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A Dumitrescu-Hurlin Panel Causality Approach to the Financial Deepening-Agricultural Labour Productivity Interplay in ECOWAS

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Abstract

The agricultural sector remains quintessential to the Economic Community of West African States (ECOWAS) in terms of its contribution to gross domestic product and employment, so, agricultural labour productivity provides a clue to the living standards in this region. In theory, models such as the endogenous growth model suggest that finance plays a crucial role in respect of its ability to engender an expansion of the real sector. This study analysed the impact financial deepening exerted on agricultural labour productivity in ECOWAS between 2008 and 2017. Owing to possible endogeneity of the regressors, the instrumental variable techniques were prioritised. The empirical results from the techniques compared are unanimous – financial deepening has not exerted a significant impact on agricultural labour productivity within the ECOWAS region but life expectancy at birth and agricultural fixed capital formation per worker has. Thus, if the status quo is maintained, life expectancy at birth and agricultural gross fixed capital formation per worker are the variables that can drive agricultural labour productivity in ECOWAS. As per finance, concerted national and regional efforts are exigent in order to improve the availability of credit to agriculturists in ECOWAS if finance should become a lever for bolstering agricultural labour productivity in this particular region.

Keywords: Finance; agriculture; labour productivity; Economic Community of West African States; instrumental variables; panel data

JEL Classification: C23; Q14

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Introduction

The contribution of the agricultural sector remains indispensablein the Economic Community of West African States (ECOWAS). According to Ecostat (2018), on the average, this sector contributed about 20 percent to the total GDP of ECOWAS between 2014 and 2016 and employs more than half of the total population. In essence, paying attention to the productivity of the agricultural sector in this region is crucial following from the fact that productivity determines the gains that accrue to actors in the agricultural sector (Obasaju, Olayiwola and Okodua; 2016).

With a substantial amount of agricultural labour in ECOWAS, the productivity of agricultural labour should be a worthy goal to pursue. The Centre for Study of Living Standards (CSLS) noted that the use of labour productivity as a partial measure of productivity and overall living standards is justified as discussed in de Avillez (2011). And given the importance of agriculture in ECOWAS, agricultural labour productivity is expected to provide a reasonable clue to the standard of living of people in this region.

Concerning the role of finance, economic growth models such as the endogenous growth model, posits that finance can contribute to the growth of the real sector. For instance, the role of finance on productivity and economic growth has been discussed in the works of King and Levine (1993) and Levine, Oliver and Warusawitharana (2016), among others. Heil (2017) noted that there are direct and indirect links between finance and productivity. Direct productivity gains come from the contributions to such inputs as labour, capital and research and development (R&D) for instance through the reduction of the costs of such inputs. Finance can boost productivity indirectly by promoting a more efficient allocation of capital. Wurgler (2000) showed that developed economies are better at allocating capital more efficiently than the less developed countries. By reducing investments in declining sectors while raising investments in growing ones, finance can also aid growth and productivity. In the literature, other indirect channels through which finance aids productivity includes through the former's impact on research and development. For example, firms that conduct R & D may have access to finance at lower cost as a result of their participation in public grant programs which may increase the activities connected to R&D and consequently enhancing gains from productivity (Heil, 2017).

As a result of the crucial role finance can play in enhancing productivity, labour productivity inclusive, it implies that the depth of financing is worth paying attention to. According to Ndebbio (2004), financial deepening(i.e. the depth of financing) simply means an increase in supply of financial asset in the country. It is a term used by economists to refer to increasing provision of financial services and may be used to refer to a wider choice of services. Financial deepening also refers to achieving a greater penetration of financial services to all levels of society, whether through the formal banking sector or through the informal channels. Its impact might be macro in nature such as in respect of a country, or micro, dealing with its impact on firms and households. Put differently, financial deepening refers to the depth of the availability of the supply of money or credit and the access to credit is expected to boost productivity. Financial deepening can generally increase the ratio of money supply to GDP (gross domestic product) and access to money can provide more opportunities for investment and growth.

In the literature, some studies based on the nexus of finance and productivity suggest that the direction of causality between this duo (finance and productivity) is not necessarily unidirectional. For instance, in theory, the supply-leading and demand-following hypotheses respectively suggest that financial development can boost growth (and/or productivity) and

that growth (and/or productivity) can in turn enhance financial development. Gries, Kraft and Meierrieks (2009) also concur that deeper financial system are associated with a more effective supply of financial services to the real sector. They observed, in the spirit of the supply-leading hypothesis that finance may lead growth in the sense of the financial sector supplying the real sector with financial services in order to expand the activities of the real sector.

Inversely, they (Gries, Kraft and Meierrieks, 2009) also note that finance follows growth viewed from the perspective that growth in the real sector can spur expansion in the financial sector through the backward linkage when the former demands for financial services; this can consequently lead to the development of the financial sector. The direction of causation, according to this same study, could also be bi-directional such that finance might be simultaneously growth leading and growth following. In this light, it becomes important to investigate the direction of causality between financial deepening and agricultural labour productivity in ECOWAS because the policy to be deployed in the different cases are not necessarily the same. The key objective of this study is therefore to investigate the direction of causality between financial deepening and agricultural labour productivity in ECOWAS using a relatively new panel Granger causality approach.

Methodology

The interest of this article is to identify the direction of causality between financial deepening and agricultural labour productivity in ECOWAS from 2008 to 2017[1]. With a sector-specific outlook, as a proxy for financial deepening relevant to the agricultural sector, agricultural credit as a share of agricultural GDP is used. In the literature on financial deepening, without a sector-specific outlook, common measures of financial deepening include private sector credit as a share of GDP, money supply as a share of GDP, etc. To measure agricultural labour productivity, we use agricultural value added per worker which is calculated as agricultural value added divided by the agricultural population[2].

In what follows, the models of interest are specified with the overarching motive of investigating whether financial deepening helps in predicting agricultural labour productivity or vice versa.

Model Specification

$$Log(ALP_{i,t}) = \alpha_i + \sum_{k=1}^{K} \gamma_{i,k} Log(ALP_{i,t-1}) + \sum_{k=1}^{K} \beta_{i,k} Log(AGCD_{i,t-1}) \quad (1)$$

$$Log(AGCD_{i,t}) = \alpha_i + \sum_{k=1}^{K} \gamma_{i,k} Log(AGCD_{i,t-1}) + \sum_{k=1}^{K} \beta_{i,k} Log(ALP_{i,t-1}) \quad (2)$$

Where ALP is agricultural labour productivity, AGCD is agricultural credit deepening, and K is the maximum lag order. Subscripts *i* and *t* refer to country and time respectively. In model 1, one-year lagged values of ALP and AGCD are meant to predict the current values of ALP. In model 2, the lagged values are meant to predict the current values of AGCD.

[1]The period of study is based on availability of data and also to capture recent developments

[2]The choice of this measure is based on availability of data. Another measure of labour productivity is value added per hour, but data on this measure is not readily available for ECOWAS countries. See OECD (2001) for a comprehensive discussion of productivity.

If what holds is that the financial sector (in this case financial deepening) Granger causes the real sector (in this case agricultural labour productivity) as in model 1, we conclude that supply-leading hypothesis holds. Conversely, if causality runs from the real sector to the financial sector as in model 2, we conclude that the demand-following hypothesis holds sway in ECOWAS. A bi-directional relationship is evidence in support of both demand-following and supply-leading hypotheses while if neither of the hypotheses holds, then independence is suggested and the behaviour of one variable cannot help in predicting the performance of the other.

Estimation Technique

Different techniques have been developed to test for causality. These include, among others, the traditional Granger causality test and Toda and Yamamoto (1995) test. A relatively recent approach is Dumitrescu and Hurlin (2012) (henceforth called D&H, 2012) which applies to heterogeneous panel data models. Since this current study being panel in nature, involves not only a time-series but also a cross-section dimension, as noted by D&H (2012), the use of cross-sectional information involves taking into cognisance the heterogeneity across individuals (which in our case is 15 ECOWAS countries). Granger (2003) noted that: "*if some variable, say X_t causes another variable, say Y_t, everywhere in the panel [..]. This is rather a strong null hypothesis."*

To this end, D&H (2012) proposed a simple test of Granger causality for heterogeneous panel data models. This test factors in the two dimensions of heterogeneity in this context which are: (1) heterogeneity of the causal relationships and (2) the heterogeneity of the regression model used. It should also be recalled that the definition of Granger causality is based on the premise that: (1) the cause preceded the effect and (2) the causal series had information about the effect that was not contained in any other series according to the conditional distributions. Granger (1969) opined that a variable *x* causes *y* if we are able to predict *y* better using all available information than in the situation in which the information set used does not include *x*.

D&H (2012) noted that the test they developed ismore powerful than those based on single time series even in a panel that has very few cross-section units. The asymptotic properties of the test remain significantly unchanged whether or not the sample is balanced or when the lag order differs across individuals. In addition, the panel statistics lead to substantial increase in the power of the Granger non-causality tests even for samples having small T and N dimensions. The null hypothesis of Homogenous non-causality is tested against the alternative of heterogeneous non-causality which allows for heterogeneity of the estimated parameters among individuals. The series being tested however have to be stationary.

To test for the stationarity of variables in a panel context, we rely on the Fisher ADF and PP test due to Maddala and Wu (1999) while validating it with the Pesaran (2007) test where possible; these tests are easy to use even if there are gaps in the data.

Sources and Description of Data

To obtain the labour productivity of the agricultural sector in ECOWAS, agricultural value added per worker, obtained from World Development Indicators (WDI), is used. Agricultural value added per worker (measure of agricultural labour productivity) is calculated by using the number employed in the agricultural sector to divide the value added in that sector. This variable is in constant 2010 US dollars. Financial deepening (proxied by agricultural credit deepening) is calculated as agricultural credit divided by agricultural GDP, then converted to percentage. Agricultural credit data is obtained from FAO while agricultural GDP data is

obtained from ECOWAS national accounts. Agricultural credit and GDP are both in constant 2010 US dollars.

Presentation and discussion of results

Summary Statistics

Table 1 presents the summary statistics from 2008 to 2017. The values are presented in their raw/untransformed forms in order to get insights from the original data. The minimum value for agricultural labour productivity (agricultural value added per worker) within the study period is about $393 which is a value specifically for Guinea in year 2009 whose value rose to $561.46 in 2017. Nigeria had the maximum value in the region, amounting to $6057.86 which was a value attained in 2010. The average value stood at $1409.94 with a somewhat high standard deviation of $1176.88 showing some reasonably high disparity in labour productivity within ECOWAS. In terms of agricultural credit deepening, the minimum value of 0.02% was attained by Guinea Bissau in 2015 while the maximum of 21.07% was attained by Mali in 2009. The mean value of 2.18% ensued and a 3.01% standard deviation shows that not much disparity exist in terms of agricultural credit deepening within ECOWAS.

Table 1: Summary statistics

Variable	*Observations*	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
ALP (constant 2010 $)	130	1409.94	1176.88	393.22	6057.86
AGCD (%)	122	2.18	3.01	0.02	21.07

Source: Authors' estimations using Stata software
Note: ALP is agricultural labour productivity and AGCD is agricultural credit deepening

Panel unit root tests

In Table 2, the result of the panel unit root test is presented. As noted earlier, D&H (2012) requires that the series be stationary. The Maddala and Wu (1999) panel unit root test is reported. Since the panel unit root test is sensitive to lag order, and since the panel tends to be micro in nature (with time series just 10), lags 0 and 1 are reported. The Pesaran (2007) test is used to validate the results when necessary. The panel unit root tests provide evidence in support of the stationarity of both variables.

Table 2: Panel unit root test

Maddala and Wu (1999) Test			
	Lags		
Variable	0	1	*Order of Integration*
LALP	61.421 (0.000)***	34.426 (0.187) *87.404 (0.000)******	I(0)
LAGCD	88.831 (0.000)***	31.729 (0.286) *-2.602 (0.001)******	I(0)

Source: Authors' estimations using Stata software
Note: *, **and *** denote significance at 10%, 5% and 1% respectively. The Pesaran (2007) values (italicized) are presented below the Maddala and Wu (1999) values in the occasion that the lags 0 and 1 of the latter test yield different conclusions.

For robustness, the Akaike and Bayesian information criteria (AIC and BIC) are used in determining the optimal lag length. The results are the same for both AIC and BIC. Both AIC and BIC tested 1 to 4 lags and chose 4 as the optimal number. The result of the standardized

average statistic which is consistent when T is relatively small (in this case much less than 50) (see Dumitrescu and Hurlin, 2012) is presented as Z-bar Tilde alongside its corresponding p-value.

The results of the Granger non-cauality test are the same using both BIC and AIC. With a p-value of 0.121, the null-hypothesis that Logged AGCD (LAGCD) does not Granger-cause Logged ALP (LALP) cannot be rejected even at the 10% level of significance. On the contrary, with a p-value of 0.001, the null hypothesis that LALP does not Granger-cause LAGD is rejected, even at the 1% level of significance. Thus, it can be concluded that a uni-directional causality exists between agricultural labour productivity and agricultural credit deepening with causality running from the former to the latter and not vice versa[3]. This is evidence in support of the demand-following hypothesis which opines that demand of the real sector on the services of the financial sector brings about an expansion of the financial sector. This also means that agricultural labour productivity contains relevant information for predicting movements in financial deepening/agricultural credit depths in ECOWAS.

Table 3: Dumitrescu and Hurlin Granger non-causality results

Independent variable	*Dependent variable*	*Z-bar Tilde*	*Interpretation*	*Remark*
Panel A: Using BIC				
LAGCD (agric credit deepening)	LALP (agric labour prod.)	1.552 (0.121)	absence of causality from LAGCD to LALP	Uni-directional causality
LALP	LAGCD	3.255 (0.001)	Presence of causality from LALP to LAGCD	
Panel B: Using AIC				
LAGCD	LALP	1.552 (0.121)	absence of causality from LAGCD to LALP	Uni-directional causality
LALP	LAGCD	3.255 (0.001)	Presence of causality from LALP to LAGCD	

Source: Author's computation using Stata software
Note: p-values are presented in parentheses ( )
Explanatory note: LAGCD is log of agriculture credit deepening; LALP is log of agricultural labour productivity.

Adeyeye, Fapetu, Aluko and Migiro (2015) investigated whether or not the supply-leading hypothesis holds in a developing economy using Nigeria as a case study between 1981 and 2013. They used the Granger pairwise causality test of Granger (1969) for the analysis and employed different measures of financial development. Their study found that although there were evidences in support of a bi-directional relationship, economic growth had greater predictive power on financial development than financial development had on it. Hence, they concluded that the demand-following hypothesis was dominant in Nigeria. Thus, their finding

[3]In auxiliary regressions not reported here, using private sector credit as a share of GDP instead of the sector-specific indicator used does not yield any significantly different conclusions. In addition, checking the sensitivity of the results to a larger dimension of T by starting from 2000 rather than 2008 also does not yield any significant differences in results. However, starting from the year 2000 leaves us with more missing data, hence we stick to year 2008.

is somewhat similar to this current study, however, the latter study covers the entire ECOWAS countries and the dependent variable is agricultural labour productivity rather than economic growth.

A more recent and similar study is that of Chow, Vieito and Wong (2019) whose study dealt with analysing whether both the demand-following and supply-leading hypotheses hold true in developing countries. Their study covered 14 developing countries namely Brazil, Chile, China, Costa Rica, El Salvador, Guatemala, India, Malaysia, Pakistan, South Africa, Sri Lanka, Thailand and Turkey, from 1950 to 2014. They used linear Granger causality test (within the setting of vector autoregressive and vector error correction models VAR and VECM respectively) and non-linear Granger causality test (using the residuals derived from Hui, Wong, Bai and Zhu; 2017 test to the residuals obtained from the VAR and VECM results). Based on the empirical results, they concluded that there will always be a type of relationship between financial development and economic growth, that is, at least there exists a uni-directional relationship and sometimes, bi-directional relationship between the two. Thus their finding of a uni-directional relationship, specifically from economic growth to financial development is to some extent similar to that of this current study which also finds evidence in support of the real sector Granger-causing the financial sector. But Chow, Vieito and Wong (2019)'s study does not include any ECOWAS country, has a different time scope, and different in the technique of analysis employed.

With the revelation that the demand-following hypothesis holds in ECOWAS as agricultural labour productivity is found to Granger cause financial deepening, and given the endogeneous nature of agricultural labour productivity in itself, we conduct a brief analysis of the determinants of agricultural labour productivity without going into details. As regressors, financial deepening (AGCD), agricultural gross capital formation per worker (AGFCFpw), trade openness, human capital index, fertilizer and life expectancy at birth are used. All the variables are logged. Different panel data techniques are compared namely the feasible generalized least square (FGLS), Driscoll and Kraay (D&K) standard errors, fixed and random effects techniques. The definition of the variables and the results are contained in the appendix. The unanimous conclusion of the various techniques is that AGFCFpw (proxy for physical stock of capital per worker/domestic investment per worker in the agricultural sector), human capital index[4] and life expectancy at birth (proxy for health) are significant determinants of agricultural labour productivity in ECOWAS[5].

5.0 Conclusion and policy recommendations

The nature of causality between financial deepening and agricultural labour productivity in ECOWAS between 2008 and 2017 has been investigated. The Dumitrescu and Hurlin (2012) Granger non-causality test was conducted. It was found that in ECOWAS, agricultural labour productivity Granger-causes financial deepening and not the other way round. Thus, this shows that it is the demand-following hypothesis that holds in the case of ECOWAS. With the revelation of causality running from agricultural labour productivity to agricultural credit deepening, this suggest that governments and policy makers in ECOWAS should device means to enhance the ability of agricultural labour to make demands on the financial sector as this is capable of expanding the financial sector.

[4]Note that as obtained from the Penn World Table, this index is based on education and excludes health.
[5]Year – and country-fixed effects are included in the regressions.

In other words, since the past and current values of financial deepening does not seem to help in predicting the behaviour of agricultural labour productivity in ECOWAS, the key to enhancing agricultural labour productivity does not seem to lie in pursuing financial deepening. Inversely, enhancing agricultural labour productivity in the ECOWAS region through its significant determinants (agricultural fixed capital formation per worker, human capital index and life expectancy at birth) is expected to help in predicting how well the financial sector expands in terms of the depth of credit supplied to the agricultural sector.

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Appendix

Description of data

Variable	Definition	Measurement	Source of data
Agricultural labour productivity (ALP)	Agricultural value added per worker. It is in constant 2010 US dollars	Absolute terms	World Development Indicators (WDI)
Agricultural gross fixed capital formation per worker (AGFCFpw)	It is a proxy for agricultural investment per worker calculated as agricultural gross fixed capital formation divided by labour employed in agricultural sector. An indirect method is used in calculating the labour employed in the agricultural sector. It is calculated as the agricultural value added divided by the agricultural value added per worker, both expressed in constant 2010 US dollars	Absolute terms	Agricultural gross fixed capital formation obtained from Food and Agriculture Organisation (FAO) and both agricultural value added and agricultural value added per worker (in real terms) obtained from WDI
Agricultural credit deepening (AGCD)	Calculated as agricultural credit divided by agricultural GDP. It is used as a proxy for financial deepening in respect of the agricultural sector	Percentage	Agricultural credit data obtained from FAO while agricultural GDP data obtained from ECOWAS national accounts
Trade openness	It is the sum of imports and exports divided by GDP.	Percentage	World Development Indicators (WDI)
Human capital index (HCI)	Calculated based on years of schooling and returns to education.	Index	Penn World Table
Fertilizer consumption (FER)	It is fertilizer consumption (kilograms per hectare of arable land)	Pure fraction	World Development Indicators (WDI)
Life expectancy at birth (LEB)	It is how long a citizen (new born) is expected to live, on the average, if current death rates do not change. It is used as a proxy for health status	Average (number of years)	World Development Indicators (WDI)

Source: Authors' design based on various databases.

	FGLS	D&K	FIXED EFFECT	RANDOM EFFECT
Dep. Variable: LALP				
Panel A				
LAGCD	0.004 (0.010)	0.035* (0.017)	0.035 (0.035)	0.034 (0.035)
LAGFCFpw	0.106*** (0.029)	0.283*** (0.032)	0.283* (0.147)	0.286* (0.152)
LTRDO	-0.059 (0.037)	-0.063 (0.049)	-0.063 (0.110)	0.051 (0.097)
LHCI	2.651*** (0.571)	2.517*** (0.307)	2.517 (1.429)	2.630 (1.859)
LFER	-0.002 (0.004)	0.011 (0.009)	0.011 (0.012)	0.010 (0.014)
LLEB	2.145*** (0.757)	2.998*** (0.596)	2.998** (1.395)	3.225** (1.470)
CONSTANT	-3.285 (3.237)	-6.068** (2.715)	-6.017 (5.964)	-7.301 (6.333)
Panel B				
Year FE	Yes	Yes	Yes (implicit)	Yes
Country FE	Yes	Yes	Yes	Yes
R-Squared	-	0.92	0.22 (overall)	0.92
Wald chi-squared(F-Stat.)	2052.11	(69246.11)	-	-
Chi-squared [p-value]	[0.000]	[0.000]	-	-
Wooldridge Auto Correlation Test (F-Stat.) [p-value]	(16.834) [0.001]	-	-	-
Modified Wald Test for Heteroskedasticity Chi-square [p-value]	634.08 [0.000]	-	-	-
Breusch-Pagan LM test of independence/cross-sectional dependence Chi-square [p-value]	503.489 [0.000]	-	-	-

Auxiliary regressions (FGLS, D&K, Fixed effects and Random effects)

Source: Author's, using Stata software

Note: Given the presence of autocorrelation, heteroscedasticity and cross-sectional dependence, the FGLS regression is run by using appropriate commands in Stata which makes the estimates robust to autocorrelation, heteroscedasticity and cross-sectional dependence. For the other techniques employed,robust standard errors which are consistent in the presence of any pattern of heteroskedasticity and autocorrelation within panels are reported in parentheses ( ) in panel A. In panel B, F statistics are in parentheses while p-values are in squared brackets. *, ** and ***, respectively, indicate significance at 10%, 5% and 1% levels. – means the estimates are not available or not reported.

Explanatory note: LALP is log of agricultural labour productivity; LAGCD is log of agricultural credit deepening; LAGFCFpw is log of agricultural gross fixed capital formation per worker; LTRDO is log of trade openness; LHCI is log of human capital index; LFER is log of fertilizer; LLEB is log of life expectancy at birth.