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Abstract

This study uses interrupted time series analysis and time series data collected from FAOSTAT(2016) to analyze the macro and long term impact of adoption of improved maize varieties on maize yield in Cameroon. The results suggest that adoption of improved maize varieties has a positive impact on maize yield in the first year of intervention or release (1987) but a negative impact over time arising from either degeneration or reduction of improved maize varieties adoption's rate over years. Therefore, research should work toward the continuous delivering of new improved seeds capable of replacing the degenerated ones. In addition, farmers should be encouraged to adopt improved maize varieties but also, they should be educated on the use of improved maize varieties at least on the number of time different improved seeds can be reused before renewing them.

Submitted: September 16, 2017.

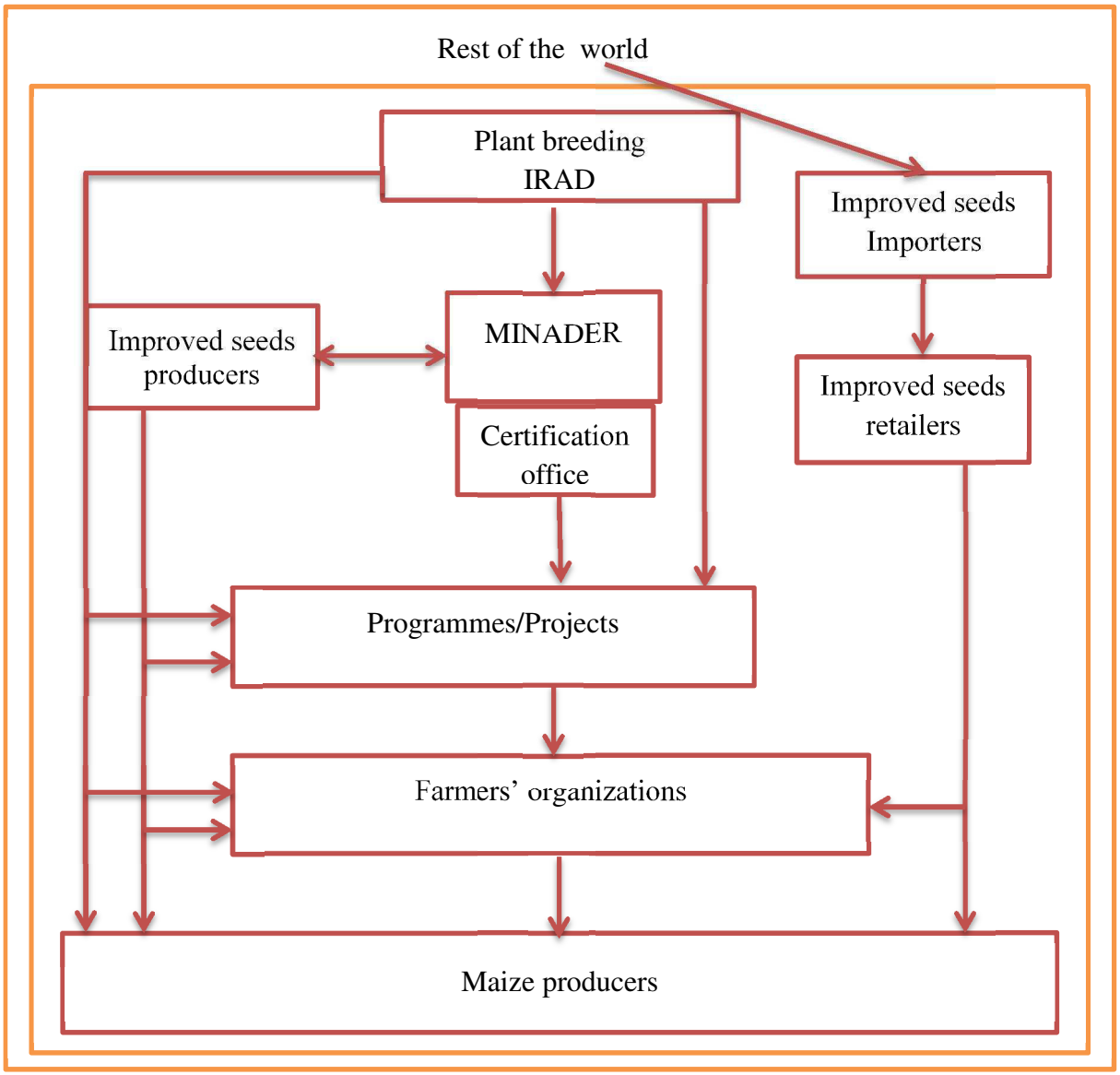
1. Introduction

In Cameroon maize is considered as a strategic crop for poverty reduction, food security and economic development by many scholars (Manu *et al.* 2014; Ntsama Etoundi and Kamgnia Dia 2008). Since its introduction in Cameroon around the sixteenth century by Portuguese (Egbe *et al.* 1995), the maize production has gone crescendo mainly as a result of increasing cultivated area rather than increasing productivity. Estimated at about 13303 tons in 2013 (FAO, 2016), the maize production provides the livelihoods for more than three millions of small rural farmers and accounts for about 25 billion FCFA each year (Manu *et al.* 2014; Ntsama Etoundi and Kamgnia Dia 2008). Cultivated everywhere within the country, maize is a staple food crop for many Cameroonian. It is consumed over diverse plates (roasted corn, boiled corn, couscous, maize pap and "sanga") according to the preferences of different ethno-linguistics groups (Nzossié *et al.* 2010). Despite, the heavy role that maize plays within Cameroonian society, its production still remains limited face to the increasing demand resulting from high population growth. Although the maize production has been increasing in Cameroon, this increase has occurred as a result of the augmentation of cultivated areas instead increasing maize productivity. Or any sustainable policy to face with the limited maize production should focus on increasing maize productivity.

Past studies identified low soil fertility, insects' attacks and diseases such as the streak and the foliar diseases, the irregularity and sometimes the insufficiency of rain, the lack of improved seeds suited to certain zones, the low availability of inputs, the low use of inputs and the drought as possible factors associated to low crop productivity in Africa (Cairns *et al.* 2013; Nkamleu, 2004). Amongst those factors, the lack of improved seeds deeply affects the level of crop productivity. For maize, two broad categories of improved maize varieties are generally distinguished: open pollinated varieties and hybrid obtained from two pure varieties. In Cameroon, the first improved maize varieties were developed in 1987 by the Agricultural Research Institute for Development (IRAD) through the National Cereals Research and Extension (NCRE) project (Ntsama Etoundi and Kamgnia Dia, 2008). From that date, numerous improved maize varieties have been developed and released within and out of the country. Today, more than 30 varieties of improved maize varieties exist in Cameroon whose dominance is locally developed by IRAD whereas others are imported mainly from Zambia and South Africa. With the idea of easing the distribution of improved maize varieties across the country and assisting maize producers, several programmes and projects have been

developed for few years. All these programmes with PNAFM[1] as leader and other actors such as MINADER, IRAD, cooperatives etc form the distribution channels of improved maize varieties in Cameroon presented in figure 1.

Figure 1: Distribution channel of improved maize varieties



Source: Author's building

Despite the effort of popularization of improved maize varieties by the government, the maize yield has remained static and was estimated at 1.95 tons per hectare in 2014 (FAO, 2016). This has raised the suspicion of rural farmers on the capacity of improved maize varieties to enhancing the maize yield. Some past studies have attempted to answer that worry in the literature by analysing the impact of adoption of improved maize varieties on yield, food security and/or poverty (Ntsama Etoundi and Kamgnia Dia, 2008; Nabasirye *et al.* 2012;

[1] Programme National d'Appui à la Filière Maïs

Manu *et al.* 2014; Ouma *et al.* 2014; Khonje *et al.* 2015; Takam Fongang, 2016). Although most studies have stressed the positive impact associated with adoption of improved maize varieties, the results are less reliable because these studies are always localized and do not take into account the entire economy. Indeed, a technology may perform better in one area and not in another one or performs better today and not tomorrow because of one reason or another. This is the case of improved maize varieties which are greatly susceptible to climate conditions and soil characteristics which constantly change over time. Thus, localized impact evaluation seeking to assess the impacts of new technologies such as improved maize varieties should be complemented by a macro and long term impact evaluation in order to determine not only the long term impact of adoption of new technologies but also to avoid falling into fallacy of composition. Accordingly, this study seeks to fill this gap by analyzing the macro and long term impact of adoption improved maize varieties on maize yield in Cameroon.

The rest of the paper is organized as follows: section 2 presents the methodological framework, section 3 exposes the results and discussion and finally section 4 gives a brief conclusion and policy implications.

2. Methodology

2.1. Source and Method of data collection

Data used in this study are annual data covering the period from 1961 to 2014. The choice of this period is based on the availability of data. Data on maize yield were collected from FAOSTAT (FAO, 2016). The maize yield is the ratio of maize production to the cultivated area and was measured in tons per hectare. The average maize yield over the period of the study is 1.472 tons per hectare with respectively 0.745 and 2.591 tons per hectare as the minimum and maximum during the same period.

2.2. Model and estimation technique

Several methods among which randomized control trial, propensity score matching, endogenous switching regression, discontinuity regression, double difference and interrupted time series analysis have been developed to carry out impact evaluation in the literature (Khandker *et al.* 2009; Linden, 2015; Linden, 2017; Fougère, 2010). However, given that the study is a macro-impact evaluation as it intends to assess the impact of improved maize varieties on maize yield in Cameroon since their release into the country in 1987, a meaningful method should be macro-perspective focus. Accordingly, even though randomized control trials is considered as the gold standard for impact evaluation (Baker, 2000; Pamies-Sumner, 2014), interrupted time series analysis have been used in this study

because it is macro-perspective focus while the other methods including randomized control trials are micro-perspective focus. Two traditional methods historically used to conduct interrupted time series are ordinary least squares method (OLS) and autoregressive integrated moving-average method but ordinary least squares was used because of its flexibility and broadly applicability in an interrupted time-series context (Linden, 2015; Linden, 2017; Velicer and Harrop, 1983). The model to be estimated by ordinary least square is as follows:

$$Yield_t = \beta_0 + \beta_1 T_t + \beta_2 D_t + \beta_3 D_t T_t + u_t \quad (1)$$

Where $Yield_t$ β_i, D_t, T_t and u_t represent respectively the maize yield measured in tons per hectare, the parameters to be estimated, a dummy variable for improved maize varieties release (taking the value 0 before intervention and 1 after intervention), the time covering the period of the study and the error term following a standard normal distribution. Amongst the parameters, three (β_1, β_2 and β_3) are of great importance. $\beta_1$represents the trajectory of maize yield until the release of improved maize varieties. β_2 is the change in maize yield level occurring in the period immediately following the release of improved maize varieties and $\beta_3$represents the difference between pre-intervention and post-intervention slopes of maize yield. In addition, the sum of β_1 and β_3 represents the post-intervention trend. Both β_2 and β_3 are used to indicate respectively an immediate treatment effect and a treatment effect over time (Linden, 2015; Linden and Adams, 2011).

3. Results and discussion

The results of OLS estimation are presented in table 1. The Newey–West variance estimator with two lags suggested by Newey and West (1987) was used to account for autocorrelation and possible heteroskedasticity. The table shows that the model is globally significant at 1%. All parameters have the expected signs except the parameter β_3 although only β_0 and β_1 are respectively significant at 1% and 5%. The results show that the initial level of maize yield was estimated at 0.611 ton per hectare and seemed to increase significantly every year prior to 1987 by 0.029 ton per hectare.

Table 1: OLS estimates

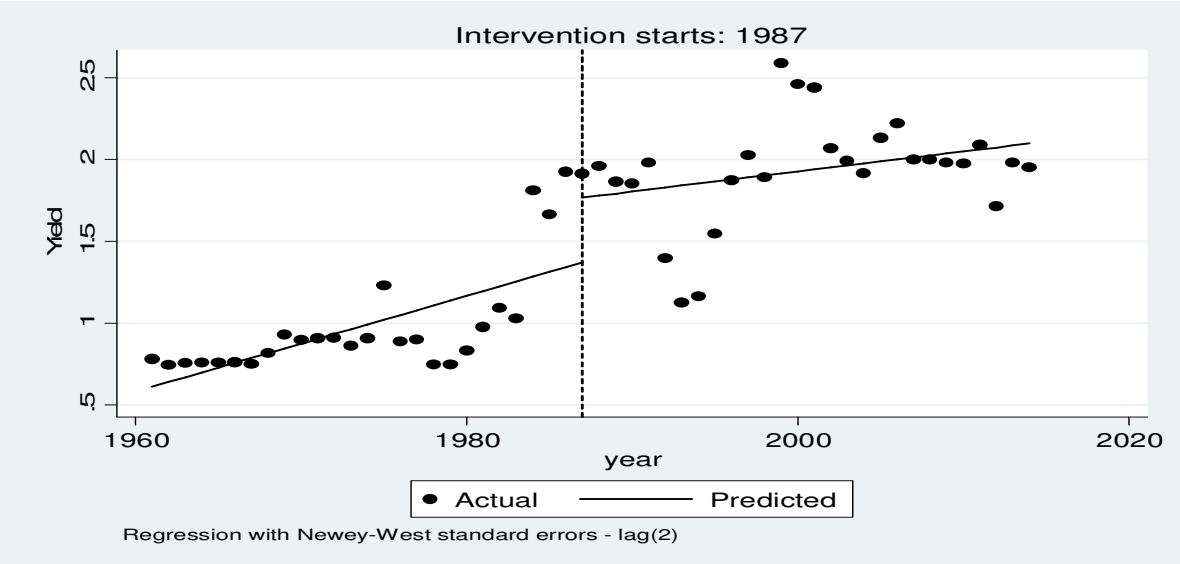
Variables	Coefficients	Standard errors
T	0.029**	0.011
D	0.396	0.263
DT	-0.017	0.014
Constant	0.611***	0.089
$\beta_1 + \beta_3$	0.012	0.008
F(3, 50)	73.34	
Prob > F	0.000	
Number of observations	54	

*** significant at 5%; *** significant at 1%*

Source: Author's calculations using STATA

The results further show that the release of improved maize varieties in 1987 has no significant impact on maize yield in Cameroon neither in the first year of intervention nor over time. The apparent increase of maize yield of 0.396 ton per hectare observed in the first year of intervention or release (1987) followed by the apparent decrease in the annual trend of maize yield by 0.017 ton per hectare per year relatively to the pre-intervention trend are not statistically different from zero. The weakness of parameters and their insignificance maybe due to the relatively low sample size. Although the maize yield has continued to increase annually after the release of improved maize varieties at a rate of 0.012 ton per hectare, this increase was insignificant and lower than that of pre-intervention period. A visual inspection of results is provided in figure 2.

Figure 2: Actual and model fitted maize yield in Cameroon before and after release of IMVs



Source: Author's building using STATA

These results contradict traditional micro-studies which often find a positive impact of adoption of improved maize varieties in the literature (Manu *et al.* 2014; Nabasirye *et al.* 2012; Ouma *et al.* 2014; Khonje *et al.* 2015; Takam Fongang, 2016). Two likely reasons may

explain the contrasted results: the poor performance of the so called improved maize varieties across the country and the low adoption of improved maize varieties. The improved maize varieties maybe effective in some parts of the country and not in others due to differences in both soil characteristics and agro-climatic conditions. Accordingly the overall performance of improved maize varieties will be poorer especially if most adopters of improved maize varieties tend to be located in inadaptable areas. The second possible reason explaining the insignificant impact of improved maize is the low adoption of improved maize varieties. Indeed, Although the theory of diffusion of innovations will predict a lower rate of adoption of improved maize varieties in the first year of release and a higher rate over years (Rogers, 1983), the rate of adoption of improved maize varieties has remained low over years. Even if some statistics from the ministry of agriculture and rural development (MINADER) show an increase of adoption's level of improved maize varieties in Cameroon (MINADER, 2012), these statistics may not depict the true reality of the level of adoption of improved maize varieties because of adopters are often assimilated to anybody who declares using improved maize varieties without paying attention to the number of time the improved seeds have been used. In fact, the real adopter refers to a farmer who sows the improved maize varieties either maximum thrice for open pollinated varieties or once for hybrid before renewing the seeds. Based on this latter definition, improved maize varieties adoption's rate in Cameroon tends to remain constantly low over years because the so called "adopters" tend to replant the same improved seeds obtained from previous agricultural campaigns.

4. Conclusion and policy implications

Many studies have shown the positive impact associated with adoption of improved maize varieties in the literature. However, in most studies, the analysis was oriented toward the micro-impact evaluation which is often localized within an area thus neglecting the macro-impact evaluation as well as the long term impact evaluation of adoption of improved maize varieties. This paper adds value to the existing empirical literature in that domain by analyzing the macro and long term impact of adoption of improved maize varieties on maize yield in Cameroon using interrupted time series analysis and data collected from FAOSTAT.

Conversely to past studies, the results have shown that the release of improved maize varieties has no significant impact on maize yield neither in the first year of intervention or release (1987) nor over years. Therefore, the study appeals for further studies to determining the effectiveness of improved maize varieties in boosting the maize yield.

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