

An Estimation of Rice Output Supply Response in Sierra Leone: A Nerlovian Model Approach

Alhaji M. H. Conteh, Xiangbin Yan, Issa Fofana, Brima Gegbe, Tamba I. Isaac

Abstract—Rice grain is Sierra Leone's staple food and the nation imports over 120,000 metric tons annually due to a shortfall in its cultivation. Thus, the insufficient level of the crop's cultivation in Sierra Leone is caused by many problems and this led to the endlessly widening supply and demand for the crop within the country. Consequently, this has instigated the government to spend huge money on the importation of this grain that would have been otherwise cultivated domestically at a cheaper cost. Hence, this research attempts to explore the response of rice supply with respect to its demand in Sierra Leone within the period 1980-2010.

The Nerlovian adjustment model to the Sierra Leone rice data set within the period 1980-2010 was used. The estimated trend equations revealed that time had significant effect on output, productivity (yield) and area (acreage) of rice grain within the period 1980-2010 and this occurred generally at the 1% level of significance. The results showed that, almost the entire growth in output had the tendency to increase in the area cultivated to the crop. The time trend variable that was included for government policy intervention showed an insignificant effect on all the variables considered in this research. Therefore, both the short-run and long-run price response was inelastic since all their values were less than one.

From the findings above, immediate actions that will lead to productivity growth in rice cultivation are required.

To achieve the above, the responsible agencies should provide extension service schemes to farmers as well as motivating them on the adoption of modern rice varieties and technology in their rice cultivation ventures.

Keywords—Nerlovian adjustment model, price elasticities, Sierra Leone, Trend equations.

I. INTRODUCTION

THERE are many problems that seem to affect modern agricultural economics, however, supply response of agricultural produce, particularly crops, appears to be the leading. One of the reasons forwarded by many researchers is due to the responsiveness of cultivators to profitable incentives, which influences the sector's input to the GDP of a nation. Constructive intervention in agricultural sector especially in food pricing policy also contributes greatly in increasing agricultural production. In such a situation, supply

response becomes a leading aspect in understanding the dynamics of price system.

In developing nations such as Sierra Leone, the principal objective of state intervention in agricultural price policy among others are; income equity among cultivators, to reduce food prices for all its citizens and increasing exports, and hence earn a huge foreign exchange.

Some key agricultural produces have been fixed below the global prices and this is achieved by employing trade bottlenecks as well as subsidies, which ensure that prices and issues of local market determine real prices.

In the early 1960s and early 1980s[1], Sierra Leone was food independent and even export some key agricultural crops such as cocoa, coffee, and rice[2] to earn foreign exchange. In addition, rice cultivation was one of Sierra Leone's base sectors of agricultural production that gave the country a place in the mid-1960s for rice exportation in the global market. However, mismanagement in the late 1980s resulted in over dependence in rice importation of this very significant staple grain.

Also, the civil conflict that engulfed the entire nation in the early 1990s to 2001, disrupted agricultural activities[3]. Consequently, there exist a wide food supply-demand gaps [4] and increasing food imports cost [5].

Between 2005 and 2011, the average domestic demand for rice was 700,078 metric tons while the average rice (milled equivalent) supply was only 309,620 metric tons. Therefore, the government needs to embark on rice importation to meet the requirement of its growing population.

Nevertheless, in an effort to increase rice output in the country, the Sierra Leone Government has prioritized agricultural sector as one of the most imperative sectors of the country's economy around which it has focuses its development efforts. However, this is not surprising as agriculture contributes about 48% of the national GDP and employs more than 60% of the national labor force.

Nevertheless, as a good policy, it is required to pioneer the final objective of independence principles which is a required aim of any nation. This type of development policy has major consequences for the changing aspects of both the socio-economic as well as institutional settings in which cultivators perform their daily activities. Agricultural experts have researched and developed a network through which cultivators can improve their competence and output.

However, in the unfolding process of agricultural policy as well as the socio-economic transformations that have continued for many years, what has been the cultivators' normal response regarding rice cultivation in Sierra Leone?

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What has been the impact on rice cultivation due to restriction on rice imports? Or how has rice import embargo, prompted by the self-sufficiency determination, does it has influence on the short-run supply as well as long-run rice supply response in the country? Or do the policies introduced successful for satisfactory rice output supply response by the general farming community? Do the output, price, non-price incentives or supply shifters satisfactory?

Rice in Sierra Leone is grown within the upland regions, using the environmentally damaging, slashing and burning system of cultivation which are been discouraged by the agricultural authorities. About 95% of the Sierra Leonean farmers reside in the rural communities where they derive their livelihoods from agricultural activities. And yet, each year the country do imports about 39% of the staple food. Subsistence rice farming is the leading agricultural activity that is practice by nearly 85% of the farming families. Though farmers do cultivate other crops such as sweet potatoes, cassava, and vegetables, rice is evidently the primary crop cultivated by most farmers.

Sierra Leone requires about 830,000 mt of milled rice[6] yearly to meet the consumption requirements of its population. The national paddy rice production was estimated at 525,000 mt in 2002 and 639,000 mt in 2004. The level of rice independence rose from 57.48 percent in 2002, to 69.50 percent in 2005 and followed by 71 percent in 2011. This implies the rest must be imported at an increasingly expensive price in the existing situation of high prices for foodstuffs including rice.

Seventy-four percent of the land area of the country, covering 5.6 million hectares is appropriate for cultivation. This area comprises 1.1 million hectares of lowland and 4.3 million of upland. About 88% of the lowland ecology is arable and suitable for rice cultivation, and these comprise the fertile inland valley swamps that are found in all the farming communities in the country, the deep flooding riverin grasslands in the southern province, the less fertile saucer shaped bolilands in the northern region and the tidal mangrove swamps of the North-Western coastal belt.

Improved rice varieties and modern rice cultivation techniques have been established and make known among most farmers in the country. Although there were low rates of adoption of improved agricultural techniques as well as improved rice varieties[7].

As the population and demand for rice grain are on the increase in Sierra Leone without a corresponding increase in domestic output of the grain, importation of this grain turn out to be crucial. Figs.1 and 2 revealed that, generally as the demand for rice grain in Sierra Leone has been increasing by 1,368,000 (mt) annually between the period 1980 and 2010, the domestic rice (milled equivalent) supply is only 992,000 (mt), and hence, this indicates that the government must import the difference to meet the domestic requirement. For instance, the average domestic demand for rice is 700,078 metric tons while the average rice (milled equivalent) supply is only 309,620 metric tons of the same period (1980-2010). Therefore, the government needs to embark on rice

importation to meet the requirement of its growing population. Also, as indicated by Figs.3 and 4, that Sierra Leone has been extremely embarking on rice grain importation and as such both quantity and cost (in US dollars) display negative trends indicating that there is a decrease in rice importation as result of the insufficient US dollars and lack of foreign exchange or reserve. Assuming that the importation of rice grain is in US currency, which Sierra Leone lacks, this will have a negative implication on the balance of payment deficit. Also, high exchange rate can worsen the situation as imports and debts servicing expenses increase with their opposing effects on domestic output, more public resources would be used to repay foreign debt. The importation of foodstuffs at higher prices could hardly be seen effective in resolving the problems of nutritional requirements since increase in foreign costs would be transferred to higher retailing prices of the rice grain in the local markets.

Therefore, the government endeavors to find ways of decreasing foreign debts through a transformed interest in agricultural supply response policy. Consequently, a clear consideration of the beliefs and issues influencing the forces of domestic rice supply and demand in Sierra Leone can create a serious problem in its policy making. Hence, this study thought to be of a direct application in rice cultivation policy decisions in Sierra Leone and in other developing nations confronting comparable circumstances.

A. Trends in Rice Output, Its Demand and Importation, 1980-2010

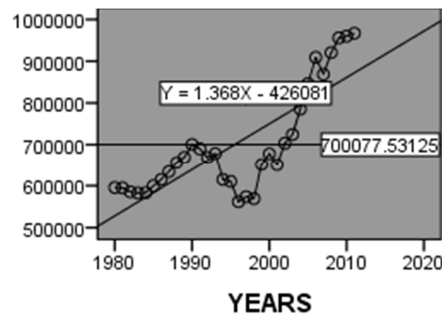


Fig.1 Domestic demand for rice (Mt)

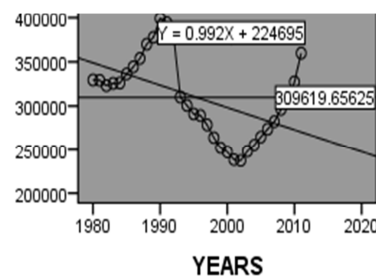


Fig. 2 Domestic rice supplied Mt)

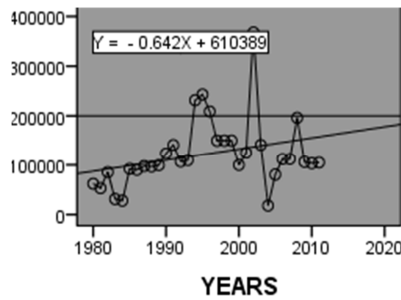


Fig. 3 Quantity of rice imported (Mt)

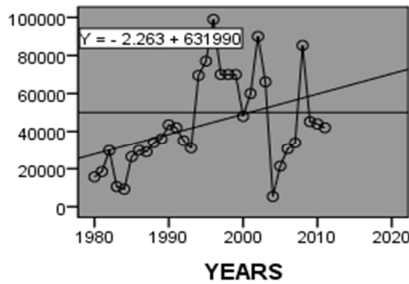


Fig.4 Value of imported rice (\$ 000)

B. Problem Statement and Research Questions

Recently, rice has become a staple food for both urban and rural consumers [8] throughout West African including Sierra Leone. Yet, the West African region has observed a sharp drop in per capita agricultural food production within the last two decades. However, attempts are ongoing to reverse that trend by significantly increasing food supplies for its growing population. Western Africa experienced slow growth in the agricultural sector [9].

Rice production has been increasing more rapidly than population in many parts of the world, but Africa has been declining behind with the exclusion of very few countries such as Kenya and Nigeria that witness to have made some improvements in food security. This difference between production and increase population growth in Africa is impacting negative effects including external debt burden. The World Food Program (WFP) accounted that, for more than 60% of the food aid delivery to Africa, assisted about 36.4 million people in 2003[9], while in 1999, it assisted about 20 million [9]. Besides numerous other economies, rice takes a central position in the economy of Sierra Leone and its state of production has both political and socio-economic implications. The country was an exporter of rice until 1960s, and there is evidence that Sierra Leone was self-sufficient in rice[10], the national staple, during certain periods [11]. Yet, this was not continued.

Sierra Leone's rice status had changed from being an exporter to an importer of rice [12]. The insufficient status of rice cultivation in Sierra Leone has resulted in high prices and an annual increase in expenses on the importation of several goods including rice grain.

This has created serious problems regarding the supply as well as demand for these commodities in addition to the use of

infrequent foreign reserve on the importation of these supplies that could have been competently produced in the country. These disparities in the annual domestic production of such crops are attributed to acreage cultivated and the output of these crops.

For this study, acreage allocation, productivity and output of the crops are the variables of interest. Consistent with other researchers, the prerequisite to increase food production in Sub-Saharan African has been emphasized in diverse summits. Agricultural output and total annual food production in Sierra Leone are miserably poor. The quality change in agricultural output is limited by its prominence. There are various factors responsible for the low performance of the sector, however, as stated by Scherr[13], that soil quality contributes relatively more to agricultural output in low-input production environments. Nevertheless, other scholars stated that in spite of all technology, capital and other resources that are invested into the agricultural sector, the rate at which agricultural productivity is continuing in Sierra Leone is disappointing. However, there is wide-spread of low productivity for key agricultural crops in Sierra Leone[14], and this mostly attributed to many factors including poor institutional environment. Inconsistency in agricultural produce in Sierra Leone was higher between 2006 and 20011 than in 1992-2005[15]. Some short-term analyses carried out by the Sierra Leone Agricultural Research Institute and the ministry of Agriculture, Forestry and Food Security (SLARI-MAFFS., 2012) revealed that, the annual coefficient of variation for key agricultural crops in Sierra Leone was far below the expected[16] between these periods. From this observation, there is need for a long-term research on this variation.

In line with FAO (2007), the inconsistency between the rates of increase in total productivity (yield per hectare) and production (output) shows that on average, households cultivate slightly less than one hectare of fertile land [17].

Repetto [18] discoursed that low productivity and reduction in output and farming activities are as a result of the increasing use of minimal lands.

Hence, this study will investigate the following research questions:

In what way does productivity and cultivated area previously influence the crops output?

What are the major contributions of productivity and cultivated area to the output of the crops?

Periodically, what is the status of the variations in these significant variables in the Sierra Leone rice cultivation?

To achieve the above, this study attempts to apply the Nerlovian adjustment model to the Sierra Leone's rice cultivation situation. The Nerlovian Adjustment model being most popular supply response model[19], has been chosen in explaining possible variations[20]. It is frequently used because it incorporates all significant variables[21]. The Nerlovian model is a dynamic model, which state that output is a function of expected price, output (area) adjustment, and some exogenous variables[22]. Specifically, this study assesses the response of rice cultivation to agricultural policies starting from 1996 (when policy was introduced) as well as

estimating the price supply response elasticities [23] for rice, established the rate of adjustment of rice output with respect to policies, and to determine the main sources of development in rice cultivation.

II. METHODS AND MATERIALS

A. Sources of Data

Through the help of the internet and search engines such as Google scholar, some data on rice yield, output and prices over the years were retrieved from Food and Agricultural Organization database (FAOSTAT, 2012). Other data were from government agencies in Sierra Leone such as, the Ministry of Agriculture, Forestry [24] and Food security (MAFFS); the Sierra Leone Agricultural Research Institute (SLARI); Statistics Sierra Leone (SSL), International Financial documents, Organization for Islamic Nations database and African Development Indicators documents.

Additionally, the study sourced information from published articles in reputable journals.

The data set covers the period 1980-2010[25].

B. Technique of Data Analysis

In an attempt to test the response of rice cultivators to price, the model that is used is the Nerlovian adjustment [26], which allows the adjustment to changes in the price to be spread for more than one year [27]. In recent years [28], the same model has been adopted and used in many studies of agricultural production [29] by many economists to data of various nations since producers are expected to adjust to different production and macro-economic environments[30].

The model is fitted within the Nerlovian dynamic models framework[31], hence, it is expected that the desired rice output(Q^e) can be given by the succeeding long-run function:

$$LnQ_t^e = \alpha + \beta LnP_{t-1} \quad (1)$$

where, P represents the price of rice at time t, Ln is the natural logarithm

Again, from assumption, the actual rice output (Q) does not instantaneously tend to (Q^e) as P changes, instead its response is in accordance with the succeeding sequence:

$$LnQ_t - LnQ_{t-1} = \pi (LnQ_t^e - LnQ_{t-1}) \quad (2)$$

where the adjustment rate (π), conforms to

$$0 \leq \pi \leq 1 \quad (3)$$

Putting (2) into (1) and introducing the time trend(t) for the justification of such effect as improvements in agro-technology in addition to policy structurings on rice and including a disturbance error term(δ), then, the full model function can be reduce to:

$$LnQ_t = S_0 + S_1 LnQ_{t-1} + S_2 LnP_{t-1} + S_3 t + \delta t \quad (4)$$

where,

$$S_0 = \pi\alpha, \quad S_1 = 1 - \pi, \quad S_2 = \pi\beta \quad (5)$$

and δ is assume to obey the resulting expression

$$\delta t = \theta \delta_{t-1} + \epsilon t \quad (6)$$

where,

$$E(e) = 0; \quad Cov(e) = \epsilon^2 I \quad (7)$$

where, β is the long-run price elasticity [32] and S_t is the short-run price elasticity of supply [33] with respect to the dependent variable [34]. For this study, area (acreage=A), output and productivity (yield) are however, used separately as dependent variables in diverse equations.

The diagnostic statistics of interest include the standard error of regression (SE), R^2 , estimates of θ as well as π and Durbin- H statistics, since Durbin Watson statistics is not applicable in this situation.

For comparison, the regression model is supposed to be re-estimated without involving the time trend; that is

$$LnQ_t = K_0 + K_1 LnQ_{t-1} + K_2 LnP_{t-1} + \sum t \quad (8)$$

The time trend t symbolizes the post 1980 era as zero and one; otherwise it is represented as the policy period on rice cultivation, this formulation is used to assess the response of rice cultivation without involving the trend variable (t).

C. Trend Equations

The generalized trend equations were estimated for each of the variables[35], with time (t) as the response variables in all the instances.

The generalized trend equation can be express as:

$$LnQ_t = c + \Re t + z \quad (9)$$

This study aims at achieving the growth rate of the variable and this can be illustrated as:

$$\Psi = \left[(\exp \Re)^{-1} \right] \times 100 \quad (10)$$

where the growth rate decomposed (\Re) into the contributions to productivity (yield=Y) and output (Q) by area (acreage=A).

Eviews software was employed in estimating the Nerlovian models as well as estimating the equations.

III. RESULTS AND DISCUSSIONS

Table I shows the results of the trend equations for all the variables of inclusion with respect to the given period. From

Table I, the output (Q) and the area (acreage=A) documented positive growth rates in all instances, while Productivity (yield=Y) only documented positive result in the 1980-1995(pre-embargo era). However, it documented negative results for both the embargo and post embargo eras (1996-2010) and over the whole period of 1980-2010.

TABLE I
VARIABLES GROWTH RATES

Growth rate (R)	Output(Q)	Area(acreage=A)	Productivity (yield=Y)
1980-2010	9.06	10.23	-0.94
1980-1995	10.12	8.09	3.16
1996-2010	5.10	10.01	-5.07

Source: Authors' analysis, 2013

TABLE II
GROWTH RATES DECOMPOSITION RESULTS

Growth decomposition	Output(Q)	Area(acreage=A)	Productivity(yield=Y)
1980-2010	100	96.0%	- 6.5
1980-1995	100	82.4	26.1
1996-2010	100	198.0	- 83.0

Source: Authors' analysis, 2013

Table II comprises of the growth rate decomposition results. In period (1980-2010), the area (acreage=A) contributed approximately 96.0% of the output whereas Productivity (yield=Y) documented a reduction of 6.5 % regardless of the rice policy that was in operation in the country. During the pre-reform period (1980-1995), the area (acreage=A) contributed 82.4% to the total output, and Productivity (yield=Y) accounted for approximately 26.1% of the total output.

During the period (1996-2010), the area (acreage=A) was accountable for 198.0% of output with Productivity (yield=Y) recorded a reduction of 83.0% contribution to the output. However, time had a major effect on all variables of inclusion (in the trend equations). For the parameters, six were significant at the 1% level and the three were significant at the 5% level (Table VII).

Again, it should be understood here that time had a significant and positive effect on both output and area for these periods and positive effect on the Productivity (yield=Y) for 1980-1995 sub-period even though it had a significant and negative effect on the Productivity (yield=Y) for both 1980-2010 and 1996-2010 sub-periods.

Table III shows the regression estimates of the supply response [36], for rice with time trend as a response variable. All estimated coefficients for both lagged output (S_1) and price (S_2) have the expected signs and are reasonable; and the goodness of fit for the estimated equations [37] as measured by R^2 is reasonably good [38].

In all the instances, the value of R^2 ranges between 0.55 and 0.88 and the coefficients of the estimated lagged area variable are significant at the 1% level. The coefficient of the estimated price is negative and significant only for yield at the 10% level.

All the parameters that are involved in trend equations are not significantly different from zero. For the effort of comparison, this result inclines to support the estimation of a model that lacks this variable.

Table IV displays the results of the model that lacks the trend variable. Here, all the coefficients of the estimated lagged output are positive and statistically significant at the 1% level of significance[39]. It is however good to state here that, all the coefficients of the estimated price are statistically significant at the 10% level of significance[40].

In comparing this second results to the first, one can deduce that the second model is better than the first.

Also, the R^2 for all equations in the second model are practically equivalent as those in the first model for all the instances. Correspondingly, the standard errors of regression are almost equivalent as those in the first model.

The coefficient of adjustment (π) for the variables is sufficiently close to one another. But since they range between 0.30 and 0.34 (Tables III and IV) and all are less than 0.5, the rate of adjustment of production is slow. However, if $\pi \geq 0.5$, the rate of adjustment is regarded as faster.

TABLE III
MODEL WITH TREND VARIABLE

Variable	S_0	S_1	S^2	S^3	R^2	SE	$\rho(\theta)$	H	π	β	DW
Output(Q)	2.98 (2.51)	0.72*** (5.19)	0.08 (0.87)	0.27 (0.55)	0.81	0.31	0.06	0.41	0.34	0.29	1.845
Area(acreage=A)	3.01 (1.64)	0.74*** (6.01)	0.06 (1.41)	0.09 (0.73)	0.88	0.27	-0.03	-0.44	0.31	0.31	2.082
Yield(Y)	2.89 (2.76)	0.64*** (4.88)	-0.08* (1.55)	0.16 (1.08)	0.55	0.24	-0.26	-0.21	0.36	-0.18	2.367 Df= 34

Source: Authors' analysis, 2013, *** Significant at 1% & * Significant at 10%

TABLE IV
MODEL WITHOUT TREND VARIABLE

Variable	S_0	S_1^1	S^2	S^3	R^2	SE	$\rho(\theta)$	H	π	β	DW
Output(Q)	2.65 (2.21)	0.73*** (5.51)	0.10* (1.02)	-	0.81	0.31	0.06	0.41	0.33	0.38	1.837
Area(acreage=A)	2.92 (1.61)	0.74*** (6.04)	0.09* (1.51)	-	0.88	0.27	-0.01	0.35	0.31	0.40	2.071
Yield(Y)	2.77 (2.41)	0.70*** (5.12)	-0.05* (1.76)	-	0.54	0.22	-0.32	2.69	0.30	-0.10	2.513 Df=34

Source: Authors' analysis, 2013, *** Significant at 1% & * Significant at 10%

A. Test of Autocorrelation:

Durbin-Watson (DW) statistic is a test statistic [41] used to detect the presence of autocorrelation in the residuals from a regression analysis [42]. It is the most renowned test for detecting autocorrelation [43], developed by Durbin and Watson [44].

Nevertheless, the test is valid only if the subsequent conditions hold; the study uses a time series data, there exist a constant in the equation, that autocorrelation is of the first order[45] and the equation does not include lagged values of the dependent variable[46] as regressor.

For this study, all the equations have lagged values of the dependent variable[46] as regressor; and since this is the situation, a modified of DW recognized as Durbin-H statistic is employed to perform the test. This test statistic can be express as follows:

$$H = \left(1 - \frac{1}{2DW}\right) \sqrt{n} / 1 - (nVar\beta) \quad (11)$$

where, DW is the calculated DW statistic, Var (β) is the variance of the coefficient of the lagged dependent variable [47], and n is the sample size.

The H statistics for both the output and area equations are respectively 0.41 and -0.44 for the trended equations. When these values are compared with the critical Z-score ($Z=1.645$) at 5% level of significance, we noticed that both H values are less than the Z value, therefore, the null hypothesis that $\theta = 0$ (there is no autocorrelation in the equation [2]) is accepted. These results are in accordance with those of Getis[48]. Hence, for these equations, the θ values are respectively 0.06 and -0.03. Nevertheless, for the trended yield equation, the H statistic is -0.21 with θ value of -0.26 and in absolute value, this is greater than 1.645. This implies that there exist a negative first-order autocorrelation[49] in its equation. A comparable result is also achieved for the untended equations. Here, the output as well as the area equations carries H statistics of 0.41 and 0.35 respectively. Therefore, the null hypothesis $H: \theta = 0$ is accepted in all the instances. Consequently, there is no autocorrelation in these equations. However, the yield equation, revealed a negative first order correlation.

Tables V and VI display the estimates of price elasticities[50] for the models with trend as well as without trend respectively. We noticed that, there are small variations in the estimates for both the short-run and long-run models. However, the long-run estimates are relatively higher than the short-run estimates. Again, we can see that the short-run as well as long-run price elasticities are all less than one and thus, they are inelastic.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

From the analysis above, we noticed that the short-run as well as the long-run prices response elasticities are both less than one. The coefficients of adjustment are also less than 0.5, and therefore are regarded as inelastic.

From the aforementioned findings, however, immediate actions that will lead to efficiency growth in rice cultivation or its production are required

To achieve the above, the responsible agencies should provide extension service structures to farmers as well as motivating them on the adoption of modern rice varieties and technology in their rice cultivation or production ventures.

TABLE V
ESTIMATING PRICE ELASTICITIES USING POLICY DUMMY

Variable	Short-run	Long-run	Differential
Output(Q)	0.04	0.16	0.12
Area(acreage=A)	0.07	0.31	0.24
Productivity(yield=Y)	-0.06	-0.18	0.13

Source: Authors' analysis, 2013

TABLE VI
ESTIMATING PRICE ELASTICITIES THE ABSENCE OF POLICY DUMMY

Variable	Short-run	Long-run	Variance
Output(Q)	0.06	0.25	0.19
Area(acreage=A)	0.09	0.40	0.31
Productivity(yield=Y)	-0.03	-0.10	0.07

Source: Authors' analysis, 2013

TABLE VII
ESTIMATED PARAMETER FROM THE TREND EQUATION

Variable	Output(Q)	Area(acreage=A)	Productivity(yield=Y)
1980-2010	0.0815*** (18.134)	0.0594*** (5.9964)	0.0311** (5.0011)
1980-1995	0.0794*** (7.0081)	0.0886*** (10.6542)	0.0512** (10.9873)
1996-2010	0.0542*** (5.0765)	0.0910*** (23.8760)	0.0059** (1.6786)

Source: Authors' analysis, 2013, *** Significant at 1% & ** Significant at 5%

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