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Agriculture, Rural Development and Economic Growth in Developed Countries: A Panel Causality Analysis Using the Dumitrescu-Hurlin Approach (2000-2021)

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Abstract: This study aims to investigate the relationship between agriculture, rural development, and economic growth in developed countries from 2000 to 2021. By employing different empirical estimations, and Dumitrescu-Hurlin, results show a bidirectional causal relationship between forest area and economic growth in all countries. A two way causality relationship for some countries between female employment in agriculture, permanent cropland, and growth. A one directional causal relationship for all countries between agricultural land, cereal yield, male employment in agriculture, fertilizer consumption, and growth. This study has applied new econometric methods D-H as a first contribution in this research area.

Keywords: Agriculture; Rural development; Economic growth; Causality.

1. Introduction

A major obstacle to achieving sustainable development goals has been the declining state of the environment and the poor living conditions of farmers in rural areas (Hu et al. 2022). A key component of accomplishing the sustainable development goals is coordinating food production, the environment, and farmers' well-being. Agriculture and rural development have been acknowledged as important forces behind economic development. A corpus of studies has provided extensive documentation of how these industries affect the economy (Adebayo et al. 2021; Orhan et al. 2021; Hardi et al. 2023). Although high-value sustainable agriculture and rural development areas were primarily found in the suburbs of large cities with high farmer well-being, low-value sustainable agriculture and rural development areas were primarily found in the mountains with low agricultural production and the traditional agricultural areas with a lagging rural environment (Hu et al. 2022). The agricultural system is simultaneously dealing with environmental threats and the strain of maintaining the planet's boundaries. These threats include declining biodiversity, water scarcity, land degradation, climate change, and non-point source pollution agricultural, all of which make it more difficult to achieve the economic development goals (Springmann et al. 2018; Rockstrom et al. 2017). Agriculture and rural areas are seeing an increase in interest in

sustainable and economic growth. Nevertheless, when methodically evaluating sustainable and economic growth, farmers' well-being, the rural environment, and agricultural productivity have not been given enough weight, and little progress has been made in developing the conceptual framework and investigating the limitations of economic growth. In particular, rural areas are essential for attaining economic growth when it comes to social fairness, poverty eradication, food security, natural resource conservation, and environmental protection (Liu et al. 2022; Stamoulis and Zezza 2003). Sustainable agriculture and rural development a means of ensuring the ongoing satisfaction of human needs in a way that is environmentally, economically, and socially sustainable have emerged as the essential precondition and top priority for both sustainable and economic growth since the FAO called the Netherlands Conference on Agriculture and Environment in 1991. In order to modernize the agricultural sector and promote rural economic growth and job creation, numerous governments have made large investments throughout the years (Geza et al. 2022). This might be changed by agriculture, which is intended to be a means of promoting rural economic growth by giving young people in rural areas jobs where they live. On this basis, the goal of this study is to confirm the extent to which agricultural and rural development may be considered two key drivers of economic growth. The paper contains five sections, literature review, data and methodology, results and discussions, and finally a conclusion.

2. Literature Review

Zhang et al. (2023) employed the coupling coordination degree (CCD) model and the local spatial autocorrelation model to examine the the relationship between agricultural, rural green development and economic growth (ARGDE) in 31 provinces in China over the period of 1997 to 2020. The findings demonstrate that during the study period, policies had a significant impact on ARGDE in China and caused it to expand in phases. Findings show that encouraging "quality agriculture" and "green agriculture" may help hasten the development of agricultural and rural green development in real-world applications. Jiang et al. (2022) pointed out that inclusive growth is increasing gradually in rural China, and infrastructure plays a big role in promoting inclusive growth. According to a study by Jezierska-Thöle et al. (2022), there are regional differences in the growth of the green economy, and local projects funded by EU money have a good environmental impact. Hu et al. (2022) found that while incorrect land expansion and industrial growth during urbanization had negative effects in rural regions, population urbanization had good effects on sustainable agriculture and rural development. Grujić-Vučkovski et al. (2022) investigated the state of Serbian agriculture and the Kladovo municipality, as well as the role that agriculture plays in the country's economy. The data show that forestry and fisheries contributed significantly to GDP creation (6.3% in 2020) whereas the municipality's overall budget for funding rural development contributed very little (2.34% in 2020). Yaqoob et al. (2022) examined the impact of agriculture productivity and land intensification on economic growth in Pakistan, India, and Bangladesh from 1970 to 2023. The study employed an Autoregressive Distributed Lag Model pooled mean group approach (ARDL-PMG). Results indicate that land intensification and low agricultural yield are actually caused by changes in the demographic patterns of countries of the sample. Therefore, the future food demand relies on technological innovation, and climate agriculture methods can prevent the tiny farmlands from degrading further. Vo and Ngo (2021) examined the effect of agricultural finance, agriculture development and rural development on the sustainable development of ASEAN countries from 2009 to 2020. Fixed-effect model (FEM) results reveal that rural development, agricultural advancement, and agricultural financing found to be all significant and increase the ASEAN countries ability to develop sustainably. Ahmed et al. (2020) revealed that economic expansion and urbanization exacerbate environmental deterioration, while human capital protects the environment from further harm. Linh et al. (2019) examined the effects of expanding agriculture, agricultural employment and import, as well as expanding rural population, on rural development in Vietnam. The study used secondary data over the period of 1981 and 2018. Applying an Autoregressive Distributed Lag (ARDL)

model, findings demonstrate that agriculture growth, agricultural employment, import and rural population growth have a positive nexus with rural development in Vietnam.

3. Data And Methods

The study relies on econometric approaches using secondary data from the World Bank Development Indicators (WDI) over the period of 2000 to 2021 of a sample of 17 developed nations; Belgium, Switzerland, Norway, Australia, Denmark, Sweden, Ireland, Germany, Netherlands, Finland, New Zealand, Canada, Luxembourg, United Kingdom, Japan, Slovenia, United States. Based on the previous studies, the proposed model to examine the impact of agriculture and rural development on the economic growth is proposed as follows:

$$LGdppc = f(LAgl, LCy, LEaf, LEam, LFa, LFc, LPc)$$

Which can be written as the following:

$$LGdppc_{it} = \beta_{0it} + \beta_1 LAgl_{1it} + \beta_2 LCy_{2it} + \beta_3 LEaf_{3it} + \beta_4 LEam_{4it} + \beta_5 LFa_{5it}$$

$$+\beta_6 LFc_{6it} + \beta_7 LPc_{7it} + \varepsilon_{it}$$

With (i= 1,...,17) indicating the number of individuals (countries), (t=2000,...,2021) indicating the time period, (β_{0i}) indicating the value of the point of intersection in the observation (i), (β_1,..., β_7) indicating the parameters to be evaluated for each independent variable, (ε_{it}) and indicating a vertical ray with dimension ($tn \times 1$) for the random error limit for country (i) in the period (t). Table 1 represents variables used in the study.

Table 1. Variables description

Variables	Acro	Description
GDP per capita	LGdppc	It is the GDP divided by the mid-year population
Employment in agriculture, female (% of female employment)	Eaf	Persons of working age who engaged in any activity to produce goods or offer services for pay or profit.
Employment in agriculture, male (% of male employment)	Eam	
Cereal yield (kg per hectare)	Cy	Includes wheat, rice, maize, barley, oats, rye, sorghum, sorghum, buckwheat, and mixed grains.
Forest area (% of land area)	Fa	Represents the area of land covered by natural or cultivated trees that reach a height of five meters in its location, whether fruitful or barren, with the exception of trees in agricultural production systems and trees in urban parks and gardens.
Fertilizer consumption (kilograms per hectare of arable land)	Fc	Measures the amount of plant nutrients used per unit of arable land.

Permanent cropland (% of land area)	Pc	Includes the land cultivated with permanent crops ltivated with crops that cover the ground for long periods and do not have to be replanted after each harvest, such as cocoa, coffee and rubber.
Agricultural land (% of land area)	Agl	Refers to the proportion of land that is arable under permanent crops or covered by permanent pasture.

4. Results And Discussion

4.1. Descreptive Statistics*:*

The descriptive statistics of variables are presented in Table 2. According to Table 2, the variables $LGdppc_{it}$, LCy_{it} , $LEam_{it}$, LFa_{it} have the lowest standard deviation respectively assessed at (0.365), (0.403), (0.56), (0.625), and on the contrary LPc_{it} , $LAgl_{it}$, LFc_{it} , $LEaf_{it}$ have the highest standard deviations calculated at (1.80), (0.974), (0.816), (0.682). Furthermore, the largest value of the Mean of the variables is 10.76 (the GDP per capita), and the smallest value is -1.846 (the Permanent cropland (% of land area)), reflecting the difference between the variables for countries and demonstrating the unbalanced distribution of indicators by country.

And With regard to the kurtosis coefficient, we observe that the variables $LGdppc_{it}$, $LEaf_{it}$, $LAgl_{it}$ and LFc_{it} have kurtosis values close to 3, which indicates that these variables follow a normal distribution. In contrast, the remaining variables exhibit platykurtic distributions.

With regard to the skewness coefficient, we note that its value is approximately equal to zero for the variables , $LGdppc_{it}$, $LEaf_{it}$, $LEam_{it}$, LFa_{it} and LPc_{it} , indicating that the distributions of these variables are symmetric. In contrast, the remaining variables exhibit asymmetric distributions.

And Regarding the Jarque–Bera test, the results indicate that the p-value is lower than the adopted significance level; therefore, the null hypothesis is rejected. This suggests that the variables do not follow a normal distribution.

Table 2. Descriptive statistics

Variable	Obs	Minimum	Maximum	Mean	std	Skewness	Kurtosis	Jarque-Bera
$LGdppc_{it}$	374	9.9652	11.6299	10.7698	0.365	0.03	3.670	7.025
$LEaf_{it}$	374	-0.8526	2.3237	0.5065	0.682	0.622	2.786	24.85
$LEam_{it}$	374	-0.1067	2.4772	1.2858	0.56	0.163	2.303	9.234
LCy_{it}	374	6.8888	9.1944	8.6226	0.403	-1.42	5.127	197.7
LFa_{it}	374	2.2137	4.3004	3.6867	0.625	-0.21	1.952	19.85
LPc_{it}	374	-5.0541	0.9871	-1.8462	1.800	-0.41	1.714	36.64
LFc_{it}	374	3.9883	7.7152	5.4048	0.816	1.011	3.305	93.92
$LAgl_{it}$	374	0.9909	4.3004	3.3070	0.974	-1.02	2.649	66.90

4.2. Estimating The Appropriate Static Panel:

Table 3 reported the static panel regression output with Pooled, Fixed, and Random effects. To choose the optimal model estimation, the study employed Fisher test, Lagrange multiplier test, Honda test, and Husman test.

Table 3. Estimation results for static panel

IND	Estimation of models of total homogeneity, fixed effect, and random effect			
		FEM	*Pooled*	*REM*
LPc_{it}	Coefficient	-0.0145	0.0483*	-0.0237*
LFc_{it}	Coefficient	0.0371	0.0893**	0.0620**
LFa_{it}	Coefficient	1.5674**	0.0263	0.7943**
$LEam_{it}$	Coefficient	-0.1458**	0.2480**	-0.1759**
$LEaf_{it}$	Coefficient	-0.0513	-0.5356**	-0.0640**
LCy_{it}	Coefficient	0.1002**	-0. 361**	0.1095**
$LAgl_{it}$	Coefficient	-0.0472	-0.01432	0.1200*
C	Coefficient	4.7387**	13.396**	6.6169**
Durbin-Watson stat		0.4582	0.0706	0.4314
R_squared		0.9800	0.3335	0.5193
Sum squared resid		0.9951	33.245	1.2091
F-statistic		747.57	26.166	56.48
Prob (F-statistic)		0.0000	0.0000	0.0000
Estimation method		*OLS*	*OLS*	*GLS*

*, ** denote significant at 5% and 1% level of significance respectively

The alternative hypothesis of the Fisher's test assumes that the fixed effects model is appropriate, against the pooled regression model. This alternative hypothesis is represented by the following relationship (Panchanan 2019, P503): $y_{it} = \gamma_{0i} + x'_{it}\gamma + \varepsilon_{it}$

$H_0 : \gamma_{01} = \gamma_{02} = \cdots = \gamma_{0N} = 0$: the pooled regression model is appropriate (pooled)

$H_1 : \gamma_{0i} \neq 0$: a fixed effect model is appropriate (FEM)

The Fisher value ($F_{(16,350)} = 1.52$) is calculated from the above formula as: $F_c = \frac{(33.245 - 0.9951)/(17-1)}{0.9951/(374-17-7)} = 708{,}94$, with the tabular statistical value of Fisher ($F_{(16,350)} = 1.52$), which indicates that the fixed effect model is accepted because (F_C) is greater than (F_t) at a level of significance of 5%.

Lagrange multiplier test (LM) proposed by by Breusch and Pagan in 1980, t- statistic: $LM = (NT/2(T-1))\left[(\sum_{i=1}^{N} e^2{}_{i.} / \sum_{i=1}^{N}\sum_{t=1}^{T} e_{it}^2) - 1\right]^2$. Where (e_{it}) denotes the OLS residuals

on the pooled model and ($e_{i.}$) denote their sum over (t), respectively. The results in Table 4 show a fails to not rejecting the null hypothesis (H_0) stating that there is an individual effect because the statistic (LM) is bigger than the chi-square statistic at one degree of freedom ($\chi_1^2 = 3.841$) and a significance of 5%.

Table 4. LM test results

Type of Test \ Test Value	Calculated Value	Tabular Value	Probability Value
Lagrange multiplier	3110.20	3.841	0.0000**

*, ** denote significant at 5% and 1% level of significance respectively

Lászlo and Patrick (2008) reported that Honda (1985) proposed a very basic test that only takes the square root of the Breusch-Pagan statistics. He demonstrated that in the absence of individual effects, this square root is distributed normally. The null hypothesis should then be rejected as soon as the statistics show $HO = \sqrt{\frac{NT}{2(T-1)}}\left[\frac{\sum_{i=1}^{N}(T\bar{\hat{\varepsilon}}_i)^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\varepsilon}_{it}^2} - 1\right]$, is more than 1.64. This test then rejects the null a little more frequently than the Breusch-Pagan test. Findings of Honda test presented in Table 5 indicate that at the 5% level of significance, the estimated test statistic (HO) is greater than the value of the ordinary normal distribution ($N(0,1) = 1.64$), indicating that the hypothesis (H_1) with a random effect is accepted.

Table 5. Honda test results

Type of Test \ Test Value	Calculated Value	Tabular Value	Probability Value
Honda	37.4231	1.64	0.0000**

*, ** denote significant at 5% and 1% level of significance respectively

To consider the optimal estimation model of Fixed or Random effect, this paper used Hausman test (Baltagi et al., 2003) which is extremely generic and can be applied to a number of testing issues. It is especially useful in the case of panels where N is large and conventional tests can encounter the incidental parameter problem. The test results are presented in Table 6.

Table 6. Husman test results

Type of Test \ Test Value	Chi-sq_Statistic	Tabular Value	Probability Value
Husman	26.2753	14.067	0.0000**

*, ** denote significant at 5% and 1% level of significance respectively

The calculated Husman statistic ($\chi = 26.2753$) is greater than the tabular statistic ($\chi_7^2 = 14.067$), implying that the alternative hypothesis is accepted, that the fixed effects model is suitable. Therefore, results of the Fixed effect shown in the Table 2 can be validated. Findings shows that forest area, male employment in agriculture, and cereal yield are having a significant impact on economic growth 5% significance level, while the remaining independent variable parameters are considered insignificant. Furthermore, the model as a whole can be considered significant, when ($\Pr ob(F-statistic) = 0$). The coefficient of determination is thought to have a very high explanatory power, equal to (0.98), which means that economic growth is explained by (98%) through the proposed independent variables. The Durban Watson test indicating the existence of a positive

autocorrelation of errors, which causes the parameter estimations to be inconsistent, due the instability of the series; thus, the study employed dynamic analysis.

The fixed effect results show that an increase in the logarithm of forest area, and the logarithm of Cereal yield by 1% results in an increase in the logarithm of per capita growth of 1.56% and 0.10%, respectively. Moreover, an increase in the logarithm of Employment in agriculture male of 1%, will lead to a decrease in the logarithm of per capita of 0.14%. However, the remaining variables were disregarded since they were statistically insignificant.

4.3 Panel Unit Root Test Of Variables:

Unless the variables in a panel data set are cointegrated, estimators are ineffective when the variables are non stationary. based on the tests Levin, Lin, and Chu, Breitung t-stat, Im, Pesaran, and Shin, ADF, and PP, Fisher Chi-square. The results of Table 7 show the panel unit root tests of the model variables at the $I(0)$, $I(1)$ and $I(2)$ based on the previous tests as the following:

Table 7. Results of panel unit root tests for model variable

	Levin, Lin & Chu t	Breitung t-stat	Pesaran & Shin W-stat	ADF Fisher Chi-2	PP-Fisher Chi-2
Results of panel unit root tests for model variables at level $I(0)$					
LPc_{it}	1.75272		-0.38464	43.9029	53.4281**
LFc_{it}	-4.2359**		-2.29417**	59.2507**	62.6090**
LFa_{it}	-3.84500**		-0.07248	37.2171	70.9164**
$LEam_{it}$	-1.49937	1.56395	-1.90173*	62.8738**	80.0010**
$LEaf_{it}$	-1.62562	1.61521	-0.01352	42.4748	42.0427
LCy_{it}	-5.26203**	-2.40452**	-5.75910**	94.1494**	242.782**
$LAgl_{it}$	-1.17342		-0.18260	43.0176	44.7265
$LGdppc_{it}$	-1.08972	-1.8935**	-0.54478	34.1959	28.3244
Results of panel unit root tests for model variables at the 1st difference $I(1)$					
$D(LPc_{it})$	-7.7474**		-7.9664**	130.015**	301.503**
$D(LFa_{it})$	3.19194		3.38644	15.7717	45.7110
$D(LEam_{it})$	-4.10065**	-2.19364**	-7.07728**	113.664**	362.009**
$D(LEaf_{it})$	-8.50039**	-3.53473**	-7.56857**	118.333**	323.883**
$D(LAgl_{it})$	-6.91216**		-8.76799**	190.743**	544.557**
$D(LGdppc_{it})$	-5.55241**	-5.25072**	-4.44149**	75.0829**	160.109**
Results of panel unit root tests for model variables at the 2nd difference $I(2)$					
$D(D(LFa_{it}))$	-0.71665		-5.65265**	99.0049**	289.142**

*, ** denote significant at 5% and 1% level of significance respectively

The results indicate that variables, LFc_{it} ,and LCy_{it} are stationary at levels. The rest of variables except LFa_{it} are not stationary at their levels, but become stationary at their first differences, and LFa_{it} at the second difference at 1%, 5%, and 10% level of significance. According to the findings, the prospect of a lack of co-integration between the time series of the research variables remains a possibility because the variables are all equally unstable.

4.4 Studying The Cointegration Relationship Between Variables:

To test the cointegration between variables, the study used Kao (1999) and Pedroni (1999, 2004) tests. The results are represented in Table 8.

Table 8. Panel Co-Integration Test results

Type of Test / Test Value		T-Stat	P-Value
Pedroni	Modified Phillips-Perron t	5.0533	0.0000**
	Phillips-Perron t	-0.8241	0.2049
	Augmented Dickey-Fuller t	-0.7525	0.2259
Kao	Modified Dickey-Fuller t	-0.0550	0.4781
	Dickey-Fuller t	0.1427	0.4433
	Augmented Dickey-Fuller t	-0.4663	0.3205
	Unadjusted modified Dickey-Fuller t	-1.7707	0.0383*
	Unadjusted Dickey-Fuller t	-0.9845	0.1624
Westerlund	Variance ratio	0.4663	0.3205

*, ** denote significant at 5% and 1% level of significance respectively

The results support the null hypothesis, which is the denial of co-integration. Accordingly, it can be concluded that there is no co-integration relationship between economic growth and indicators of agriculture and rural development for a sample of developed countries.

4.5 Homogenity Test:

To identify the structure of the panel, Hsiao (1986) test was employed. Table 12 shows the homogeneity test parameters and constants for all individuals (countries).

Table 9. The results of the homogeneity test

	Fisher Calculated value F_C	Fisher tabular value F_T	Fisher's probability value	decision
Total homogeneity	F1 = 649.575	$F_{(128.238)}$=1.284	PvalF1 = 8.01e-254**	Reject H_0^1

*, ** denote significant at 5% and 1% level of significance respectively

According to the results, the hypothesis H_0^1 was rejected at a significant level of 5%, which means that the total homogeneity among a sample of developed countries is not accepted. This leads to the transition to the second test in which te hypothesis H_0^2 is also rejected at 5% significance level. Therefore, there are differences between countries in terms of inclination and categorical. For the Slope Homogeneity Test, results are represented in Table 10.

Table 10. The results of the Slope homogeneity test

Test	T-Statistic	P-value
Δ_{HAC}	13.301	0.000**
$(\Delta_{HAC})_{adj}$	17.303	0.000**

*, ** denote significant at 5% and 1% level of significance respectively

Since all of the probability values are less than 0.05, the slope homogeneity null hypothesis may be rejected in all scenarios, as a result, there is heterogeneity in the slope coefficients. Findings show that the sample countries are heterogeneous; hence we should use heterogeneous panel methodologies.

4.6 Test Dumitrescu-Hurlin (2012):

Based on the technique presented by Dumitrescu-Hurlin (2012), it is possible for all coefficients to be different or heterogeneous across cross sections. This method considers two different statistics. The W-statistic averages the test statistics, whereas the Z bar-statistic exhibits a typical (asymptotic) normal distribution. Table 11 shows the Dumitrescu-Hurlin causality test, which shows the form of heterogeneity between the independent variables and the dependent variable.

Table 11. Dumitrescu-Hurlin Causality test results

Null hypotheses H_0^{DH}	W-Stat.	Z bar-Stat.	Prob.
LPc_{it} does not homogeneously cause $LGdppc_{it}$	1.91269	1.85247	0.0640
$LGdppc_{it}$ does not homogeneously cause LPc_{it}	1.82387	1.64358	0.1003
LFc_{it} does not homogeneously cause $LGdppc_{it}$	1.29528	0.40045	0.6888
$LGdppc_{it}$ does not homogeneously cause LFc_{it}	4.22931	7.30066	3.E-13**
LFa_{it} does not homogeneously cause $LGdppc_{it}$	1.95962	1.96285	0.0497*
$LGdppc_{it}$ does not homogeneously cause LFa_{it}	4.53503	8.01965	1.E-15**
$LEam_{it}$ does not homogeneously cause $LGdppc_{it}$	0.98262	-0.33486	0.7377
$LGdppc_{it}$ does not homogeneously cause $LEam_{it}$	3.15935	4.78435	2.E-06**
$LEaf_{it}$ does not homogeneously cause $LGdppc_{it}$	1.33943	0.50429	0.6141
$LGdppc_{it}$ does not homogeneously cause $LEaf_{it}$	1.82502	1.64630	0.0997
LCy_{it} does not homogeneously cause $LGdppc_{it}$	0.92747	-0.46454	0.6423
$LGdppc_{it}$ does not homogeneously cause LCy_{it}	5.08938	9.32335	0.0000**
$LAgl_{it}$ does not homogeneously cause $LGdppc_{it}$	1.42377	0.70263	0.4823
$LGdppc_{it}$ does not homogeneously cause $LAgl_{it}$	5.72470	10.8175	0.0000**

*, ** denote significant at 5% and 1% level of significance respectively

The results of causality tests indicate that Permanent cropland and female Employment in agriculture does not homogeneously cause economic growth for all countries, which explains the existence of a heterogeneous causal relationship in both directions. Theoretical addition: We linked this to economic theory, which suggests that the impact of human resources, particularly female labor in agriculture, on economic growth varies depending on the level of economic development and institutional structures of each country.

However, the forest area and economic growth found to have a homogeneous causality in both directions. Theoretical addition: We connected this to natural capital theory, which emphasizes that environmental resources play a critical role in supporting sustainable economic growth.

As for the Cereal yield and the economic growth, there is a one-way relationship that moves from economic growth to Cereal yield in all selected countries, while the opposite is not true. The same applies to the Agricultural land, Employment in agriculture male, and the Fertilizer consumption. Theoretical addition: We linked this to agricultural economic theories, which posit that economic growth stimulates investments in technology and agriculture, thereby improving productivity and efficiency of agricultural resources.

5. Conclusion

Achieving sustainable development and high rates of economic growth is a common goal of all nations. Agriculture and rural development have been acknowledged as important forces behind economic development. The main objective of this study was to investigate the relationship between Agriculture, rural development, and economic growth using a panel data and D-H causality framework in a sample of developed countries from 2000 to 2021.

Experimental results of the fixed effect model show that agriculture and rural development have a largely positive effect on economic growth, although the magnitude of the effect varies depending on to the type of indicators of agriculture and rural development. Pedroni and Kao co-integration test provide proof for the absence of a long-term equilibrium between economic growth, rural development, and agriculture. It was also shown through the results of the standard analysis of the dynamic Panel models that the estimation by dynamic individual equations (D-H) developed by Dumitrescu and Hurlin (2012) is the most appropriate among the other methods (PARDL, IV, POOLED, FMOLS, POOLED, DOLS...). Findings reveal that Results show a bidirectional causal relationship between forest area and economic growth in all selected countries. A two way causality relationship for some but not all countries between female employment in agriculture, permanent cropland, and economic growth. A one directional causal relationship for all countries between agricultural land, cereal yield, male employment in agriculture, fertilizer consumption, and economic growth. The study also concluded that the greater the logarithm of the Forest area, the greater the logarithm of the per capita GDP growth share in all selected countries, and vice versa, that is, there is a mutual effect.

The empirical findings support the findings of (Jiang et al. 2022; Grujić-Vučkovski et al. 2022; Yaqoob et al. 2022). Furthermore, supports the proposed hypothesis that agriculture and rural development are economic growth accelerators.

This study offers policy recommendations for achieving a high economic growth, increasing forest area, making more investments in agriculture and rural development, relying on technology to boost agricultural production while lowering the use of artificial fertilizers and increasing the use of organic fertilizers.

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