

Research Article

Effects of Natural Disasters on West Africa Sahel's Economy: The Case of Burkina Faso, Mali and Niger

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Abstract

The Sahel region is facing the adverse effects of the natural disasters due to the drought and floods which are the most frequent events. These effects can be spread and affected the all the Sahel States economy. Therefore, this study attempts to analyze the effects of these natural disasters on the macroeconomic variables such as production, consumption, investment and inflation in the three (3) the northern central Sahel States. To do so, the panel vector autoregressive model (PVAR) is run on the World Bank and the International Emergency Disasters Database (EM-DAT) data from 1990 to 2021. The results revealed that the occurrence of drought shock generates significantly a negative impact on the GDP per capita at 5% level across the northern central Sahel countries (Burkina Faso, Mali, and Niger). Also, the lagged of the macroeconomic variables such as production, investment and inflation have respectively a significant and positive impact on consumption at 5% level, production at 5% level and consumption at 10% level. Furthermore, the results show an asymmetry of natural disaster shocks at the scale of the northern central Sahel States but these shocks are symmetrical in pairs. As a result, the appropriate policies must make to absorb these shocks and avoid any hysteresis effect.

Keywords

Natural Disasters, Northern Central Sahel Region, VAR Model

1. Introduction

The Sahel region is facing a set of multifaceted crises including conflicts, terrorism and natural disasters, which have affected its economic and social development for several years. It is considered as the most sensitive areas to extreme climatic events in Africa, due to its limited adaptive capacities to the climate change. Thus, it is mostly impacted by natural disasters due to erratic rainfall, increasing the intensity and frequency of droughts and floods, which weaken the region by generating substantial macroeconomic losses. These effects can be attributed to a higher level of vulnerability due to poverty and unemployment rates, distributional inequalities,

socioeconomic exclusion of the poor from basic services, rapid population growth, and a lack of strong national and local institutions to respond to natural disasters [1]. By 2050, these effects could be particularly detrimental in the northern central Sahel countries known as Liptako Gourma, with forecast temperatures 1.5 times higher than the global average [11]. Fewer studies attempt to analyze the effects of natural disasters on macroeconomic variables in the West Africa Sahel countries. However, [9] have provided evidence about the impact of natural disasters on macroeconomic variables throughout the continent of Africa. They found that the nat-

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ural disasters cause a significant and continuous reduction of GDP many years after the event, but these effects depend on the level of capital and aspects of governance quality. Furthermore, by examining many nations from different economic zones, this study neglected the transmission of the impacts. Yet, the theory of the economic and monetary zone developed as an extension of the IS/LM model shows the possibility of transmitting of effects between partners. For countries that agree to come together in a union, they freely indulge in bequeathing part of their economic power to a common institution, thus making the adjustment variable beyond national control after the natural disasters [18]. The novelty in this study concerns the application of the PVAR model in northern central Sahel countries (Burkina Faso, Mali, and Niger) to evaluate the effects of natural disasters on the macroeconomic variables while analyzing the intensity of the shocks.

Generally, studies in this direction use the vector autoregressive modeling (VAR) to detect similarities and divergences in behavior captured using the symmetry or asymmetry of shocks affecting a member at a given time. Most of them used two or three variables, which include economic growth and inflation. In economic theory, these variables are indeed, expected to provide helpful information for the analysis of the real and nominal supply and demand shocks. In addition, they use a measurement state model to study behavior in a dynamic universe. Therefore, this study attempts to continue a typical research on the northern central Sahel countries by evaluating the effects of the natural disasters notably drought and flood on the macroeconomic variables such as investment, production, consumption and inflation.

2. Literature Review

Regarding structural VAR modeling, numerous studies have continued to be interested in the econometric literature since the 1980s. However, these studies admit that various variations depending on the space, the structure or the variables on which the analysis is focused. These researches were based on traditional economic theory in terms of cyclical variations. They argue that free trade increases the well-being of countries member, which is proven by the study of [8], according to whom rapid economic growth is linked to openness. Therefore, [22] believe that economic integration leads to strong growth. However, study from the IS/LM model, and in particular that of [20] has shown the possibility of strong transmission of fluctuations. In this context, the partisans of the real business cycle (RBC) have empirically shown the possibility of transmitting crises and certain political measures to collaborate economies. As a result, according to [13], it is expected that the countries involved in economic and commercial zone will experience the crises firsthand. For the theory of fundamental contagion, these phenomena are the result of interdependencies. [19] concludes that the propagation channel is that of unobservable aggregate shocks. These

shocks can result from changes in demand, exogenous liquidity, foreign interest rates, [...] and the effect of speculation and operator panic. Given these facts, the economic and monetary integration study emphasizes cost-benefit analysis for partners who accept the coordination of some of their policies [14]. Indeed, agreeing to belong to an economic and monetary zone implies the pooling of the foreign exchange reserves of all the countries member and thereby the abandonment of an adjustment variable to real and monetary shocks entails a cost to be weighed against the gains of monetary integration [15]. To this effect, there is an interest in assessing the intensity of shocks and their degree of influence on national macroeconomic variables. Thus, most of studies attempt to determine the similarity of demand and supply shocks between countries belonging to an economic and monetary zone. According to the theory of optimal monetary zone [18], the shocks are considered as symmetry when they affect a group of countries simultaneously and in the same proportions. In contrast, they are asymmetry when they only hit one country or a group of countries in different proportions. The analysis of the symmetry of shocks is carried out with a structural VAR model.

Indeed, structural VAR modeling comes under economic theory and expresses a process as an infinite sum of structural shocks. The case of study of [6] on GDP and unemployment is an example. They revealed that the fluctuations in real GDP and unemployment are a consequence of certain shocks having permanent effects on production. Likewise, [3] applied the same model to determine the behavior of real GDP and the price level. Thus, they identified structural shocks by imposing some restrictions on aggregate demand, prices and output. In the study of [15] on GDP, money supply, and inflation, he applied the structural VAR model and identified disparities and similarities in the propagation of shocks in the FCFA zone. From the perspective of structural VAR models, [17] studied the symmetry of shocks in Asian countries. Similarly, [10] on his study on real GDP, inflation and money supply in euro zone determines the supply and demand shocks via the structural VAR model. As an extension of these types of study, [6] explored the role of natural disasters in macroeconomic fluctuations in Central America and the Caribbean. They used the vector autoregressive model to capture the effects of exogenous disaster shocks on the economy as well as the dynamic responses of these economies. They used macroeconomic variables as endogenous and those of natural disasters as exogenous. In Africa, [18] used a vector autoregressive panel model to assess the production, remittances, temperature and annual precipitation dynamics in terms of shocks on a panel of 5 countries of Maghreb.

3. Methodology

3.1. Study Area

The northern Central Sahel of the West Africa Sahel region,

known locally as the Liptako Gourma zone, covers 370,000 square kilometers and has already led to the creation of the Liptako Gourma Authority (ALG) in December 1970 in Ouagadougou, Burkina Faso. Its creation follows the recommendations of United Nations institutions (CEA, UNDP). Its objective is to develop the mining, energy, hydraulic, agro-pastoral and fisheries potential that abound in their area. This area also shares other common realities, which are social, geographical and climatic. As a result, [4] in his study on the history of famines in the Sahel related the spread of events such as infestation, drought, floods and famines in all these States. From an economic point of view, this area is rich in minerals that the three countries have exploited, including gold, since the 1970s [16]. Additionally, the area is rich in pasture welcoming the breeders of the sub-region. Nevertheless, these countries began to suffer from terrorist attacks with the Arab Spring which have led to the fall of the Libyan regime in 2011. To overcome these phenomena, an international coalition intervened to support the “stabilization” of this zone.

3.2. Data Source and Variables

The data entering in this study come from the World Bank website (<https://data.worldbank.org/>) and the emergency and disaster database (EM-DAT: <https://public.emdat.be/>) from 1990 to 2021. The conceptualization of the study allows us to directly identify the useful macroeconomic and disaster variables for our analysis. Thus, the exogenous variables such as production measured by GDP, consumption, investment and inflation measured by the GDP deflator, and the two most frequent phenomena in these countries, namely droughts and floods are considered.

Indeed, to define the different variables, we assume a priori that each country in the northern central Sahel area undergoes the shocks of a different nature at each time t (supply shocks, real and nominal demand) due to various reasons including among others natural disasters. Based on the IS/LM model which jointly includes all economic dimensions in its approach and its extensions, we also assume (*ceteris paribus*) that:

1. Supply shocks have a permanent effect on economic growth and a transitory effect on real and nominal demand shocks;
2. Real and nominal demand shocks are offset by the proportional change in long-term prices;
3. There is no compensation for the effects of real demand shocks through foreign trade;
4. Natural disasters are variables exogenous to the system but with shocks on macroeconomic variables. However, this can be controversial given the externalities caused by economic activities [6];
5. Natural disasters are climatic phenomena that have no spatial boundaries. In other words, we assume that the processes generating disasters are the same for the three countries, given their geographical proximity and their

economic and social similarity.

The nature of the data considered in this study, particularly for the disasters, and the characteristics of the economies require considering only the year of occurrence of one of the events. Indeed, these countries are characterized by a lack of statistics in terms of economic and financial damage. In addition, the economic cost is the only common point in terms of the impacts of natural disasters. However, the floods do not inflict the same damage as droughts and both do not have the same effects as locust infestations, zoonoses or sandstorms. Thus, it would be risky to take the number of deaths or injuries in a study including these types of events because this will undoubtedly lead to particularly underestimating the invasion of locusts and by extension droughts. In addition, considering the public or private infrastructure destroyed would only represent flooding, putting aside other types of events would be underestimated. Likewise, taking the number of people affected for all these events, undoubtedly the invasion of locusts or epizootics would be poorly appreciated. Indeed, the events do not have the same magnitude and even less the units of measurement. To overcome these difficulties, apart from economic evaluations and financial, the alternative would be to consider the occurrence of these events as a dichotomous variable taking the value one (1) if the event occurs regardless of the number of times in the year in one of the countries and the value zero (0) otherwise. This conceptualization also suffers from certain shortcomings particularly in terms of quantified impacts on the economic variables and the life of populations, which are undoubtedly not the same depending on the type of event, and do not always have a national scale (generally located in space). Therefore, we consider the number of affected people of these phenomena in our analysis.

3.3. Analysis Model

After contextualization, the model is described as follows:

$$x_{i,t} = x_0 + \sum_{k=1}^n A_k x_{i,t-k} + \sum_{k=0}^n B_k d_{i,t-k} + e_{i,t} \quad (1)$$

$i = 1, \dots, N$, countries et $t = 1, \dots, T$, time

$x_{i,t} = (production_{i,t} \ consumption_{i,t} \ investment_{i,t} \ inflation_{i,t})$

is the vector of dependent variables with mx_1 dimensions,

$d_{i,t} = (drought_{i,t} \ flood_{i,t})$ is the vector of the exogenous variables with lx_1 , A_k is the matrix of dependent variables with kxm dimensions. B_k is the matrix of the exogenous variables with $kx1$ dimensions, and $e_{i,t} = \mu_i + \varepsilon_{i,t}$ is the vector of the errors including the unobservable individual fixed effects and error term.

The specification verifies the usual conditions of the nullity of mean and the constancy of the variance of errors.

Given the hypothesis on the uniformity of the processes generating disasters for all countries, parameters A and B are

therefore common and can be together estimated by a fixed effects VAR or alternatively by OLS. In their analysis, [5] highlighted that the presence of lagged dependent variables creates a risk of bias when N is large. However, this risk of bias decreases when T is simultaneously high. To this effect, the generalized method of moments (GMM) were proposed to produce consistent estimates even though some transformations proposed in empirical studies pose some difficulties, especially for unbalanced panels or missing data. This missing data can be replaced by the value zero. Also, the transformation by orthogonal deviation that gives results has been proposed by [2]. By this transformation, the average of all observations is subtracted minimizing thus the loss of data. As an illustration, the compact writing of equation (E3.1) gives the equation below, the asterisk of which denotes a transformation to be carried out, which can be logarithmic, first difference (FD), forward orthogonal deviation (FOD) etc.

$$X_{it}^* = \tilde{X}_{it}^* A + e_{it}^* \quad (2)$$

$$\begin{aligned} X_{it}^* &= \begin{bmatrix} x_{it}^{1*} & x_{it}^{2*} & \dots & x_{it}^{k-1*} & x_{it}^{k*} \end{bmatrix} \\ \tilde{X}_{it}^* &= \begin{bmatrix} x_{it-1}^* & x_{it-2}^* & \dots & x_{it-p+1}^* & x_{it-p}^* & d_{it}^* \end{bmatrix} \\ e_{it}^* &= \begin{bmatrix} e_{it}^{1*} & e_{it}^{2*} & \dots & e_{it}^{k-1*} & e_{it}^{k*} \end{bmatrix} \\ A' &= \begin{bmatrix} A_1' & A_2' & \dots & A_{p-1}' & A_p' & B' \end{bmatrix} \end{aligned}$$

For the variable $m_{i,t}$ the transformation is the forward orthogonal deviation (FOD) is given by:

$$m_{i,t}^* = (m_{i,t} - \bar{m}_{i,t}) \sqrt{T_{i,t} / (T_{i,t} + 1)} \quad (3)$$

$T_{i,t}$ is the number of the available future observations for the panel (i) at the time (t), and $\bar{m}_{i,t}$ is the mean of all available future observations. Indeed, the estimator of generalized method of moments (GMM) for a group of observations through the panel is given by:

$$A = (Y'^* Z W Z' Y^*)^{-1} (Y'^* Z W Z' Y^*) \quad (4)$$

W is the matrix assumed to be no single, symmetric and positive semi definitive, $L \geq kp + l$, the common parameters given by the vector $Z_{i,t}$. Also, we assimilate the variance between the vector $Z_{i,t}$ and errors null, and that of transformed variable and the vector of the parameters equal to $kp + l$.

For the following, the transformation by standardization consisting of a double transformation of centering by the mean and reduction by the standard deviation is applied. Thus, the variables become clear from the erratic variations and follow a normal distribution. The interpretation of the standardized values is done related to the benchmark constituted by the normal distribution law (Gauss curve). In addition, the

interpretation of the coefficients resulting from the regression is easier than that of regressions with other types of transformation. Indeed, in the standardized regression, an increase in the unit of the variable is equal to its standard deviation. When a variable differs from its mean by one standard deviation, it is in some way the typical deviation according to the Statistique Canada¹. Again, in this interpretation, the independent variables having the highest coefficients are those having the most impact on the variable of interest.

For the interpretation of causalities, Wold's theorem admits that for a VAR a representation in the form of a moving average (VMA) and the exogenous variables have a stable co-variation with the errors. Indeed, the function of interest only depends on exogenous variables through their effects on the coefficients of A . As a result, the equation can be simplified by omitting these variables without going toward to the generality. However, note that the A are jointly estimated with B , which is the matrix of coefficients of the exogenous variables. The causal interpretation of the IRFs and FEVDs functions requires strict heterogeneity of the exogenous variables. The equation without the exogenous variables of a VAR is:

$$x_{i,t} = x_0 + A_1 x_{i,t-1} + \dots + A_p x_{i,t-p} + e_{i,t} \quad (5)$$

In the form of moving averages (VMA), the writing is given by:

$$x_{i,t} = \mu + \sum_{i=0}^{\infty} \Phi_i e_{i,t-i} \quad (6)$$

$$\text{or } \Phi_i = \begin{cases} I & \text{si } i = 0 \\ \sum_{j=1}^i \Phi_{i-j} A_j & \text{si } i = 1, 2, \dots \end{cases}$$

For stable VARs with exogenous variables, the equation is as follows:

$$x_t = \sum_{i=0}^{\infty} D_i d_{i,t-i} + \sum_{i=0}^{\infty} \Phi_i e_{i,t-i} \quad (7)$$

$$x_t = x_0 + A_1 x_{t-1} + \dots + A_p x_{t-p} + B_0 d_t + B_1 d_{t-1} + \dots + B_q d_{t-q} + e_t \quad (8)$$

D_i is the dynamic multiplier functions called also transfer functions because they specify the way the change in the exogenous variables is transferred into the endogenous variables.

$$D_i = J_d A_d B_d \quad i \in \{0, 1, \dots\} \quad (9)$$

$J(k, p, q)$ is the over identification Restriction Statistics between the k panel variant for order p and moment conditions based on the q lags of the endogenous variables of the sampling.

¹ <https://www150.statcan.gc.ca/n1/edu/power-pouvoir/ch12/5214891-fra.htm>

Equation (E3.9) under conditions of VAR stability allows us to express the estimated covariance variance matrix: $B(d_i d_i')B' = AE(e_i e_i')A' = \Sigma$. Given the hypotheses of identity and triangularization, we can therefore write: $\Sigma = AA'$.

This equation equality facilitates the identification of the components of A. The matrix of variance-covariance being symmetrical and with $n(n+1)/2$ orthogonal constraints, it remains to determine $n(n-1)/2$. However, the appropriate identification procedure is that carried out by [5]. Based on economic theory and the supposed relationships between the variables in the long term, the constraints to be imposed are determined. This aspect encounters a limitation, which does not allow the elements of A to be constrained in place of those of B and vice versa. In addition, we cannot mix short-term and long-term constraints. Therefore; it is necessary to separate the constraints for each parameter A and B. To overcome these difficulties, [6] suggested the use of the generalized impulse response function (IRFs) obtained from the moving average form of the VAR, which does not take into account the order of identification of the variables in the system. Alternatively, the transfer function (FEVDs) in a VAR model with exogenous variables may be used. However, before analyzing the functions of IRFs, FEVDs, the different correlations that could exist between countries are detected according to the economic variables and natural hazards variables.

4. Results and Discussion

The results of the country-to-country correlations demonstrate that, whether or not droughts occur, there is a significant relationship between the GDPs of the three (3) northern central Sahel countries. This connection is more consistent between Burkina Faso and Mali, but is weaker between Niger and Mali. The relationship between GDP/capita is more important when there is a simultaneous occurrence of this event at the area level. Finally, a divergent relationship appears between the GDP/capita of Niger and that of the two other countries when there is only a drought in Mali. When the flooding occurs in the three (3) northern central Sahel countries, the correlation is greater between the GDP/capita of Niger and Burkina Faso but always lower between the GDP/capita of Mali and Niger. However, in the absence of floods in all countries, we observe a negative relationship between the GDP/capita of Niger and that of two other countries. This negative relationship becomes clearer with consumption per capita but it remains less compared to that of GDP/capita. When there is flooding simultaneously in each country, the relationships between consumption levels are positive. In terms of investment whatever the event, the relations are positively more important between Niger and Mali. The consistency of this relationship decreases between the countries when these events do not occur in the three countries.

Furthermore, the strong correlations among nations are

emphasized based on the macroeconomic factors and natural calamities. Indeed, in terms of per capita production levels with or without occurrences of droughts and floods, Burkina Faso has a more consistent relationship with Mali than with Niger. Moreover, in the absence of floods, there is a divergence between the per capita consumption levels of Niger and that of the two other countries. In terms of per capita investment levels, the strong relationship is detected between Niger and Mali in the presence of floods but which becomes more significant between Niger and Burkina Faso in the event of a simultaneous occurrence of drought in the three countries. Within each country, economic and disaster variables exhibit behaviors that deserve to be explained. In Burkina Faso, droughts are negatively correlated with the level of production per capita, the level of consumption per capita, the level of investment per capita and the occurrence of floods. Thus, in Burkina Faso, only droughts have a positive relationship with inflation. In other words, the occurrence of droughts over the course of a year leads to a decline in the other economic variables such as the level of production per capita, the level of consumption per capita, the level of investment per capita but it causes an increase in prices. As for floods, they are positively correlated with all economic variables in this country, but negatively with droughts. Thus, we deduce that floods in Burkina Faso are synonymous with economic performance. In Mali, the droughts and floods are all positively related to each other. They also have positive correlation with other economic variables except inflation. Unlike Burkina Faso, natural disasters cause the decline in prices in Mali but they boost other economic variables. In Niger, droughts are positively correlated with economic variables but their relationship with floods is negative. When droughts occur, as opposed to floods, more economic factors are involved. Thus, the floods are positively correlated with the level of production and that of investments, but they are negatively correlated with the level of consumption, inflation and droughts.

Overall, the negative relationships between floods and droughts in Burkina Faso and Niger could be explained by the climatic characteristics of these phenomena. Indeed, looking carefully the oceanic disturbances of El Nino and La Nina, pluvial floods and droughts must particularly diverge. As a result, dry years cannot be wet and the occurrence of one phenomenon excludes that of the other. Thus, the positive relationships observed in Mali may be due to the types of floods, which could be more frequent i.e., they can be fluvial (floods) or rises in the groundwater unrelated directly with rainfall disturbances. Additionally, the relationships found between economic variables and those of disasters may be questionable because droughts and floods were not considered in terms of economics impacts but rather as number affected people. Anyway, these results corroborate with the conclusions of practitioners regarding the possible relationships between economic variables and disasters. In addition, the increase in investments for reconstruction and prevention actions can be understood in terms of the costs to prevent the

future occurrence of floods. Likewise, following one of the disasters, the increase in the level of consumption can be explained by the aid provided by the State and its partners to relieve the populations. Furthermore, since the three (3) northern central Sahel countries depend on cattle and agriculture, years that are wet or dry can be interpreted as periods of prosperity or scarcity, respectively. Consequently, the droughts being slow-onset disasters, their indicators alert the authorities who adapt by building up stocks of food, which they resell at a moderate price in order to reduce the shock or call on international aid to curb the situation.

The estimation's findings shown in the table below are consistent with the findings of previous studies on the relationship between economic variables and disasters. Therefore, in contrast to floods, droughts have a negative and severe impact on production at a level of 5%. Drought does, in fact, cause a negative impact on GDP/capita in the three (3) northern central Sahel zone by at least 4.83%. This result is in line with the neoclassical growth model predicts that disasters lower GDP per capita on impact by destroying the capital stock. Empirically, this result is similar to the those obtained by [7] the disaster-prone developing countries. For the case of Africa, [9] found the same effect of the natural disasters on the GDP many year after the event. Likewise, [12] revealed that, in the poor countries a minimum of 0.45 percentage points of growth damage is associated with the worst 5% disaster years. Specifically, in Malawi, [21] found that on average every year 1.7 percent of its gross domestic product is lost due to the combined effects of droughts and floods. Indeed, with the climate change, the Sahel countries are recording sporadic

rains with great intensity in record time. Moreover, there is the low infiltration with its corollaries of destruction of crops in rural areas and that of homes in urban areas. At the same time, Sahelian urban centers are unprepared to welcome a new form of migration (called internally displaced persons) created by the security situations and disasters, forcing people to take generally refuge in urban centers without any insurance.

Additionally, the coefficients of the lagged economic variables notably production, investment, and inflation are statistically significant at respectively 5%, 5%, and 10% levels for the current consumption and production. Indeed, the lagged of production affect positively the current production and the current consumption. This finding is consistent with Friedman's theory of permanent income, which holds that consumption today depends on production today and also lags behind production that was previously projected. In addition, the findings show that the lagged of investment increases significantly the current production and the current investment. This is consistent with Karl Marx's classical economic theory, which states that the excess value from delayed investments will be reinvested for growing capital. However, the lagged inflation acts positively on contemporary consumption at significance of 10%. This result contradicts the economic theory because inflation discourages consumption at the household level and producers anticipate falling prices and decide not to invest. Nevertheless, the households expect that this inflation can continue to increase in the future; they increase their demand for goods and services to prepare/anticipate.

Table 1. Results of PVAR model's estimation.

VARIABLES	PVAR model			
	production	consumption	Investment	Inflation
L. production	0.935*** (0.0803)	0.220** (0.105)	0.123 (0.101)	-4.195 (2.786)
L. consumption	-0.0262 (0.0512)	0.774*** (0.0774)	-0.0711 (0.0709)	1.576 (1.805)
L. investment	0.135** (0.0575)	0.0678 (0.0806)	0.931*** (0.115)	1.164 (1.235)
L. inflation	-0.00171 (0.00378)	0.00874* (0.00489)	-0.00199 (0.00870)	0.0206 (0.102)
Drought	-0.0483** (0.0205)	-0.0138 (0.0202)	-0.00299 (0.0422)	0.541 (0.410)
Floods	0.0325 (0.0201)	-0.0120 (0.0245)	0.0376 (0.0276)	0.463 (0.289)

VARIABLES	PVAR model			
	production	consumption	Investment	Inflation
Observations	90	90	90	90

Standard errors in parentheses and p-value: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The study of impulse responses shows that at the area level, an investment shock generates a lasting increase in the level of consumption per capita as well as that of production per capita. It causes an increase in inflation in the first period but declines thereafter. A shock to consumption leads to a decline in all the economic variables in the model except inflation that increases first, then declines slowly and only fades after several periods. An inflation shock has no significant effect on any variable in the model, thus relating the expectations of the economic agents of the area to the policy of the Central Bank of the West African states to which they belong. A shock to the level of production per capita generates an exponential increase in consumption and investment. This shock leads to a drop in inflation for the first period that increases thereafter, remaining below the target value until the tenth period. The estimated model presents values inside the unit circle as shown in the figure above, thus ensuring its stability condition. The stability of a PVAR model does not a sine qua condition to guarantee better forecasts.

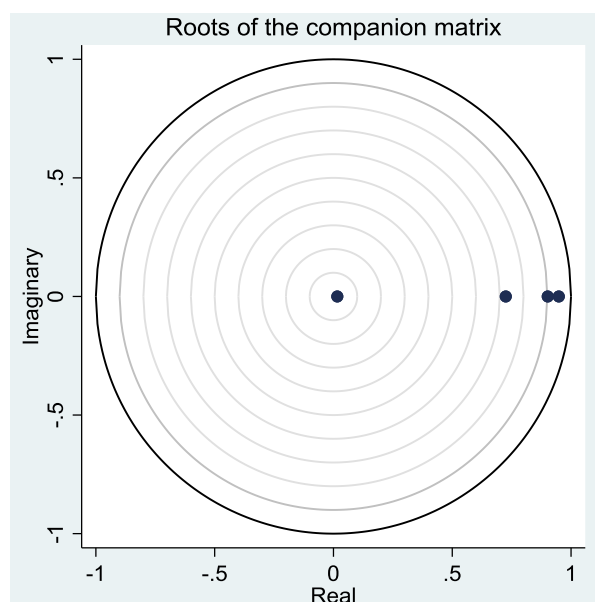


Figure 1. Model stability.

The analysis of the variance decomposition shows that the level of production is explained by its own values for the first 5 periods at more than 86%. From the 6th period, investments come into play at more than 15%. The variance in consumption per capita is explained by more than 40% by production per capita, from the 5th period. The level of production per capita occupies a part that is on average 15% in the composition of the variance of investment per capita. Finally, production per capita explains less than 5% of the variance in inflation even at the 10th period.

Regarding the natural disaster shocks, the analysis is done using the transfer function. The transfer function is a powerful innovation for capturing and analyzing the reactions of endogenous variables given the behaviors of exogenous ones, we seek to verify the effects of floods and droughts on macroeconomic variables in the three (3) northern central Sahel States. As shown in [Figure 2](#) below, dynamic reactions vary depending on the macroeconomic magnitude and the disaster that exogenously affect the economy. The dynamic multiplier analysis is more informative than the orthogonalized one, because the first studies the behavior of endogenous variables following a shock to exogenous variables while the second analyzes the reactions of variables following a shock to another endogenous variable, which does not exclude possible errors on fallacious behavior. In order to better capture the reactions of macroeconomic variables following disasters, we favored the dynamic duplicator. Thus, the dynamic behavior of the level of production per capita and that of investments are almost similar following a flood shock and this for all the periods considered. Following large-scale floods, these variables will experience a slight shrinkage at the beginning of the periods but the variation intervals widen over time. For the same shock, per capita consumption is exponential and becomes elusive over time. The flood shock lowers inflation in the first period and keeps its variations within a small range over the other periods. The level of production, the level of investment and that of consumption have similar dynamic behaviors following a drought shock but with different variation intervals. Inflation shows the same behavior following droughts as after floods, which confirms its maintenance at a stable level within the framework of the convergence criteria by the BCEAO.

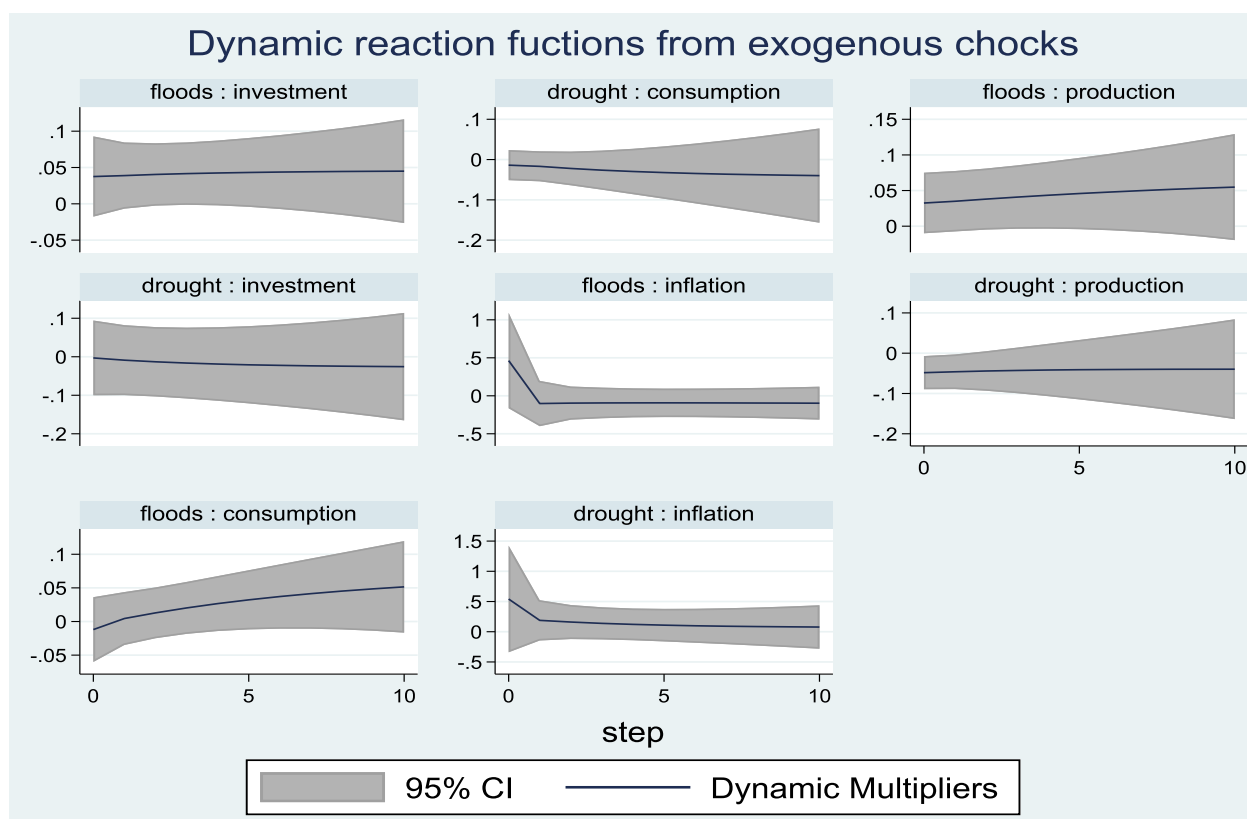


Figure 2. Transfer functions.

5. Conclusion and Policy Implications

The natural disasters are affecting the three (3) northern central Sahel countries. These effects with their corollaries on agriculture and food security intertwine with the consequences of crime and banditry exacerbating the situation of the rural population, which is already weakened by permanent poverty. This study applied a vector autoregressive model (VAR) to estimate the effects of the severe natural disasters notably floods and droughts on the key economic variables. The results revealed that the occurrence of droughts in the northern central Sahel area generates significantly a negative deviation of 4.83% for GDP/capita at 10% level. This situation could be explained by the fact that the drought shocks compared to supply shocks have permanent effects on the economy. Furthermore, the lagged of the macroeconomic variables such as production, investment and inflation have respectively a significant and positive impact on consumption at 5% level, production at 5% level and consumption at 10% level. Our results show also an asymmetry of natural disaster shocks at the scale of the three (3) northern central Sahel States, but these shocks are symmetrical in pairs. As a result, the appropriate policies must make to absorb these shocks and avoid any hysteresis effect. Indeed, floods and droughts have different weights and effects according to the countries and the economic variables. Thus, policies must be designed to

curb their effects. Given that the three (3) northern central Sahel countries are dependent on agriculture and livestock, predictions of dry or wet years can be seen as a famine or prosperous years, respectively. In this sense, early warning systems, forecasts and information sharing must be strengthened at the area level.

Abbreviations

PVAR	Panel Vector Autoregressive
IRF	Impulse Response Function
FEVD	Forecast Error Variance Decomposition
EM-DAT	Emergency and Disaster Database
GDP	Gross Domestic Product
BCEAO	Central Bank of the West African States

Author Contributions

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Authors Statement

1. We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere;
2. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed;

3. We further confirm that the order of authors listed in the manuscript has been approved by all of us;
4. We understand that the Corresponding Author is the sole contact for the Editorial process. He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Impulse response

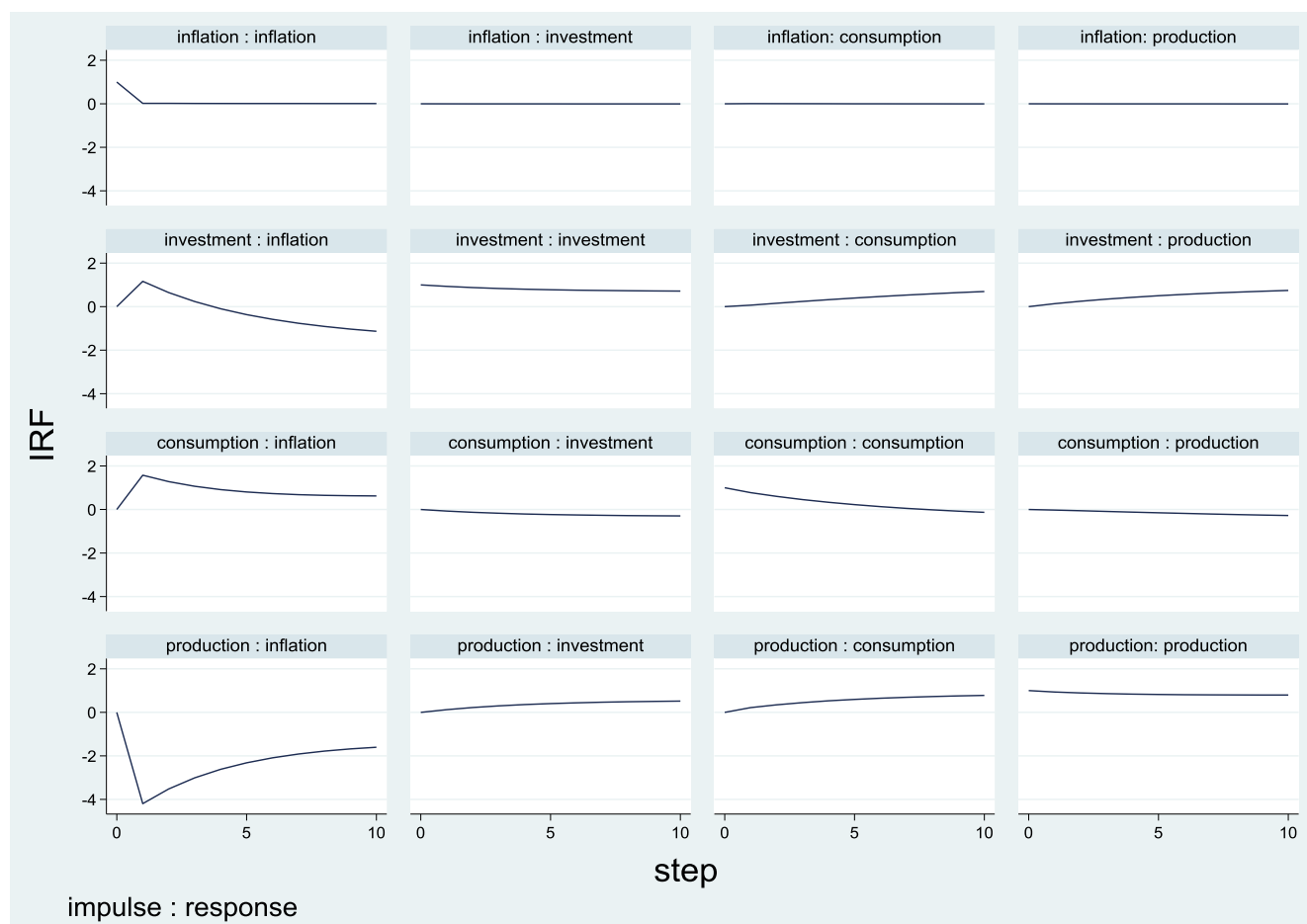


Figure 3. Impulse response function.

Correlation matrix between the variables

	Production	Inflation	Consumption	Investment
Production	1.0000			
Inflation	-0.1692	1.0000		
Consumption	0.6509	-0.1181	1.0000	
Investissement	0.8566	-0.1605	0.5493	1.0000

References

- [1] AGRHYMET Regional Centre A capacity assessment. (2022).
- [2] Arellano, M., & Bover, O. (1995). *Another look at the instrumental variable estimation of error-components models*. 68(August 1990), 29–51.
- [3] Bayoumi, T., & Eichengreen, B. (1993). Shocking Aspects of European Monetary Union. *Adjustment and Growth in the European Monetary Union*, 3949, 193–229.
- [4] Blanchard and Quah, (1989) THE DYNAMIC EFFECTS OF AGGREGATE DEMAND AND SUPPLY DISTURBANCES, NBER Working Paper, Cambridge, MA 02139.
- [5] Bernus, E. (1994). Boure ña Alpha Gado. Une histoire des famines au Sahel: Étude des grandes crises alimentaires (fixe-xxe siècle). *Journal Des Africanistes*, 64(1), 109–110. https://www.persee.fr/doc/jafr_0399-0346_1994_num_64_1_2398_t1_0109_0000_1
- [6] Borda, P., & Wright, A. (2017). Macroeconomic Fluctuations Under Natural Disaster Shocks in Central America and the Caribbean. *SSRN Electronic Journal*, December. <https://doi.org/10.2139/ssrn.2761034>
- [7] Cantelmo, A., Melina, G., & Papageorgiou, C. (2023). Macroeconomic outcomes in disaster-prone countries. *Journal of Development Economics*, 161, 1–30. <https://doi.org/10.1016/j.jdeveco.2022.103037>
- [8] Cooper, R. N., & Maddison, A. (2001). The World Economy: A Millennial Perspective. *Foreign Affairs*, 80(6), 176. <https://doi.org/10.2307/20050348>
- [9] Diop, S., Asongu, S., & S. Tchamyou, V. (2021). Mitigating the Macroeconomic Impact of Severe Natural Disasters in Africa: Policy Synergies. *SSRN Electronic Journal*, 111840. <https://doi.org/10.2139/ssrn.3991506>
- [10] Est, U. P. (2009). *Sym érie des chocs d ' offre et de demande dans la Zone Euro : une analyse par les mod ès SVAR*. 1–39.
- [11] Faso, B., & Ackern, P. Van. (2022). *vuln érabilit éet s écurit éau Sahel*.
- [12] Felbermayr, G., & Gröschl, J. (2014). Naturally negative: The growth effects of natural disasters. *Journal of Development Economics*, 111(4439), 92–106. <https://doi.org/10.1016/j.jdeveco.2014.07.004>
- [13] Forbes, K. J., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market comovements. *Journal of Finance*, 57(5), 2223–2261. <https://doi.org/10.1111/0022-1082.00494>
- [14] Fornaro, L. (2022). A Theory of Monetary Union and Financial Integration. *Review of Economic Studies*, 89(4), 1911–1947. <https://doi.org/10.1093/restud/rdab057>
- [15] Goma, J. B. N. (2000). *CAHIER 13-2000 ANALYSE DES CHOCS D' OFFRE ET DE DEMANDE DANS LA ZONE CFA : UNE MÉTHODE STRUCTURELLE D' AUTORÉGRESSION VECTORIELLE Jean-Michel BOSCO N' GOMA CAHIER 13-2000 ANALYSE DES CHOCS D' OFFRE ET DE DEMANDE DANS LA ZONE CFA: UNE MÉTHODE STRUCTUR*.
- [16] Gourma, A. de L. (2024). *Presentation of Liptako Gourma*.
- [17] Guillaumin, C. (2008). (A)sym érie et convergence des chocs macroéconomiques en asie de l'est: Une analyse dynamique. *Economie Internationale*, 114(2), 29–68. <https://doi.org/10.3917/ecoi.114.0029>
- [18] Habib, H. (2022). Climate change, macroeconomic sensitivity and the response of remittances to the North African countries: a panel VAR analyse. *International Journal of Sustainable Development & World Ecology*, 29, 401 - 414.
- [19] Masson, P. R. (1999). Contagion: macroeconomic models with multiple equilibria. *Journal of International Money and Finance*, 18, 587–602.
- [20] Mundell, R. A. (1961). American Economic Association A Theory of Optimum Currency Areas. *Source: The American Economic Review*, 51(4), 657–665.
- [21] Pauw, K., Thurlow, J., & van Seventer, D. (2010). *Drought and Floods in Malawi: Assessing the Economywide Effects*, IFPRI Discussion Paper 00962. 03/09/2010. <http://www.ifpri.org/publication/droughts-and-floods-malawi>
- [22] Sachs, J. D., Warner, A., Aslund, A., & Fischer, S. (1995). Economic Reform and the Process of Global Integration. *Brookings Papers on Economic Activity*, 1995(1), 1. <https://doi.org/10.2307/2534573>

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