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Agriculture gross production value – arable land – active population in agricultural sector and energy consumption causality in 76 countries: A dynamic panel data approach

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Abstract

The overall goal of this paper is to investigate the long run and casual relationship between agriculture gross production value (AGPV), arable land (AL), total economically active population in agricultural sector (APA) and total primary energy consumption in the agricultural sector given the historical trend of these variables. For a panel of 76 countries during the period 1991–2012, the paper's three main findings are that: (i) Neutrality hypothesis is adopted because there is no causality between AL and AGPV.; (ii) APA-led AGPV; (iii) Feedback hypothesis indicates that there are four cases of bidirectional causality between the rest of the variables. Adaptation measures are recommended for both authorities and farmers to ensure food security, such as providing incentives for farmers to adopt more recent technologies, which consumes less energy, land reclamation, steer more employees towards the agricultural sector.

Keywords: Agriculture gross production value, arable land, active population, energy consumption, panel co-integration, panel Granger causality.

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1. Introduction

Agriculture received considerable attention, since ancient times, by the human community as one of the main arteries that must be met for the survival of humanity strain. Agriculture has lived this attention to the present day, where it knew very important developments in different areas. As the world is undergoing profound changes and needs of agriculture to draw its future. Indeed, agriculture plays a major role in human societies, speaking at numerous levels: food, territory, international trade, energy resources, relationship to nature, social balance . . . Following this agricultural importance and since the 2008 overall food crisis, and with the increased demand unceasing during the period of 2010–2011.

The agricultural commodity markets were at the heart of the worldwide economic concerns and have become, for the first time in 2011, a top world priority. Several factors are regularly needed to explain the recent episodes of agricultural crop production, but among the most important factors we can cite: urbanisation, agricultural water use, total agricultural energy demand, extreme weather events, biofuel development, emerging economies growth, monetary instability. All these components make agriculture a heavyweight in the world economy and a major player in the evolution of humanity. In this regard, Theodore Schultz began his acceptance speech for the Nobel Prize in economics. In 1979, by making the following observation: ‘Most of the people in the world are poor; therefore, study the economics of poverty would bring us a lot of information on economic principles that really matter.

Around the world, the poor derive mainly on agriculture for their income; therefore, studying agricultural economics would bring us a lot of information on the economy of poverty’ (Schultz, 1979). So far, we find that the most of the people in developing countries whose livelihoods depend on agriculture are still generally much poorer than those working in other sectors of the economy and they represent a high proportion – most often – of all the poor in their country. Indeed, the most cautious appears to be the academics. The worry about the potential destabilising impact, one example of speculation is as old as the creation of financial markets themselves, and economists have addressed this issue early.

From Adam Smith (1776) to Milton Friedman (1953), through John Stuart Mill (1871), the traditional approach is to consider that speculators have a stabilising role. However, the main idea of this approach reckons on an idealised outlook of financial markets where there are neither limits to arbitrage, nor information asymmetries and nor possibility of manipulation, etc., The main matter of the (de)stabilising impact of derivatives markets has also attracted many empirical studies, where we meet foremost the traditional approach which is used to compare the instability on the underlying market before and after the establishing of derivatives. Some earlier studies can be found at the late nineteenth century (Emery, 1898; Hooker, 1901) and they concluded that derivatives rather have a stabilising impact.

Further lately, some studies also find a decrease in volatility or do not detect any particular effect. Only Brorsen (1989) (cattle) suggests that volatility could be higher. Over the past two years, several studies were carried to analyse the causality link between changes in commodity prices and positions of various types of traders on derivatives markets, among these studies that may be mentioned are IMF (2008), Buyuksahin and Harris (2009), Brunetti and Buyuksahin (2009), Gilbert (2010a, 2010b), Stoll and Whaley (2010), and Sanders and Irwin (2010, 2011a, 2011b). Overall, these studies generate any proof that index trading in commodities had an impact on price changes. However, as stated by Sanders and Irwin (2011b), the power of the standard statistical tests might be too low. Such as agriculture also depends on energy, this latest is considered as an important requirement. Energy requirements in agriculture are categorised into two groups: direct and indirect. According to Singh (2000), direct energy is related for the agricultural crop production processes such as land preparation

i.e. direct energy is directly used at farms and on fields. According to Kennedy (2000), indirect energy is not directly used on the farm.

Major items for indirect energy are fertilizers, seeds, machinery productions and pesticides. The ‘agricultural technology and energy demand nexus’ has become a major issue in the recent literature on sustainable development. Many studies were performed to show how each one can influence the other and vice versa. The link between energy consumption and agricultural technology is well documented in the literature; even so, the direction of causation of this relationship remains litigious. That is, if the agricultural technology leads to energy consumption or vice versa. The direction of causality has significant policy implications (Aqeel, 2001).

Amongst these studies, we might quote; Braun (1988) searches the impacts of technological change in agriculture to production and income effects, and to consumption and nutritional effects in West Africa (The Gambia).

The results show that technological change effects conducted through income and it is attributable to increased food consumption at the household level. Bonny (1993) analyse the energy intensity trend in French agriculture as a whole during the period of 1959–1989, and for one of its principal field crops, wheat, between 1958 and 1990. The results indicate that agriculture seems being more efficient in its use of energy, concerning wheat, at least during the past 15 years. Nkamleu, Gokowski and Kazianger (2003) have computed the changes in agricultural crop productivity in 10 countries in African Sub-Saharan countries from 1972 to 1999.

Unlike with significant progress in Asia, Nkamleu et al. concluded that, on average, total factor productivity fallen in that period by 0.2% annually. They indicate that, whereas, yield was constant, technological change was the main reason of the defeat of total factor productivity to increase. Ozkan, Akcaoz and Fert (2004) have examined the energy use in the Turkish agricultural sector for a period ranges from 1975 to 2000. The results show that total energy input augmented from 17.4 GJ/ha in 1975 to 47.4 GJ/ha in 2000. Likewise, global output energy rose from 38.8 to 55.8 GJ/ha at the same period. As a result, the output–input ratio was estimated to be 2.23 in 1975 and 1.18 in 2000.

This result indicates that there was a decline in the output–input energy ratio. Eames and McDowall (2010) made a study with respect to broader developments in the fields of foresight, expectations and socio-technical transitions to sustainability. Referring to highlighting from the evolution of renewable energy consumer and producer awareness and action, concerning Cooke (2010) provided that the thesis based on innovation was reached through regional knowledge spillovers and was relatively easy to find in exemplar renewable energy regions. He concluded that those regions with innovative development agencies of the kind discussed would thrive from tapping new horizontal cross-fertilisation opportunities, which are relatively costless and are easily turned into international knowledge portals. Emerging technologies present both challenges and opportunities for national technology strategies.

Guellil, Belmokaddem and Benbouziane (2016), examine the long-run impacts of the world crude oil prices and the real effective US dollar exchange rate on the world agricultural commodity prices, using panel cointegration and panel Granger causality methods for a panel composed of twenty-two agricultural products based on annual prices ranging from 1980 to 2015. The results show a significant way, which is a cointegrating relationship between agricultural commodity prices and the set of variables. The results also indicate bidirectional causality between these variables, which could be a good tool to prioritise the allocation of resources across industries to ensure a better agricultural policy in general and economic outcomes.

In addition to all of the above, there are several methods used to study different aspects of agriculture and among the best methods used to study the relationship between variables and mutual influences them, is panel cointegration method. The panel Granger causality methods can be applied to various fields; for example in cardiology and neurology fields. we find the study of Ghouali, Feham & Ghouali (2014a, 2014b, 2014c, 2017), in tourism, we can cite the study of Guellil, Belmokaddem,

Sahraoui and Ghouali (2015), who have examined the long-run relationship between tourism spending and economic growth for 49 countries classified into one panel, using cointegration and panel Granger causality tests during a period from 1988 to 2012. The results show a significant way, which is a cointegrating relationship between economic growth and tourism spending. The results also indicate bidirectional causality between tourism spending and economic growth, which could be a good tool to prioritise the allocation of resources across industries to ensure a better tourism in general and economic outcomes. Ghouali, Belmokaddem, Sahraoui and Guellil (2015), analysed the long-term relationship between the total energy consumption, FDI, economic growth and the CO2 emission in the BRICS countries using the cointegration tests and panel Granger causality in panel over the period of 1990–2012. The results show significantly that there is a cointegration relationship between CO2 emissions and economic variables. The results also indicate the existence of a unidirectional causality from CO2 to the independent variables.

To achieve the millennium development goal of halving poverty by 2015, we must find ways to increase the income of these populations. What can the government do to support this increase? Specifically, how can we improve public action in the field of development cooperation, trade and agriculture, for the agriculture that contributes more to fight against poverty? This document is for an initial aim of a research project that seeks to answer this question. The more specific goals of this paper are to empirically investigate, if the statistical link between agriculture gross production value (AGPV) and the others variables (arable land (AL), total economically active population in agricultural sector (APA) and total primary energy consumption (ENR)) in 76 countries is unidirectional (the explanatory factors affect/cause AGPV or AGPV affect/cause them). Whether the statistical relationship between the AGPV and all others variables in all countries is bi-directional (each one affect/cause the other and vice versa); or the all variables (the explanatory factors and AGPV) do not influence each other (causality independent). In this regard, the overall objectives are accomplished by examining panel Granger causality test between AGPV and explanatory variables (AL, APA and ENR). The remaining of the paper is organised as follows. Section 2 presents data and methodology. Section 3 reports the empirical results. Finally, Section 4 offers some concluding remarks.

2. Data and Methodology

All data used in this study are annual observations covering the period from 1991 to 2012 obtained from two sources. Data on AGPV (expressed in current million US\$), AL (specified in 1000 ha) and APA (presented per thousand person) are obtained from the Food and Agriculture Organization. The ENR (measured in Quadrillion Btu) are extracted from the International Energy Agency. Our database includes 76 countries. We classify all countries into only one heterogeneous panel to examine if there are any structural differences. When analysing the long-run relationship in panel data, the selection of the suitable technique is an important theoretical and empirical issue. Panel cointegration approach is the most appropriate technique to study the long-term relationship between AGPV, AL, APA and ENR in 76 countries. The empirical strategy used in this paper can be divided into three principal steps. First, unit root tests in panel series are undertaken. Second, if they have the same order of integration, the panel cointegration tests are used. Third, if the series are cointegrated, we proceed to panel Granger causality to determine the sense of the causality.

3. Empirical Results

The general specification of the model which we estimate can be written as follows:

$$y_{it} = a_{0i} + b1iX_{1it} + b2iX_{2it} + b3iX_{3it} + \varepsilon_{it} \quad (1)$$

With: y is the AGPV of country i , for the period t , X_1 is the AL of country i , given at the period t , X_2 represents the APA, X_3 refers to ENR and ε is an error term. This equation is considered as a balanced long-term relationship if it has cointegration relations. The data must then be integrated in the same order. We will test the stationarity and the relationship of long-term series between AGPV, AL, APA

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and ENR, the technical unit root and cointegration panel data require a minimum of homogeneity in order to draw more general conclusions. It is for this reason that we constitute our sample from 76 countries, to draw more appropriate conclusions.

For precision, variables are abbreviated as follows:

- AGPV: Agriculture gross production value.
- AL: Arable land.
- APA: Total economically active population in agricultural sector.
- ENR: Total primary energy consumption.

3.1. Unit root tests

To investigate the stationarity of the series used, we use the unit root tests on panel data (LLC, IPS, BRT, MW and Hadri). The results of these tests are presented in Table 1 and Table 2:

Table 1: Unit root tests for the variables in seventy-six countries

Methods	Variables	Null: Unit root				Null: No unit root		
		Levin, Lin and Chu (LLC) (2002)	Breitung (2000) t-stat	Im, Pesaran and Shin (IPS) (2003) W-stat	MW-ADF Fisher Chi-square	MW-PP Fisher Chi-square	Hadri (2000a) Z-stat	Heteroscedastic consistent Z-stat
Level	Log AGPV	3.84083 (0.9999)	NA	7.84252 (1.0000)	75.4626 (1.0000)	77.5160 (1.0000)	20.4866 (0.0000)*	17.7202 (0.0000)*
	Log AL	-2.75744 (0.0029)*	NA	3.60380 (0.9998)	139.261 (0.5960)	142.546 (0.5186)	22.2552 (0.0000)*	20.2624 (0.0000)*
	Log APA	6.96413 (1.0000)	NA	10.3910 (1.0000)	168.914 (0.1650)	663.303 (0.0000)*	25.6987 (0.0000)*	24.4445 (0.0000)*
	Log ENR	-7.61098 (0.0000*)	NA	-0.51366 (0.3037)	182.380 (0.0469)	221.337 (0.0002)*	25.6530 (0.0000)*	21.9850 (0.0000)*
First difference	Δ Log AGPV	-29.2020 (0.0000)*	NA	-27.1343 (0.0000)*	904.592 (0.0000)*	1147.00 (0.0000)*	5.81375 (0.0000)	6.60922 (0.0000)*
	Δ Log AL	-21.6197 (0.0000)*	NA	-20.5725 (0.0000)*	709.428 (0.0000)*	960.220 (0.0000)*	2.63503 (0.0042)	4.79812 (0.0000)*
	Δ Log APA	-344.994 (0.0000)*	NA	-135.567 (0.0000)*	1098.36 (0.0000)	1087.87 (0.0000)*	8.08686 (0.0000)*	10.7283 (0.0000)*
	Δ Log ENR	-31.8106 (0.0000)*	NA	-29.6904 (0.0000)*	995.571 (0.0000)*	1149.72 (0.0000)*	2.07711 (0.0189)	4.70486 (0.0000)*

*: Significance at 1%. Δ: is the first difference operator.

All variables are non-stationary panel in level, but in first differences, all variables are stationary. The stationarity for all countries in the first difference leads us to study the existence of a long-term relationship. Therefore, we find that all variables are integrated at the first order.

3.2. Cointegration

We have seen that all variables are integrated of the first order. Based on these panel unit root test results, we proceed to test cointegration panel and that by relying on Pedroni tests. The results are as follows:

Table 2: Cointegration tests for the seventy-six countries

Methods	Within dimension (panel statistics)			Between dimension (individuals statistics)		
	Test	Statistique	Prob	Test	Statistique	Prob
LOG AGPV						
Pedroni (1999)	Panel v-statistic	0.585657	0.2791	Group ρ -statistic	2.094172	0.9819
	Panel rho-statistic	-2.965653*	0.0015	Group pp-statistic	-4.801485*	0.0000
	Panel PP-statistic	7.612055*	0.0000	Group ADF-statistic	-6.370376*	0.0000
	Panel ADF-statistic	-8.094741*	0.0000			
Pedroni (2004) (Weighted statistic)	Panel v-statistic	-0.930664	0.8240			
	Panel rho-statistic	-1.087981	0.1383			
	Panel PP-statistic	-5.156577*	0.0000			
	Panel ADF-statistic	-5.317289*	0.0000			

















* Significance at 1%.

The Table 1 and 2 summarises the results of seven (07) statistical cointegration Pedroni, four probability values are less than 1%. It is mainly (Panel pp-Statistic) and (Panel ADF-Statistic) in both Pedroni tests (Pedroni, 1999; & Pedroni, 2004) regarding intra-individual dimension, and we have (Group pp-statistic) and (Group ADF-Statistic) for testing inter-individual dimension. As we notice another significance at the level of Pedroni (1999), which is (Panel rho-statistic) and this latter indicates the presence of the long-run relationship, all this proves that there is a relationship of cointegration between the variables in the model. The results obtained show the relevance and power of cointegration tests in panel compared to the tests of time series.

3.3. Panel Granger causality results


The existence of cointegration implies the existence of causality at least in one direction. Having established that the AGPV is cointegrated in the long-term with AL, APA and ENR. This step is done which aimed to examine the causal link between these variables using panel Granger causality test. A panel Granger causality analysis is performed to determine if there's a potential predictability power from one indicator to another. The results of panel Granger causality test for all individuals are summarised in Table 3. It should be noted that optimal structure of delays was determined using the Akaike and Schwarz information criteria.

Table 3: Panel Granger causality test results for the seventy-six countries

Lags = 5	AGPV	AL	APA	ENR
AGPV	 (0.6829)	0.62218  (0.1870)	1.31953  (0.0991)	1.64931  (0.0991)
AL	0.52605  (0.7567)	 (0.0158)	 (3.E-07)	 (3.E-09)
APA	5.78104*  (7.E-09)	2.80655*  (0.0158)	 (0.0184)	6.64953*  (3.E-11)
ENR	5.68802*  (1.E-08)	17.6239*  (6.E-17)	2.35699*  (0.0184)	

* Significance at 1%.

 : Denotes that there is causality.

 : Absence of causality sens.

 : Means the relationship between each Variable and himself.

Our study aims to illustrate the interactive relationships between all the variables AL, APA, ENR and between AGPV, but that does not preclude the study of all possible relationships. From the tests, results of panel Granger causality presented in the Table 3, we can deduce the direction of causal relationships between variables, which can figured at the critical threshold (error probability) of 5%.

The Granger causality test results in Table 3 shows that the both null hypothesis: ‘AL does not Granger cause AGPV’ and ‘AGPV does not Granger cause AL’ are rejected for the seventy-six countries at 5% level; this suggests that we hold neutrality hypothesis because there is no causality exists between AL and AGPV. The results indicate also the existence of unidirectional causality, which runs from APA to AGPV for the whole panel. Furthermore, we note four cases of bidirectional causality as follows: AGPV-ENR, AL-APA, ENR-AL and ENR-APA for the entire panel.

The findings of this study can be summarised into three main points:

- Neutrality hypothesis is adopted because there is no causality between AL and AGPV.
- APA-led AGPV.
- Feedback hypothesis indicates that there is bidirectional causality between some variables.

4. Conclusions and Policy Implications

The present paper empirically establishes the factors affecting AGPV trajectory for 76 countries by using panel cointegration test and panel causality. A long-run relationship between the set of variables has been approved in a meaningful way. This study makes three contributions in the current literature on AGPV trajectory in the world.

First, our results show that there is no causality between AL and AGPV, which means that for agricultural states having a large surface of the AL is not a main condition to increase their level of AGPV rate. Second, APA-led AGPV hypothesis is adopted and this implies that the increased participation of the active population in agricultural sector exerts a positive influence on the agricultural productivity and the effectiveness of the company in general.

This report makes a qualitative evaluation of this research and particularly aims at understanding how the participation of the employees can improve the productivity. Third, our results show that the four cases of bidirectional causality refer to strong long-run relationship between variables, we can

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note that the increase in the domestic requirements in energy, following the variation of the various factors such as the increase in the agricultural production, the increase in the working population in the agricultural sector which involve an over-exploitation of resources natural, in other hand we argue that effective AL use needs an important workforce in agricultural sector, as these strategies are critical to preserve an increasing rate of agricultural productivity.

These results demonstrate the crucial necessity for designing integrated strategic plans for both agricultural and energy sectors. In addition, these results may help a government to establish priorities regarding to the assignment of the resources for national strategies to development of agriculture. Future research should focus upon the modelling of the relationship between various characteristics of a country that influence agriculture's contribution to economic growth.

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