

FACTORS AFFECTING FARM PERFORMANCE AMONG SMALL-SCALE FARMERS IN THE VOLCANIC HIGHLANDS OF RWANDA: WHAT IS THE ROLE OF INSTITUTIONS?

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ABSTRACT

This study attempted to examine the role of institutions in boosting rural and agricultural development in the region of the Volcanic Highlands of Rwanda. Both qualitative and quantitative data were collected from a random sample of 401 small-scale farmers through a questionnaire. Data were analyzed using a weighted least-squares method to account for heteroscedasticity, a common issue in cross-sectional studies. Results from crop output function reveal a positive and significant effect of cooperative membership, a negative but significant effect of extension services, and a negative non-significant effect of land tenure, credit access, and market access on farm production, respectively. In terms of net farm income function, the results demonstrate that farmer cooperation, land tenure, extension services, and access to output markets have a positive, non-significant influence, but that access to finance has a negative non-significant effect. Results also point to a positive and significant effect of some household characteristics, namely family size, farming experience, land size, and farm yield, on farm production. As for net farm income, education of the head, family size, farm experience, land size, farm yield, selling price, and cattle proved to be among primary determinants. It was therefore suggested that agricultural sector programs and activities should be readapted and strengthened in order to leverage rural and agricultural development in Rwanda.

Contribution/Originality: This study is one of very few studies to have investigated the role of institutions on farm performance in the Volcanic Highlands of Rwanda. Credit access had a negative but significant effect on both crop output and net farm income. In addition, extension services had a negative but significant effect on farm production.

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1. INTRODUCTION

The status of global poverty has improved substantially, but there is a high number of people who still suffer from extreme poverty. Many of the world's poor are smallholder farmers (Ogutu & Qaim, 2019). Agricultural sectors play an important role in the process of economic development, especially in developing countries (Linh, Long, & Lebailly, 2019).

In order to find practical and sustainable solutions to development issues in Africa, Kirsten, Dorward, Poulton, and Vink (2009) suggested the setting up of working economic and political institutions. They stated that institutions should “facilitate *coordinated* exchange and resource management, facilitate *low-cost* exchange and resource management and encourage trust, and *provide incentives* for exchange and resource management that create profitable opportunities for investment and exchange”. The importance of institutions in rural and agricultural development can be looked at across three pillars, namely expanding access to assets (land and capital), development of markets, and investment in public goods. It was also specified that good institutions (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1999) are expected to make safer, easier, and less expensive the transactions, investments, and payments. However, Kirsten et al. (2009) highlighted that working institutional successes in the agricultural sector are far too rare, and their scope has been far too limited to significantly boost overall agricultural output and the welfare of farmers and consumers throughout the continent.

By highlighting the importance of good institutions in rural and agricultural development, an assessment by Dorward, Kydd, and Poulton (2005) revealed that low-income economies are characterized by high transaction costs and risks, poor information flows, and a weakened institutional environment. Actors suffer enormous costs in getting information and enforcing property rights, particularly those with limited financial and social resources or political influence. Market development and access to current markets are both hampered by these expenses. It is in this vein that Kirsten et al. (2009) listed the reasons behind the failure of certain institutions (covariance of risk and high costs of monitoring behavior to protect against asymmetric information, impediment to the development of a sustainable model of rural financial services, and demotivation of private economic actors), which in turn constrains economic and technological development. Low economic activity causes weak markets, insufficient coordination, high transaction costs and risks, and high unit costs for infrastructure construction. Consequently, a low-level equilibrium trap can easily arise as a result. Constraints, a lack of investment incentives, and a stagnating rural economy all reinforce each other in this situation.

This research work is pertinent, specifically at this time in which most developing countries including Rwanda are developing their agricultural sector. The setting up of good working institutions must take precedence in all development strategies for rural and agricultural development in Rwanda. In Section 2, different research works explain how institutions (extension schemes, rural organizations, farm output markets, financial markets, and land tenure) impact on the rural and agricultural sectors. Almost all reaffirm the positive effect on farm households' welfare (crop productivity, farm efficiency, poverty reduction, and farm income). Access to *credit* (either formal or informal) permits small-scale farmers to adopt new farming technologies (Wossen, Berger, & Di Falco, 2015) and to afford quality farm supplies (Ogundeji, Donkor, Motsoari, & Onakuse, 2018), as well as employment opportunities for farmers, helping them expand crop output and improve welfare conditions (Luan & Bauer, 2016). Crop *output markets* are reversely influenced by limited surpluses (caused by lack of credit), and consequent disincentives for private trade (Kirsten et al., 2009). *Cooperatives* are often associated with collective action and social capital and are therefore often thought to be more poverty reducing than other types of institutional innovations such as contract farming (Verhofstadt & Maertens, 2015). Agricultural *extension* is important for spreading farming information to different categories of farmer, and has been highlighted as a critical tool to convert subsistence farming into developed and market-oriented agriculture to sustain household food security, improve income, and alleviate poverty (Wanyama, Mathenge, & Mbaka, 2015). *Tenure* is another major control variable that is thought to improve households' access to credit (Deininger & Feder, 2009), as studies have found that weak or undefined land rights are negative drivers for investment and productivity (Pritchard, 2013). Land tenure structures affect farmers' ability to borrow, expand, or exit with a lump sum, through land-market transactions, as well as incentives for land improvement (Kirsten et al., 2009). This therefore justifies the need to conduct a study on the determinants of farm output and net farm income in Rwanda, with special focus on the role of institutions working in the agricultural sector.

The government of Rwanda has put in place the mechanisms to develop cooperatives, improve farmers' access to markets, microfinance institutions to enhance access to credit in rural areas, and land tenure security. The purpose of this study is to examine the role of institutions in rural and agricultural development. It specifically aims to assess the effects of institutions on crop output and the farmers' net income in the Volcanic Highlands of Rwanda. The weighted least-squares estimator was adopted for this study, to account for heteroscedasticity that is common in cross-sectional data. The remainder of this paper comprises four sections. Section 2 presents the materials and methods, Section 3 summarizes the results and discusses the main findings while Section 4 concludes the paper.

2. MATERIALS AND METHODS

2.1. Research Area, Data and Study Variables

A farmer survey was conducted from October to December 2019 to gather data for this study. Data were collected via a questionnaire that covered the socioeconomic characteristics of the farmers and their households, as well as the preferred farming practices employed on the farms. This study used a random sample of 401 small-scale farmers from Rwanda's Volcanic Highlands (also known as the "Birunga" region). This region spans four districts,

with 101 farmers surveyed in Burera, 101 in Musanze, 100 in Nyabihu, and 99 in Rubavu. Along with Imbo, Impala, Kivu Lake Borders, Congo Nile Crest, Eastern Plateau, Central Plateau, Buberuka Highlands, Mayaga, Bugesera, and Eastern Savannah, the Birunga region is one of the 12 agro-ecological zones in Rwanda (Maniriho, Musabanganji, & Lebailly, 2020).

The region of the Volcanic Highlands is well known for its primarily agricultural soil (altitudes of 1600–2500 m, highly permeable black volcanic soils with excellent agricultural value), with potato, vegetables (red onion, white onion, etc.), corn, beans, wheat, and other crops being the main crops. This region is characterized by regular rains; fairly shallow soil, resulting in simple farming equipment and generalization of cropping; lower risk of erosion thanks to bedding cultivation, soil permeability and often minimal uneven terrain; and black soils rich in humus (andosols or andepts) with good fertility, suitable for temperate climate crops, but whose acidity ranges from low to high throughout the region (Maniriho et al., 2020).

2.2. Model Specification and Estimation

A linear regression model was specified to assess the role of institutions on farm net income. It was hypothesized that crop output (measured in kg) and net farm income (expressed in Rwandan francs) are significant institutional factors (market access, land tenure, cooperative membership, output market access, and credit access), but we have also controlled the socioeconomic characteristics of households. Following Wooldridge (2016), these relationships are expressed by Equation 1 using the variables described in Table 1.

$$Y_i = \alpha + \beta_{1i}IF_i + \beta_k X_{ki} + \varepsilon_i \quad (1)$$

Where Y_i is the dependent variable (net farm income, crop output), IF is a vector of institutional factors, X_i is a vector of household and farm controls, k is their number ($k = 1, 2, \dots, 15$), i is the order of the household, α and β_s are the coefficients, and ε is the disturbance term.

We attempted to estimate Equation 1 using ordinary least squares (OLS), but the results from Breusch–Pagan (BP) test reported in Table 2 show the presence of heteroscedasticity, which makes OLS estimation less efficient. Consequently, the weighted least squares (WLS) approach was used to account for heteroscedasticity. It is the generalized least squares (GLS) estimators for correction of heteroskedasticity that are called WLS estimators. The WLS approach was motivated by the inconsistency of the usual measure of precision (estimated variance–covariance matrix).

3. RESULTS AND DISCUSSION

Table-1. WLS estimations: effects of institutions on crop output and net farm income.

Variable	Crop output			Net farm income		
	Coeff.	Std. Err.	P-value	Coeff.	Std. Err.	P-value
Cooperation	295.25	98.39	0.003***	-25700.00	45368.92	0.571
Tenure	108.24	136.88	0.430	-185000.00	20083.94	0.000***
Credit access	-914.04	81.36	0.000***	-42900.00	17766.16	0.016***
Extension	-118.63	70.82	0.095*	69572.04	20738.41	0.001***
Market access	145.07	134.91	0.283	689000.00	98494.33	0.000***
Age	-69.47	6.33	0.000***	-14000.00	2076.01	0.000***
Sex (1 = female)	62.17	67.96	0.361	-73900.00	21193.51	0.001***
Experience	67.50	5.65	0.000***	13661.98	2042.35	0.000***
Education	28.04	22.84	0.220	37654.67	4776.64	0.000***
Family size	146.11	19.61	0.000***	20455.93	6307.96	0.001***
Land size	0.99	0.04	0.000***	40.19	13.91	0.004***
Combination	136.15	26.24	0.000***	-39800.00	14733.19	0.007***
Residue	-115.97	22.23	0.000***	10430.02	7373.73	0.158
HYV	-381.83	50.97	0.000***	-167000.00	18203.58	0.000***
Rotation	54.23	35.31	0.125	-14200.00	9030.18	0.117
Manure	-177.71	35.61	0.000***	-77200.00	12789.81	0.000***
Farm yield	0.26	0.01	0.000***	76.31	3.25	0.000***
Price	-0.52	0.07	0.000***	1353.72	106.22	0.000***
Cattle	-152.51	30.85	0.000***	29328.74	10880.43	0.007***
Constant	1466.81	409.68	0.000***	776000.00	128000.00	0.000***
Number of observations	380			380		
R^2	0.99			0.96		
F-test	1956.88			400.59		
$P > F$	0.000			0.000		

Note: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. HYV, high-yielding varieties.

3.1. Econometric Estimation

Results from WLS estimations, using crop output and net farm income as dependent variables, are reported in Table 1 for two models. Results from crop output function indicate a positive significant effect of cooperation, a negative but significant effect of both credit access and extension services, and a positive non-significant effect of land tenure and output market access. With net farm income as the dependent variable, results from the subsequent function point to positive and significant effect of both extension services and market access, a negative but significant effect of both land tenure and credit access, and a negative non-significant effect of cooperation. The effect of each individual household or farm control variables can be observed in the table.

It is very important to test for the robustness of the WLS estimations reported in Table 1, and OLS coefficients estimated for comparison are reported in Table 2. Results from the crop output function reveal a positive and significant effect of cooperative membership, a positive non-significant effect of extension services, and a negative non-significant effect of land tenure, credit access, and market access. As for net farm income function, results show a positive non-significant effect of farmers' cooperation, land tenure, extension services, and access to output market but a negative non-significant effect of access to credit. It is worth noting the presence of heteroscedasticity in the data used for this study: BP chi-square statistic statistically different from zero (Table 2).

Table-2. OLS estimations: Effects of institutions on crop output and net farm income.

Variable	Crop output			Net farm income		
	Coeff.	Std. Err.	P-value	Coeff.	Std. Err.	P-value
Cooperation	612.17	209.74	0.004***	169000.00	121000.00	0.162
Tenure	-138.74	196.39	0.480	16530.56	113000.00	0.884
Credit access	-36.85	113.11	0.745	-68200.00	65087.52	0.296
Extension	45.05	123.70	0.716	1129.43	71183.53	0.987
Market access	-177.05	181.61	0.330	32690.64	105000.00	0.755
Age	-10.93	11.68	0.350	-5354.45	6723.58	0.426
Sex (1 = female)	41.72	107.60	0.698	-48600.0040	61918.03	0.433
Experience	7.83	11.31	0.489	7473.55	6509.13	0.252
Education	-5.87	36.09	0.871	10917.62	20765.02	0.599
Family size	67.19	41.68	0.108	46134.23	23982.82	0.055*
Land size	0.85	0.05	0.000***	148.91	30.78	0.000***
Combination	-24.49	60.39	0.685	-81700.00	34749.56	0.019**
Residue	-76.23	43.66	0.082*	-54500.00	25125.03	0.031**
HYV	-232.76	102.84	0.024***	48137.71	59174.49	0.416
Rotation	-2.80	52.44	0.957	44138.05	30177.49	0.144
Manure	-96.47	98.91	0.330	4160.45	56917.41	0.942
Farm yield	0.33	0.01	0.000***	110.86	7.14	0.000***
Price	0.27	0.29	0.361	1991.12	166.75	0.000***
Cattle	103.03	45.39	0.024**	-2244.93	26118.33	0.932
Constant	-1629.68	798.36	0.042**	-1650000.00	459000.00	0.000***
Number of obs		380			380	
R ²		0.91			0.74	
F-test		176.92			51.38	
P > F		0.000			0.000	
BP chi ²		106.34			476.29	
P > chi ²		0.000			0.000	

Note: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

The significant difference of BP chi² from zero in Table 2 indicates that the OLS approach is not reliable in the case of heteroscedasticity: the WLS method has proved to be superior to OLS. The results show that WLS estimates are more efficient than those of OLS with robust standard errors: R² from WLS estimates (0.99 for crop output function and 0.96 for net income function) is greater than that from OLS estimate errors (0.91 for crop output function and 0.74 for net farm income function), and the F-statistic behaves in the same way. In addition, there are more variables that significantly affect both crop output and net farm income when WLS is used rather than OLS.

3.2. Discussion of Findings

The results from econometric estimations pointed to a positive and significant effect of cooperative membership on farm output. This finding is aligned with the results of other researchers who recognized cooperation as a factor with significant influence on farm productivity (Herrera et al., 2018), on farm income (Tolno, Kobayashi, Ichizen, Esham, & Balde, 2015), or reported as an important institution to leverage farmers' incomes and welfare (Maniriho, 2021). For a negative effect of loan access on farm output, this contrasts with the existing literature which states that access to credit and financial services is very important for the improved wellbeing of rural households (Ogundeji et al., 2018) and thus highlights that credit is required to purchase productive inputs such as high-yield planting materials, adoption of improved farming techniques, farm implements, and the renting of arable land (Ogundeji et al., 2018). Such a contrasting situation could be due to suboptimal use of credit, and implies that credit has not yet

reached the optimal level or that its services do not meet the real needs of small-scale farmers in the study area (Maniriho et al., 2020).

Similar to credit effect, results point to a negative but significant effect of extension services on crop production, a finding that rejects (Albore, 2018) the view that the agricultural extension service is among the institutional support services that has a vital role to play in the process of agricultural revolution. It also contrasts with Danso-Abbeam, Ehiakpor, & Aidoo (2018), who reaffirmed the critical role of extension programs in enhancing farm productivity and household income, and endorses the idea that the sustainable delivery of extension services should be conducted through suitable recruitment and regular training of extension agents, as well as adequate provision of necessary facilities. The negative effect of extension services on crop output could imply that these services are not well adapted to meeting the real needs of small-scale farmers in the study area (Maniriho et al., 2020).

In regards to land tenure, Nilsson, Backman, Bjerke, and Maniriho (2019) showed that this has a positively significant effect on both household consumption and crop production. Bizimana, Nieuwoudt, and Ferrer (2004) found that land tenure certainty contributed largely to the expansion of operating farm size. It was also highlighted that land tenure security improves yields and technical efficiency among maize producers in Eastern Rwanda (Ngango & Hong, 2021). Stronger land rights enhance land-attached investment according to Bambio and Agha (2018), and land investment has a beneficial influence on stronger land rights.

Results show that some household factors affect farm performance significantly. The significant and negative effect of the farmer's age implies that older farmers do not readily adopt new varieties of crops and new farming techniques. It could be also alleged that, at a certain age, a farmer is no longer physically fit to perform his job despite his experience. This is in agreement with Maniriho and Nilsson (2018), who found that age is negatively associated with income diversification. However, it contrasts with the findings of Olujenyo (2008), who reported a positive effect of farmer's age and farm production. The inverse effect of farmer's gender on farm income entails simply the significant difference of net farm income between male and female farmers. This finding does not support Agyeman, Asuming-Brempong, & Onumah (2014), who found a positive effect of female household head on household income diversification.

The farmer's experience was mentioned one of the factors with a positive and significant effect on crop output and income. This finding confirms the results from Itam, Ajah, and Agbachom (2014), who revealed that farming experience improves the level of farm output. Regarding level of education, the results underline its positive and significant effect on crop output and farm income. This is supported by different scholars, such as Maniriho and Nilsson (2018), who found that education, especially vocational and technical, has a positive effect on income diversification; Olujenyo (2008), who reported a positive and significant effect of education on farm (maize) production; and Kalita and Sarma (2020), who indicated a positive and significant effect of education on household farm income. In regard to family size, its positive and significant effect on crop output and farm income is explained by the fact that the larger the household, the more people of working age, and the higher the output and income. However, a study by Itam et al. (2014) established no significant effect of farm size on farm income.

Concerning farm characteristics and farming techniques, results indicated a positive effect for some on farm performance. The combination of crop and livestock agriculture was found to affect positively and significantly farm performance. In support of this finding, livestock rearing provides the manure necessary to restore soil fertility (Kato, Ringler, Yesuf, & Bryan, 2011), and farming income (Nilsson et al., 2019), that can be used as a source of farm investment, while crops provide feed for domestic animals. The return of crop residues to the soil resulted in a negative effect on crop output, which could be due to poor utilization and a low level of adoption in the study area. This finding opposes the view of Hiel et al. (2018), who stated that return of crop residues to the soil is very important for nitrogen fixation and thus for soil fertility restoration. The positive and significant effect of the adoption of high-yielding crop varieties on farm income is aligned with Loevinsohn, Sumber, and Diagne (2012), who confirmed that high-yielding crop varieties contribute substantially to increase in farm income.

The significant impact of manure application on crop output could be attributed to increased access to organic manure and soil nutrition, which enhances soil quality and allows small-scale farmers to raise per-hectare yields (Kato et al., 2011). The positive and significant effect of farm yield on farm income reflects the adoption of new farm management methods, especially those aimed at raising output and reducing the average cost of production, resulting ultimately in increased farm income (Challa, 2013). In regard to selling price, whose effect on farm income is also positive and significant, being another indicator of market access, this finding highlights the results of Ahmed et al. (2016) that output market access has a positive and significant effect on farm income.

4. CONCLUSION

Institutions are very important in agricultural development as they enable optimal functioning of the sector, especially for networking the sectorial actors and reduction in transaction costs. This paper aimed to assess the contribution of rural institutions to farm performance (crop production and farm income) in Rwanda, with particular focus on the agro-ecological zone of the Volcanic Highlands. Qualitative and quantitative data collected from a random sample of 401 small-scale farmers were analyzed using a weighted least-squares method to account for heterogeneity, the issue commonly observed in cross-sectional data. Results pointed to a positive and significant effect of both cooperative membership and land tenure on farm output and net farm income, as well as a negative and significant effect of credit access and extension services. Results also indicated a positive and significant effect of market access on net farm income. Therefore, the initiatives and activities of institutions in the agricultural sector should be readapted and enhanced to leverage rural and agricultural development.

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