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Research Article

Productivity and Harvested Area. Analysis Short and Long - Term Relationship in Ecuador

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Abstract

The relationship between farm size and productivity is a recurrent topic in development economics, almost as old as the discipline itself. This paper emphasizes the importance of determine the relationship between productivity and harvesting area in Ecuador, period 1960-2016, autoregressive models and vector error correction will be implemented, which will reveal whether the variables have a short or long term relationship. The main results allow us to determine that the production of bananas and cocoa beans fulfill a long and short term relationship; whereas, green coffee and palm oil only fulfill a short-term relationship; at the same time, it is verified that the inverse relationship between farm size and productivity is also fulfilled in this study, since the greater the harvesting area of these products is, it generates lower agricultural productivity.

Keywords: Productivity; Harvesting Area; Yield; Food Sovereignty

Introduction

The factors of nature and human activity, generate several changes in the relationship between agricultural productivity and the area devoted to harvesting; that is why agricultural productivity is fundamental for the development of countries that possess an agriculture based economy, at the same time, it is fundamental to achieve social welfare through food sovereignty.

Productivity and crop yields worldwide are susceptible to several natural changes such as pests, land use and external agents such as the applied agricultural supplies [1]. That is why authors like Vieira and Fornazier [2] say that to evaluate agricultural productivity between and within countries it is necessary to determine the technological and productive differences that allow better crop yield.

According to Zilio (2012), in the case of underdeveloped countries show a different behavior of the relationship between economic growth and the environment, because most of the protected areas are in constant competition with the agricultural, livestock and industrial sectors; while, in developed countries, environmental quality is demanded by the population since their basic needs are complete. Similarly, Ekins [3] affirms that the poorest sectors, mainly rural, are most vulnerable to environmental degradation due to greater reliance on natural resources.

Therefore, adequate use of natural resources is one of the objectives of environmental economics; additionally, within agricultural activities it is considered a key element to achieve high agricultural productivity, resulting in the development of this economic sector, which in turn will guarantee the food sovereignty of the population [4]. The productivity of the agricultural sector according to the United Nations Food and Agriculture Organization [5], is also influenced by the redistribution of labor and capital factors within an economy, since most of them are displaced towards the industrial and services sectors. According to Anríquez, Foster and Váldes [6], agricultural reforms can also boost the increment of agricultural production; such is the case of Brazil, Argentina and Chile, which after the implementation of reforms, could achieve an annual growth in agricultural exports of 3%, due to strong institutions and policies to improve family farming.

Based on these approaches, and in order to determine the relationship between the harvesting area and agricultural productivity, data from Ecuador existing in the FAO is being used, the variables of agricultural area, yield and production of: bananas, cocoa beans, green coffee and palm oil, all measured in tons; considering that these products are the most influential in the non-oil exports of the country [7].

This article analyzes the determinants of the relationship between productivity and harvesting area in Ecuador. The rest of this article is structured as follows: The following section presents the theoretical framework and empirical studies related to the relationship between the size of the farm and agricultural productivity. The subsequent section describes the materials and methods. Next, the results are described. The following section presents the discussion of the results including an analysis of public policy, while the final section includes.

Theoretical framework and hypothesis development

As an approximation, it links up the existing theory of the relationship between farm size and productivity, which has generated several criticisms and empirical contributions; starting with the studies given by Sen [8] in India, demonstrating that crop productivity decreases to an increase in farm size; also, Berry and Cline, at the end of the 70s, contribute significant econometric results for this study [9].

On the other hand, Bhalla and Roy [10] and Benjamin (1995), reported that the quality of the unobserved land is directly related to the productivity of the farm, but it is negatively related to the size of the farm, which could explain the inverse relationship between the size of the farm and the productivity. According to Masterson [11], differences in the quality of land can be the result of either: natural differences in soils and the ones made by man, such as fertilizers that could lead to a better quality of land.

However, Ladvenicová and Miklovičová [12], in their study about the inverse relationship in Slovakia, highlighted the idea of Havnevik and Skarstein about land ownership and agricultural productivity, here they argue that smaller farms are more productive in the short term, but in the long term, this soil productivity decreases due to excessive cultivation of the land to maintain productivity. Whereas, Dyer (1996), mentioned that larger farms generally have a greater relationship between land, labor force and capital, which weakens the inverse relationship under study.

According to Sen [13], the dualism of the labor market is also introduced, here people prefer to work on their own or with their family rather than hire someone else. An empiric study of agriculture in Nepal shows that the family size coefficient reveals the importance of family labor in farm productivity in most rural areas, in addition, the evidence found rejected the hypothesis that the inverse relationship is due to decreasing returns to scale (Sridhar, 2007).

Several theoretical and empirical studies analyze different agents and their impact on farm size and productivity, as well as other variables, qualitative or quantitative, that have a positive or negative impact on the relationship under study. Some of these studies describes the inverse relationship in different cities or nations, likewise, it indicates the impact agents that are used to affirm or contradict this relationship through different econometric techniques (Table 1). Later, this information will be useful to analyze the discussion of the results, where it will be possible to determine if the present research shows similar results for the variables used.

Material and Methods

For the empirical analysis, data from series time have been selected from the United Nations Food and Agriculture Organization' statistical sources [18]. The data used is from annual intervals, corresponding to the period between 1961 and 2016; therefore, to meet the objective of determining the relation between harvested area and productivity, data from Ecuador is being used with the following variables: agricultural area measured in hectares, yield and production of bananas, cocoa beans, green coffee and oil palm, measured in tons. Variables units and description are detailed below on Table 2.

The analysis of the harvested area ratio and long-term productivity will be done using the vector autoregressive (VAR), and the vector error correcting (VEC) to determine the short-term ratio. The VAR model considers several endogenous variables as a whole, but each endogenous variable is explained by its lagged or past values and by the lagged values of all the other endogenous variables in the model. To determine the ratio of harvested area and long-term productivity (VAR), equations 1 and 2 are proposed:

$$\Delta SA_t = \alpha_O + \alpha_1 \sum_{i=1}^{n} PA_{t-i} + \alpha_2 \sum_{i=1}^{n} \Delta SA_{t-i} + \mu_{1t} \quad (1)$$

$$\Delta PA_t = \alpha_3 + \alpha_4 \sum_{i=1}^{n} \Delta SA_{t-i} + \alpha_5 \sum_{i=1}^{n} PA_{t-i} + \mu_{2t} \quad (2)$$

Where Δ is the operator of first differences; SA_t is the agricultural surface; while PA_t is agricultural productivity, and finally the μ_t parameter is called stochastic error. According to the authors Gujarati and Porter [19], the variables of time series in levels are non-stationary, which means that the variables increase or decrease with the passage of time. Therefore, it is necessary to verify if the two series have this behavior, for which the Dickey and Fuller Augmented test (1979) is applied, which is indicated later in the Results section.

To verify if there is a short-term equilibrium, the VEC model is implemented, according to Gujarati and Porter [19], the short-term equilibrium implies that the dependent variable responds immediately to the shocks of the independent variable. The error correction model known as VEC proposed by Engle and Granger [20] states that the error term obtained in the VAR model is delayed by one period and is included as an independent variable in the VEC model. With these elements, the VEC model is presented in equations 3 and 4:

$$\Delta SA_t = \alpha_O + \alpha_1 \sum_{i=1}^{n} PA_{t-i} + \alpha_2 \sum_{i=1}^{n} \Delta SA_{t-i} + \alpha_3 E_{t-1} + \mu_{1t} \quad (3)$$

$$\Delta PA_t = \alpha_4 + \alpha_5 \sum_{i=1}^{n} \Delta SA_{t-i} + \alpha_6 \sum_{i=1}^{n} PA_{t-i} + \alpha_7 E_{t-1} + \mu_{2t} \quad (4)$$

In addition to the variables previously defined, E_(t-1) is the equilibrium error of the VAR model generated to verify the existence of short-term equilibrium. According to Gujarati and Porter [19], if the parameter or coefficient associated with this term is statistically significant, it is concluded that there is equilibrium in the VEC model. In the logic of this research, if in the VEC model there is equilibrium in the short term, it means that the agricultural surface has immediate changes before variations in productivity.

Results

The following section shows the results of a VAR and VEC analysis, to determine if the variables raised affect the relationship of the agricultural area and productivity. To better understand the results, this section also shows the statistical data specifically regarding the yield and production of the four analyzed products (bananas, cocoa beans, green coffee and palm oil), as well as the Dicky Fuller unit root test to determine the non-stationarity to ensure the model.

Source	Impact factors	Factors to which impact	Impact	Other aspect
Chen, Huffman and Rozelle. [14]	Output Land area (heterogeneities) Number of household members Equipment and machinery	Small-scale agriculture	Positive Positive Positive Negative	Log, Endogeinity test
Thapa, S [15]	Output per hectare Cropland Labor hours Cash input per hectare Ratio or irrigated land Villages Family size Manure per hectare	Farm size and productivity, Returns to scale	Negative Negative Positive Positive Positive Positive Positive Positive	Log, Cobb-Douglas (CD)
Verschelde, D'haese, Vandamme and Rayp [16]	Agricultural output Size cultivated land Family labor Labor cost Total cost production inputs Share staple crops Share coffee Share banana Share under step slope Share good quality soil Fragmentation index Age of household head Share income off-farm Use of chemical Use of animal manure Extension visit	Farm size and productivity, Returns to scale	Positive Negative Positive Positive Positive Positive Positive Positive Positive Positive Negative Positive Negative Positive Positive Positive	Cobb Douglas, Log, Translog specification, Nonparametric Kernel regression
Ladvenicová and Miklovicová [12]	Farm a rea planted Credits per hectare Legal form Natural conditions	Output per hectare	Negative Positive Positive Positive	Least-squares, Fixed effect model
Helfand and Taylor [17]	Capital per hectare Family Labor per hectare Inputs per hectare Intermediate	Farm size and land productivity	Positive Positive Positive Positive	Quadratic Specification, Cobb Douglas, Total Factor Productivity Index, Pseudo Panel

Table 1: Empirical studies of the relationship between agricultural productivity and harvested extension.

Variable	Units	Description
Agricultural Area	Hectares	Extension and surface of cultivated land, sown and harvested.
Performance		
Bananas yield	Tones	Maximum performance that can be achieved by a particular crop in a specific area, considering the biophysical limitations climate and soil.
Cocoa beans yield	Tones	
Green coffee yield	Tones	
Palm Oil yield	Tones	
Production		
Bananas production	Tones	Generate foodstuffs with proper use of natural resources.
Cocoa production	Tones	
Green coffee Production	Tones	
Palm Oil production	Tones	

Table 2: Description of the variables used in the vector autoregressive (VAR) model.
Source: (FAO, 2016).

Variable	Mean	Standard deviation
a) Agricultural area		
Agricultural Area	6,634.00 thousand has	1,274.61 thousand has
b) Yield		
Bananas yield	24.95 tones	6.91 tones
Cocoa beans yield	0.28 tones	0.07 tones
Green coffee yield	0.27 tones	0.10 tones
Palm Oil yield	10.47 tones	3.30 tones
c) Production		
Bananas production	4,117.53 tones	1,944.06 tones
Cocoa beans production	86.46 tones	36.44 tones
Green coffee Production	75.10 tones	48.02 tones
Palm oil production	1,005.16 tones	974.46 tones

Table 3: Estimation of the mean and standard deviation of: a) Agriculture area; b) Yield and c) Production of bananas, cocoa beans, green coffee and palm oil in Ecuador.

Source: Authors computation from data FAO (2016).

The average agricultural area in Ecuador is 6,634 thousand hectares with a standard deviation of 1'274.000 hectares, both for performance and for the production of the four products under study (Table 3a).

Banana and palm oil yield variables are in greater proportion than their average (24.95 and 10.47 tons), with a standard deviation equal to 6.91 and 3.30 tons, respectively. While, for the cocoa and coffee yield variables, values of 0.10 and 3.30 are determined corresponding to the standard deviation of the latter, however, these results do not differ in a greater proportion from their average, 0.28 and 0.27 tons, respectively (Table 3b).

The banana production variable is the one with a very high average (4'117.532 tons) in comparison with the other products, likewise its standard deviation shows an extensive and distant value from its average, equal to 1'944,060. The palm oil production variable is another one that shows distant values, but to a lesser degree than the aforementioned, being its average of 1'005.160 tons and a standard deviation of 974.465 tons. As analyzed in the first group, cocoa and coffee production have values of both average (86.46 and 75.10 tons) and standard deviation (36.44 and 48.02) very close (Table 3c).

Agricultural area and productivity over time

With the obtained data, graphs are made to analyze their evolution over time, as well as the correlation between the size of the farm and the productivity of each of the products under analysis.

Figure 1 shows that the total agricultural area in Ecuador has maintained a practically constant behavior over the analyzed period, although there are two important points, the first one being a growing increase starting in the mid-70's, followed by a pronounced decline in 2012 with a negative trend up until the last year of analysis. The reduction of the agricultural surface can be positive for the preservation of the environment, however, it also generates a problem in the dependent economies of the agricultural sector by indicating that there is a reduction in the use of this natural resource.

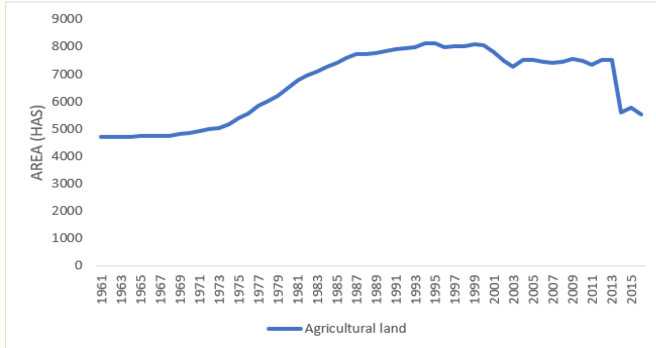

Figure 1: Evolution of the agricultural area in thousands of hectares Ecuador in the period 1960-2016.

Source: Authors computation from data FAO (2016).

In this context, the behavior of the production of bananas, cocoa beans, green coffee and palm oil is also analyzed to meet the research objective of determining whether the agricultural productivity of these products is influenced by the agricultural area.

Figure 2: Evolution of banana and palm oil production in tonnes in Ecuador in the period 1960-2016.

Source: Authors computation from data FAO (2016).

Figure 2 shows the evolution of banana and palm oil production in Ecuador between 1960 and 2016. The behavior of banana production could be due to the fact that banana exports in Ecuador represent 2% of the general GDP and approximately 35% of the agricultural GDP; It also highlights that the production of bananas in the country is generated by the family economy and the Economía Popular y Solidaria (EPS), being located in the provinces of El Oro, Guayas and Los Ríos in 41%, 34% and 16%, respectively [21]. The production of palm oil in Ecuador has had a constant behavior in its production, according to Report on the Palmiculturist Sector issued by the Ministerio de Comercio Exterior [22] mentioned above it, states that palm oil also has a significant contribution to agricultural GDP of approximately 4%, with an average annual growth of 8%, and managing exports of about 58% of its production. In addition, this sector generates around 150,000 jobs in the marginal and vulnerable areas of the provinces of Esmeraldas, Sucumbíos, Santo Domingo, Los Ríos and Pichincha, since palm oil is produced by 99.7% of small and medium producers.

Figure 3: Evolution of cocoa beans and green coffee production in tonnes in Ecuador in the period 1960-2016.

Source: Authors computation from data FAO (2016).

Figure 3 shows the evolution of the production of cocoa beans in Ecuador for the period 1960-2016. According to statistics from the Ministerio de Agricultura y Ganadería [23], cocoa beans have an agricultural share of 12%, with an export weight of approximately 295 tons, the places where there is greater sowing of cocoa are Guayas, Los Ríos, Santo Domingo, Cañar and El Oro. Whereas coffee with crops in the provinces of Manabí, Loja, El Oro and Azuay achieves agricultural participation of 1.3%, with around 14,000 tons of exports. The evolution of the production of green coffee in Ecuador shows little constant behavior until the mid-nineties, then there are continuous increases and decreases until the beginning of 2000, and finally a negative trend continues to the last year of analysis. This atypical behavior in the period 1994-2004 decade is due to the effects of a special law for the coffee sector and the generation of an agency that financed 2% of exports, resulting in the largest coffee production group in the country. The country takes advantage of the imports of coffee with a zero tariff, decreasing traditional coffee production and increasing the consumption of international soluble coffee [24].

The analysis of the evolution of the harvested area and the production of bananas, cocoa beans, green coffee and palm oil are useful to know and then compare the analysis of the statistical tests and econometric models that will be used to determine the relationship between the harvested agricultural area and productivity.

Non-stationary processes

This section is going to show the results of the statistic Dicky Fuller unit root test to determine the non-stationarity of a time set; this way the statistical and critical values are detailed below through the Dicky Fuller test.

The agricultural area has a Z-value of 58.2%, which complies with the established values to accept the null hypothesis of non-stationarity (Table 4a). Meanwhile, the yield of bananas and palm oil have Z values of 0.65 and 0.17, respectively, which are valid to accept non stationarity. However, the yield of cocoa and coffee have no significant Z values (Table 4b), However, regarding production, three of the four products have significant values, which means, bigger than 0.05, being: 0.86 for bananas, 0.65 for coffee and 0.89 for palm oil; only cocoa has a value lower than that required to accept the non-stationarity (Table 4c).

Variable	Statistic Test	Z (t)
a) Agricultural area		
Agricultural Area	1.39	0.58
b) Yield		
Performance Bananas	1.23	0.65
Cocoa beans yield	4.98	0.00
Green coffee yield	4.85	0.00
Palm Oil yield	2.27	0.17
c) Production		
Bananas production	0.61	0.86
Cocoa beans production	3.22	0.01
Green coffee Production	1.23	0.65
Palm oil Production	0.47	0.89
Residuals	5.20	0.00

Table 4: Estimation of the non-stationarity through Dicky Fuller of: a) Agricultural area; b) Yield and c) Production in Ecuador.

Source: Authors computation from data FAO (2016).

Determinants of the relationship between productivity and harvesting area

Vector autoregressive (VAR) results

To start the analysis of the VAR model, some results indicate that there is the presence of unit roots so it is essential to apply first differences to the production and performance variables of the four products under analysis (bananas, cocoa beans, green coffee and oil palm) in order to convert them in order I.

After the calculation of the lags, the autoregressive vector was estimated, obtaining the parameters, standard errors, value and Z probability that are shown below.

In Tables 5a and 5b it is shown that at a level of significance of 99% of the agricultural area and the yield of bananas are significant on the first and third lags; that shows they have a short and long term relationship. Regarding the production in Table 5c, while cocoa yield is like this in the third lag, and coffee and palm oil yield in the first, being a long and short term relationship, respectively. With respect to production in Table 5c, the results show that only bananas and cocoa are significant in the first and third lags, respectively; however, coffee, palm oil and constant value showed no significant results for the long-term relationship.

Specification tests

Specification tests are carried out to determine the normality and non-autocorrelation of the lags, through the statistical tests of Jaquer Bera to determine if the data has the asymmetry and curtosis of a normal distribution.

[1]Kurtosis is understood as a statistical measure, which indicates the degree of concentration presented by the values of a variable around the central area of the frequency distribution.

Variable	Coef.	Std. Err.	z	P> | z |
a. Agricultural area				
Agricultural Area				
L1.	0.7595	0.1329	5.71	0.000 *
L2.	0.2692	0.1691	1.59	0.112
L3.	-0.2747	0.1415	-1.94	0.052 **
b. Yield				
Bananas Yield				
L1.	0.1278	0.0511	2.50	0.013 ***
L2.	-0.0137	0.0724	-0.19	0.849
L3.	-0.0883	0.0513	-1.72	0.086 ***
Cocoa beans yield				
L1.	-0.0026	0.0225	-0.12	0.907
L2.	0.0030	0.0241	0.13	0.900
L3.	0.0533	0.0225	-2.37	0.018 ***
Green coffee Yield				
L1.	0.0313	0.0172	1.82	0.069 ***
L2.	0.0265	0.0160	1.66	0.098 ***
L3.	0.0132	0.0165	0.80	0.422
Aceite de Palma Yield				
L1.	0.1001	0.0385	2.60	0.009 *
L2.	0.0021	0.0391	0.05	0.956
L3.	0.0214	0.0423	0.51	0.612
c. Production				
Bananas production				
L1.	0.0935	0.0558	1.68	0.094 ***
L2.	-0.1088	0.0760	-1.43	0.153
L3.	0.0333	0.0540	0.62	0.537
Cocoa beans production				
L1.	0.0181	0.0224	0.81	0.417
L2.	0.0272	0.0264	1.03	0.305
L3.	-0.0416	0.0240	-1.73	0.084 ***
Green coffee Production				
L1.	0.0060	0.0154	0.39	0.695
L2.	0.0151	0.0147	1.03	0.305
L3.	-0.0057	0.0162	-0.35	0.723
Palm oil Production				
L1.	-0.0295	0.0299	-0.99	0.324
L2.	-0.0001	0.0335	-0.01	0.996
L3.	-0.0128	0.0258	-0.50	0.619
_cons	-0.6232	0.5835	-1.07	0.286

Table 5: Vector autoregression model estimation results of: a) Agricultural area; b) Yield and c) Production.

Notes: *, **, *** stand for significance at 90%, 95% and 99%, respectively. Source: Authors computation from data FAO (2016).

Table 6a shows the probabilistic values of the specification tests for the variables proposed. Therefore, it is determined that the agricultural area presents significant values for Jaquer Bera, symmetry and kurtosis. However, banana and coffee yield variables present significant values to accept normality, while cocoa yields are valid for the Jaquer Bera test and kurtosis, but not for symmetry,

Variable	Jaquer Bera Prob> chi2	Symmetry Prob> chi2	Curtosis Prob> chi2
a. Agricultural area			
Agricultural Area	0.000 *	0.000 *	0.000 *
b. Yield			
Bananas yield	0.000 *	0.00 1 *	0.000 *
Cocoa beans yield	0.0 35 **	0. 479	0.0 12 *
Green coffee yield	0.000 *	0.0 13 *	0.00 4 *
Palm oil yield	0. 176	0. 110	0. 337
c. Production			
Bananas production	0.0 35 **	0.0 66 ***	0.0 69 ***
Cocoa beans production	0.0 07 *	0. 258	0.0 03 *
Green coffee Production	0.0 96 ***	0. 823	0. 886
Palm oil Production	0.000 *	0.0 10 ***	0.000 *

Table 6: Normality estimation.

Notes: *, **, *** stand for significance at 90%, 95% and 99%, respectively. Source: Authors computation from data FAO (2016).

and, in the case of palm oil yield no symmetrical values or kurtosis are appreciated (Table 6b).

In Table 6c for the cocoa and palm oil production variables, the statistical values are accepted when they are lesser than 0.05; however, the banana production variable presents valid probabilities for Jaquer Bera, but not for symmetry and kurtosis, and, in the coffee production variable, no statistical value is accepted for the null hypothesis of normality.

The values of the estimated no autocorrelation in the second order lags explain that for banana, cocoa beans, green coffee and palm, the null hypothesis of no autocorrelation was accepted in VAR Model, since all of them present values greater than 0.05 (Attached 1); that means, the disturbance term related to any one observation should not be influenced by the disturbance term related to any other observation.

Variable	Chi2	Prob> chi2
Bananas	13.42	0.64
Cocoa beans	16.10	0.44
Green coffee	08.10	0.94
Palm oil	11.26	0.79

Attached 1: Estimation of non-autocorrelation.

Source: Authors computation from data FAO (2016).

Vector error correction (VEC) results

In the error correction vector model, we start by determining the number of lags with which subsequent tests will be analyzed, this value is equal to 2 lags.

Table 7 shows the statistical and critical values in a maximum range ranging from 0 to 2, likewise they are explained by each of the analyzed products. In the case of bananas and cocoa beans, there is no significance of the statistical value in contrast to the critical value to accept the null hypothesis of non cointegration of the variables; while green coffee and palm oil accept the alternative cointegration hypothesis since they all present a statistical value greater than the critical value.

Maximum range	Statistical trace	Critical value
a. Bananas		
0	60.75	47.21
1	32.17	29.68
2	10.37	15.41
b. Cocoa beans		
0	78.30	47.21
1	38.65	29.68
2	12.10	15.41
c. Green coffee		
0	85.62	47.21
1	44.46	29.68
2	11.68	15.41
d. Palm oil		
0	71.21	47.21
1	36.72	29.68
2	11.25	15.41
Lags: 2		

Table 7: Johansen cointegration estimate.

Source: Authors computation from data FAO (2016).

Variable	Coef.	Std. Err.	Z	P> | z | **
a. Agricultural area				
Agricultural Area				
LD.	0.2037	0.1598	1.27	0.203
L2D.	0.4392	0.1548	2.84	0.005 *
_ce1				
L1.	-0.2671	0.1126	-2.37	0.018 *
b. Yield				
Bananas Yield				
LD.	0.1277	0.0588	2.17	0.030 **
L2D.	0.0721	0.0585	1.23	0.217
Cocoa beans yield				
LD.	0.0575	0.0266	2.16	0.031 **
L2D.	0.0532	0.0259	2.06	0.040 **
Green Coffe Yield				
LD.	0.0005	0.0194	0.03	0.978
L2D.	0.0087	0.0183	0.48	0.633
Palm Oil Yield				
LD.	-0.0443	0.0616	-0.72	0.472
L2D.	-0.0408	0.0487	-0.84	0.401
c. Production				
Bananas production				
LD.	0.1315	0.0618	2.13	0.033 **
L2D.	-0.0251	0.0645	-0.39	0.697
Cocoa production				
LD.	0.0320	0.0273	1.17	0.242
L2D.	0.0529	0.0271	1.95	0.051 **
Coffee Production				
LD.	0.0255	0.0186	1.37	0.170
L2D.	0.0270	0.0171	1.57	0.116
Palm Oil Production				
LD.	-0.1696	0.0311	-0.55	0.585
L2D.	-0.0026	0.0294	-0.09	0.928

Table 8: Vector of Auto regression.

Notes: *, **, *** stand for significance at 90%, 95% and 99%, respectively. Source: Authors computation from data FAO (2016).

In Table 8 it is shown that the model fits well, the estimates have the right signs and imply a rapid adjustment towards equilibrium. The estimate of the Agricultural area coefficient L. ce1 is -.2; therefore, when the average agricultural production is very high, it quickly adjusts to the level of the agricultural area.

Specification tests

The specification tests were carried out with the purpose of determining the normality of the lags, through the statistical tests of Jaquer Bera to check if the data have the asymmetry and kurtosis of a normal distribution.

The probabilistic values of the specification tests of the variables proposed. Therefore, it is determined that the agricultural area is statistically significant at 90% for the corresponding tests (Attached 2a).

The banana and coffee yield variables present significant values to accept normality, while palm oil yield is valid for the Jaquer Bera test and kurtosis, but not for symmetry, and, in the case of the cocoa, yield does not show symmetrical values or kurtosis (Attached 2b).

For the production of palm oil, statistical values are acceptable for the null hypothesis to be less than 0.05; the banana production variable presents vivid probabilities for Jaquer Bera and symmetry but not for kurtosis, and cocoa beans production is significant in Jaquer Bera and kurtosis but not in symmetry; in the coffee production variable, no statistical value is accepted for the null hypothesis of normality (Attached 2c).

Variable	Jaquer Bera Prob> chi2	Symmetry Prob> chi2	Curtosis Prob> chi2
a. Agricultural area			
Agricultural Area	0.000 *	0.000 *	0.000 *
b. Yield			
Bananas yield	0.000 *	0.0 04 *	0.00 2 *
Cocoa beans yield	0. 209	0.50 3	0. 101 ***
Green coffee yield	0.000 *	0.000 *	0.000 *
Palm oil yield	0. 014 **	0. 1 4 6	0. 011 *
c. Production			
Bananas production	0.0 07 *	0. 009 *	0.0 78 ***
Cocoa production	0.00 3 *	0. 417	0.00 1 *
Coffee Production	0. 523	0. 997	0. 255
Palm oil Production	0.000 *	0.0 01 *	0.000 *

Attached 2: Normality estimation.

Notes: *, **, *** stand for significance at 90%, 95% and 99%, respectively. Source: Authors computation from data FAO (2016).

The values of the estimate of non-autocorrelation in the second order of lags allow us to guaranteeing a correct explanation of the model for bananas, cocoa, coffee and palm oil given that the disturbance term related to any observation is not influenced by the disturbance term related to any other observation of the model due that the null hypothesis of no autocorrelation was accepted in VEC Model (Attached 3)

Variable	Chi2	Prob> chi2
Bananas	16.84	0. 39
Cocoa beans	11.69	0.23
Green coffee	13.82	0.61
Palm oil	16.91	0.39

Attached 3: Estimation of non-autocorrelation.

Source: Authors computation from data FAO (2016).

Discussion

The relationship explained in this research, between agricultural productivity and the harvested area, proved to be a topic of great importance in developing economies, especially those that use agricultural activities as a connection link in foreign trade, and thus achieve economic growth. This relationship is affirmed in the empirical studies included in this research that take into account the proxy study variables and has been carried out in India, China, Pakistan, Nepal and Brazil affirming the inverse relationship between agricultural areas and agricultural productivity.

However, Fan and Chan-Kang [25] empirical contribution states that there is a positive relationship between small farms and agricultural performance, an improvement in labor productivity and income. Vandamme and Rayp (2011) and Chen, Huffman and Rozelle [14], show that shared products of different crops generates yield of scale growth on small farms, checking the inverse relationship. While, researchers such as Thapa [15], Ladvenicová and Miklovicová [12] and Helfand Taylor [17], verify that the existing capital and the credits accessed by farmers decrease the inverse relationship in a significant way, as they have the resources for the purchase of supplies, improvement of irrigation and implementation of physical capital that improves the productivity of crops.

The descriptive and models results are significant and consistent with the theory presented. In the VAR model, correct signs are observed in the estimated coefficients to accept the inverse relationship, but only banana and cocoa products are the ones that have a long-term relationship. In the case of the VEC model, the statistical values of Z have suitable sign coefficients, however, there is no short-term relation in the palm oil product; concluding that the greater amount of the agricultural area destined to the crops of these products diminishes its productivity. Likewise, Sepúlveda, Irinuska, Mendoza, and Louiza [26], in a productivity study for the cultivation of coffee and cocoa, show that only productivity increases if there is a diversification of crops in certain periods of time, since this increases the quality of the soil in a natural way; however, it can cause a decrease in farmers' income since replacement crops have lower demand in the international market.

It is important to highlight that the application of public policies should be made according to the product groups at different levels of the government, through agricultural development programs that promote the creation of value-added products that will allow farmers to develop crops and more products competitive in the market [27]; in addition, the investment in technical assistance in the rural sector together with the installation of technology according to the type of crops, which allows a more efficient production and at the same time reduces the environmental impact; together this would increase agricultural productivity with lower inputs and resources [2], since in the case of Ecuador the production of bananas and palm oil is done mostly on a larger scale, while, cocoa and coffee has production in the rural sector and in groups family or associative. For this it is also essential to promote the development of household farming as an alternative to increase agricultural productivity, which was also proven in the empirical studies, since household work in contrast to hiring additional staff is more productive to have a relationship direct with the good [28-30].

Conclusion

In this investigation, data on the four primary products of Ecuador that have large-scale production to meet national demand and export have been included. This analysis has the purpose of explaining whether the agricultural productivity of these products is related to the agricultural area destined for cultivation, and the volumes of the autoregressive vector and the error correction vector models have been implemented to characterize the simultaneous interactions between a groups of variables.

The main results allow us to determine that the production of bananas and cocoa beans meet a short and long term relationship, considering that green coffee and palm oil only meet a short term relationship; at the same time, it is verified that the inverse relationship between farm size and productivity is also fulfilled in this study, since the larger the crop area of these products, the lower the agricultural productivity.

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