently and are significant factors of instability and insecurity in the Sahel. On the other hand, certain policies, such as repressive policies associated with the politicization of security institutions, contribute to the emergence of conflicts in the Sahel.
- **The rise of jihadist and criminal networks**: This phenomenon, observed in countries such as Mali and Nigeria, has had both internal and regional repercussions. Some more exposed countries transmit insecurity to other nearby countries through the neighbour effect, as was the case for Burkina Faso, Cameroon and Niger, with serious consequences.
- **Widespread corruption and social and economic deprivation**: with considerable natural resources but an inefficient management system in the face of the youth population explosion and the resulting unemployment problems. Corruption reinforces the rhetoric of extremist insurgent movements and provides justification for their cause.

Other studies have been able to identify sociodemographic and economic factors that may have an impact on the risk of insecurity.

Using a panel of some 150 countries over 50 years, Collier and Hoeffler (2004) show that young men are more likely to take up arms when income opportunities in agriculture or the formal sector are less favourable than their expected income as combatants. In other words, when the opportunity cost of war is low. Collier and Hoeffler argue that insecurity is fundamentally motivated by economic opportunities rather than political grievances, such as repression against particular social groups. They find that low income growth, low per capita income, dependence on natural resources, declining male secondary school enrolment, rebel military advantages, and total population are all positively and significantly associated with the onset of civil conflict. They also find that democracy does not reduce the likelihood of civil war, which they consider as further support for their view that civil war is not motivated by political grievances.

Fearon and Laitin (2003) also used a panel of around 150 countries over 50 years to analyse the links between insecurity and other sociodemographic and economic factors. They find that the decline in per capita GDP is significantly linked to the outbreak of civil war. Fearon and Laitin also argue that there is no strong link between poverty and civil war, due to the weakness of the armed forces and poor road conditions. By also using geographical data, they highlight the role of rugged (mountainous) terrain in supporting insurgencies. Fearon and Laitin also find that ethnic diversity does not contribute to the outbreak of conflict.

Having conducted studies on the probability of the onset of a new crisis, the continuation of an ongoing crisis, or both, Elbadawi and Sambanis (2002) confirm most of Collier and Hoeffler's conclusions on the role of economic factors. They also find that ethnic division has a statistically significant quadratic relationship with the incidence of civil war and that democracy reduces the incidence of civil war.

Miguel, Satyanath and Sergenti (2004) estimated the effect of per capita GDP growth on the occurrence of armed conflict using rainfall as a source of exogenous income variation. Using a sample of 41 African countries over the 1981–1999 period, their results show that a one percentage point decrease in per capita GDP is linked to an average increase of more than two percentage points in the probability of conflict the following year.

More recent studies, using more accurate precipitation, drought and temperature climate data, tend to confirm the results of Miguel et al. (2004). In particular, Harari and La Ferrara (2018) use very detailed geocoded data to measure climatic shocks, based on a soil evapotranspiration and precipitation index (the Standardized Precipitation-Evapotranspiration Index, SPEI), measured during the growing season of local crops. They observe that climatic shocks have a positive impact on the risk of conflict during the growing season. Furthermore, they do not measure any significant effect of local climate shocks on conflict risk outside this period – a result that supports the idea that climate affects conflict indirectly, via agricultural yields and revenue, rather than directly. The significant impact of the negative and positive variations observed seems to validate both theoretical channels that link income to the risk of conflict.

III. Methodology and data source

This section presents the data used and the methodology adopted to meet the various study objectives.

a) Data source

The study sample is a balanced panel of 11 Sahelian countries over a 12-year period (2008–2019). The panel thus comprises the G5 Sahel countries (Burkina Faso, Chad, Mali, Mauritania, and Niger) plus Algeria, Cameroon, Ethiopia, Nigeria, Senegal and Sudan. Aside from Cape Verde, which the IEP does not assign a GPI score to, other Sahelian countries such as South Sudan and the three countries of the Horn of Africa (Djibouti, Eritrea and Somalia) are, however, excluded from the sample due to the unavailability of data on the study variables.

For the study variables, selection is based not only on the literature but also on the availability of data. On this basis, nine variables likely to influence insecurity were selected during the analysis. These include the Global Peace Index (GPI), which measures the level of insecurity and is provided annually by the

IEP.[11] The GPI is used as a dependent variable in the modelling. The main explanatory variables are youth unemployment, arable land area, GDP growth, literacy rate, international migration, the share of GDP allocated to health expenditure, and the population under 14 years of age. These data are taken from the World Bank World Development Indicators (WDI) database. Finally, a variable measuring local democracy, provided by the United Nations Development Programme (UNDP), was added to the explanatory variables.

b) Methodology

To assess the sociodemographic factors that foster insecurity in the Sahel, we used the spatiotemporal approach of the fixed effects Durbin model. This method is well suited to this study because it reduces the bias caused by the unobserved heterogeneity specific to each country. Taking spatial effects into account in the model also further corrects the spatial dependency; if these were not included, bias would be created in the estimates (Anselin, 2013). The model is firstly validated through spatial autocorrelation tests; the Moran's I statistic is applied to each year, and then overall, to test for the existence of any spatial dependency. Secondly, starting from a general spatial model, a series of tests is carried out to select the most appropriate model.

The fixed effects SDM was thus selected to estimate the effects of the factors on the dependent variable (see the results of the procedure in the appendix). The Hausman test was used to choose between a fixed effects and a random effects model. The results of the tests are presented in the appendices.

IV. Results

This section presents all the results obtained using the methodology outlined above. Using the GPI, we first describe the security situation in the Sahel. This descriptive analysis enables potential relationships between the selected explanatory variables and the GPI to be considered. The results of the modelling will make it possible to confirm or reject suspected relationships between insecurity and selected sociodemographic factors.

a) The security situation in the Sahel

The GPI is used to rank the countries of the world according to their level of peacefulness. Indicators used for ranking include national levels of violence and crime and factors concerning countries' international relations, such as military expenditure and war. It also evaluates the degree of harmony or discord within a nation by assessing 10 indicators considered to describe societal safety and security. Countries with a GPI score of less than 2 are considered to have a low or very low level of insecurity; those that score between 2 and 2.3 are considered to have a medium or intermediate level of insecurity; and countries that score above 2.3 are considered to have a high or very high level of insecurity.

Analysis of Figure 1 shows that the overall level of insecurity in the Sahel region is high. In fact, of the 12 countries, only Senegal had a low level of insecurity (under 2). Nigeria, Mali and Sudan are ranked as the countries most affected by insecurity in the area. Chronologically, over the last 12 years, changes in the level of insecurity are far from homogeneous among countries. For some countries, the security situation has improved over these years. This is the case in Algeria, Chad, Ethiopia, Mauritania, Senegal

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and Sudan. For other countries, insecurity has gradually taken hold over this period. This is primarily the case in three G5 Sahel member states (Burkina Faso, Mali and Niger), as well as Cameroon and Nigeria. These countries incorporate the Liptako-Gourma region, which straddles Burkina Faso, Mali and Niger and is considered the epicentre of the security crisis in the Sahelo-Saharan strip. Rising insecurity in this area is attributed to the exacerbation of three phenomena: violent extremism, transnational organized crime and local conflicts (ISS, 2019).

FIGURE 3.1: Spatial and temporal situation of insecurity in the Sahel

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sudan	3.12	3.12	3.20	3.29	3.29	3.17	3.24	3.28	3.22	3.20	3.17	3.00
Chad	2.91	2.98	3.03	2.76	2.68	2.48	2.56	2.54	2.48	2.56	2.50	2.52
Nigeria	2.59	2.58	2.61	2.58	2.71	2.74	2.86	2.94	2.87	2.87	2.88	2.90
Ethiopia	2.59	2.81	2.58	2.57	2.65	2.54	2.38	2.28	2.27	2.35	2.43	2.43
Mali	2.35	2.35	2.27	2.25	2.28	2.33	2.42	2.65	2.56	2.70	2.69	2.71
Cameroon	2.04	2.09	2.18	2.11	2.10	2.05	2.09	2.30	2.30	2.37	2.47	2.54
Algeria	2.35	2.35	2.37	2.51	2.35	2.31	2.28	2.26	2.20	2.19	2.19	2.22
Mauritania	2.38	2.51	2.35	2.42	2.39	2.27	2.32	2.38	2.28	2.36	2.35	2.33
Niger	2.17	2.16	2.16	2.13	2.16	2.13	2.09	2.33	2.27	2.42	2.44	2.39
Burkina Faso	1.89	1.83	1.79	1.75	1.77	1.91	1.82	1.90	2.05	2.07	2.02	2.18
Senegal	2.05	2.05	2.16	2.13	2.05	2.03	1.99	1.90	1.97	1.94	1.85	1.88

Source: Authors' calculations

b) Description of factors

The literature review highlighted a number of factors that are likely to foster insecurity. Primarily, these include youth unemployment, arable land area, GDP growth, literacy rate, international migration, health expenditure, the population under 14 years of age and democracy. This part is subdivided into two sections. In the first section, we describe the immediate factors (unemployment, economic growth and health expenditure) and, in the second, we describe the structural factors (the youthfulness of the population, democracy, the environment and the literacy level).

b.1. Immediate factors

A. Youth unemployment and insecurity

Figure 3.2 shows a positive link between youth unemployment and insecurity in the Sahel. Any increase in the proportion of young people who are unemployed is accompanied by increased insecurity and vice versa. From 2008 to 2014, unemployment fell from 60 per cent to less than 57 per cent and average insecurity

Modelling the relationship between demography, peace and security

in the area also fell from 2.4 to 2.37. Equally, since 2014, youth unemployment in the area has continued to rise and insecurity has worsened on average, from 2.37 to over 2.45.

FIGURE 3.2: Changes in unemployment and the Global Peace Index in the Sahel from 2008 to 2019
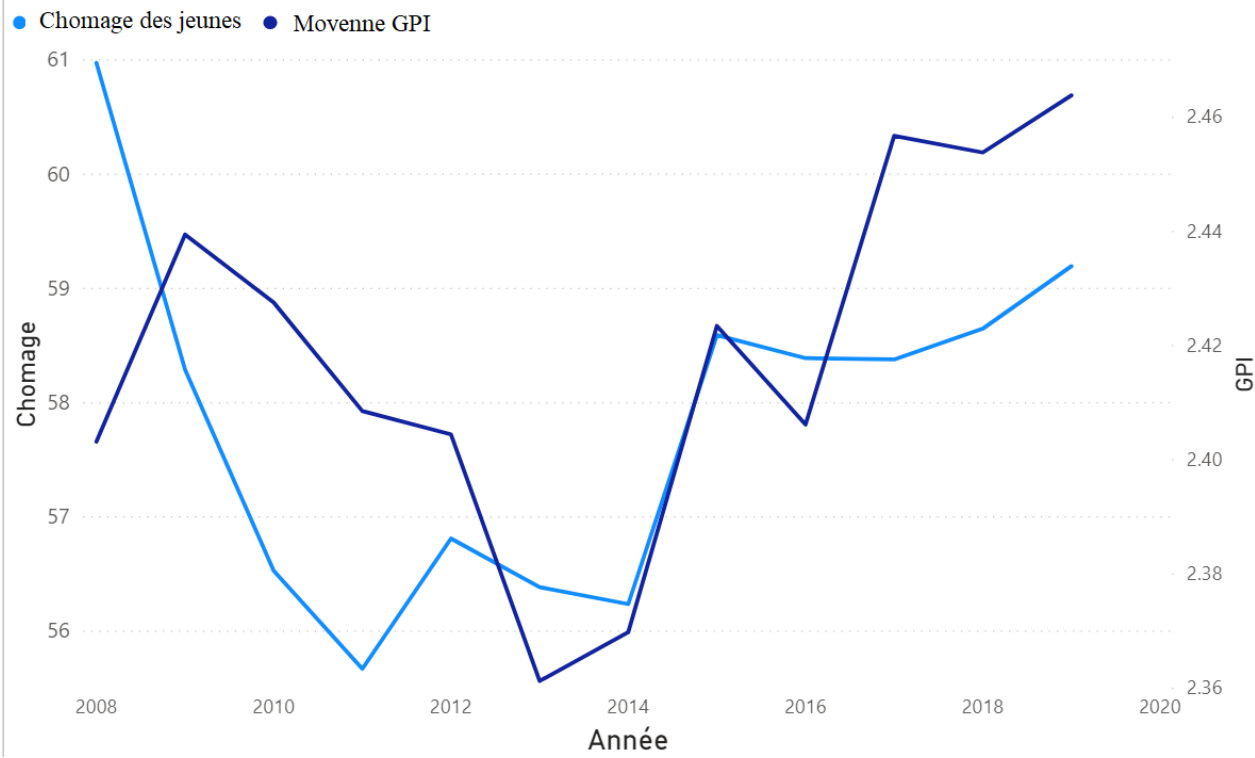
Source: Authors' calculations

A country-by-country analysis also shows the same trend. For Burkina Faso, Mali, Mauritania, Nigeria and Senegal, changes in security and youth unemployment go hand in hand and vary in the same direction.

B. Health expenditure and insecurity

The share of health expenditure in GDP moves in the opposite direction to the GPI. An increase in insecurity means that state resources are reallocated to purchase military equipment to ensure the security of the population. The figure below confirms this negative relationship between security and health expenditure in the Sahel region. With a time lag of one year, any increase in insecurity translates into a decrease in the share of GDP allocated to health expenditure.

Changes in health expenditure and the Global Peace Index in the Sahel from 2008 to 2019
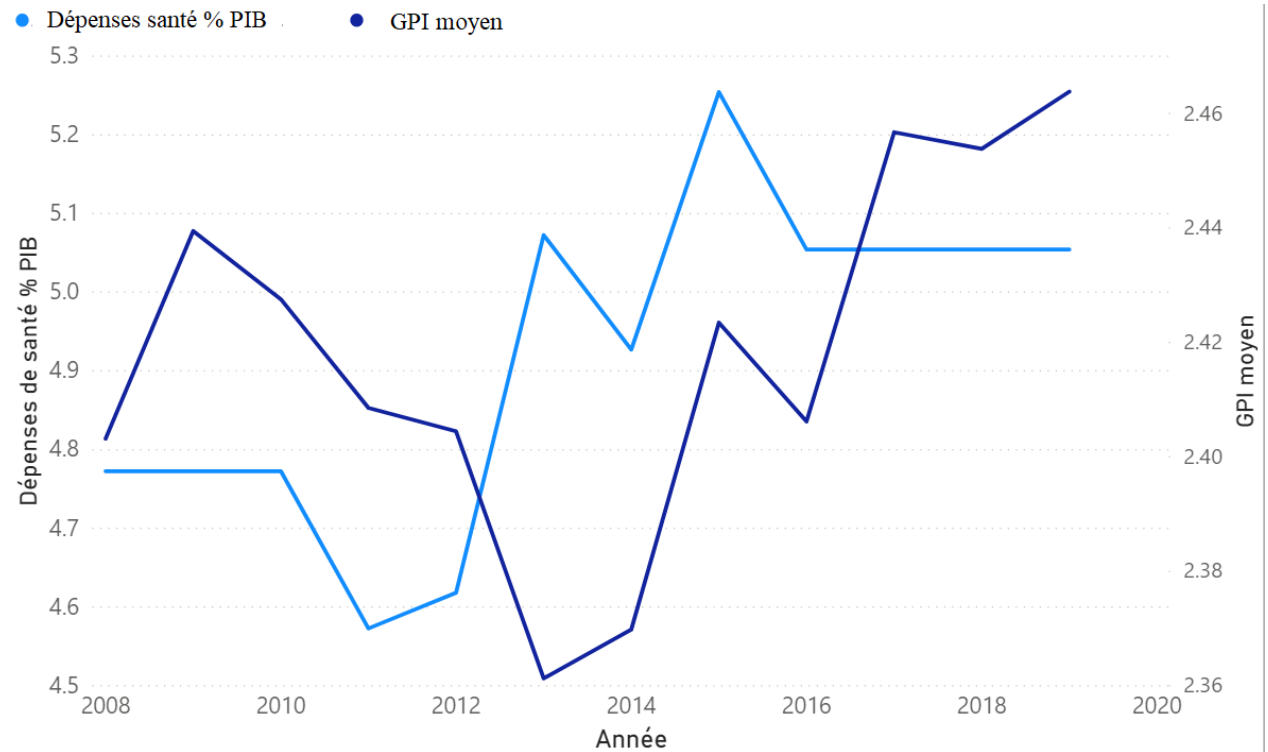
Source: Authors' calculations

This inverse relationship between increased insecurity and a decline in the share of GDP allocated to health expenditure is evident in many Sahelian countries. Figure 3.5 below confirms this relationship in Algeria, Chad, Ethiopia, Mali, Mauritania, Niger and Senegal.

FIGURE 3.5: Changes in the share of gross domestic product allocated to health expenditure in selected Sahelian countries from 2008 to 2019
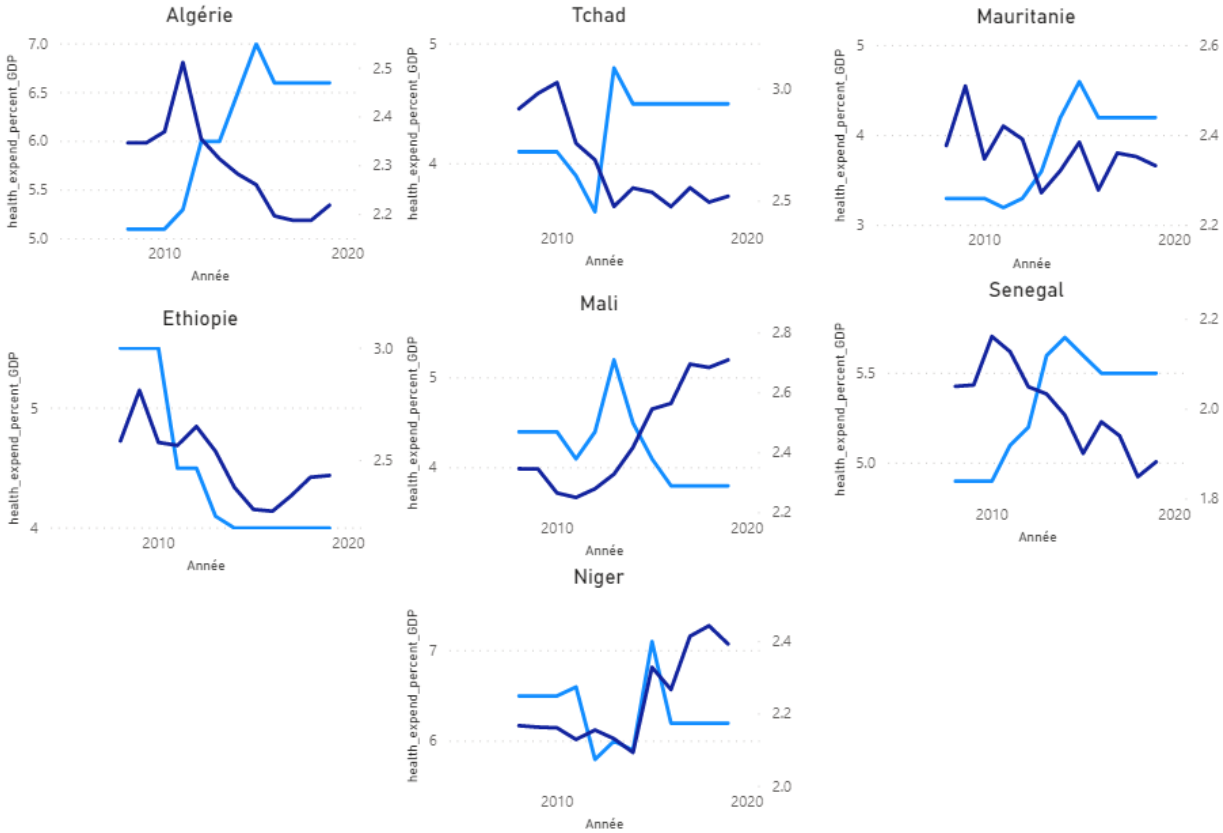
Source: Authors' calculations

C. Economic growth and insecurity

In the literature, many authors have established a significant relationship between economic growth and reduced insecurity. An analysis of Figure 6, below, confirms this relationship between the two phenomena in the Sahel region. Periods marked by accelerated economic growth correspond to periods of reduced insecurity. Conversely, periods of decelerated growth coincide with periods of increased insecurity.

FIGURE 3.6: Changes in economic growth and the Global Peace Index in the Sahel from 2008 to 2019
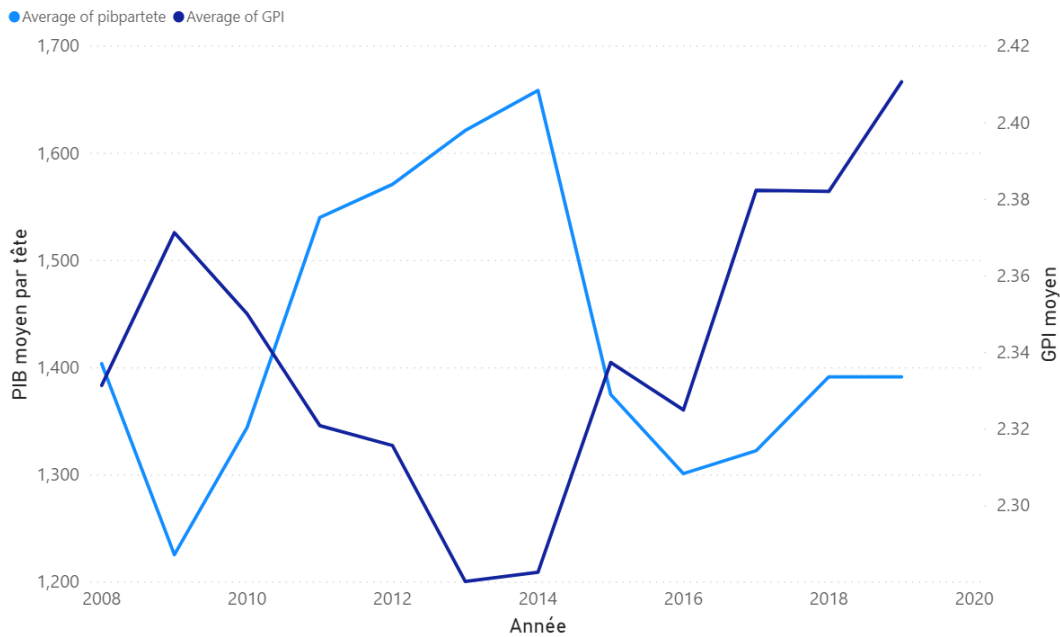
Source: Authors' calculations

At the country level, the relationship seems to be confirmed in countries such as Ethiopia, Niger and Senegal. However, it should be noted that this relationship remains mixed for the other eight countries in the study.

FIGURE 3.7: Changes in economic growth and the Global Peace Index in the Sahel from 2008 to 2019
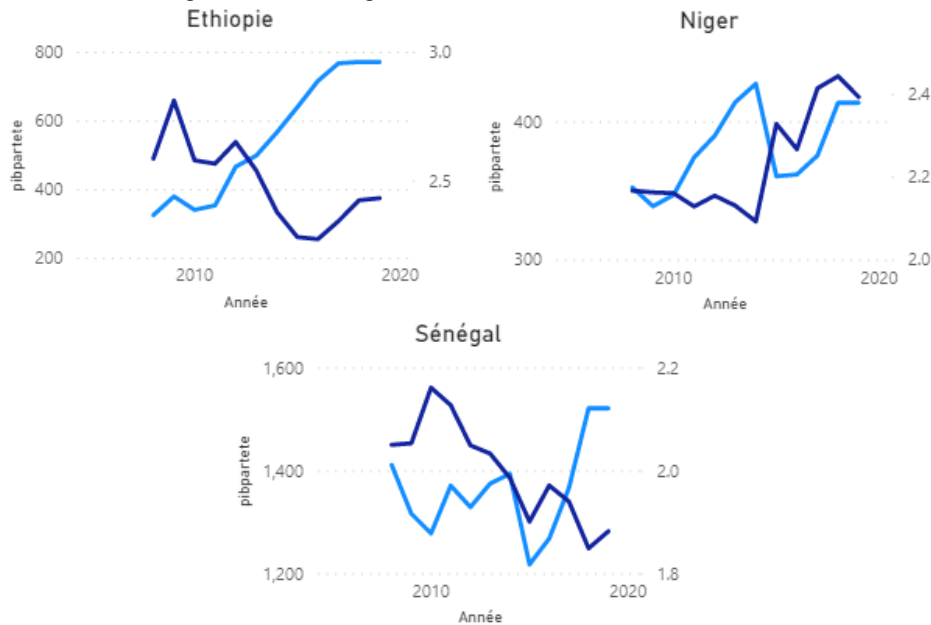
Source: Authors' calculations

D. Structural factors

In this section, we describe the other variables that are likely to be correlated with insecurity, and which are not greatly affected by chronology (they vary little over a ten-year period, according to our data). These

are: the youthfulness of the population, measured by the proportion of young people under 14 years of age; the area of arable land; the literacy rate; international migration; and democracy.

TABLE 3.1: Description of structural factors in the Sahel in 2019

Pays	GPI	% pop moins 14 ans	Taux d'alphabé-tisation 15 ans et plus	Supérficies arables	Indice de Démocratie
Sudan	3.00	40.51	60.70	19823160	0.00
Nigeria	2.90	43.87	62.02	34000000	0.44
Mali	2.71	47.54	35.47	6411000	0.15
Cameroon	2.54	42.63	77.07	6200000	0.01
Chad	2.52	47.13	22.31	4900000	0.04
Ethiopia	2.43	40.78	51.77	15119000	0.04
Niger	2.39	49.98	30.56	16800000	0.00
Mauritania	2.33	40.08	53.50	450000	0.02
Algeria	2.22	30.15	81.41	7404200	0.02
Burkina Faso	2.18	44.95	41.22	6000000	0.58
Senegal	1.88	43.06	51.90	3200000	0.15
Sahel	**2.46**	**42.79**	**51.63**	**120307360**	**0.13**

Source: Authors' calculations

a. Analysis of the results of the modelling

Estimation of the spatial panel model aimed at confirming or rejecting the existence of a link between insecurity and factors such as youth unemployment, the adult literacy rate, health expenditure, international migration, economic growth, democracy, the environment and the youthfulness of the population.

The results of the model are interpreted through its direct, indirect and total effects. These effects reflect the impact on the dependent variable (the GPI) of a change in the coefficients of one unit. According to LeSage and Pace (2009), the direct effect provides a summary measure that represents an average of the impacts on insecurity resulting from regional changes in the factor concerned (region-specific effect). The indirect effect measures the impact on insecurity in country i resulting from changes in the relevant factor in all other regions (spatial knock-on effect). The total effect includes both the direct and indirect effect. It measures the average cumulative impact of changing the explanatory factor for one country across all other countries. Moreover, the sign of the coefficient reflects the direction of the link between the factor and insecurity. A positive sign coefficient means that the variation in the factor and the level of insecurity are moving in the same direction. Conversely, a negative sign coefficient indicates that the variation is moving in an opposite direction. The values of these different effects in the Sahel region are shown in Table 3.2 below.

TABLE 3.2: Results of the spatial panel modelling

Variable	Direct effect	Indirect effect	Total effect	Spatial	Variance
Youth unemployment	0.0268	0.0232	0.0500*		
	(-0.0181)	-0.0202	-0.0271		
Area of arable land	-5.89E-09	2.62E-08	2.03E-08		
	-2.49E-08	-3.26E-08	-3.17E-08		
Gross domestic product (GDP) growth per capita	0.0052	-0.00331	0.00189		
	-0.00408	-0.00492	-0.00536		
Adult literacy rate	0.0138***	0.00187	0.0156**		
	-0.00506	-0.00749	-0.00698		
International migration	2.70e-07*	8.43e-07***	1.11e-06***		
	-1.61E-07	-2.64E-07	-3.45E-07		
Health expenditure as % of GDP	-0.0325	-0.0425	-0.0750*		
	-0.0283	-0.0375	-0.0389		
Democracy index	-0.231	-0.0709	-0.302		
	-0.175	-0.195	-0.25		
Proportion of young people aged under 14 years.	-0.0268	0.147***	0.120***		
	-0.0272	-0.0369	-0.0297		
Rho				-0.253**	
				-0.105	
Sigma2_e					0.0114***
					-0.00142
R2	0.31	0.31	0.31	0.31	0.31

Source: Authors' calculations

In short, the estimation of the spatial panel model confirms the existence of a link between insecurity and factors such as youth unemployment, the adult literacy rate, health expenditure, international migration and the youthfulness of the population. Moreover, for all effects, all the estimated coefficient values reflect the signs expected, with the exception of the literacy rate. We can state that high unemployment, high international migration or a high proportion of young people foster increased insecurity in the Sahel. In addition, a significant proportion of GDP allocated to the health of the population would result in a low level of insecurity. Furthermore, the results indicate an inverse relationship between literacy levels and security. In other words, the Sahelian countries affected by insecurity tend to have relatively higher literacy rates compared with other Sahelian countries that are less affected by insecurity. This could be explained by the deteriorating GPI in Nigeria and Cameroon, which have good literacy rates. More detailed information is obtained by breaking down the total effect of a factor into direct and indirect effects.

V. Discussion

Spatial panel modelling has shown a positive relationship between youth unemployment and insecurity. This result is comparable to those found by three CRES researchers, Fougère, Kramarz and Pouget, in their study "Youth Unemployment and Crime in France", conducted in September 2009. According to Fougère et al. (2009), the extent of economic crimes, burglaries, car thefts, armed robberies, pickpocketing and drug trafficking depended on the increase in youth unemployment.

The model found that the net international migrant stock is positively correlated with insecurity in the Sahel. In other words, if insecurity increases, so does net migration. This could be because insecurity and difficult social conditions often push people to emigrate to better destinations. Moreover, an increase in insecurity considerably reduces the attractiveness of a country, and therefore the number of people wanting to emigrate there. This all increases net international migration as insecurity deteriorates.

With regard to the literacy rate, the results of the modelling established a positive link with insecurity. In other words, high literacy is a factor that fosters insecurity (direct effect) in the Sahel. These results run counter to our initial assumptions that high literacy rates would lead to lower levels of insecurity. Even though education is considered as a vehicle for peace, several arguments have, however, been put forward to explain the theory of "education as a source of conflict". These include the more or less indirect link between the literacy rate (proxy for education) and unemployment. Every year, training schools and universities send out new graduates into an already saturated labour market, thus increasing the level of unemployment, itself a factor that fosters insecurity. As a result, high levels of education combined with a lack of employment opportunities could contribute to a deterioration in security. For example, the Arab Spring was triggered by highly educated young people who were victims of unemployment. Their level of education and intensive use of modern communication technologies (internet and mobile phones) played a decisive role in raising collective awareness.

The model revealed a close link between the youthfulness of the population (captured by the proportion of young people under 14 years of age) and insecurity in the Sahel. This result is consistent with the findings of Hewitt et al. (2003) and Leahy et al. (2007). The youthfulness of the population is strongly correlated with the dependency ratio of young people on older adults. This leads to lower growth in income per capita than in income per active member of the population. Furthermore, the lack of employment opportunities makes these young people more vulnerable to human trafficking and more easily tempted to join armed groups.

Ultimately, Durbin's model revealed an inverse relationship between the share of GDP allocated to health expenditure and insecurity. The negative sign of this effect indicates that, as health expenditure increases throughout the study area, the level of insecurity will tend to decrease in each Sahelian country. Health expenditure plays an important economic and sociopolitical role in a country by helping to reduce socioeconomic inequalities and poverty in general. It also reduces maternal deaths and therefore avoids social unrest caused by the situation of orphaned and abandoned children. Investing in health systems in the Sahel region is therefore an opportunity to advance peace, save millions of lives and prevent socioeconomic inequalities and privatization.

VI. Conclusion

Knowledge of the factors that explain insecurity in the Sahel is of paramount importance in designing development programmes and policies. Given the available data, the spatial econometric method based on panel data has made it possible to identify a number of factors that are contributing to the steadily increasing insecurity in the Sahel.

Empirical results show that the GPI in one country is related to the GPI in neighbouring countries. However, we used the SDM, Spatial Error Model (SEM), and Spatial Autoregressive Confused (SAC) model to interpret these relationships. After applying the corresponding tests, we selected the Durbin fixed effects model as the best model.

The estimated results of the model show that the total effects are more pronounced than other effects on insecurity in the Sahel. Unemployment tends to worsen insecurity in all parts of the Sahel. This is also the case for international migration, the literacy rate and the youthfulness of the population. This means that, in all Sahelian countries, as these sociodemographic variables increase, so does the risk of insecurity. On the other hand, health expenditure has an overall positive effect, improving security.

It should be noted that no relationship has been established between the insecurity prevailing in the Sahel and certain factors that could influence it such as growth in per capita GDP, the amount of arable land or democracy. While we should clarify that the model does not reject the existence of a relationship between these factors and insecurity, there is simply no confirmation that these factors affect insecurity in the Sahel region.

This study uses macroeconomic data to identify the factors that foster insecurity in the Sahel. This is a considerable limitation because some socioeconomic aspects related to individuals or households are not addressed. An analysis using micro-level data collected at the household or individual level would be more appropriate and informative.

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APPENDICES

APPENDIX 1.1: List of countries comprising the different groups

```
CLASSE  1 / 3
Aust  Aust  Bela  Belg  Bulg  Cana  Croa  Cypr  Czec  Denm  Esto  Finl  Fran  Germ  Gree
Hung  Icel  Irel  Isra  Ital  Japa  Kore  Latv  Lith  Maur  Mont  Neth  New   Norw  Pola
Port  Roma  Serb  Sing  Slov  Slov  Spai  Swed  Swit  Trin  Ukra  Unit  Unit
```

```
CLASSE  2 / 3
Alba  Alge  Arge  Arme  Azer  Bahr  Bhut  Boli  Bosn  Bots  Braz  Chil  Chin  Colo  Cong
Cost  Cuba  Djib  Domi  Ecua  Egyp  El S  Equa  Erit  Gabo  Geor  Indo  Iran  Iraq  Jama
Jord  Kaza  Kore  Koso  Kuwa  Kyrg  Leba  Liby  Mace  Mala  Mexi  Mold  Mong  Moro  Nica
Oman  Pana  Para  Peru  Phil  Qata  Russ  Saud  Sout  Sri   Syri  Thai  Tuni  Turk  Turk
Unit  Urug  Uzbe  Vene  Viet  Taiw  Pale  Swaz
```

```
CLASSE  3 / 3
Afgh  Ango  Bang  Beni  Burk  Buru  Camb  Came  Cent  Chad  Cong  Cote  Ethi  Gamb  Ghan
Guat  Guin  Guin  Guya  Hait  Hond  Indi  Keny  Lao   Leso  Libe  Mada  Mala  Mali  Maur
Moza  Myan  Nami  Nepa  Nige  Nige  Paki  Papu  Rwan  Sene  Sier  Soma  Sout  Suda  Taji
Tanz  Timo  Togo  Ugan  Yeme  Zamb  Zimb
```

APPENDIX 1.2: Characterization of groups by variables

```
CLASSE  2 / 3
-------------------------------------------------------------------------------------------------------------
V.TEST  PROBA ---- POURCENTAGES ---- MODALITES                                                            IDEN
POIDS
              CLA/MOD MOD/CLA GLOBAL  CARACTERISTIQUES    DES VARIABLES
-------------------------------------------------------------------------------------------------------------
                            41.72  CLASSE  2 / 3                                                          aa2a
68
  3.05  0.001   45.03  100.00  92.64  C8=NO_WCAR          Region_WCAR                                     AD_1
151
 -3.05  0.001    0.00    0.00   7.36  C8=WCAR             Region_WCAR                                     AD_2
12
 -3.23  0.001    0.00    0.00   7.98  C6=Very High        Levelofsecurity                                 AA_4
13
-------------------------------------------------------------------------------------------------------------
```

```
CLASSE  2 / 3
+--------+-------+------------------+------------------+----------------------------------------------------------+
| V.TEST | PROBA |     MOYENNES     |   ECARTS TYPES   |              VARIABLES CARACTERISTIQUES
|
|        |       |  CLASSE  GENERALE |  CLASSE   GENERAL | NUM.LIBELLE                                            IDEN
|
+--------+-------+------------------+------------------+----------------------------------------------------------+
|              CLASSE  2 / 3        ( POIDS =    68.00    EFFECTIF =   68 )                               aa2a
|
|
|   4.00 | 0.000 |   67.02   58.31 |   17.08   22.18 | 11.Urbanpopulationoftotal                              C12
|
|   2.83 | 0.002 |   42.24   39.84 |    7.43    9.12 | 13.Gini                                                C14
|
|        |       |                 |                 |                                                       
|  -3.28 | 0.001 |   39.59   47.18 |   12.78   23.64 | 14.Agedependencyratioyoungo                            C15
|
|  -3.45 | 0.000 |   10.97   15.68 |   10.47   14.12 |  9.Arablelandoflandarea                                C10
|
|  -3.48 | 0.000 |    4.68    5.41 |    1.94    2.20 |  8.GDI                                                 C9
|
+--------+-------+------------------+------------------+----------------------------------------------------------+
```

```
-------------------------------------------------------------------------------------------------------------
V.TEST  PROBA ---- POURCENTAGES ---- MODALITES                                                            IDEN
POIDS
              CLA/MOD MOD/CLA GLOBAL  CARACTERISTIQUES    DES VARIABLES
-------------------------------------------------------------------------------------------------------------
                            26.38  CLASSE  1 / 3                                                          aa1a
43
  5.69  0.000  100.00   30.23   7.98  C6=Very High        Levelofsecurity                                 AA_4
13
 -2.88  0.002    3.85    2.33  15.95  C6=Low              Levelofsecurity                                 AA_2
26
 -2.93  0.002    9.30    9.30  26.38  C6=Medium           Levelofsecurity                                 AA_3
43
-------------------------------------------------------------------------------------------------------------
```

```
CLASSE  3 / 3
-------------------------------------------------------------------------------------------------------------
V.TEST  PROBA ---- POURCENTAGES ---- MODALITES                                                            IDEN
POIDS
              CLA/MOD MOD/CLA GLOBAL  CARACTERISTIQUES    DES VARIABLES
-------------------------------------------------------------------------------------------------------------
                            31.90  CLASSE  3 / 3                                                          aa3a
52
  4.92  0.000  100.00   23.08   7.36  C8=WCAR             Region_WCAR                                     AD_2
12
 -2.52  0.006   20.00   25.00  39.88  C6=High             Levelofsecurity                                 AA_1
65
 -2.55  0.005    0.00    0.00   7.98  C6=Very High        Levelofsecurity                                 AA_4
13
 -4.92  0.000   26.49   76.92  92.64  C8=NO_WCAR          Region_WCAR                                     AD_1
151
-------------------------------------------------------------------------------------------------------------
```

```
CLASSE  3 / 3
+--------+-------+------------------+------------------+----------------------------------------------------------+
| V.TEST | PROBA |     MOYENNES     |   ECARTS TYPES   |              VARIABLES CARACTERISTIQUES
|
```

The model, written in matrix format, gives:

The model, written in matrix format, gives:

$$Y = \lambda(I_T \otimes W_N)Y + X\beta + \mu$$

where y is an NT*1 matrix of observations of the dependent variable; X is an NT*k matrix of the mix of the explanatory variables; *IT* is the identity matrix of dimension T; *WN* is the spatial weight matrix of dimension N*N, this matrix is known and is established as a constant, its diagonal elements are equal to zero and _ is the spatial parameter. Here N is the number of countries (53) and T is the number of periods (10, from 2008 to 2016 or 2019 depending on the data). We will use the Baltagi *et al*. (2003) specification to estimate the parameters. In this model the *μ* parameter is specified as follows: $\mu = (i_T \otimes I_N)\delta + \in$

where *iT* is a vector of 1 of dimension T*1; *IN* is an identity matrix of dimension N*N; δ is a vector characterizing individual effects (not spatially autocorrelated) and $\in$ is a vector of spatially autocorrelated errors following a spatial autoregressive process of the form:

$$\in = \theta(I_T \otimes W_N) \in + \tau$$

With θ ($|\theta|$ *inférieur* à 1) as the spatial autoregressive parameter; W_N as the spatial weight matrix, $\tau_{it} \sim IID(0, \sigma_\tau^2)$. In the panel data models, there were two types of individual effects: fixed effects and random effects. In random effects models, unobserved individual effects are uncorrelated with the other explanatory variables in the model. In this case, $\delta_i \sim IID(0, \delta_\tau^2)$. δ_i and the error terms can be rewritten as follows: $\epsilon = (i_T \otimes B_N^{-1})\tau$ or $B_N = (I_N - \theta W_N)$. And the error terms thus become $\mu = (i_T \otimes I_N)\delta + (i_T \otimes B_N^{-1})\tau$.

The variance-covariance matrix has the following form:

$$\Omega_\mu = \sigma_\delta^2(i_T i'_T \otimes I_N) + \sigma_\tau^2(I_T \otimes (B'_N B_N)^{-1})$$

The variance-covariance matrix of the errors is divided by the variance of the error σ_ε^2.

Let's pose: $\phi = \frac{\sigma_\varepsilon^2}{\sigma_\delta^2}$, $\bar{J}_T = \frac{J_T}{T}$, $E_T = I_T - \bar{J}_T$ and $A_N = (I_N - \theta W_N)$

The variance-covariance matrix of corrected errors Σ then takes the following form:

$$\Sigma = \phi \left(J_T \otimes I_N \right) + I_T \otimes (B_N' B_N)^{-1}$$

Both its inverse and its determinant can be written as follows:

$$\Sigma^{-1} = J_T * \left((T\phi I_N + (B_N' B_N)^{-1})^{-1} + E_T * B_N' B_N \right.$$

$$|\Sigma| = |T\phi I_N + (B_N' B_N)^{-1}||(B_N' B_N)^{-1}|^{T-1}$$

Using Anselin's (1988) formula for parameter estimation in spatial econometric models, the likelihood of the random effects spatial panel model can be written as:

$$L(\beta, \sigma_\varepsilon^2, \lambda, \phi, \theta)$$

$$= -NT\pi - \frac{NT}{2}\ln(\sigma_\tau^2) + Tln|A| - \frac{1}{2}ln|T\phi I_N + (B_N' B_N)^{-1}| + (T-1)lnB_N$$

$$- \frac{1}{2\sigma_\tau^2}\mu'\Sigma^{-1}\mu$$

Maximum likelihood is obtained using an iterative procedure (Millo and Piras, 2012). $, \lambda, \phi, et\ \theta$ are initialized and β and σ_ε^2 are obtained from first-order conditions:

$$\beta = (X'\Sigma^{-1}X)^{-1}X'\Sigma^{-1}AY$$

$$\sigma_\tau^2 = \frac{(Ay - X\beta)'\Sigma^{-1}(Ay - X\beta)}{NT}$$

Nevertheless, the probability can be maximized respectively by $\lambda, \theta\ et\ \phi$ and the values are in turn used to update A and Σ^{-1}. This process is repeated until the convergence criteria are met.

A fixed effects spatial panel model can be written in the following form:

$$Y = \lambda(I_T \otimes W_N)Y + (i_T \otimes I_N)\delta + X\beta + \epsilon$$

with λ as the autoregressive spatial parameter; W_N as the spatial weight matrix whose elements

are known; i_T as a vector of 1; I_N as the identity matrix of order N and $\epsilon \sim IID(0, \sigma_\tau^2)$.

The presence of the spatial lag introduces a form of endogeneity that violates the assumptions of standard regression models (regressors are uncorrelated to the error term). Elhorst (2003) suggested transforming this equation by removing the fixed effects part and using the transformed variables to maximize the likelihood function. The transformation is obtained by extracting the average for each individual over time. And thus the fixed effect and the constant are no longer part of the model.

The transformation takes the following form:

$$Y^* = \lambda(I_T \otimes W_N)Y^* + X\beta + \epsilon^*$$

With $Y^* = Q_0 Y, \ X^* = Q_0 X, \ \epsilon^* = Q_0 \epsilon$

The log-likelihood function is written: $L = \frac{NT}{2}\ln(2\pi\sigma_\epsilon^2) + T\ln|I_N - \lambda W_N| - \frac{NT}{2\sigma^2}e'e$

With $e = \lambda(I_T \otimes W_N)y + X\beta$ and $ln|I_N - \lambda W_N|$ is the Jacobian determinant. Elhorst (2009) proposes a concentrated likelihood to maximize log-likelihood. After transformation, the concentrated likelihood gives:

$$L = C + Tln|I_N - \lambda W_N| - \frac{NT}{2}(e_0^* - \lambda e_{\ast}^*)'(e_0^* - \lambda e_0^*)$$

With C as a constant that does not depend on λ. To maximize this concentrated likelihood, linear optimization is used to find the value of λ, maximizing the likelihood. Estimators of β et σ^2 are obtained from first-order conditions by replacing the value of λ obtained in the maximization. Estimators of β can also be obtained from the generalized least squares method with a variance matrix $\sigma_\epsilon^2 Q_0$

A neighbourhood matrix makes it possible to define the functional form linking the observations, i.e. their potential interactions. For n geographic sites, a weight matrix W is of $n \times n$ size and its element w_{ij} indicates the intensity of the dependency of zone i on zone j (it specifies the topology of the domain). By convention, the diagonal elements of W are zero, $w_{ii} = 0$ for all i.

The neighbourhood matrix thus provides information on the geographical, social or technological proximity between statistical individuals (in our framework, countries). Social proximity introduces a more microeconomic framework (individuals). In this study, only geographical proximity will be taken into account. There are two types of geographical proximity: the distance between capitals or the fact that countries share common borders. The distance between capitals is measured using the geographical coordinates of the centroids of the capital cities, using distance formulas. The matrix puts these individuals in rows and columns. The intersection between a row and a column provides information on the distance between the element in the row and the element in the column. In terms of shared borders between two countries, the intersection between a row and a column in the matrix takes the value 0 or 1, depending on whether the two countries share a border.

APPENDIX 3.1: The spatiotemporal approach of the fixed effects Durbin model.

The spatiotemporal approach of the fixed effects Durbin model is adapted in a context of country-specific unobserved heterogeneity. It has the advantage of taking spatial effects into account in the model and further corrects spatial dependency (Anselin, 2013). This model is firstly approved through spatial autocorrelation tests (the Moran's I statistic). Secondly, starting from a general spatial model, a series of tests is carried out to select the most appropriate model.

APPENDIX 3.2: The spatial autocorrelation test

Spatial autocorrelation is defined as the positive or negative correlation of a variable with itself due to the spatial location of the observations. Spatial dependence was taken into account by specifying the neighbourhood structure between the Sahelian countries in the sense of Queen contiguity: two countries will be considered spatially as neighbours if they share a common administrative border. The neighbourhood matrix W for this study is defined as a square matrix of 11, such that:

$$w_{ij} = \begin{cases} 1 & if\ i\ and\ j\ are\ spatially\ linked\ and\ i \neq j \\ 0 & otherwise \end{cases}$$

To confirm the presence of spatial autocorrelation at the level of the dependent and explanatory variables, the Moran's I statistic or Moran Index was used. Spatial autocorrelation indices make it possible to characterize the correlation between measures that are geographically similar to a measured phenomenon.

If autocorrelation tests confirm the presence of possible spatial effects, the next step in the modelling will focus on selecting the most appropriate spatial model.

APPENDIX 3.3: The Spatial Auto Regression (SAR) model

Here, spatial interaction is modelled through the introduction of the spatially shifted dependent variable Wy_t.

$$y_t = \rho W y_t + X_t \beta + \mu + \varepsilon_t \quad t = 1\ldots, T$$

It is assumed that $\mu \sim N(0, \sigma_u^2)$ in the case of a random effect. In the case of a variable fixed effect, μ is the vector of parameters to be estimated.

$$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$$

$E(\varepsilon_{it}\varepsilon_{js}) = 0$ for $i \neq j$ and/or $t \neq s$

APPENDIX 3.4: The Spatial Error Model (SEM)

In SEM models, spatial interaction is captured through spatial autoregressive specification of the error term Mv_t

$$y_t = X_t \beta + \mu + v_t \quad t = 1\ldots, T$$

$$v_t = \lambda M v_t + \varepsilon_t$$

APPENDIX 3.5: The Spatial Autoregressive Confused (SAC) model

This model simultaneously involves a spatial autoregressive process of the dependent variable and the error term.

$$y_t = \rho W y_t + X_t \beta + \mu + v_t \quad t = 1\ldots, T$$

$$v_t = \lambda M v_t + \varepsilon_t$$

Where M is a weight matrix that may or may not be equal to W.

APPENDIX 3.6: The Spatial Durbin Model (SDM) model

This model simultaneously involves a spatial autoregressive process of the dependent variable and the spatially shifted explanatory variables.

$$y_t = \rho W y_t + X_t \beta + W Z_t \theta + \mu + \varepsilon_t \quad t = 1\ldots, T$$

Test	P value		Result
Spatial Durbin Model (SDM) fixed effects vs. random effects	0		Fixed effects accepted
SDM and Spatial Auto Regression (SAR) model	0.0003		SDM accepted
SDM and Spatial Error Model (SEM)	0		SDM accepted
SDM and Spatial Autoregressive Confused (SAC) model	Akaike Information Criterion (AIC) SDM = -176.5		SDM accepted
	AIC SAC = -163.5		
	Bayesian information criterion (BIC) SDM = -124.6		
	BIC SAC = -131.8		
Final Conclusion: Fixed effects SDM selected			

The Spatial Durbin Model (SDM) involves spatial autocorrelation in both the independent variables and the dependent variable. According to LeSage and Pace (2009), the SDM is the only spatial model that gives acceptable results for an estimate regardless of the actual data generation process (i.e. whether it is a spatial lag or spatial error model). This is why the SDM is often considered the dominant spatial model, among others.

The interpretation of coefficients in the estimation of the SDM model differs from traditional fixed effects regression; the regression coefficient of an explanatory variable cannot be interpreted as the marginal effect of a change in the independent variable on the dependent variable (LeSage and Pace, 2009). The marginal effect of an independent variable is a function of the spatial autoregressive variable and the results should be interpreted as direct, indirect and total effects.

The direct effect is the average effect that the independent variable for country i has on the Global Peace Index (GPI) level for the same country i.

The indirect spatial spillover effect captures the diffusion effect or externalities: the social interaction between neighbouring countries. Statistically, it refers to the average effect that a change in the independent variable in neighbouring countries j, has on the GPI level of country i.

The average total effect is simply the sum of the direct and indirect effects. It measures the impact on the dependent variable in the country resulting from a change in an independent variable in the same proportions in all countries, while taking into account both the effects of country i and the effects j of neighbouring countries (LeSage and Pace, 2009). It is possible for the direct and indirect effects to be insignificant, while the total effect is significant. This occurs when the indirect and direct effects do not individually reach the accepted significance threshold (pvalue <0.05), but taken together, the influences of the country and neighbouring countries produce a significant effect on country i on the GPI level. Similarly, when the direct and indirect effects are in opposite directions, the total effect may not be significant (LeSage and Dominguez, 2012).

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