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ORIGINAL ARTICLE

Climate Change, Cotton Prices and Production in Cameroon

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Abstract
This study aims to examine the impact of (i) climate change and international market price volatility on cotton production in Cameroon, (ii) climate change and international market price volatility on the prices of cotton farmers, (iii) the purchase price of cotton farmers on cotton production, (iv) cotton production on the purchase price of cotton farmers. The statistics used mainly come from the SODECOTON database, the World Bank Group Climate Change Knowledge Portal and Trading Economics. Econometric estimates made using a VAR model reveal that (i) the purchase price of seed cotton tends to significantly boost production, (ii) production does not significantly influence the purchase price of seed cotton, and (iii) the increase in the world price of cotton and significant variations in temperature are conducive to a revaluation of the purchase price of seed cotton. To improve cotton production, it would be advisable, in particular, to (i) make the purchase price of seed cotton more attractive to cotton growers and (ii) adopt effective adaptation or mitigation techniques against variations in rainfall.

Keywords Climate change · Prices · Production · Cotton

Résumé
Cette étude vise à examiner l'incidence (i) du changement climatique et de la volatilité des prix du marché international sur la production cotonnière au Cameroun, (ii) du changement climatique et de la volatilité des prix du marché international sur le prix aux cotonculteurs, (iii) du prix d'achat aux cotonculteurs sur la production cotonnière, (iv) de la production cotonnière sur le prix d'achat aux cotonculteurs.

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Les statistiques utilisées proviennent essentiellement de la base de données de la SODECOTON, la World Bank Group Climate Change Knowledge Portal et la Trading Economics. Les estimations économétriques effectuées à l'aide d'un modèle VAR révèlent que (i) le prix d'achat du coton graine tend à booster significativement la production, (ii) la production n'influence pas significativement le prix d'achat du coton graine et (iii) l'augmentation du cours mondial du coton et les variations importantes des températures sont propices à une revalorisation du prix d'achat du coton graine. Pour améliorer la production du coton, il serait judicieux notamment (i) de rendre incitatifs les prix d'achat du coton graine aux cotonculteurs et (ii) d'adopter des techniques d'adaptation ou d'atténuation efficaces contre les variations de la pluviométrie

JEL Classification F18 · O13 · O55 · Q11 · Q17

Introduction

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as any change in climate over time caused either by natural variability or human activities (Parry et al. 2007). Climate change is manifested by, among other things, (i) a rise in average temperature, (ii) a rise in sea level and salinization of ecosystems, (iii) an increase in the frequency and intensity of extreme events (floods, droughts, cyclones, etc.). These climatic variations have an impact on agricultural development, livestock, fisheries, human health, food security, migration and poverty.

According to forecasts of Muller et al. (2009), developing countries, particularly Cameroon, will be more exposed and less resistant to climate risks. The agricultural sector, which occupies a prominent place in the economies of these countries, is sensitive to climate variations. In the literature, the effects of climate change on agriculture vary according to crops, regions and the adaptation measures implemented (Fig. 1).

Based on Fig. 2 below, the sinusoidal trend in temperature and rainfall between 1985 and 2015 in Cameroon shows about 10 peaks. The highest temperatures and rainfall were recorded in 1998 and 2007 respectively. The lowest temperatures and rainfall were observed in 1992 and 2015 respectively.

Cotton production underwent variations during the period 1985–2015 marked by phases of growth and contraction. Between 1985 and 1994, its average annual growth rate was 2.8%. Between 1995 and 2004, this rate was 4.29%. On the other hand, it shows a negative value (−0.3%) between 2005 and 2015. The quantity produced in 2011 is significantly half to that of 2005, which is the most prolific season (Fig. 3).

Although it followed an upward trend during the period under review, the evolution of the price at which seed-cotton was purchased from farmers was often unstable. The average annual growth rate of this indicator showed a negative

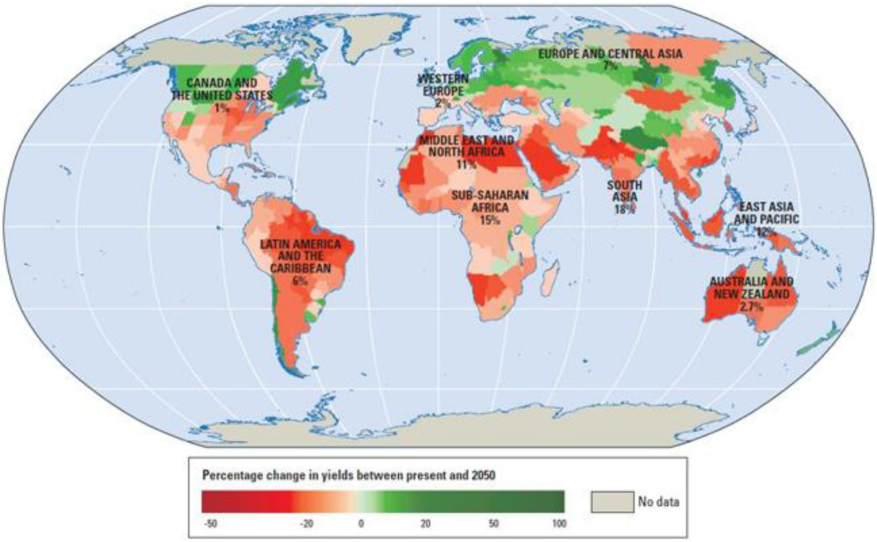

Fig. 1 Effect of climate change on countries' agricultural yields in 2050, if current agricultural practices and crop varieties continue to be used. *Source* Muller et al. (2009)

value between 1985 and 1994 (−0.11%). In contrast, it was 2.02% and 3.42% respectively during the periods 1995–2004 and 2005–2015 (Fig. 4).

Most studies in the literature have examined the effect of climate change on the production or yield of cereals or livestock products. Very few have examined the impact of climate change on seed cotton production or yield (Butt et al. 2005; Paeth et al. 2008) and their results are not identical. With an estimated 4.5% representativeness in the overall value of exports, cotton is the 4th most exported product by Cameroon after petroleum products, cocoa and wood in 2016 (Cameroon Ministry of Trade 2017). The same ranking is observed when cumulating exports over the period 2012–2016. In addition, cotton cultivation is one of the main sources of income for farmers in the 3 northern regions (Far North, North and Adamawa), which have exclusive rights to cotton production in Cameroon (Mpabe et al. 2017). The poverty rate in Cameroon is 37.5% and the regions that harbor the majority of the poor are the Far North (35.8%), the North (20.1%) and the North West (13.2%).

In the literature, research works often relied on climate models that do not require the use of time series. None of these studies have examined (i) the effects of climate change on the prices of cotton, (ii) the interactions between cotton production and the purchase price of seed cotton from farmers, and (iii) the impact of the international price of cotton on cotton production and the purchase price of seed cotton. This study goes beyond all these limitations.

It is in light of the above that the following questions have been raised: (i) what are the interactions between seed cotton production and its purchase price from farmers and (ii) what are the effects of climate change on cotton production and the purchase price of seed cotton from cotton farmers in Cameroon.

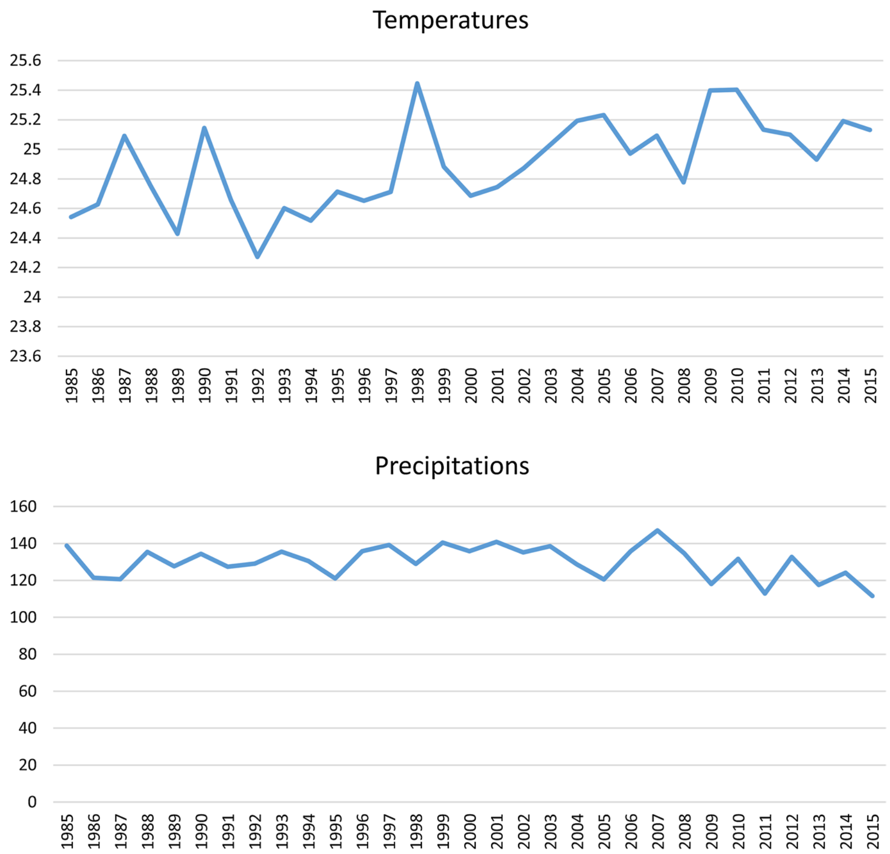

Fig. 2 Annual change in temperature and rainfall in Cameroon between 1985 and 2015. *Source* Author, using data from the World Bank Group Climate Change Knowledge Portal (2017)

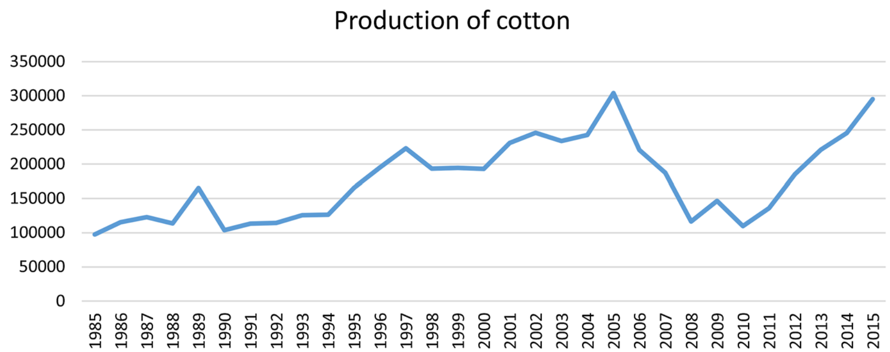

Fig. 3 Evolution of cotton production in Cameroon between 1985 and 2015 (in tons). *Source* Author based on SODECOTON data (SODECOTON: Cotton Development Company)

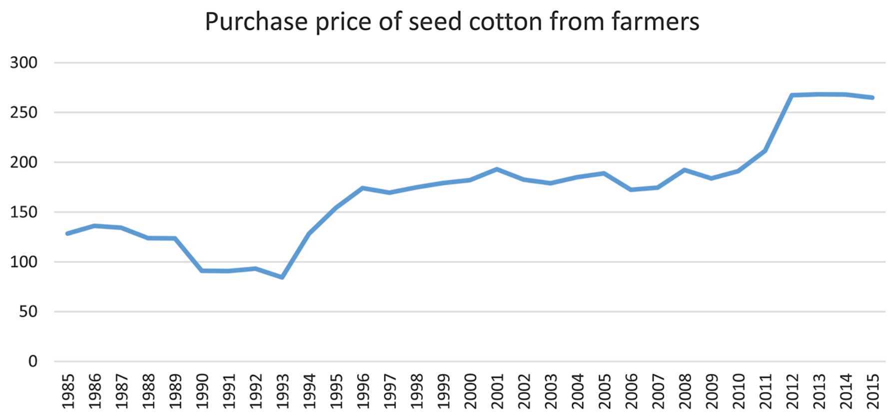

Fig. 4 Evolution of the purchase price of seed cotton from farmers in Cameroon between 1985 and 2015. *Source* Author based on SODECOTON data

The rest of the article is organized as follows: "Literature review" section outlines a synthetic review of the state of art, "Methodology of the study" section outlines the methodological strategy and "Results of the study" section analyzes the statistical and econometric results.

Literature Review

The Determinants of the Prices of Agricultural Products

Domestic Agricultural Production

A distinction is made between neoclassical market prices and heterodox market prices (Dallery et al. 2009). Neoclassical market prices result from the confrontation between supply and demand and are imposed on entrepreneurs. Ricardian price theory teaches that a reduction in supply leads to an increase in the market price above the natural price if demand remains stable. Heterodox market prices are set by the entrepreneur based on (i) the business project, (ii) aggregate consumer satisfaction, and (iii) cost constraints. Thus, we agree with Barrere (2002) that prices can no longer be defined solely as modes of adjustment of economic quantities such as (i) supply and demand and (ii) production and consumption.

In the literature, many studies confirm the predictions of King's Law. This law can be verified in certain circumstances that prevent regulation by foreign trade (wars, insecurity, rapidly perishable nature of the product…) or because of the slowness of certain adjustments. Thus, when the price of a product increases, signaling insufficient supply, many producers will be encouraged to increase production.

World prices for wheat, coarse grains, rice and oilseeds almost doubled between the 2005 and 2007 marketing years (OECD 2008). This increase, which is mainly due to the production deficit, also corroborates King's Law. While the increased production of cassava, milk, fish, and meat has resulted in a contraction of world market prices, the decline in the supply of cereals, oilseeds, oils, oil meals and oil cakes has not been accompanied by an increase in prices (FAO 2017).

Transmission of International Market Prices

The relationship between producer prices and international prices has rarely been the subject of empirical analysis (Subervie 2007). One would expect that in a context marked by trade liberalization, international prices would strongly influence producer purchase prices. However, the empirical results are not unanimous. Mundlak and Larson (1992) find that (i) a significant proportion of international price variations are transmitted to producer prices and (ii) variations in producer prices are essentially due to those in international prices.

Subervie (2007) examined the transmission from international market prices to producer prices in 48 countries and for 10 agricultural products including cotton. It finds that the increase in international prices is significantly favorable to the increase in domestic producer's prices (i) in the majority of countries and (ii) for all 10 agricultural products. This panel data analysis of the transmission of international prices to producer prices led to elasticities that are significantly lower than those estimated by Mundlak and Larson (1992).

On the other hand, Hazell et al. (1990) show that the variation of producer prices is not essentially due to that of international prices. Using the cointegration tests, Baffes and Gardner (2003) do not systematically find a cointegrating relationship between the producer price and the price in the international market.

Climate

Adams et al. (1998) show that an increase in temperature of 5 °C, combined with an invariant rainfall and a CO_2 level equal to 530 ppm, leads to a 15% increase in the price of agricultural products in the USA. On the other hand, for the same level of CO_2, these authors find that a 2.5 °C increase in temperature, coupled with a 7% increase in rainfall induces a 19% price contraction. Using the GISS and UKMO climate models, Darwin et al. (1995) demonstrate that climate change causes a slowdown in cereal prices at the global level.

The study by Nelson et al. (2009) reveals that without climate change, world prices are expected to increase over the period 2000–2050 for the main agricultural crops (rice, wheat, maize and soybean) as a result of population growth and increased demand for biofuels. Even without climate change, the price of rice would increase by 62%, corn by 63%, soybeans by 72% and wheat by 39%. Climate change is expected to induce additional price increases: rice by 32–37%, corn by 52–55%, wheat by 94–111% and soybeans by 11–14%. Greater farm efficiency thanks to CO_2 fertilization will lead to a 10% reduction in these prices by 2050.

Determinants of Agricultural Production

Climate

In the literature, the economic theoretical analysis of the effects of climate on agriculture has been carried out using several approaches, notably the production function approach (Rosenzweig and Parry 1994) and the Ricardian approach (Mendelsohn et al. 1994; Chang 2002; Gbetibouo and Hassan 2005; Ouédraogo et al. 2006; Maddison et al. 2007; Ouédraogo 2012).

It is with the aim to correct the bias presented by the production function approach (i.e. the overestimation of climate change damage to production by omitting the various possibilities for farmers to adapt in response to socio-economic and environmental conditions) that Mendelsohn et al. (1994) developed the Ricardian approach. Thus, this approach makes it possible to examine the determinants of agricultural production or yields by taking into account both climatic and non-climatic factors. However, the basic Ricardian model leaves room for criticism. As a limitation, it is criticized for (i) considering prices as constant (Deressa et al. 2005) and (ii) not describing the types and costs of climate change adaptation measures (Elbehri and Burfisher 2015).

Climate variations impact agricultural production through different channels (Lobell and Gourdji 2012), such as (i) exposure to insect pests and diseases, (ii) damage to plant cells, (iii) impact on vapor pressure deficit, (iv) rate of photosynthesis, respiration and grain filling, (v) plant growth rate and (vi) soil quality. In the literature, it can be noted that the effects of climate on agriculture vary from region to region and depending on the crops. The effects of climate change on agriculture are not only negative. Higher temperatures are a stressful factor for plants, but they can also extend the growing period and allow a wider choice of crops. Higher CO_2 concentrations can accelerate growth. On the other hand, diseases can spread more quickly in a milder climate. Agriculture is highly adaptable: new varieties can withstand other conditions and good soil management can combat water stress.

Chang (2002) shows that in a study of 60 products of the plant kingdom in Taiwan, variations in temperature and rainfall significantly impact agricultural yields. Nevertheless, he reveals that the effects of climate change are not monotonous. In the same vein, Tingem et al. (2003), using GISS climate model, find that by 2080, maize and sorghum yields will decrease due to climate change by 14.6% and 39.9% respectively in 8 regions of Cameroon. On the other hand, they show that this effect is not uniform as groundnut, bambara groundnut and soya beans yields will increase by 17.9%, 12.9% and 54.6% respectively. Also, Gbetibouo and Hasan (2005) find that when farmers do not make use of climate change adaptation techniques, (i) a 2 °C increase in temperature leads to an 11% decrease in agricultural yields during winter, but a 26% increase during summer, (ii) a 5% decrease in rainfall leads to a 4% and 1% decrease in agricultural yields respectively. On the other hand, regardless of the season, a 2 °C increase in temperature or a 5% decrease in rainfall is favorable to agriculture when measures to adapt to climate variations are implemented. Furthermore, using data collected from 10,000 farmers in 11 countries in Sub-Saharan Africa, Maddison et al (2007) concluded that climate change could have a devastating global impact on agriculture in Sub-Saharan Africa. Nevertheless, this effect could be (i) intense in countries where climates are already very hot and (ii) more modest in countries with already colder climates. In addition, Lobell et al. (2011) estimated that global warming trends reduced wheat and maize yields by about 6% and 4%, respectively, over the period 1980–2008. In contrast, global soybean and rice yields were found to be relatively unaffected by climate change so far.

This otherness does not appear in the study by Parry et al. (2004) who use the HadCM3 climate model. They predict that whatever the scenario, climate variations will have a negative effect on cereal yields in Africa in 2020, 2050 and 2080. To examine the impact of climate change, Lobell et al. (2008) used crop models and climate projections for 2030 in 12 food insecure regions. They found that the negative impacts of climate change on crop yields are expected to be greater for maize than sorghum in Southern Africa, and for cowpea than sorghum in Eastern Africa. Similarly, Nelson et al (2009), using the IMPACT climate model and the DSSAT model, find that by 2020, as a result of climate change, there will be (i) a relatively large decline in crop yields in developing countries for most crops without CO_2 fertilization. In Sub-Saharan Africa, for example, rice production will decrease from 14.5 to 15.2%, wheat from 33.5 to 35.8%, maize from 7.1% to 9.6%, millet from 6.9 to 7.6% and sorghum from 2.3 to 3%. In a sample of 1530 farms in Burkina Faso, Ouedraogo (2012) finds that (i) a rise in temperature of 2.5 °C and 5 °C will lead to a decrease in farm income of 46% and 93% respectively and (ii) a contraction in rainfall of 7% and 14% will also lead to a decrease in farm income of 148% and 296% respectively.

Gerardeaux et al. (2013), using the CROPGRO model, predict that by 2050 climate change will have a positive effect on cotton production in Cameroon if conservation agriculture and CO_2 enrichment and are practiced. By applying the SARRA-H climate model in 4 West African countries, Sultan et al. (2013) obtain the following results: (i) climate variations have a negative impact on sorghum and millet crop yields, (ii) when warming exceeds + 2 °C, the negative impacts caused by temperature increase cannot be compensated by a change in rainfall, (iii) the likelihood of reduced crop yields seems to be higher in the Sudanian region, due to an exacerbated sensitivity to temperature changes compared to the Sahelian region, where crop yields are more sensitive to rainfall change. Singh and Cohen (2014) demonstrate that Haiti is facing profound climate change, particularly with regard to seasonal rainfall, frequency and intensity of hurricanes and tropical storms that cause flooding and accelerate soil erosion. These changes in climate have devastating impacts on agriculture, forestry and fisheries. Mwongera et al. (2014) found that the risk of crop failure 15 days after germination is 6.7 times higher for long rains than for short rains, due to the difficulty in predicting onset, the irregularity of rainy days and the duration of dry spells during the crop emergence phase. After conducting a survey of 3204 farmers over the period 1961–2006, Leclerc et al. (2014) found that seed losses were due to (i) 81% of farmers to rainfall variations, (ii) 73% to drought and (iii) 8% to very wet conditions.

The Price

Indeed, the rise in the price of an agricultural product tends to increase the income of farmers. With a view to increasing their welfare, the latter may be encouraged to increase the size of the areas and the quantity of labor for this crop (Adams et al. 1998). In a study of 12 cotton-producing countries in West Africa, Camara (2014) shows that increasing the purchase price of seed cotton from farmers stimulates production. Cotton supply is highly elastic to price in the medium term. Cotton growers can change speculation relatively easily with each new production cycle, but they are not assured of greater benefits than if they were growing cotton. Cotton supply responds strongly to changes in its price from one cycle to the next.

Using a multiple linear regression model, Dieng (2006) demonstrates that over the period 1960–2003, the increase in prices lagged by one period was favorable to millet, maize and rice production in Senegal. Some studies have criticized the price mechanism in the cotton sector in Africa (Nubukpo and Keita 2005; Nubukpo 2006; Mpabe et al. 2017). For Nubukpo (2006), the mechanisms for determining the purchase price from the cotton producer suffer from a high degree of opacity: "This price is defined in relation to prices that are unobservable by most agents (anticipated world price, costs and marketing and processing margins of the cotton companies)". It demonstrates that this mechanism proposes prices that are unfavorable to cotton production in Mali.

By simulating the effects of a 25% reduction in the producer purchase price for seed cotton, Nubukpo and Keita (2005) obtain a drop in the incomes of cotton growers and non-cotton households of 29.5 billion FCFA and 18 billion F CFA respectively. For the Malian economy as a whole, this decline would result in a loss of CFAF 62.32 billion, or a 1.86% reduction in Mali's GDP. Furthermore, they simulate that a contraction of 50 FCFA in the purchase price of seed cotton from cotton growers would lead to a 25% drop in production.

In Cameroon, Mpabe et al (2017) recommend a revision of the mechanism for setting the seed-cotton purchase price and the mechanism for replenishing the price risk management fund. Indeed, they criticize the seed cotton purchase price setting mechanism for not taking into account production costs, which are often relatively higher. Bourdet (2004) reveals that cotton growers complain of an increase in production factor costs that does not seem to be compensated for by changes in the purchase price of seed cotton. It is essentially indexed to world fiber prices. Yet, as Hugon and Mayeyenda (2003) recognize, "real prices and world prices do not seem to be incentive indicators for producers".

The economic theory of supply and demand reveals that the supply of products is an increasing function of the prices offered in the market. Moreover, despite some nuances and divergences in the hypotheses, proponents of classical thinking all agree on one point: the value of a good is derived from the amount of labor required to produce it. The price of the good, which measures its value, must be determined according to the costs of production (Gnos 2000).

Methodology of the Study

To estimate the effects of climate on agriculture, Rötter and Höhn (2015) distinguish 3 empirical approaches: (i) the approach based on agro-climatic indices (Trnka et al. 2011), (ii) process-based crop simulation models, including climate and crop models (Parry et al. 2004; Sultan et al. 2013) and (iii) statistical or econometric models (Lobell et al. 2011).

Climate and crop models, depending on the scenarios, allow (i) to estimate in a predictive manner the effects of climate variations on agriculture over time, (ii) to compare the impact of climate change according to localities or periods. There are about fifteen climate models (Le Treut 2004), developed by multidisciplinary teams, such as HadCM3, IMPACT, SARRA-H, etc., which are used to estimate the impact of climate change on agriculture. These models often give rise to a certain amount of mistrust on certain aspects, notably the fact that atmospheric circulation is not deterministically predictable beyond a few days (Le Treut 2004).

Statistical or econometric models have the advantage of simultaneously taking into account all the factors likely to influence agricultural production or yields and are useful to assess the impact of climate change in the real conditions of farmers who are characterized by sub-optimal management of their agricultural activities (Rötter and Höhn 2015). Econometric and statistical models used in this field are multiple linear regression models (Gbetibouo and Hasan 2005; Ouedraogo 2012), panel data models (Camera 2014) and Heckman's method (Maddison et al. 2007).

In this study, the estimation of interactions between the purchase price of seed cotton from cotton farmers and cotton production led us to use VAR modeling.

This type of econometric model is very popular in the economic literature, particularly in macroeconomic studies. Indeed, VAR models are multivariate time-series models in which each dependent variable is a function of (i) its lagged variables, (ii) other dependent variables and (iii) exogenous variables. This has the advantage of simultaneously analyzing the interactions between the variables.

Also, it should be recalled that Sims (1980) introduced VAR modelling to overcome the shortcomings of Keynesian macro-econometric models, including:

- an a priori restriction on the parameters that is too strong compared to what the theory predicts, in other words the exogeneity of certain variables is postulated without being formally tested;
- an absence of tests on causal structure, i.e. the choice of functional forms (restrictions, exclusion of variables, delay structure) is a matter of arbitrary decisions;
- Inadequate treatment of agents' expectations. VAR models include unrestricted VAR models, Bayesian VAR models and error-corrected vector models.

The VAR model is formulated as follows:

$LNPAP_{i,t}$ and $LNPRO_{it}$ represent the model-dependent variables; $\Delta LNPAP_{i,t-h}$ and $\Delta LNPRO_{i,t-j}$ represent the delayed dependent variables. d ε_{1t} and ε_{2t} are white noise. The matrix $X_{i,t}$ consists of the following exogenous variables: $LNPWM_{i,t}$;$LNVPWM_{i,t}$;$LNT_{i,t}$;$LNVT_{i,t}$;$LNP_{i,t}$; $LNVT_{i,t}$ and *MA*. The study carried out during the period 1985–2015. Only the availability of data to justify the choice of this study period.

LNPAP, LNPRO, LNGRO and LNARE are quantitative variables that make it possible to assess respectively the logarithm of the purchase price of seed cotton from farmers, the logarithm of the annual production of seed cotton, the logarithm of the number of farmers per year growing cotton and the logarithm of the agricultural area devoted to cotton growing in Cameroon. The SODECOTON database (2016) provides this information. The purchase price of seed cotton from cotton growers is given in FCFA per kilogram and is determined before the start of the cotton season. The agricultural area is estimated in hectares and production in tons.

LNPWM is the quantitative variable that measures the logarithm of the annual price of cotton fiber on the world market. Several data sources exist, but we will use data from Trading Economics (2016). *LNVPWM* is the quantitative variable that allows us to assess the volatility of cotton prices in the world market. Cariolle (2012) proposes a literature review on the calculating methods of instability or volatility. Measuring price instability means evaluating the gap between the realizations of the "price" variable and its equilibrium value. This equilibrium value refers to the existence of a permanent state or trend (Cariolle 2012). In the literature, instability can be measured statistically by: (i) the second-order moment in the distribution of a variable around its mean or trend, (ii) the standard deviation of the residual of an econometric regression, and (iii) the standard deviation of the cycle isolated by a statistical filter. Hugon and Mayeyenda (2003) use the coefficient of variation to measure producer price instability. Drawing on Minot's (2012) study, to determine price volatility, we chose the standard deviation. Thus, for each year, the standard deviation of the monthly price of cotton in the world market was estimated and then the logarithm was applied.

LNR and *LNT* are quantitative variables that allow us to assess rainfall and temperature respectively. Temperature is expressed in degrees Celsius while rainfall is expressed in mm (Gbetibouo and Hassan 2005; Ouedraogo 2012). This information is provided monthly by the Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016). After calculating the averages for each year, the logarithm was applied. Several other sources of data exist, including those of the UNDP. The CCKP is a climate change knowledge portal that brings together data and publications on climate change from around the world. These data come mainly from North American institutions such as the National Center for Atmospheric Research (NCAR) and the International Research Institute of University of Columbia. LNVR and LNVT are quantitative variables that allow us to assess variations in rainfall and temperature, respectively. To determine these variables, in this study the standard deviation of the monthly level was calculated for each year and then the logarithm was applied.

SPEI, which is the normalized precipitation and evapotranspiration index, measures the severity of drought. Compared to the normalized precipitation index (SPI), it takes into account the soil water balance and temperatures. This information is provided monthly by the Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016).

LNVH, LNVS and LNVW are quantitative variables that allow the level of humidity, wind and solar exposure to be assessed. To determine these variables, in this study, we chose to calculate the standard deviation of the monthly level for each year. Subsequently, the logarithm was applied. These are the meteorological reanalysis data provided by the ERA-Interim Database of the European Centre for Medium-Range Weather Forecasts.

MA represents climate change mitigation or adaptation measures implemented in Cameroon. It is a qualitative variable that takes 2 values: 1 for the period from 1996 to 2015 and 0 otherwise. It was from 1996 that major actions in favor of climate change mitigation or adaptation began to be taken, notably the development of the National Environmental Management Plan (NEMP) (Table 1).

Some variables could not be integrated because cotton cultivation is practiced in the 3 regions of northern Cameroon. The agricultural policy is common to each of these regions. Farmers adopt, for the most part, the same strategies for adapting to climate change. Soil characteristics as well as the agricultural production techniques used by the cotton farmers seem similar. Also, they have the same experiences with climate variation.

Results of the Study

The purchase price of seed cotton is positively and strongly correlated to its production. This suggests that either an increase in the purchase price of seed cotton from cotton growers leads to a decrease in production or an increase in production leads to a decrease in the purchase price from cotton growers. Harmignie et al. (2005) obtain a similar result in a study of several agricultural products in the Belgian Walloon region. Hugon et al. (1994) find a weak correlation between prices and quantities offered in the Franc zone countries.

Moreover, the purchase price from producers is positively correlated: (i) strongly to the price of cotton fiber in the international market and to temperatures, and (ii) weakly to the volatility of cotton prices in the world market and to temperature variations. This suggests that the increase in the world price of cotton fiber and the increase in temperatures are favorable to the increase in the purchase price of seed cotton from cotton farmers. On the other hand, the purchase price of producers is negatively and weakly correlated to the level of rainfall and variations in rainfall. It can be envisaged that the increase in rainfall is not conducive to cotton growing.

Seed cotton production is positively and weakly correlated to the global cotton fiber price, temperature level and temperature variations. Thus, it can be assumed that higher temperatures and higher world market prices of cotton are favorable to cotton production. On the other hand, cotton production is negatively and weakly correlated with rainfall, the volatility of the world cotton fiber price and changes in rainfall. It can therefore be predicted that the increase in rainfall and the high

Table 1 Summary description of variables and data sources

Variables	Description	Average	Std-dev	Minimum	Maximum	Data sources
LNPAP	Quantitative variable that allows to appreciate the logarithm of the purchase price of seed cotton to the farmers. The purchase price of seed cotton to the farmers is given in FCFA per kilogram and is determined before the start of the cotton campaign	5.107	0.322	4.435	5.592	SODECOTON database (2016)
LNPRO	Quantitative variable that allows to appreciate the logarithm of the annual production of seed cotton. The latter is estimated in tons	12.060	0.324	11.550	12.624	SODECOTON database (2016)
LNPWM	Quantitative variable that measures the logarithm of the annual price of cotton fiber on the world market	6.614	0.349	5.866	7.390	Trading Economics (2016)
LNVPWM	Quantitative variable that allows to assess the volatility of cotton prices on the world market. To determine price volatility, we chose the standard deviation. Thus, for each year, we will estimate the standard deviation of the monthly world market price of cotton and then applied the logarithm	1.749	0.755	0.464	3.858	Trading Economics (2016)
LNVT	Quantitative variable that allows to appreciate temperature variations. To determine this variable, the standard deviation of the monthly level was calculated for each year and then the logarithm was applied	0.201	0.141	−0.096	0.424	Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016)
LNVR	Quantitative variable that allows to appreciate the variations of rainfall and temperature. To determine this variable, the standard deviation of the monthly level was calculated for each year and then the logarithm was applied	4.524	0.095	4.340	4.721	Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016)
LNT	Quantitative variable that allows to appreciate the temperature. The temperature is expressed in degrees Celsius. After calculating the averages for each year, the logarithm is applied	3.215	0.012	3.189	3.236	Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016)

Table 1 (continued)

Variables	Description	Average	Std-dev	Minimum	Maximum	Data sources
LNR	Quantitative variable that allows to appreciate the rainfall. Precipitation is expressed in mm	4.865	0.068	4.714	4.990	Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016)
SPEI	A variable that captures the normalized precipitation and evapotranspiration index measures the severity of drought	0.020	0.212	−0.420	0.540	Climate Change Knowledge Portal (CCKP) of the World Bank Group (2016)
LNGRO	Quantitative variable which makes it possible to appreciate the logarithm of the number of growers per year of cotton	12.351	0.321	11.754	12.818	SODECOTON’s database (2016)
LNARE	Quantitative variable that allows to appreciate the logarithm of the agricultural areas devoted to cotton cultivation. It is estimated in hectares	11.877	0.341	11.202	12.354	SODECOTON’s database (2016)
LNVH	Quantitative variable that allows to appreciate the level of humidity. To determine this variable, we chose to calculate the standard deviation of the monthly level for each year. Subsequently, the logarithm was applied. These are the meteorological re-analysis data provided by the ERA-Interim database of the European Centre for Medium-Range Weather Forecasts	− 7.180	1.171	− 8.960	− 4.921	Meteorological re-analysis data provided by the ERA-Interim database of the European Centre for Medium-Range Weather Forecasts
LNVW	Quantitative variable that allows to appreciate the wind level. To determine this variable, we chose to calculate for each year the standard deviation of the monthly level. Subsequently, the logarithm was applied	−2.376	0.753	− 4.766	− 1.161	Meteorological re-analysis data provided by the ERA-Interim database of the European Centre for Medium-Range Weather Forecasts
LNVS	Quantitative variable that allows to appreciate the level of sun exposure. To determine this variable, we chose to calculate for each year the standard deviation of the monthly level. Subsequently, the logarithm was applied	15.752	1.356	9.729	16.988	Meteorological re-analysis data provided by the ERA-Interim database of the European Centre for Medium-Range Weather Forecasts

Table 1 (continued)

Variables	Description	Average	Std-dev	Minimum	Maximum	Data sources
MA	Variable that represents the climate change mitigation or adaptation measures implemented in Cameroon. It is a qualitative variable that takes 2 values: 1 for the period from 1996 to 2015 and 0 otherwise			0	1	Built by the Author

Source Author

volatility of cotton prices on the world market are detrimental to cotton production in Cameroon.

Changes in rainfall and temperature levels do not appear to be synchronous. It is therefore possible to use these 2 variables simultaneously as explanatory variables in our econometric model (Table 2).

The parameters of a VAR model can only be estimated on stationary time series. The variables *LNP, LNT, LNVP, LNVPWM, LNVT, SPEI, VHUM, VWIND* and *VSOLAR* are level stationary. On the other hand, the variables *LNPAP, LNGRO, LNPWM, LNPRO* and *LNARE* are not level-stationary. In order to make them level-stationary, they have been transformed into the first difference. Thus, they are integrated in order 1 and there is therefore a risk of co-integration (Table 3).

To perform the Granger causality test, the number of delays of the VAR(p) model must first be determined. Reading the information criteria (see Appendix), the optimal delay p is equal to 1. The Granger causality test shows that the purchase price of seed cotton from the cotton growers has a significant influence on production at a 5% threshold. On the other hand, seed-cotton production does not significantly impact the price paid to farmers. In sum, it is preferable to predict cotton production by taking into account the purchase price of cotton from the growers. In Cameroon, farmers know the purchase price of seed cotton before the start of the cotton season (Table 4).

Johansen's co-integration test reveals the absence of a co-integration relationship between the purchase price from cotton farmers and production. Therefore, a vector error-correction model cannot be used to estimate the coefficients of the explanatory variables. An unrestricted VAR model will be used (Table 5).

The increase in production delayed by one period negatively influences the price at which seed cotton is purchased from farmers in period t. Since this effect is insignificant, it seems difficult to validate King's law. The increase in the purchase price of seed-cotton from farmers boosts agricultural production. This price increase will be an incentive for farmers. There will be no risk of substitution of cotton by food crops in the event of a relative increase in the purchase price of seed-cotton. Cotton production cannot be adjusted during the year, once the farmers have decided on the cropping plan; as a result, cotton supply is relatively inelastic to short-term variations in demand and depends on the price observed the previous year or the price observed at the beginning of the season. Dieng (2006) and Camara (2015) find similar results for cereals and cotton in West Africa, respectively. Hugon and Mayeyenda (2006) find that producer prices do not significantly influence cotton production in the Franc Zone.

Although not significant, the increase in temperature is favorable to cotton cultivation in Cameroon. This result does not seem to be in line with Barrios et al. (2008) who indicate that rising temperatures have had a negative impact on cotton production. Furthermore, the effect of rainfall on cotton production in Cameroon does not seem significant. However, the increase in rainfall favors cotton production. This result is similar to that obtained by Camera (2015) and Dieng (2006). Furthermore, Barrios et al. (2008) find that the decline in rainfall has led to a decline in cotton production. Cotton cultivation requires a lot of sunshine, water for at least

Table 2 Correlation coefficients of the model variables

	LNPAP	LNPGRO	LNPLU	LNPWM	LNPRO	LNARE	LNTEMP	LNVH	LNVP	LNVPWM	LNVS	LNVT	LNVW	SPEI
LNPAP	1	0.364**	− 0.253	0.743***	0.662***	0.781***	0.518***	0.402	− 0.03	0.141	− 0.08	0.193	− 0.062	0.261
LNPGRO	0.364**	1	0.359**	0.335*	0.721***	0.811***	0.169	− 0.05	0.248	− 0.168	− 0.18	0.013	0.051	− 0.009
LNPLU	− 0.253	0.359**	1	− 0.202	− 0.051	0.036	− 0.286	0.086	0.769***	− 0.13	0.042	0.043	− 0.138	− 0.158
LNPWM	0.743**	0.335*	− 0.202	1	0.382**	0.532***	0.318*	0.332*	0.092	0.397**	− 0.02	0.026	− 0.177	0.042
LNPRO	0.662***	0.721***	− 0.051	0.382**	1	0.907***	0.247	− 0.07	− 0.18	− 0.358**	− 0.11	0.21	0.075	0.12
LNARE	0.781***	0.811***	0.036	0.532***	0.907***	1	0.395**	0.179	0.021	− 0.186	− 0.07	0.145	0.051	0.169
LNTEMP	0.518***	0.169	− 0.286	0.318*	0.247	0.395**	1	0.253	− 0.18	0.214	− 0.35	0.059	0.139	0.475***
LNVH	0.402**	− 0.054	0.086	0.332*	− 0.071	0.179	0.253	1	0.364**	0.283	− 0.02	0.151	0.036	0.166
LNVP	− 0.033	0.248	0.769***	0.092	− 0.176	0.021	− 0.181	0.364	1	0.232	− 0.05	− 0.021	− 0.051	− 0.07
LNVPWM	0.141	− 0.168	− 0.13	0.397**	− 0.358**	− 0.186	0.214	0.283	0.232	1	− 0.06	− 0.093	− 0.106	0.075
LNVS	− 0.075	− 0.176	0.042	− 0.022	− 0.107	− 0.074	− 0.347*	− 0.02	− 0.05	− 0.061	1	− 0.196	− 0.209	− 0.11
LNVT	0.193	0.013	0.043	0.026	0.21	0.145	0.059	0.151	− 0.02	− 0.093	− 0.2	1	0.009	− 0.036
LNVW	− 0.062	0.051	− 0.138	− 0.177	0.075	0.051	0.139	0.036	− 0.05	− 0.106	− 0.21	0.009	1	0.388**
SPEI	0.261	− 0.009	− 0.158	0.042	0.12	0.169	0.475***	0.166	− 0.07	0.075	− 0.11	− 0.036	0.388	1

Source Author (***, ** and * correspond to significance at 1%, 5% and 10% respectively)

Table 3 Increased Dickey–Fuller stationarity test of model variables

Variables	Level	Primary difference
LNPAP	– 2.111	– 4.525***
LNGRO	– 1.408	– 96.911***
LNPLU	– 4.480***	
LNPWM	– 2.713	– 5.268***
LNPRO	– 2.360	– 6.075***
LNARE	– 1.912	– 5.260***
LNT	– 4.875***	
LNVP	– 4.396***	
LNVPWM	– 3.481*	
LNVT	– 7.075***	
SPEI	– 5.88***	
VHUM	– 6.41***	
VWIND	– 10.29***	
VSOLAR	– 8.91***	

Source Author (***, ** and * correspond to significance at 1%, 5% and 10% respectively)

Table 4 Estimation of Granger's causality test

Null hypothesis:	Obs	F-Statistic	Prob.
D(LNPRO) does not Granger Cause D(LNPAP)	29	0.689	0.413
D(LNPAP) does not Granger Cause D(LNPRO)		4.938**	0.035

Source Author (** corresponds to significance at 5%)

Table 5 Results of the Johansen co-integration test

No. of CE(s)	Eigen value	Statistic	Critical value	Prob
None	0.126	4.636	15.494	0.846
At most 1	0.023	0.703	3.841	0.401

Source Author

120 days to ensure growth, and at the end of the cycle, dry weather to facilitate boll dehiscence and prevent fiber decay.

High variations in rainfall significantly influence cotton production in Cameroon. Increased variations in rainfall are not conducive to cotton cultivation because of the soil degradation it causes. Erosion is particularly active at the beginning of the cotton growing cycle, during the months of May and June, when the soil, loosened by poorly managed and shallow but still bare ploughing, is subjected to devastating rainfall episodes. During this period, intense and discontinuous rains exceed the cotton plant's needs, fuel runoff, and promote the degradation of the physical and chemical characteristics of the soil by impoverishment, acidification or mechanical disintegration. Hauchart (2008) shows that high variations in rainfall have contributed to the degradation of 80% of the soils in the Mouhoun cotton-growing region in Burkina Faso.

International prices and their variations positively but not significantly influence cotton production in Cameroon. This result shows that adjustments in cotton supply are sheltered from changes in world prices. This can be justified by the implementation of the price management mechanism in force in Cameroon. Hugon and Mayeyenda (2006) find that world prices do not seem to be an incentive for producers in the Franc Zone because the international price/supply elasticity is negative and insignificant.

Variations in the international market price of cotton do not significantly influence the price at which seed cotton is purchased from cotton growers. This result can be justified by the international market price smoothing technique used in the seed cotton purchase price setting mechanism. On the other hand, the increase in cotton prices in the international market is favorable to the increase in the purchase price of seed-cotton to farmers. This result, which is significant at the 5% threshold, is in line with that of Subervie (2007). The formula for determining the floor price of seed cotton to farmers is essentially based on the evolution of prices in the world market.

The increase in the purchase price from farmers delayed by one period positively and significantly influences its value in period t. There would therefore be a price memory effect. Collange and Guillaumat-Tailliet (1988) obtain a similar result for the index of world prices of non-oil raw materials between 1973 and 1987. They justify this result by the fact that the sharp increases in oil prices observed during the 1973–1974 and 1979–1980 periods exerted upward pressure on the world prices of other raw materials. Temple et al. (2009) obtain contrasting results on the domestic food market in Cameroon. Indeed, according to the authors, "the different price series do not all react in the same way to their past. While the prices of wheat, cassava and plantain do not really take into account past price values, the price of imported rice seems to be fixed from one period to the next by taking into account the last price value.

Increasing temperatures and rainfall do not have a significant impact on the price at which seed cotton is purchased from farmers. Similarly, changes in rainfall do not have a significant influence on the purchase price of seed cotton. On the other hand, wide variations in temperature seem to favor increasing the price at which seed cotton is purchased from farmers. This effect is significant at the 5% threshold.

The climate change adaptation or mitigation measures implemented in Cameroon have not had significant effects on its cotton sector. Environmental strategies face many difficulties, including the problem of climate financing, the issue of cohesion between the different environmental programs implemented, the issue of maturity and management of environmental projects and the contradictions between the effects of mitigation measures and climate change adaptation measures.

The sensitivity tests carried out demonstrate the robustness of our results since the signs of the explanatory variables remain stable from one model to another.[1] The

[1] See Table 6 in the Appendices.

intensity of the drought, as captured by the SPEI variable, has a significant and negative effect on cotton production and on the purchase price of cotton from producers.[2] This can be explained by the proliferation of insect pests. The increase in the number of cotton growers does not significantly influence cotton production. However, it does have a significant and negative impact on the price paid to farmers. The increase in the size of the agricultural area significantly favors the increase in cotton production and the purchase price to farmers.[3]

The errors of the 2 models are normally distributed.[4] The heteroscedasticity test of White's residuals reveals that the variance of the residuals is constant.[5] There is therefore homoscedasticity; the risk of error amplitude is the same whatever the period.

We will proceed to the analysis of impulse response functions. A positive shock on the purchase price to producers results in a positive effect on the latter during the first 6 years. From the 7th year onwards, this effect tends to cancel out. A positive shock in seed cotton production results in a negative effect on the purchase price to producers until the 4th year. From the 5th year onwards, this effect tends to cancel out. A positive shock in the purchase price of seed cotton from cotton growers on cotton production results in a positive effect until the 5th year. From the 6th year onwards, this effect cancels out. Finally, a positive shock to cotton production on itself results in an effect (i) positive in the 1st year, (ii) negative in the 2nd year and (iii) zero from the 3rd year onwards.

Conclusion and Recommendations

The fight against climate change, the increase in the purchase price of seed cotton and the expansion of cotton production are of crucial importance for increasing the income of cotton farmers and thus reducing poverty in the northern part of Cameroon. This study highlights the impact of (i) climate change and international market price volatility on cotton production, (ii) climate change and international market price volatility on the price to cotton farmers, (iii) the purchase price to cotton farmers on cotton production, (iv) cotton production on the purchase price to cotton farmers. At the methodological level, we used descriptive statistics techniques and VAR modeling by exploiting 3 databases, namely SODECOTON (2016), Trading Economics (2016) and World Bank Group (2016). The results of descriptive and econometric statistics reveal that (i) the purchase price of seed cotton from farmers tends to significantly boost production, (ii) cotton production does not significantly

[2] See Model 4 of Table 6 in the Appendices.

[3] See Models 6, 7 and 8 of Table 6 in the Appendices.

[4] Voir annexes.

[5] Voir annexes.

influence the purchase price of seed cotton from farmers, (iii) large variations in rainfall are not favorable to cotton production, (iv) the increase in the world price of cotton fiber and large variations in temperature are favorable to an increase in the purchase price of seed cotton from farmers.

In light of the results of this study, certain measures concerning the fight against climate change, rising prices and increased cotton production could improve the development of the cotton sector in Cameroon. To improve cotton production, it would be advisable in particular (i) to make the purchase price of seed cotton more attractive to cotton growers, for example by choosing a mechanism for setting the purchase price of seed cotton that combines the evolution of prices in the world market and production costs, and (ii) to adopt effective adaptation or mitigation techniques against variations in rainfall. In the same vein, it seems appropriate to strengthen international trade negotiations on cotton, particularly at the WTO, which could lead to the reduction of US production subsidies that drive down world cotton prices.

It would also be interesting for future studies to examine the effects of agricultural production and farmers' prices on climate change. We were unable to do this study because Cameroonian cotton is pluvial. Also, its cultivation is not polluting because the cotton plant grows in its natural environment, thus respecting biodiversity. The fibers are well parallelized and without preparation because the harvest is manual and the ginning is done gently.

Appendix

See Fig. 5 and Tables 6, 7, 8, 9, and 10.

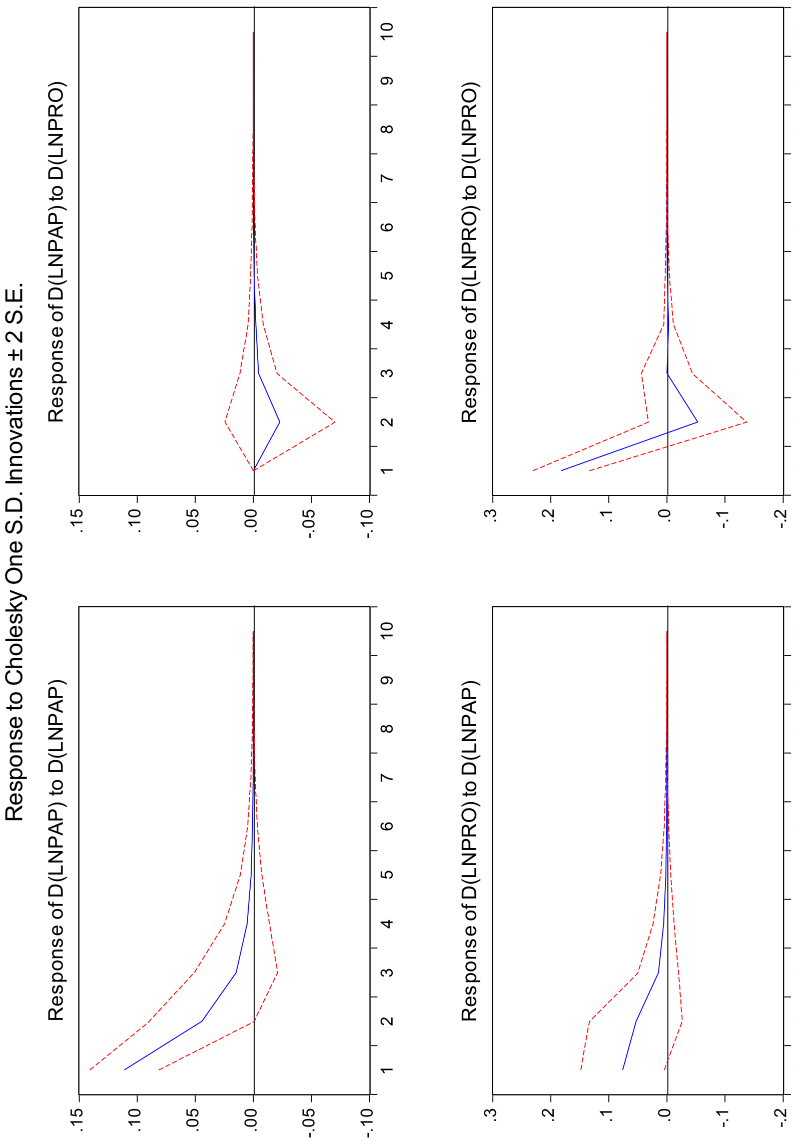

Fig. 5 Impulse response functions. *Source* Author

Table 6 Descriptive statistics of the model variables

	LNPAP	LNPRO	LNPWM	LNT	LNP	LNVPWM	LNVT	LNVP	LNARE	LNGRO	LNVH	LNVS	LNVW	SPEI
Mean	5.107	12.060	6.614	3.215	4.865	1.749	0.201	4.524	11.877	12.351	− 7.180	15.752	− 2.376	0.020
Median	5.187	12.141	6.661	3.216	4.880	1.660	0.233	4.531	11.910	12.249	− 7.481	16.027	− 2.284	0.035
Maximum	5.592	12.624	7.390	3.236	4.990	3.858	0.424	4.721	12.354	12.818	− 4.921	16.988	− 1.161	0.540
Minimum	4.435	11.550	5.866	3.189	4.714	0.464	− 0.096	4.340	11.202	11.754	− 8.960	9.729	− 4.766	− 0.420
Std-dev	0.322	0.324	0.349	0.012	0.068	0.755	0.141	0.095	0.341	0.321	1.171	1.356	0.753	0.212

Source Author

Table 7 Determination of optimal delay

Lag	AIC	SC
0	– 1.648.110	– 1.077.165
1	– 1.649.026*	– 1.0887*
2	– 1.468.382	– 0.516.807

Source Author

Table 8 Result of the error normalization test

Component	Jarque–Bera	df	Prob.
1	1.613	2	0.446
2	3.598	2	0.165
Joint	5.212	4	0.266

Source Author

Table 9 White's Heteroscedasticity test

Joint test:					
Chi-sq	df	Prob.			
60.33311	48	0.109			
Individual components:					
Dependent	R-squared	F(16.11)	Prob.	Chi-sq(16)	Prob.
res1*res1	0.872	4.688	0.006	24.418	0.080
res2*res2	0.458	0.581	0.842	12.829	0.685
res2*res1	0.762	2.207	0.093	21.350	0.165

Source Author

Table 10 VAR model estimates

Variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	D(LNPAP)	D(LNPRO)	DLN-PAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO
D (LNPAP (-1))	0.484**	0.677*	0.400**	0.985***	0.398**	0.939**	0.375*	0.569	0.322	0.555	0.192	− 0.020	0.193	− 0.057	0.136	0.270
	(0.212)	(0.377)	(0.204)	(0.381)	(0.196)	(0.369)	(0.200)	(0.386)	(0.215)	(0.422)	(0.213)	(0.304)	(0.224)	(0.327)	(0.302)	(0.412)
D (LNPRO (-1))	− 0.125	− 0.289	− 0.099	− 0.428**	− 0.099	− 0.422**	− 0.018	− 0.183	0.006	− 0.176	− 0.054	− 0.180	− 0.013	− 0.124	− 0.085	− 0.277
	(0.128)	(0.228)	(0.115)	(0.215)	(0.113)	(0.212)	(0.126)	(0.245)	(0.133)	(0.260)	(0.112)	(0.160)	(0.126)	(0.184)	(0.127)	(0.173)
D (LNPWM)	0.197**	0.028	0.199**	0.016	0.199**	0.028	0.182**	0.014	0.188**	0.016	0.165**	− 0.113	0.162**	− 0.110	0.174**	− 0.065
	(0.085)	(0.151)	(0.086)	(0.160)	(0.083)	(0.157)	(0.078)	(0.150)	(0.079)	(0.155)	(0.075)	(0.107)	(0.077)	(0.112)	(0.082)	(0.112)
LNVPWM	0.033	0.016	0.035	− 0.000	0.035	− 0.003	0.050*	0.032	0.050*	0.032	0.030	0.030	0.039	0.040	0.022	0.029
	(0.032)	(0.058)	(0.031)	(0.058)	(0.030)	(0.057)	(0.030)	(0.059)	(0.030)	(0.061)	(0.028)	(0.040)	(0.030)	(0.044)	(0.032)	(0.043)
LNVT	0.455**	0.368	0.372**	0.575*	0.371**	0.540*	0.402**	0.315	0.368**	0.306	0.270	0.312	0.277	0.305	0.241	0.243
	(0.198)	(0.353)	(0.183)	(0.340)	(0.176)	(0.330)	(0.183)	(0.354)	(0.190)	(0.375)	(0.182)	(0.259)	(0.186)	(0.272)	(0.211)	(0.287)
LNVP	0.238	− 0.900*	− 0.028	− 0.013	− 0.028*	− 0.020	0.127	-1.010**	0.077	-1.023**	0.404*	− 0.149	0.322	− 0.273	0.443	0.160
	(0.253)	(0.450)	(0.016)	(0.031)	(0.015)	(0.029)	(0.236)	(0.457)	(0.249)	(0.489)	(0.241)	(0.344)	(0.273)	(0.398)	(0.293)	(0.399)
LNT (-1)	− 0.554	1.091					− 0.324	1.318	− 0.266	1.333	-1.149**	− 0.196	− 0.935	0.094	− 0.986	0.271
	(0.599)	(1.066)					(0.557)	(1.077)	(0.570)	(1.118)	(0.557)	(0.795)	(0.630)	(0.919)	(0.667)	(0.909)
LNP (-1)	0.115	0.098					0.064	0.048	0.067	0.049	0.359	0.244	0.292	0.160	0.250	− 0.323
	(0.376)	(0.669)					(0.344)	(0.665)	(0.348)	(0.683)	(0.331)	(0.473)	(0.347)	(0.506)	(0.435)	(0.592)
SPEI							− 0.230**	− 0.227**	− 0.264**	− 0.236			− 0.116	− 0.140		
							(0.103)	(0.199)	(0.114)	(0.224)			(0.130)	(0.190)		
D (LNGRO)											− 0.832**	− 0.294	− 0.698*	− 0.077	− 0.863**	− 0.588
											(0.290)	(0.415)	(0.363)	(0.530)	(0.363)	(0.494)
D (LNARE)											1.036**	1.483**	0.863**	1.239**	1.101**	1.686**
											(0.342)	(0.488)	(0.418)	(0.609)	(0.394)	(0.537)
VH															− 0.004	− 0.050*
															(0.022)	(0.030)

Table 10 (continued)

Variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	D(LNPAP)	D(LNPRO)	DLN-PAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO	DLNPAP	DLNPRO
VW															− 0.029	0.033
															(0.042)	(0.057)
VS															− 0.015	− 0.025
															(0.018)	(0.024)
MA			− 0.002	− 0.058					0.036	0.009			− 0.005	0.031	− 0.017	− 0.009
			(0.049)	(0.091)					(0.050)	(0.098)			(0.052)	(0.077)	(0.055)	(0.075)

Source Author (***,** and * correspond to significance at 1%, 5% and 10% respectively)

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