The Role of Agriculture in Economic Growth: A Comparison of Mediterranean and Northern Views in Europe

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Abstract

The main objective of this paper is to identify the causal relationship that exists between agricultural value added per worker and Gross Domestic Product per capita in Europe. More specifically, the role of agriculture in economic growth is examined with special emphasis to the differences and similarities among Mediterranean and Northern countries. In order to examine short-run and long-run relationships, recent methods of linear co-integration are employed while the role of agricultural value added in economic growth is also examined by Granger causality tests. Results show a bi-directional relationship between agricultural value added and economic growth in the northern EU countries and only in one Mediterranean country. From a policy point of view, this relationship is of crucial importance since it can facilitate successful economic decisions. Taking into consideration that the role of agriculture in economic growth is an issue that always attracts the interest of scholars, this research could be prove extremely interesting and useful. Especially for this period of economic crisis, when the whole growth approach is reexamined and reevaluated, the research findings provide evidence that agriculture can lead as an engine of growth in several EU countries and can play stabilizer's role in the whole EU economy.

Keywords: Agricultural value-added, GDP, Causality, Co-integration

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1. Introduction

The role of agriculture in economic growth was first analyzed, by the middle of twentieth century, mainly by historians and institutionalists. In particular, Clark (1940) and Kuznets (1966) provided the first basic facts regarding the agriculture's role during the growth process. Since then, the role of agriculture was always an issue that attracted the global interest of economists that focused on how agriculture could best contribute to the overall economic growth and modernization. All the while, the vast majority of studies are referred in theoretical models attempting to measure the impact of agriculture in economic growth or identify the relationship between agriculture and the rest of the economy. However, dual-economy or two-sector model was firstly used by Lewis (1954) bases on the idea of surplus labor in the agricultural sector and consequently the linkage from agriculture to economic growth. Few years later the two-sector model has been extended by Ranis and Fei (1961) and then has been adopted by many researchers (Matsuyama 1992; Steger 2000; Vollrath 2009). According to Johnston and Mellor (1961), most of the classical analyses consider agriculture as a vigorous and dynamic economic sector that plays an active role in economic growth through important production and consumption linkages. The significance of such linkages was further stressed by Singer (1979) and explicitly embodied in general equilibrium idea of Agricultural Demand Led-Industrialization (ADLI). Adelman (1984) suggests that ADLI is suitable for low-income countries which are not yet export-driven. However, Gollin (2010) considers that the large share of agriculture in several developing countries does not directly imply that overall growth has to be based on an ADLI-type strategy.

Traditional agriculture, that particularly was characteristic of developing economies, was slow and weak in its response to market signals, owing to such constraints as imperfect factor mobility (Prebisch, 1950; Singer, 1950). This assumption caused structuralists to disregard these linkages in their strategy (Myrdal, 1957). In fact, little empirical evidence was produced regarding the strength or extent of the interrelationship between agriculture and the larger economy and thus agricultural sector was perceived as having few or weak linkages with the rest of economy and thus, unable to serve as an engine of growth (Valdes, 1991).

More recently, in Gardner's (2005) study it is claimed that agriculture does not seem to be a primary force behind Gross Domestic Product (GDP) per capita growth. However, World Development Report's 2008 (World Bank, 2007) suggests that in agriculture-based economies, agriculture could be the main engine of growth, while in transforming countries agriculture is already less important as an economic activity but is still a major instrument to reduce rural poverty. An empirical approach to evaluate the impact of agriculture on economic growth is to augment theories of endogenous growth by including the potential contribution of agriculture (Barro and Sala-i-Martin, 1994; Botrić, 2013; Gouveia, 2014). This approach is tested empirically by Hwa (1988) and proves that agriculture might benefit from non-farm growth since agriculture's growth depends mostly on the provision of "modern" inputs and technology from the industrial sector. In addition, computing linkages between agriculture and overall economy at the aggregate level has relied on Mundlak-type, multi-sectoral simulation models which trace the dynamic interaction of exogenous changes in agricultural productivity with the rest of the economy (Mundlak and Cavallo, 1982; Mundlak et al., 1989; Block and Timmer, 1994; Loizou et al., 1997; Naanwaab and Yeboah, 2014). In several studies the relationships between agricultural and non-agricultural growth are estimated and modeled at regional or local level. The regional process uses household data on consumption and incomes joined to a regional Social Accounting Matrix (SAM) to investigate the impact of exogenous changes in agricultural productivity on incomes in non-agricultural households (Bell et al., 1982; Haggblade et al., 1989; Ranis et al., 1990). Some studies use a SAM-based Computable General Equilibrium (CGE) modeling (Winters et al., 1997) which has been mainly used for assessing the effects of supply and demand shocks on the agricultural sector, on other sectors or on the overall economy (Dervis et al., 1982; Higgs, 1986; Greenaway and Milner, 1993).

Other empirical investigations that examine the causal relationship between agriculture and economic growth provide conflicting results. Thus, some of them consider that the export of surplus resources from agriculture leads to an agricultural driving economic growth while others, argue that increases in the non-agricultural productivity thereby implying that causality runs from general economic growth to agriculture. For example, Estudillo and Otsuka (1999) prove that growth in the non-agriculture economy is the key driver of growth in agricultural wage rates. In addition, the relationship between the average rate of economic growth and the rate of agricultural growth for developing countries is examined by Stern (1996) whose findings prove that there is significant and positive relationship during the years before 1980. Furthermore, Echevarria (1997) investigated 62 countries, for the period 1970-1987, and show that a positive linkage exists between the average rate of growth and agriculture’s share of GDP while Timmer (2002) also prove that a positive correlation exists between growth in agricultural GDP and non-agricultural GDP growth using a panel of 65 developing countries, for the period 1960-1985. Self and Grabowski (2007) investigated the period 1960-1995 for a cross-section of countries and show that the relationship between average growth of real GDP per capita and different measures of agricultural productivity is positive.

Many empirical studies establish a correlation between agriculture and GDP growth and they do not imply causality in either direction. But when both sectors have been growing independently or as a result of a common third factor, the correlation observed could be spurious. For this reason, several authors consider that there is a causal effect of agricultural sector to economic growth and finally, address the problem of endogeneity in empirical work. Bravo-Ortega and Lederman (2005) re-estimate the effect of agricultural growth on the total economic growth using panel data tools such as Granger causality tests for the period 1960-2000. They prove that in developing countries an increase in agricultural GDP raises non-agricultural GDP, but there is not a reverse relationship in developed countries. Similar findings revealed from the study of Tiffin and Irz (2006) that investigate the direction of causality between agricultural value added per worker and GDP per capita for 85 countries and address the problem of endogeneity using Granger causality tests in the panel data. Their results provide evidence that agricultural value added causes GDP in developing countries, while the causality in developed countries is not clear except from countries with highly competitive agriculture.

A drawback of cross-country studies is that differences in country conditions do not permit to a general relationship between agricultural and aggregate economic growth. Matsuyama (1992) argues that the relation between agricultural and total economic growth depends on the "openess" of a country to international trade. Several authors have tried to enlighten on the significance of linkages between the agricultural sector and the rest of economy in different developing countries because these linkages differ across countries. The study of De Janvry and Sadoulet (2009) find that 1% of agricultural growth have an effect of 0.45% on aggregate growth in China for the period 1980-2001, while the indirect effect through the non-agricultural sector is almost half that amount.

According to Chenery and Syrquin (1975), a probable solution for the problem of cross-country studies is the combinatorial analysis of cross-section and time-series data. Moreover, cointegration analysis, VAR (vector auto-regression) and VEC (vector error correcting) models provide useful insights regarding the relationship between agriculture and the rest of the economy (Robertson and Orden, 1990). Several studies usually examine causal relationships using the Johansen framework for co-integration whereas the Vector Error Correction (VECM) framework is further used to provide estimates for both short-run and long-run dynamics in the series (Haldar and Mallik, 2010; Mishra, 2011; Matchaya et al., 2013). In some studies, an unconditional VEC model that only has endogenous variables has been extended to a conditional VEC model by adding exogenous policy variables providing stronger and more robust results (Robertson and Orden, 1990; Ardeni and Rausser, 1995).

Similarly, Gemmel et al., (2000) examine the significance of inter-sectoral linkages for agricultural growth in Malaysia and deal with the problem of endogeneity of the variables using a VAR approach to the estimation of the model, which permits to examine for Granger causality. Results show that expansion of manufacturing output causes negative agricultural growth in the short-run, as sectors compete for fixed endowment of resources, while positive agricultural growth in the long-run, considering that manufacturing growth spills-over to the farm sector. On the contrary, expansion of the agricultural sector does not affect the other sectors of the economy. Consequently, manufacturing growth stimulates demand for agricultural commodities and provides the agricultural sector with new technology and inputs. Samini and Khyareh (2012) examine the relationship between agriculture and economic growth of Iran using annual time-series data for the period 1970-2009. By multivariate Granger causality tests based on the ARDL-ECM estimates prove that there is short-run and long-run relationship from agriculture value added to real GDP per capita. Moreover, they show that real GDP per capita causes agricultural value added only in the short-run.

The main objective of this paper is to identify the relationship that exists between agricultural value added per worker and GDP per capita in Europe. An exploratory study among Mediterranean and Northern countries is applied in order to examine possible differences and similarities concerning agriculture's role in economic growth. The analysis employs an Autoregressive Distributed Lag (ARDL) approach for cointegration and the Granger causality test in an attempt to examine the role of agriculture in economic growth by short-run and long-run relationships, as well as the direction of causality. The bi-directional relationship between agricultural value added and economic growth is of crucial importance since it can facilitate successful economic policies in EU countries.

The rest of the paper develops as follows: The next section describes the data and the methodological framework employed in the study, while the third section presents the empirical results and finally concluding remarks are offered in the last section.

2. Employed Methodology

2.1 Data

The data used in this paper to study the relationship between agriculture and economic growth are the real Agricultural value added per worker (AVAw) and real Gross Domestic Product per capita (GDPc) in constant prices (2000 US$). AVAw is a measure of agricultural productivity and is also considered as a good indicator because the sector generates for each productively engaged person over and above the cost of inputs outside agriculture. GDPc represents the economy's growth.

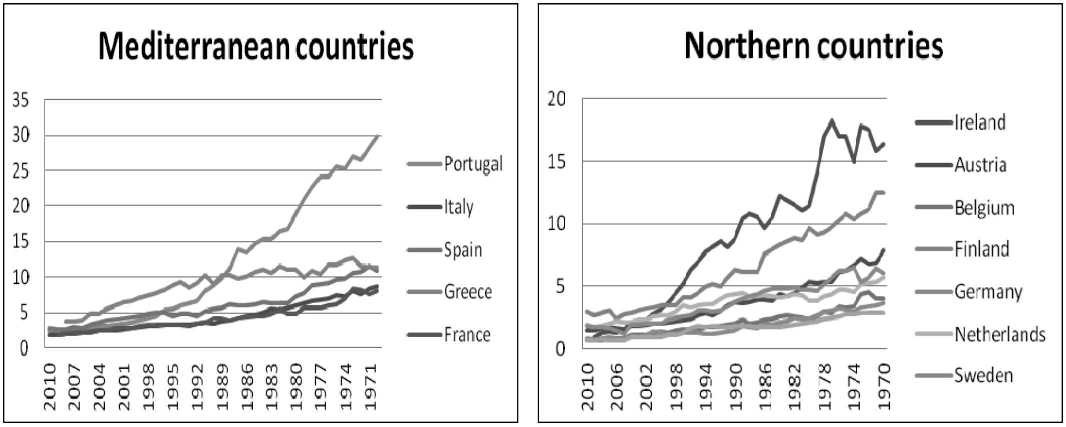
Annual time series data are used in the analysis for the 14 oldest member states of the European Union (EU-15 except Luxembourg which is a country with non-significant agricultural sector). The sample is divided in the five Mediterranean countries and the nine Northern EU countries (table 1). The specific sample was selected in order to examine the existence of similarities and differences regarding the role of agriculture in economic growth between the Mediterranean and northern countries of EU.

Table 1: Period of examined Mediterranean and Northern EU countries

Mediterranean countries		***Northern countries***			
Country	*Period*	*Country*	*Period*	*Country*	*Period*
France	1970-2011	Austria	1970-2011	Ireland	1970-2011
Greece	1981-2011	Belgium	1970-2011	Netherlands	1970-2011
Italy	1977-2011	Denmark	1980-2010	Sweden	1970-2011
Portugal	1980-2010	Finland	1980-2010	Un. Kingdom	1970-2011
Spain	1970-2011	Germany	1980-2011		

The economic contribution of agriculture varies significantly among the most developed Northern EU countries and the less developed Mediterranean countries. This situation continues to exist despite the many important changes observed the last years, mainly through the various reforms of the Common Agricultural Policy (CAP). As it can be seen in Figure 1, a significant reduction in agricultural value added as share of GDP is observed during the period 1970-2010. Mainly, in the Mediterranean countries such as Portugal (from 29,8% to 2,4%), Spain (from 10,9% to 2,7%), Italy (from 8,8% to 1,9%), France (from 8,1% to 1,8%) and Greece (from 11,4% to 3,4%). A different view is observed from the northern EU countries. Thus, an exploratory study among Mediterranean and northern EU countries may provide useful information for the role of agriculture.

Figure 1: AVA (% of GDP) in Mediterranean and Northern EU countries



Source: World Bank

The main source of data was the World Bank database; nominal agricultural gross value added and GDP per capita were taken from United Nations Statistics Division (UNSD), employment in agriculture from International Labor Organization (ILO) and consumer price index (CPI) from the International Monetary Fund (IMF). It is important to mention that all data are converted to natural logarithms. In time series analysis this transformation is often considered to stabilize the variance of a series (Brooks, 2008). Moreover, taking the differences of the examined variables, the growth rates are obtained.

2.2 ARDL approach to cointegration

Cointegration analysis naturally arises in economics and is widely used in empirical macroeconomics. It is most often associated with economic theories that imply equilibrium relationships between time series variables which are referred to as long-run equilibrium relationships (Greene 2000; Gujarati 2004), because the economic forces that act in response to deviations from equilibrium may take a long time to restore equilibrium. As a result, cointegration is modeled using long spans of low frequency time series data.

Cointegration analysis is used to examine the study's objectives and specifically the Autoregressive Distributed Lag (ARDL) approach that was originally introduced by Pesaran and Shin (1999) and later extended by Pesaran et al. (2001). The ARDL approach presents numerous advantages in contrast to other cointegration methods (Katrakilidis et al. 2013). It is an efficient technique for determining cointegrating relationships even if the sample size is small. Additionally, the ARDL approach can be applied irrespectively of the regressors' order of integration. Thus, allowing for statistical inferences on long-run estimates that are not possible under alternative cointegration techniques. Moreover, the ARDL technique generally provides unbiased estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous (Harris - Sollis 2003).

First, in order to find out the appropriate ARDL (p, q_i) model, an estimation with the OLS method was made for all possible values of p=0, 1, 2,…, m, q_i= 0, 1, 2,…, m, i=1, 2, ..., k; namely a total of $(m+1)^{k+1}$ different ARDL models. The maximum lag (m), is determined by the frequency of the data set and all the models are estimated on the same sample period, namely t=m+1, m+2,..., n. One of the $(m+1)^{k+1}$ estimated models using the Akaike information criterion (AIC) is selected. The ARDL model used in this study is represented in Table 2.

Table 2: Presentation of ARDL approach to Cointegration

Equations	No	Variables
ARDL model $\Delta Y_t = \lambda' w_t + a_1 Y_{t-1} + a_2 A_{t-1} + \sum_{i=1}^{k} \gamma_{1i} \Delta Y_{t-i} + \sum_{i=0}^{k} \gamma_{2i} \Delta A_{t-i} + \varepsilon_{1t}$	(1)	w_t: a s x 1 vector of deterministic variables Δ: the first difference operator ε_{1t} : is error term (white noise) Y_t: dependent variable (GDPc or AVAw) A_t: independent variable (AVAw or GDPc) ψ: the coefficient of the ECM
Long-run equation $Y_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{i=0}^{k} \beta_{2i} A_{t-i} + \varepsilon_{2t}$	(2)	
Short-run equation $\Delta Y_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \sum_{i=0}^{k} \delta_{2i} A_{t-i} + \psi ECM_{t-i} + \varepsilon_{3t}$	(3)	
Error correction term's equation $ECM_t = Y_t - \beta_0 - \sum_{i=1}^{k} \beta_{1i} Y_{t-i} - \sum_{i=0}^{k} \beta_{2i} A_{t-i}$	(4)	

The bounds testing procedure is based on the joint F-statistic or Wald statistic that is testing the null hypothesis of non-cointegration, H_0: $\alpha_1=\alpha_2=0$ against the alternative hypothesis, H_1: $\alpha_1 \neq 0$ and $\alpha_2 \neq 0$. In Pesaran et al. (2001) there are critical value bounds for all classifications of the regressors into purely I(0), purely I(1) or mutually cointegrated. If the calculated F-statistics is below the upper critical value, then we cannot reject the null of non-cointegration. If it lies between the bounds, the results would be inconclusive. The null hypothesis is rejected and there is cointegration whether the calculated F-statistics are above the upper level of the band.

The existence of long-run relationship between the two variables was examined. If there is evidence of long-run relationship, cointegration between the variables, then there is a short-run equation. The error correction model is applied to investigate the short-run relationship between the variables. The value of the coefficient ψ in equation 3 must be negative and statistical significant that indicates how far we are from the long-run equilibrium which will show the short-run equilibrium between the variables.

2.3 Granger causality test

The next step in the analysis employs the Granger causality test to investigate the causal relationship between the variables under examination. The conventional Granger causality test involves the testing of the null hypothesis that a variable Y_t does not cause variable A_t and vice versa (Granger 1969). Unfortunately, this test does not examine the basic time series properties of the variables. If the variables are cointegrated, then this test incorporating different variables will be mis-specified unless the lagged error-correction term is included (Granger 1988). In addition, this test turns the series stationary mechanically by differencing the variables and consequently eliminates the long-run information embodied in the original form of the variables. As opposed to the conventional Granger causality method, the error-correction-based causality test allows for the inclusion of the lagged error-correction term derived from the cointegration equation. By including the lagged error-correction term, the long-run information lost through differencing is reintroduced in a statistically acceptable way.

However, the existence of a long-run relationship between Y_t and A_t suggests that there should be Granger causality in at least one direction. The direction of the causality in this case is only determined by the F-statistic or Wald statistic and the lagged error-correction term. As the t-statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship, the F-statistic or Wald statistic on the explanatory variables represents the short-run causal effect. It should be noted that only equations where the null hypothesis of non-cointegration is rejected will be estimated with this process. Table 3 presents the Granger causality model.

An alternative method to test Granger causality when variables are non-cointegrated is Toda and Yamamoto (1995) approach. This approach ignore any possible non-stationarity or cointegration between series when testing for causality and fitting a standard VAR in the *levels* of the variables rather than first differences [as is the case with the Granger (1969) and Sims (1972) causality tests]; thereby, minimizing the risks associated with possibly wrongly identifying the orders of integration of the series or the presence of cointegration and minimizes the distortion of the tests' sizes as a result of pre-testing (Giles 1997; Mavrotas - Kelly 2001).

The Granger causality test based on Toda-Yamamoto procedure is a modified Wald test for restriction on the parameters of the VAR (k) with k being the lag length of the VAR system. The correct order of the system (k) is augmented by the maximal order of integration (d_{max}) then the VAR ($k+d_{max}$) is estimated with the coefficients of the last lagged d_{max} vector being ignored. Toda and Yamamoto (1995) confirm that the Wald statistic converges in distribution to a χ^2 random variable with degrees of freedom equal to the number of the excluded lagged variables regardless of whether the process is stationary, possibly around a linear trend or whether it is cointegrated. As regards the asymptotic distribution, Kurozumi and Yamamoto (2000) find that in a small sample the asymptotic distribution might be a poor approximation to the distribution of the test statistic however the distortion remains lower than other and it may still be preferable for small sample size.

Following the approach of Toda and Yamamoto (1995) based Granger causality, the bivariate VAR model (Table 3) shows the relationship between AVA per worker and GDP per capita for each country. In equation 7, the null hypothesis can be drawn as "Y_t does not Granger cause A_{it}" if $\gamma_{1i}=0$ against the alternative hypothesis "Y_t does Granger cause A_{it}" if $\gamma_{1i}\neq0$ for each i. Similarly, in equation 8 the null can be drawn as "A_{it} does not Granger cause Y_t" if $\delta_{1i}=0$ against the alternative "A_{it} does Granger cause Y_t" if $\delta_{1i}\neq0$ for each i.

Table 3: Presentation of Granger causality tests

Equations	No	Variables
Granger causality model $\Delta Y_t = \delta_0 + \sum_{i=1}^{k}\delta_{1i}Y_{t-i} + \sum_{i=0}^{k}\delta_{2i}A_{t-i} + \psi ECM_{t-1} + \mu_t$	(5)	ECM_{t-1}: the lagged error-correction term (from the long-run equilibrium relationship)
$\Delta A_t = \delta_0^{'} + \sum_{i=1}^{k}\delta_{1i}^{'}A_{t-i} + \sum_{i=0}^{k}\delta_{2i}^{'}Y_{t-i} + \psi^{'} ECM_{t-1} + \mu_t$	(6)	
Toda & Yamamoto procedure $A_{it} = a_o + \sum_{i=1}^{k}a_{1i}A_{it-i} + \sum_{j=k+1}^{d_{max}}a_{2j}E_{it-j} + \sum_{i=1}^{k}\gamma_{1i}Y_{t-i} + \sum_{j=k+1}^{d_{max}}\gamma_{2j}Y_{t-j} + \varepsilon_{1t}$	(7)	A_{it}: AVAw Y_t: GDPc ε_{1t}, ε_{2t}: error terms (white noise)
$Y_t = b_o + \sum_{i=1}^{k}b_{1i}Y_{t-i} + \sum_{j=k+1}^{d_{max}}b_{2j}Y_{t-j} + \sum_{i=1}^{k}\delta_{1i}A_{it-i} + \sum_{j=k+1}^{d_{max}}\delta_{2j}A_{it-j} + \varepsilon_{2t}$	(8)	

3. Results

The order of integration is identified in an attempt to investigate the existence of the Granger causality between AVAw and GDPc. Stationarity tests for each variable are conducted, prior to the testing of cointegration, using the Augmented Dickey-Fuller (ADF), Dickey-Fuller GLS, Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (see Table 4). The results of the unit root tests indicate that the variables used are a mix of I(0) and I(1) series. So, in this paper an ARDL approach for cointegration is applied, which is the most appropriate analysis because of the fact that the examined variables with different order of integration, are I(0) and I(1). Even if the ARDL framework does not require pre-testing variables to be used, the unit root tests provide evidence whether the ARDL approach should be applied or not. For example, the ARDL procedure is not suitable when any of the series are I(2).

Table 4: Results of the Unit Root Tests

Variable	Unit Root test		Countries
AVAw	ADF	I(0)	BEL, GR, IRL
		I(1)	AUT, DEU, DNK, ESP, FIN, FRA, GBR, ITA, NLD, PRT, SWE
AVAw	DF	I(0)	BEL, ESP, FRA, GBR, IRL, SWE
		I(1)	AUT, DEU, DNK, FIN, GR, ITA, NLD, PRT
AVAw	PP	I(0)	BEL, GR, IRL
		I(1)	AUT, DEU, DNK, ESP, FIN, FRA, GBR, ITA, NLD, PRT, SWE
AVAw	KPSS	I(0)	BEL, DNK, ESP, FIN, FRA, IRL, ITA, SWE
		I(1)	AUT, DEU, GBR, GR, NLD, PRT
GDPc	ADF	I(0)	AUT, BEL, NLD
		I(1)	DEU, DNK, ESP, FIN, FRA, GBR, GR, IRL, ITA, PRT, SWE
GDPc	DF	I(0)	ESP, GBR, ITA, SWE
		I(1)	AUT, BEL, DEU, DNK, FIN, FRA, GR, IRL, NLD, PRT
GDPc	PP	I(0)	GR, PRT
		I(1)	AUT, BEL, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, NLD, SWE
GDPc	KPSS	I(0)	BEL, DEU, ESP, FIN, FRA, ITA, NLD, SWE
		I(1)	AUT, DNK, GBR, GR, IRL, PRT

The conventional stationarity tests which lead to the non-rejection of a unit root may be suspect when the sample under consideration incorporates economic events capable of causing shifts in regime. Breakpoint unit root tests are also conducted such as Zivot and Andrews (1992) and Perron (1997) that allows an endogenous structural break. The null hypothesis of these tests is that series has a unit root against the alternative of a trend stationarity process (TSP) with a structural break. The results of the breakpoint unit root tests for the examined variables in each country (Table 5) show that there are statistically significant breaks for the AVAw in Greece, Italy, Portugal, Spain, Sweden and United Kingdom while concerning to the GDPc, significance is found in Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain and United Kingdom. The findings are inconclusive because there are differences between the Zivot-Andrews and Perron test as regards the existence of a structural break and the dates (the breakpoints which found in the Perron test are usually lagging 1 year of those that obtained by the Z-A test). However, in our analysis we took into account that variables have structural breaks and have to be adjusted prior to entering the ARDL model. For this reason dummies were used when it was required.

Table 5: Results of Breakpoint Unit Root Tests

Variable	Unit Root test		Countries
AVAw	Zivot-Andrews	I(0)	ESP (‘81^{C}, ‘84^{T}), GBR (‘81^{C}, ‘84^{T}, ‘87^{B}), GR (‘03^{C}), ITA (‘99^{C}, ‘02^{T}, ‘00^{B}), PRT (‘87^{T}), SWE (‘05^{T})
	Perron	I(1)	AUT, BEL, DEU, DNK, FIN, FRA, IRL, NLD
GDPc	Zivot-Andrews	I(0)	ESP (1980)^{C,B}, ITA (2002)^{C,B}
	Perron	I(1)	AUT, BEL, DEU, DNK, FIN, FRA, GBR, GR, IRL, NLD, PRT, SWE

Note: C, T and B denote model with intercept (a change in the level), trend (a change in the slope of the trend function) and both (intercept and trend), respectively.

Therefore, the ARDL cointegration procedure is preferable to other conventional approaches such as Johansen multivariate test which require all the variables be of equal degree of integration. The results of the ARDL bounds test for cointegration are reported in Table 6 and prove that when the real AVAw is used as the dependent variable, the calculated F-statistic is higher than the critical value in Austria, France, Greece, Ireland, Portugal and Sweden. Moreover, when the real GDPc is used as the dependent variable, the calculated F-statistic is higher than the upper-bound critical values in all examined EU countries except for Greece and Spain. A number of diagnostic tests were applied so as to examine the reliability of the ARDL models. Results of diagnostic tests in all ARDL models (for each country and dependent variable) indicate that there is no evidence of residual serial autocorrelation (LM test) and the residuals are linearly independent. The Ramsey RESET tests show that all ARDL models are correctly specified.

Table 6: Results of bounds F-statistic for cointegration

Country	Model	Dependent variable	F-statistic	Wald-statistic
Northern countries				
AUT	ARDL(1,1)	LAVAw	9.3479**	18.6959**
	ARDL(1,1)	LGDPc	8.4785**	16.9570**
BEL	ARDL(1,1)	LAVAw	2.8546	5.7092
	ARDL(2,0)	LGDPc	10.2715*	20.5430*
DEU	ARDL(1,1)	LAVAw	2.7889	5.5778
	ARDL(1,1)	LGDPc	4.6285**	9.2570**
DNK	ARDL(1,0)	LAVAw	5.2884	10.5768
	ARDL(2,1)	LGDPc	14.8314*	29.6629*
FIN	ARDL(1,0)	LAVAw	2.3233	4.6466
	ARDL(2,4)	LGDPc	6.0262**	12.0524**

GBR	ARDL(1,1)	LAVAw	4.1344	8.2688
	ARDL(2,1)	LGDPc	9.3721**	18.7443**
IRL	ARDL(1,1)	LAVAw	5.2569***	10.5138***
	ARDL(2,0)	LGDPc	14.8450*	29.6901*
NLD	ARDL(1,3)	LAVAw	2.2508	4.5016
	ARDL(2,1)	LGDPc	8.4436**	16.8871**
SWE	ARDL(1,1)	LAVAw	9.0179**	18.0359**
	ARDL(1,1)	LGDPc	8.7496**	17.4992**
Mediterranean countries				
ESP	ARDL(1,1)	LAVAw	1.4665	2.9330
	ARDL(2,1)	LGDPc	1.7136	3.4273
FRA	ARDL(1,3)	LAVAw	4.0422***	8.0844***
	ARDL(2,1)	LGDPc	17.2484*	34.4968*
GR	ARDL(1,2)	LAVAw	7.9797**	15.9595**
	ARDL(1,1)	LGDPc	2.9415	5.8830
ITA	ARDL(3,1)	LAVAw	3.3480	6.6961
	ARDL(3,1)	LGDPc	6.5403***	13.0806***
PRT	ARDL(1,0)	LAVAw	9.5934**	19.1868**
	ARDL(2,2)	LGDPc	7.9025*	15.8050*

Note: *, ** and *** denote statistical significance at the 1%, 5% and 10% levels, respectively. Critical value bounds (see appendix, Table A1) are obtained from Pesaran et al. (2001)

It should be mentioned that in a cointegrating relationship, the residuals from the long-run equation by the ARDL procedure, must necessarily be stationary, I(0). Otherwise, the results of the F-statistic for the existence of long-run equilibrium relationship between the examined variables are unreliable.

Therefore, in order to confirm the claim that exist cointegration between the variables an ADF unit root test is applied on the residuals. The results (Table 7) show that the residuals from the long-run equation when the AVAw is the dependent variable are a stationary series and there is cointegration only for Austria, France, Greece and Sweden. Additionally, when the real GDPc is the dependent variable the residuals are stationary and exists cointegration in Belgium, France, Germany, Italy, Netherlands, Portugal and Sweden. However, the residuals from the long-run equation when the AVAw is the dependent variable are a non-stationary series for Ireland and Portugal. Moreover, the residuals are not I(0), when the dependent variable is the real GDPc for Austria, Denmark, Finland, United Kingdom and Ireland.

Table 7: Results of ADF Unit Root Test in residuals

Country	Depend. variable	ADF test statistic	Country	Depend. variable	ADF test statistic	Country	Depend. variable	ADF test statistic
Northern countries								
AUT	LAVAw	-3.971167 (0.0177)**	DNK	LGDPc	-0.199828 (0.6059)	IRL	LAVAw	0.823025 (0.8855)
	LGDPc	1.838282 (0.9825)	FIN	LGDPc	1.086117 (0.9236)		LGDPc	1.785970 (0.9805)
BEL	LGDPc	-4.178951 (0.0105)**	GBR	LGDPc	0.389331 (0.7917)	SWE	LAVAw	-2.852160 (0.0600)***
DEU	LGDPc	-3.762670 (0.0078)*	NLD	LGDPc	-5.097078 (0.0009)*		LGDPc	-3.639190 (0.0091)*
Mediterranean countries								
FRA	LAVAw	-5.039799 (0.0010)*	GR	LAVAw	-2.194389 (0.0293)**	PRT	LAVAw	2.165963 (0.9910)
	LGDPc	-3.751948 (0.0071)*	ITA	LGDPc	-3.650771 (0.0097)*		LGDPc	-4.210757 (0.0148)**

Note: *, ** and *** denote statistical significance at the 1%, 5% and 10% levels, respectively and probability reported in parenthesis. Critical values are reported in appendix, Table A2.

Tests for the causality between the variables used are applied by incorporating the lagged error correction term. The causality is examined through the statistical significance of the coefficient of the lagged error correction term and joint significance of the lagged differences of the explanatory variables using the Wald test (see Table 8). In order to test the reliability of the error correction models, a number of diagnostic tests were applied. No evidence of autocorrelation in the disturbance of the error term is found. The results indicate that there is heteroskedasticity only in France (model with dependent variable AVAw), Germany and Netherlands (models with dependent variable GDPc). However, since the time series constituting both the equations are of mixed order of integration, I(0) and I(1), it is natural to detect heteroskedasticity (Shrestha - Chowdhury 2005). Moreover, all models pass the Jarque-Bera normality test suggesting that the errors are normally distributed and the stability Ramsey RESET tests indicate that all models are correctly specified. The high values of R^2 for all models prove that the overall goodness of fit of the model is satisfactory.

The long-run causality from the real GDPc to AVAw is statistically significant in France and Greece (Mediterranean countries). Relating to the northern EU countries is significant in Austria but not in Sweden. The reverse long-run causality from AVAw to GDPc is statistically significant in France, Italy, Portugal (Mediterranean countries), Belgium, Germany, Netherlands and Sweden (northern countries).

Table 8: Results of causality test

Country	Dependent variable	Model	Long-run relationship	Short-run relationship	ECM	Causal flow
			Wald statistic (χ^2)		*t-statistic*	
Northern countries						
AUT	LAVAw	ARDL(1,1)	63.4771*	108.2242*	-0.61723 (-4.0817)*	GDPc → AVAw (long-run and short-run)
BEL	LGDPc	ARDL(2,0)	15.8404*	13.4400*	-0.50494 (-6.3243)*	AVAw → GDPc (long-run and short-run)
DEU	LGDPc	ARDL(1,1)	2089.8*	17.4650*	-0.18014 (-1.8800)***	AVAw → GDPc (long-run and short-run)
NLD	LGDPc	ARDL(2,1)	8.2070*	85.1407*	-0.31004 (-4.0266)*	AVAw → GDPc (long-run and short-run)
SWE	LAVAw	ARDL(1,1)	1.7282	80.0178*	-0.44772 (-2.5958)**	GDPc → AVAw (short-run)
	LGDPc	ARDL(1,1)	43.4875*	95.8112*	-0.34881 (-3.7122)*	AVAw → GDPc (long-run and short-run)
Mediterranean countries						
FRA	LAVAw	ARDL(1,2)	66736.0*	74.5371*	-0.33973 (-2.8419)*	GDPc → AVAw (long-run and short-run)
	LGDPc	ARDL(1,3)	2.8156***	117.3427*	-0.40747 (-4.8029)*	AVAw → GDPc (long-run and short-run)
GR	LAVAw	ARDL(1,2)	40.3565*	32.0008*	-0.72358 (-3.9750)*	GDPc → AVAw (long-run and short-run)
ITA	LGDPc	ARDL(3,1)	6.6675*	153.9298*	-0.27751 (-3.0638)*	AVAw → GDPc (long-run and short-run)
PRT	LGDPc	ARDL(2,2)	17143.9*	1.7579	-0.14155 (-3.1338)*	AVAw → GDPc (long-run)

Note: *, *** denote statistical significance at the 1%, 10% levels, respectively and t-statistics reported in parenthesis.

The coefficient of the lagged error correction term, ECM, is negative and statistically significant, as expected, in all models and EU countries making certain that the series is non-explosive and that long-run equilibrium is attainable. ECM measures the speed at which dependent variable adjust to changes in the explanatory variable before converging to its equilibrium level and depicts that adjustment in dependent variable (GDPc or AVAw) does not occur instantaneously. As regards the northern EU countries, in Belgium 51%, Germany 18%, Netherlands 31% and Sweden 35% of the disequilibria of the previous year's shock to GDPc adjust back to the long-run equilibrium in the current year, while in France 41% and Greece (Mediterranean countries) the percentage is 72% which suggests a fast adjustment process. In Austria 62% (northern country) of the disequilibria of the previous year's shock to agriculture adjust back to the long-run equilibrium in the current year. Concerning the Mediterranean countries, in France, Italy and Portugal, the percentages are 34%, 28% and 14% respectively which imply a slow adjustment procedure.

The short-run causality from the real GDPc to AVAw is statistical significant in two northern EU countries, Austria, Sweden and two Mediterranean countries, France, Greece. Moreover, AVAw cause GDPc and there is statistically significant short-run relationship in Belgium, Germany, Netherlands, Sweden (northern EU countries), France and Italy (Mediterranean countries). The short-run relationship from GDPc to agriculture is not significant in Portugal (Mediterranean country).

The empirical results show that in most of the examined and cointegrated EU countries there is a distinct unidirectional causal flow from GDPc to AVAw and vice versa. However, there is a bi-directional relationship between the variables in the both long-run and short-run for France (Mediterranean country) and only in the short-run for Sweden (northern country). The bi-directional causality indicates a feedback relationship and these findings suggesting that AVAw and GDPc mutually influence each other.

Furthermore, in relation to the EU countries which their variables are not cointegrated with the ARDL approach an alternative test was applied to investigate the causality. The results of Granger causality by Toda and Yamamoto approach (Table 9) show that there is no causal relationship in northern EU countries such as Finland and Ireland. On the other hand, there is Granger causality from real GDPc to AVAw for Denmark, United Kingdom (northern EU countries) and Spain (Mediterranean country). In addition, AVAw causes real GDPc in Denmark. Consequently, there is a bi-directional Granger causality for Denmark which indicates a feedback relationship signifying that real GDPc and AVAw jointly influence each other. Diagnostic tests were applied in each VAR model and the findings show that there are not heteroskedasticity and autocorrelation problems. As regards the dynamic stability of each model, the inverse roots associated with the characteristic equation corresponding to the model for each country, lie within the unitary circle.

The empirical findings prove that there is a unidirectional causal relationship from agricultural value added per worker to GDP per capita and vice versa in several Mediterranean and northern countries in Europe, but feedback relationship (bi-directional causal relationship) exists only in one Mediterranean country and two northern EU countries.

Table 9: Results of Granger causality by Toda & Yamamoto approach

Country	Dependent variable	Independent variable	Modified Wald statistics	Causality
Northern countries				
DNK	LAVAw	LGDPc	4.339112** (0.0372)	GDPc → AVAw
	LGDPc	LAVAw	3.282986*** (0.0700)	AVAw → GDPc
FIN	LAVAw	LGDPc	1.086111 (0.5810)	No
	LGDPc	LAVAw	4.034331 (0.1330)	No
GBR	LAVAw	LGDPc	5.832381*** (0.0541)	GDPc → AVAw
	LGDPc	LAVAw	2.917743 (0.2325)	No
IRL	LAVAw	LGDPc	3.216726 (0.2002)	No
	LGDPc	LAVAw	0.623493 (0.7322)	No
Mediterranean countries				
ESP	LAVAw	LGDPc	9.107974** (0.0105)	GDPc → AVAw
	LGDPc	LAVAw	3.610824 (0.1644)	No

Note: ** and *** denote statistical significance at the 5% and 10% levels, respectively and p-values reported in parenthesis.

4. Conclusion

In this paper, an effort was made to identify the relationship between agricultural value added per worker and GDP per capita in a sample of Mediterranean and northern countries in Europe by employing cointegration analysis and Granger causality tests. Results regarding the autoregressive distributed lag (ARDL) model show that there is a distinct unidirectional relationship from AVAw to GDPc both in the long-run and short-run for Belgium, Germany, Netherlands, (northern countries) and Italy, while only in the long-run for Portugal (Mediterranean countries). The reverse causality from GDPc to AVAw both in the long-run and short-run exist for Austria (northern country) and Greece (Mediterranean country). There are bi-directional long-run and short-run relationships between the examined variables in France (Mediterranean country) and only in the short-run for Sweden (northern country). Additionally, Granger causality test by Toda and Yamamoto approach prove that GDPc cause AVAw in United Kingdom (northern country) and Spain (Mediterranean country). There is also feedback between the investigated variables for Denmark (northern country).

Despite the fact that the contribution of agriculture in Northern EU countries is marginal, findings provide evidences that agriculture might drive economic growth, especially in Germany and Belgium. The relative economic significance of agriculture in these northern countries is not high however the sector maintains an essential role in the growth process. Northern EU country such as the Netherlands and Mediterranean countries such as France, Italy and Portugal have a clear comparative advantage in agriculture and are major exporters on world agricultural markets.

Results prove that there are many Mediterranean and northern countries in which causality exists in one direction from AVAw to GDPc, or, in other words, that agriculture can lead to growth in European Union. Those findings are consistent with studies supporting that agricultural productivity growth is essential to bear the economy into growth (get the economy moving) because of the fact that releases a surplus of raw materials, food, capital, labor and simultaneously generates demand for industrial goods and services. Moreover, there are several northern countries and only one Mediterranean country (Greece) which the causal relationship exists from GDPc to AVAw. A possible explanation of this finding is that increases in the non-agricultural wage lead to relocation and raises in agricultural productivity thereby implying that causality runs from economic growth to agriculture. Additionally, the bi-directional relationship between agriculture and economic growth occurs in two northern EU countries (Denmark and Sweden) and only in one Mediterranean country (France) which indicates that there are “strong” economies in this period of economic crisis.

On the other hand, some crucial differences among the Mediterranean and northern countries in Europe were observed. Thus, the speed at which GDPc adjusts to changes in agricultural value added per worker before converging to its equilibrium level is lower in Spain and Portugal than in the northern EU countries. In particular, Greece has faster adjustment process than the northern EU countries when the causality runs from GDPc to AVAw. However, the empirical results failed to provide obvious differences and strong evidence as regards the agriculture’s role in economic growth among northern and Mediterranean countries in Europe. So, it would be useful to re-examine the role of agriculture in economic growth adding Central and Eastern European countries in the sample.

In conclusion, it is noteworthy that although in the European Union is observed a significant reduction in AVA as a percentage of GDP agriculture may lead to economic growth in several EU countries. Hence, policy makers have to take into account the fact that agriculture can become the engine of growth in Europe and play the stabilizer’s role in the whole EU economy especially for this period of economic crisis.

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Appendix

Table A1: Critical value bounds of the F-statistic and Wald-statistic

Critical value bounds of the F-statistic						*Critical value bounds of the Wald-statistic*					
1%		5%		10%		1%		5%		10%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Case I: No intercept and no trend						***Case I: No intercept and no trend***					
5.020	6.006	3.145	4.153	2.458	3.342	10.040	12.011	6.291	8.307	4.916	6.684
Case II: Intercept and no trend						***Case II: Intercept and no trend***					
7.057	7.815	4.934	5.764	4.042	4.788	14.114	15.630	9.867	11.528	8.085	9.576
Case III: Intercept and trend						***Case III: Intercept and trend***					
9.063	9.786	6.606	7.423	5.649	6.335	18.126	19.571	13.212	14.847	11.299	12.670

Source: Pesaran et al. (2001)

Table A2: Critical values of ADF Unit Root Test in residuals

Dependent variable	**Country**	**Critical values**		**Country**	**Critical values**		**Country**	**Critical values**	
LAVAw	AUT	1%	-4.198503	FRA	1%	-4.198503	SWE	1%	-3.600987
		5%	-3.523623		5%	-3.523623		5%	-2.935001
		10%	-3.192902		10%	-3.192902		10%	-2.605836
LGDPc		1%	-2.622585		1%	-3.621023		1%	-3.600987
		5%	-1.949097		5%	-2.943427		5%	-2.935001
		10%	-1.611824		10%	-2.610263		10%	-2.605836
LAVAw	GR	1%	-2.644302	IRL	1%	-2.624057	PRT	1%	-2.647120
		5%	-1.952473		5%	-1.949319		5%	-1.952910
		10%	-1.610211		10%	-1.611711		10%	-1.610011
LGDPc	GBR	1%	-2.622585		1%	-2.622585		1%	-4.394309
		5%	-1.949097		5%	-1.949097		5%	-3.612199
		10%	-1.611824		10%	-1.611824		10%	-3.243079
LGDPc	DNK	1%	-2.644302	ITA	1%	-3.639407	BEL	1%	-4.198503
		5%	-1.952473		5%	-2.951125		5%	-3.523623
		10%	-1.610211		10%	-2.614300		10%	-3.192902
LGDPc	FIN	1%	-2.647120	NLD	1%	-4.198503	DEU	1%	-3.762670
		5%	-1.952910		5%	-3.523623		5%	-2.960411
		10%	-1.610011		10%	-3.192902		10%	-2.619160