Tenure security, investment and the productivity of agricultural farms in the communal area of Kavango West region of Namibia: Any evidence of causality?

Uchezuba, D[1], Amaambo, P[2]. & Mbai, S[3]

1. Senior Lecturer, Department of Agriculture and Natural Resource Sciences, the Namibian University of Science and Technology, P.M.B 1338, Windhoek, Namibia, Tel: +264810425716, E-mail: stickydamap@gmail.com. (Corresponding author)

2. Post-graduate student, Department of Agriculture and Natural Resource Sciences, the Namibian University of Science and Technology Windhoek, Namibia. Tel: +264 61 207 2327, E-mail: amaambo@gmail.com

3. Head of the Department of Agriculture and Natural Resource Sciences, the Namibian University of Science and Technology, Windhoek, Namibia, Tel: +264813902376, Email: smbai@nust.na

Contributed Paper prepared for presentation at the 93rd Annual Conference of the Agricultural Economics Society, University of Warwick, England. 15 – 17 April 2019

Abstract

The study aims to determine causality amid the decision to apply for leasehold land right, increased farm investment, and total farm productivity on livestock farms in the Kavango West region of Namibia. Various econometric models have been used to model these relationships in the literature. However, there is a growing concern that methods which do not explicitly account for the endogeneity of regressors and which are used to investigate the relationship between property rights and the economic activities on agricultural farms often produce bias estimates that are inefficient and inconsistent. This study applied an instrumental variable (IV) regression using a survey data of 510 farmers to correct for endogeneity. A test of endogeneity of tenure security, investment, and farm productivity in the various models shows that tenure security is exogenous to farm investment decision and farm productivity. On the other hand, farm investment decision was found to be exogenous to farm productivity, which implies that farmers make investment decisions given a secure tenure right that enhances their productivity on the farm.

Overall, there was no evidence to support reverse causality in any of the tests. These findings highlight the importance of secure property rights as being a stimulus for increased agricultural investment and productivity.

***JEL**: (C01, C13, C26, C36, C38, CC83, C87 & D01)*

***Keywords**: Property right, tenure security, endogenous, exogenous, investment.*

1 Introduction

Since Namibia gained independence in 1990, the issue of land reform has been a top government priority aimed at redressing the skewed land ownership orchestrated by the apartheid government. An early attempt was the call for a National Land Conference in 1991, which resolved a comprehensive programme of commercial land reform. According to Sherborne (2017), at the time of the conference, the land audit showed that out of a total of 6,292 number of farms, 6,123 were privately (white) owned, whereas, a mere 181 were owned by communal (black) farmers (Sherborne, 2017). This disparity in land ownership resulted in the call for a policy reform which culminated in the promulgation of the Communal Land Reform Act (CLRA) in 2002. Under the CLRA (Act No. 5 of 2002), the rights that may be allocated to individuals comprise: a) a customary land right, b) a leasehold right and c) an occupational land right. An occupational land right is granted to not-for-profit social development projects such as churches, schools, hospitals and recreational parks. Customary land rights assign rights to establish homesteads for residential purposes and subsistence agricultural purposes on lands adjacent to residential areas. Land is also held under freehold for commercial farming. Leasehold rights are issued for land that is intended for business enterprise development, such as farms in the communal areas[1]. Leasehold rights are issued for a typical period of 25 years, up to a maximum of 99 years[2]. On expiration of the lease, the holder can reapply for a grant of leasehold rights. Leasehold ensure security and entitlement to the land – the reason why strengthening tenure right is important. The issue of strengthening property rights is provided for in the constitution of Namibia. Article 16 of the constitution commits the government to guarantee the rights of all persons to own private property, as well as to pay just compensation for all land acquired through land reform

[1]. For the rest of this paper, the emphasis is placed on the leasehold right, which is the central theme of this research.

[2]. It can only terminate when the person dies, and can be transferred to the heir subject to fresh application. The period is determined by Act of the Parliament, and not by any person or entity.

initiatives (the Republic of Namibia, 1990). Article 100 and Schedule 5 recognise communal land ownership. Consequently, the Communal Land Reform Act (CLRA) (Act No. 5 of 2002) was enacted to deal with the administration and management of communal land. The Act is administered through the Communal Land Board, whose functions among other things are: a) to exercise control over the allocation and the cancellation of customary land rights by chiefs or traditional authorities under the CLRA (Act No. 5 of 2002), b) to consider and decide on applications for leasehold rights under the CLRA (Act No. 5 of 2002), and c) to establish and maintain a register, and a system of registration for recording, the allocation, transfer, and cancellation of customary land rights and leasehold rights under the CLRA (Act No. 5 of 2002).

Further steps to redress skewed land distribution within the confines of CLRA included the introduction of the communal land registration programme in March 2003 under the communal land development programme. This programme involves the registration of customary, occupational and leaseholds land rights. The programme aims to give increased access to communal land by the previously disadvantaged people, with the aim that this will stimulate investment and productivity in the rural economy. Prior to the reform programme, there was no tight control over land in Namibia (Werner, Adams & Vale, 1990). There was a disparity in the acquisition of land rights. For instance, while the commercial or freehold land is surveyed and registered, the communal land is not. As a result, uncertainty over the rights of ownership arises, resulting in tenure insecurity, boundary disputes, low investment and poor land management.

Nonetheless, traditional authorities may issue authority over land[3] under the Traditional Authorities Act (Act No. 25 of 2000). The leasehold land rights issued before 2002 by a chief or by the Ministry of Land and Resettlement (with permission to occupy (PTO) certificates) are operationally tenure insecure because they are not held under secure tenure rights. However, an occupant who had held leasehold land in this manner for a period longer than ten years would then acquire a legal claim over the land. In other words, prior to reaching the landmark of 10 years, farmers would not make fixed improvement on the land for fear of losing it. After 2002, PTOs ceased to have effect unless the land under leasehold was registered. The registration programme serves to enhance tenure security for beneficiaries, thereby giving them legal documentary proof to the land, preventing conflicts arising

[3] Which are a form of leasehold or letter of consent, and not a land right

between landowners and intruders, and conferring on them the opportunity to invest. Investments in this regard include those that facilitate productivity, such as in fencing, boreholes, farmhouses and electricity generators. For a livestock farm, a fence provides security while excluding intruders, and a borehole and water reticulation provide water supply via an on-farm alternative energy generator. Other investments include capital investment such as purchasing bulls, weighing scales and other on-farm facilities. All these investment activities are assumed to be facilitated by the presence of a leasehold right, whereby the holder can generate a decent income, create employment opportunities and contribute to the growth and the development of the economy of the country.

Nevertheless, the land registration process is not devoid of controversy. There is a concern that the portion of land allocated through registration is meagre[4]. Therefore, the registration exercise has not resulted in huge success in most areas. Given this prevailing circumstance, this research seeks to investigate the tenure security-investment-productivity nexus. The aim is to determine whether the uncertainty in land distribution has resulted in a shift in the common nexus among tenure security, investment and farm productivity. Therefore, the question is whether all the land beneficiaries did invest in land, and how productive those who invested are. Some highlights from the CLRA (Act No. 5 2002) show that land rights:
(a) Cannot be registered as legal deeds and as such cannot be used as surety in any transaction; (b) They are not freely tradable; and (c) in terms of termination upon death, land may be reclaimed by chiefs, even when transferred to an heir unless he/she have applied for it.

Factors such as these can destroy the incentive to invest in the land. However, the strength of the evidence in support of this claim is not known with certainty. The answer to these questions is what motivates the study. Although the application is on data generated in Namibia, its entirety is novel and applies to what obtains elsewhere. Namibia is chosen as a case study, firstly, because it has a history of land deprivations and, as previously stated, the skewness in land ownership is high. Secondly, the economy is dualistic, with the minority represented by established commercial farmers who hold large portions of land, while the majority are peasant, mainly subsistent, communal farmers with limited access to land. Thirdly, in 2007, some parts of Namibia, namely the Kavango, Ohangwena, Zambezi,

[4]. A maximum of 20 hectares is stated to be allocated per person. Hence, landholders are reluctant to apply to the Land Board.

Omusati, and Omaheke, were designated and gazetted as small-scale commercial farming areas in the communal areas, with the aim of transforming farmers in these areas from communal farmers into commercial livestock farming entrepreneurs.

In this regard, the study empirically investigates leasehold land ownership in the communal area, using various econometric tests. The aim is to determine the relationship among tenure security, farm investment and productivity in the livestock sector in the Kavango West region (North of the Veterinary Condor Fence (NVCF)) of Namibia, where no known evidence exists of a similar study. In this region, leasehold rights are held by the private communal farmers, who are often referred to as small-scale commercial farmers[5] (SSCFs). An SSCF, though subject to registration, may make improvements on the farm. On the other hand, communal farms may not, because of tenure insecurity. However, there may be an exception because, in some areas, fixed improvements have been made on communal land (including fencing) by households who claim to have permission to do so from the relevant authority[6]. The study investigates the circumstances of such occurrences and the effect they may have on investment and productivity in the selected region.

2 The concept

The issues of property rights, tenure security, farm investments, and agricultural productivity are central to land reform and agrarian transformation. Property rights confer rights to use the land, but exclude the rights to transfer the land or its output to other users (Demsetz, 1967; Alchian & Demsetz,1973; Norton & Alwang, 1993). A typical right to transfer includes the rights to sell, rent, inherit, pledge, mortgage, and offer the land as a gift. Implicitly, secured property rights bestow tenure security (given appropriate tenure reform) on the holders, which facilitates investment and productivity on the land. However, many schools of thought argue that this framework is location-specific; however, the mixed empirical, analytical underpinnings in these schools of thought, and the available stylised fact, are not sufficient to comprehensively assess the links amongst property rights, tenure security, investment, and

[5]. The scenario is different in the Southern Veterinary Condor Fence (SVCF). In the SVCF, there are both commercial and communal farms with fixed farm improvements such as fencing and farmhouse, with or without leasehold. This is rarely applicable in the NVCF; hence, this study focused on farms in a specific region in the NVCF (Kavango West) which have the most significant number of farmers with leasehold certificates.

[6] The legality of this claim is questionable, however, it is alleged to be an arrangement made by the communities themselves and endorsed by the chief. This practice is not observed everywhere.

agricultural productivity (Besley, 1995; Roth, Barrow, Carter & Kanel, 1989; Holden & Ghebru, 2016). For instance, Feder and Onchan (1987) found that ownership of land title increased capital accumulation and investment in Indonesia. According to Roth et al. (1989), title ownership is not synonymous with tenure security. In some instances, the property right may be usufructuary in nature, which is granted to operators as long as they remain on the land, and this is the situation in Ghana (Besley 1995). Under the usufructuary arrangement, tenure system may be weak and confer rights that are to some extent tenure insecure (Besley 1995). Under insecure tenure, there will be uncertainty in the traditional tenure system. Uncertainty in the traditional tenure system may destroy incentives to invest because operators are afraid of the loss of land and property due to land eviction and appropriation. As mentioned earlier, this situation applies to Namibia.

Nonetheless, in some instances (with no exceptions to Namibia), an investment may be made to secure the right to the land (See Besley, 1995; Brasselle, Gaspart & Platteau, 2002; Place & Otsuka, 2001; Atwood, 1990). This implies that there may be no clear practical evidence that secured land tenure enhances investments and agricultural productivity; hence, tenure rights may be endogenous to investment (Besley, 1995; Place & Hazell, 1993; Bruce, 1988). Other studies with similar findings are those of Do and Lyer (2008) for Vietnam; Brasselle, Gaspart, and Platteau (2002) for Burkina Faso, and Gavian and Ehui (1999) for Ethiopia. Contrary to these findings, operators with stronger user tenure rights to land are likely to invest more resources and increase their productivity (Deininger & Jin, 2006; Deininger, Ali, Holden & Zevenbergen, 2008). Studies by Smith (2004) in Zambia; Gebremedhin and Swinton (2003) in Ethiopia; and Graham and Darroch (2001) in South Africa have shown that land tenure security enhances investments and agricultural productivity. Other studies with similar findings are those of Alemu (2000); Awudu, Victor and Renan (2010); Besley (1995); Dercon and Ayalew (2005); and Mwakubo (2002).

With due consideration of the mixed findings, an important question to be answered in this study is whether there is a causal link amongst tenure security, investment, and increased farm productivity. In other words, does tenure security stimulate investment and farm productivity? Is there a reverse causality amongst these variables of interest?

3 The model

The formulation of models in the literature for the estimation of the relationships amongst property rights, investment and productivity follow a system of simultaneous equation modelling. Simultaneous Equation Models (SEMs) applied by Feder and Onchan (1987); Place and Hazell (1993); Place and Migot-Adholla (1998) are widely used in the literature to model optimisation problems involving farm investments and production decisions, with or without tenure rights. The general assumption underlying the SEM specification in the literature is that tenure security (TS) increases farmers' capacity to obtain credit (C) used to finance farm investment (I) for optimal productivity (Y). Farmers are risk-averse and are assumed to maximise income, output and net welfare subject to constraints, which might include access to credit. In the models, tenure security (TS) is assumed to be exogenous to credit (C), investment (I) and productivity (Y). Credit (C) is assumed to be exogenous to Investment (I) and productivity (Y) because farmers obtain credit to finance investment and productivity. Investment (I), Credit (C) and Tenure security (TS) are exogenous to productivity. An investment fund may include production credit; therefore, credit (C) is assumed to be exogenous. Tenure security may directly or indirectly affect productivity through increased investment. It may affect it directly because farmers with insecure tenure rights may decide not to produce at all. The variables TS, C, I, and Y all depends on sets of exogenous variables such as household (HH) and farm characteristics (F). It is assumed that the way in which farmers understand the nature of their tenure rights will influence their household (HH) investment decisions. If farmers perceive tenure as being insecure (Feder and Onchan, 1987), and being risk-averse, they would invest in movable capital assets, which can be retrieved in case of farm loss through eviction or appropriation.

On the other hand, fixed investments, such as land improvements (fences, trees and boreholes) and operational cost outlays, are lost during evictions. Farmers are unlikely to invest in fixed assets unless there is a high level of trust in the tenure right, which might be weak and unreliable. The SEM for the above formulations can be represented with the following structural models:

Credit model: $C = f(HH, F, TS)$, (1)

Investment model: $I = f(HH, F, C, TS)$, (2)

Productivity model: $Y = f(C, I, TS, HH, F)$, (3) The variables in these models are defined above. Reduced forms of the models (1) to (3) have been used to model different types of tenure rights (freehold, leasehold, customary etc.), investments (short-term and long-term) and credit markets (institutional and non-institutional). By assumption, reduced-form equations are estimated by expressing tenure security in terms of credit and investment on the right-hand side of equations (1) to (3) (Place and Migot-Adholla, 1998; Dube and Guveya, 2013; Hayes, Roth and Zepeda, 1997). In some studies, a reduced-form recursive regression of the models has been fit, for instance in Dlamini and Masuku (2011), where the fitted values (or even residuals) are recursively included in Equations (2) and (3), instead of the actual C and I variables.

The study used a treatment effect and instrumental variable method to establish relationship and to model endogeneity of regressors of interest. The Instrumental Variable (IV) estimator provides consistent estimates, conditional on the presence of a valid instrument. Consider the equation:

$$y = \beta_1 + \beta_2 x_1 + \beta_3 x_2 +, \ldots\ldots, \beta_k x_k + \mu \qquad (4)$$

where x_1 and x_2 are endogenous and exogenous variables, respectively. A suitable instrument says z is chosen to correlate with x_1 and not μ so that the estimator will be a consistent estimator of β_2. To ensure there is no endogeneity in the regressors, the IV method regresses y on x variables using z, such that $E(\mu_i \mid z_i) = 0$. To identify the estimable simultaneous equation model (SEM), the order condition of identifiability was applied to ensure that the model is either exactly identified (EIM) or over-identified (OIM). Model identification is discussed in Section 5.2.

4 Data and sampling

The study was carried out in the Kavango West region of Namibia. The Kavango West Region has eight constituencies: Kapako; Mankumpi; Mpungu; Musese; Ncamangoro; Ncuncuni; Nkurenkuru; and Tondoro. The Kavango West is situated in North-Eastern Namibia. The region covers an area of about 24591.27 km² and lies directly south of Angola, overlying the Kavango River (Ministry of Land and Resettlement MoLR, 2015). It is a semi-arid region with an average summer temperature of about 30° Celsius. Although the 2011 census and regional profile of the region show that about 53 per cent of the agricultural households are crop farmers, greater income is generated from livestock enterprises than crop farming, which makes up 22.8 per cent, while poultry constitutes only 7.9 per cent of the total household participation in agriculture. Livestock was chosen for this study because of its importance as a significant income-generating enterprise in the region and the country at large, as well as the fact that the region is one of the regions in the country with the highest numbers of livestock farmers with leasehold certificates (562). Open access to communal land constitutes 45.7% of the land in the region, whereas the small-scale commercial farmers in this community make up 29.6% (Ministry of Land and Resettlement MoLR, 2015).

The data collection was conducted using a survey method. A multistage sampling method was adopted. First, the respondents were stratified by gender. Second, simple random sampling was used to select respondents who were to be interviewed. Data were collected through a questionnaire administered by trained enumerators. The enumeration was carried out in nine villages from the Mpungu constituency namely, Cause, Mbeyo, Mpoto, Mpungu, Munkala, Nkata, Ntopa, Simco and Situvel, as shown in Figure 1. In total, 510 respondents were randomly selected and interviewed, of whom 255 were private commercial farmers with leasehold rights, and 255 communal farmers without leasehold rights. The aim is to compare the level of investment and productivity between the two groups and relate them to the presence or absence of tenure rights.

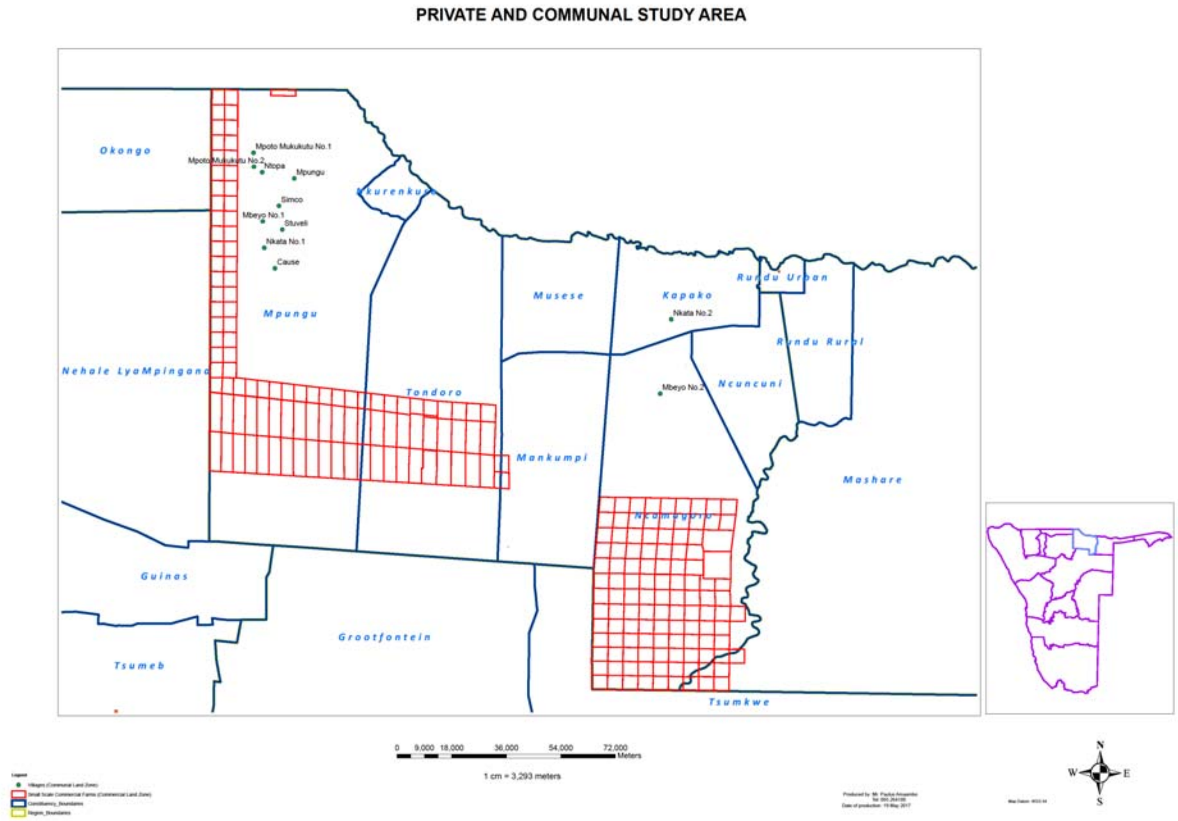

Figure 1: Study area: Private (SSCFU) and communal (village) land zones. Source: Author's computation.

5 Empirical result and discussions

5.1 Descriptive statistics

The critical information gathered from the survey consists of the farmers' demographic characteristics, availability of tenure certificate, farm investment, credit, and farm productivity. Farmers' demographics include age, education, household size, experience, and income. It is assumed that experience comes with age, and that with better education, experienced farmers make better decisions. If farmers earn high income from their farming enterprise, they would probably seek a secure property right to optimise investment and productivity. They may likely become more risk-averse when they are older, as compared with the younger, adventurous farmers. The survey shows that the average age of the respondents on a private farm is 51 years, whereas communal farmers are, on average, 54 years old. An average, a typical private farmer has attained at least grade 12 education, compared to the communal farmers' average school achievement of grade 8. The average household size for both types of farmers is 5 (Table 1). According to the table, the mean farm experience is 21 years for both types of farmers. This is an indication of the presence of a generation of young farmers in the study area. On- and off-farm income is high, with the highest income recorded of more than a million Namibian dollars. As expected, fixed improvements constitute the bulk of farm expenditure, as compared with operational expenditure. The percentage changes in the various income and expenditure items for the farms are given in Tables 2 and 3. The aim is to highlight and compare the differences in farm operations between private farmers who have tenure certificates and communal farmers who do not.

As previously mentioned, a measure of the property rights in the study area was obtained by interviewing farmers who had applied for and obtained leasehold certificate and those who had not. The record shows that the farmers that have leasehold certificates had obtained them during the years 2000 to 2016. Farm fixed investments include fences, boreholes, water troughs, water tanks, farmhouses, solar panels, and electric generators for an alternative energy source. These investment parameters constitute a dummy variable, where 1 indicates a farmer who has made investments, and zero otherwise. The farmers' fixed investment activities, recorded as a percentage of total fixed investments, are shown in Table 2. The Table shows that private farmers with leasehold certificates had more fixed farm investments than communal farmers did. In the real communal system, livestock is raised on open range land; hence, none of the communal farmers had a fence. More numbers of communal farmers had made an investment in a farmhouse than the private farmers had because, in most cases, their farm is situated around their homestead.

Table 1 Summary statistics

Items	Description	Mean	Std. Error	Median	Std. Dev	Min	Max
Gender	Categorical[7]	0.7	0.0	1.0	0.5	0.0	1.0
Education	Categorical	10.1	0.2	12.0	4.9	0.0	19.0
Age	Continuous	52.4	0.5	53.0	11.4	29.0	86.0
Household size	Continuous	5.1	0.1	4.0	2.3	2.0	16.0
Farm Experience	Continuous	21.0	0.4	21.0	8.4	1.0	41.0
Tenure Security	Categorical	0.5	0.0	0.5	0.5	0.0	1.0
Fence	Categorical	0.5	0.0	0.0	0.5	0.0	1.0
Borehole	Categorical	0.2	0.0	0.0	0.4	0.0	1.0
Farm House	Categorical	0.7	0.0	1.0	0.4	0.0	1.0
Electricity Generator	Categorical	0.1	0.0	0.0	0.3	0.0	1.0
Solar Energy	Categorical	0.1	0.0	0.0	0.3	0.0	1.0
Water Pipes Roll	Categorical	0.1	0.0	0.0	0.2	0.0	1.0
Water Tank	Categorical	0.1	0.0	0.0	0.3	0.0	1.0
Goats	Categorical	0.2	0.0	0.0	0.6	0.0	6.0
Cattle	Categorical	0.0	0.0	0.0	0.2	0.0	1.0
Bull	Categorical	0.0	0.0	0.0	0.2	0.0	1.0
Feed Supplements (N$)	Continuous	0.1	0.0	0.0	0.3	0.0	1.0
Medicine & Pesticides (N$)	Continuous	0.0	0.0	0.0	0.2	0.0	1.0
Non-farm Income (N$)	Continuous	79742.8	5758.7	33000.0	130050.4	0.0	1207895.0
Total Income (N$)	Continuous	88891.3	6231.5	41500.0	140727.4	1.0	1207895.0
Total Production	Continuous	61.2	3.3	22.5	73.4	1.0	429.0
Calving Rate	Continuous	0.3	0.0	0.3	0.1	0.0	0.6
Support service	Categorical	0.5	0.0	0.0	0.5	0.0	1.0
Farm Credit	Categorical	0.2	0.0	0.0	0.4	0.0	1.0
Operating expense (N$)	Continuous	217.0	57.0	0.0	1288.0	0.0	18900.0
Capital Invest. (N$)	Continuous	1408.7	306.8	0.0	6927.8	0.0	85200.0
Loan (N$)	Continuous	24845.4	2946.2	0.0	66535.4	0.0	425000.0
Fence cost (N$)	Continuous	26568.3	2810.0	0.0	63457.9	0.0	1000000.0
Borehole cost (N$)	Continuous	16395.8	1703.2	0.0	38463.5	0.0	230000.0
Farm house cost (N$)	Continuous	5769.2	520.2	2500.0	11746.8	0.0	109000.0
Generator cost (N$)	Continuous	1207.9	203.6	0.0	4596.8	0.0	60000.0
Solar panel cost (N$)	Continuous	950.6	179.1	0.0	4044.4	0.0	50000.0
Water Pipes cost (N$)	Continuous	119.6	29.9	0.0	675.7	0.0	10000.0
Water trough cost (N$)	Continuous	79.8	30.3	0.0	685.0	0.0	11000.0
Water Tank cost (N$)	Continuous	950.8	133.7	0.0	3019.6	0.0	27000.0
Goat cost (N$)	Continuous	618.4	164.1	0.0	3706.0	0.0	72500.0
Cattle cost (N$)	Continuous	338.4	138.9	0.0	3136.3	0.0	50000.0
Supplement cost (N$)	Continuous	187.4	54.1	0.0	1222.2	0.0	18000.0
Bull cost (N$)	Continuous	1108.2	338.8	0.0	7651.3	0.0	94000.0
Medicine cost (N$)	Continuous	33.1	9.6	0.0	217.7	0.0	3100.0

[7] Categorical variable take the value of 1, if the event occurred, zero otherwise.

Another type of farm investment includes capital investment (such as the purchase of cattle, bulls, goats and sheep) and farm inputs (feed supplements, licks, medicines, pesticides etc.). The details in Table 2 show that the private farms invested more resources in these capital assets than the communal farmers did. This is perhaps due to financial leverage derivable from the credit market, because a property right (secure tenure) may serve as collateral for a loan (Table 2). On the other hand, none of the communal farmers had obtained any form of credit from any source, as shown in Table 2. A measure of output per input used is shown in Table 2. The table shows that private farms are more productive than the communal farms are, as shown by the total numbers of livestock produced, income and non-farm incomes. Output (productivity) is a continuous variable – a measure of the total number of livestock produced (herd size) during the survey period. The costs for both fixed and capital investments are shown in Table 3. As expected, the percentage of cost outlay for the private farms outweighs that for the communal farms. The reason is, as explained previously, that private farmers invest more resources and have more cost outlays than the communal farmers have.

Table 2 Farm tenure, investments and other activities as a percentage of the total

Activities	Items	Private farms (%)	Communal farms (%)	Total
Tenure	Tenure certificate	100	0	100
Farm investment types	Fence	100	0	100
	Borehole	90	10	100
	Farm House	32	68	100
	Electric Generator	80	20	100
	Solar Energy	93	7	100
	Water Pipes	73	27	100
	Water Tank	95	5	100
Capital investment	Goats	55	45	100
	Cattle	58	42	100
	Bull	94	6	100
Farm inputs	Feed Sup	98	2	100
	Medicine & Pesticides	83	17	100
Farm Income	Non-Farm Income	88	12	100

	Farm-Income	86	14	100
Productivity	Production	91	9	100
Farm credit	Farm Loan	100	0	100

Table 3 Investment costs as a percentage of total

Activities	**Items**	**Private farms (%)**	**Communal farms (%)**	**Total**
Farm investment types	Fence	100	0	100
	Borehole	100	0	100
	Farm house	39	61	100
	Electricity generator	86	14	100
	Solar Energy panel	97	3	100
	Water Pipe	56	44	100
	Water trough	81	19	100
	Water Tank	97	3	100
Capital Investment	Goats	84	16	100
	Cattle	95	5	100
	Bull	99	1	100
Variable costs	Feed Supplements	99	1	100
	Medicine	92	8	100

5.2 Regression analysis

In this section, a causal relationship among the variables (tenure security, farm investment, and productivity) was investigated. It is observed that there were too many categorical investment variables to be included as indicators in the investment model. Including the entire catalogue of variables might introduce bias. Therefore, the dimensionality of the variables was reduced using a Principal Component Analysis (PCA) method. The PCA analysis of the investment variables resulted in the identification of four principal components and component scores. Other variables, such as the various costs of investment items, were not used in the underlying regression analysis because there were too many measurements that are either unobserved or missing. To model the envisaged relationship, various estimators were employed. Firstly, an Ordinary Least Square (OLS) regression was fit. The aim is for this to serve as a starting point for the comparison of the various estimators used for the case of an Exactly Identified Model (EIM). Secondly, an IV regression for the correctly identified model (EIM) was fit. Thirdly, a test of regressor endogeneity was carried out for each pair of the model was investigated. For the case of an endogenous binary regressor, a treatment effect causal model was fit, whereas, for a discrete dependent variable model, a linear probability (LPM), a Probit and an IV-Probit choice model were fit. These models were fit for the purpose of comparing the results.

To identify the estimable simultaneous equation model (SEM), the order condition of identifiability was applied to ensure the model is either precisely identified (EIM) or over-identified (OIM). For each model, instruments were first selected and then a case of Exactly Identified Model (EIM) and Over Identified Model (OIM) restriction was conducted[8]. To test for over-identifying restrictions, the following estimators were used: the Two-Stage Least Square (2SLS) corrected for heteroscedasticity; the optimum Generalised Method of Moment (GMM) corrected for heteroscedasticity; the iterated GMM; the optimal GMM with clustered errors (GMM_Cluster); and the 2SLS with errors that do not adjust for heteroscedasticity[9]. The aim of using various estimators is for comparison. The Sargan score test of over-identified restriction rejects the null hypothesis of over-identification in all the tests. The results of the model over-identification restriction tests are shown in Table 4. The instrument, lease period (*LeaseP*), was used to instrument the tenure security variable. Lease period is the period of the leasehold for the farmer, being either 25 years or ninety-nine years. Some farmers have a short lease period (25 years), while some have an extended period (99 years). Therefore, the variable *(LeaseP)* is a dummy that takes the value I if the lease period is long (99 years), otherwise zero. The variable *(LeaseP)* was used as an instrument for tenure security because farmers with a long lease have greater tenure security than those with a short lease do, and so might invest more resources; hence, in this instance, lease period will correlate with tenure security.

On the other hand, the composite cost of investment (*Cindexts*) and the calving rate (*Calvrate*) were used to instrument investment and productivity variables, respectively. The variable (*Cindexts*) is the instrument chosen for an investment variable because the cost of investment is assumed to correlate with investment. On the other hand, the calving rate

[8] An SEM model is exactly identified if $K-k=m-1$, it is over-identified if $K-k>m-1$, where, K is the number of exogenous variables in the model plus the intercept, k is the number of exogenous variable in the equation, and m is the number of endogenous variables in the equation (Gujarati and Porter, 2009).

[9] For more on the test for over-identification restriction, readers can consult STATA 13 User's Guide.

(*Calvrate*) was chosen to correlate with livestock production. The results show that using the instrument *LeaseP, Cindexts and Calvrate,* the IV models were exactly identified (Table 4).

Table 4 Sargan test* of over-identified restrictions in IV2SLS Models

	Investment		Tenure security		Productivity	
Regressors	Tsecurity	Productivity	Investment	Productivity	Investment	Tsecurity
2SLS	19.157 (0.0000)	12.5360 (0.0004)	0.1138 (0.0000)	11.0352 (0.0000)	11.5308 (0.0007)	28.5876 (0.0000)
GMM_het	19.157 (0.0000)	12.5360 (0.0004)	0.1138 (0.0000)	11.0352 (0.0009)	11.5308 (0.0007)	28.5876 (0.0000)
GMM_IGMM	19.34 (0.0000)	12.3531 (0.0004)	0.1138 (0.0000)	10.91 (0.0000)	11.46 (0.0000)	28.32 (0.0000)
GMM_cluster	10.0069 (0.0000)	7.7638 (0.0053)	0.8699 (0.0000)	6.63183 (0.0000)	9.14973 (0.0025)	15.6491 (0.0000)
2SLS_def	34.1311 (0.0000)	19.0448 (0.0000)	0.8555 (0.0000)	10.161 (0.0000)	13.3857 (0.0000)	37.7805 (0.0000)

*Note Sargan test is distributed as Chi-square test with degrees of freedom equal to the number of restrictions. IV Variables: Tsecurity = Lease period (*LeaseP*); Investment = Cost of composite investment (*Cindexts*) and Productivity = Calving rate (*Calvrate*) Figures in parenthesis are p-value

5.2.1 *Composite investment model*

A composite index was constructed by multiplying the principal component variance for each component with the value of component scores for each variable to fit a composite investment model, and this was summed to obtain the index. Following Equation (4), a composite investment model was fit, where the dependent variable y is the investment composite index (*Cindexts),* x_1 is the endogenous variable (*Tsecurity)* and x_2 represents a vector of exogenous variables *(Age, education, household size, experience and extension support).* The period of the lease (*LeaseP)* was used to the instrument (*Tsecurity).*

The results of an OLS and an IV 2SLS, being an exactly identified model estimation (with robust standard errors after correcting for heteroscedasticity errors), are shown in Table 5. The results show that farming experience and tenure security positively influence composite investment on the farm. The assumption is that tenure security in this model is endogenous to composite farm investment. If tenure security is exogenous, then the IV 2SLS estimator may still be consistent, but is less efficient than the OLS estimator is. The Hausman endogeneity test is used to test whether a regressor is endogenous or not. The test compares the difference between an IV and an OLS potential endogenous parameter estimates. It is based on the assumption that if the difference between the OLS and IV 2SLS estimates is negligible, then the regressor (for example tenure security) is exogenous. Hence, there is no need to instrument the model, otherwise, a significantly large difference between the estimates indicates that it is endogenous[10]. The Hausman test follows a chi-square distribution with a degree of freedom of one. The null hypothesis of the test is that the regressor is exogenous, and rejecting the null confirms endogeneity. Considering the Hausman assumption, Table 5 (Row 2, Cols 2 and 3) shows that the difference between the coefficients of *Tsecurity* for both OLS and the IV 2SLS models is 1.24%. The difference is negligible, which is an indication of exogeneity, although more robust test statistics are required. The Hausman test statistic, however, cannot be used because its assumption is too strong, and it may not yield robust standard errors if homoscedasticity and orthogonality are not strictly met. As an alternative, the related Durbin-Wu-Hausman (DWH) test statistics were used (Davidson 2000). Two DWH tests were calculated, one with ordinary DWH, and another with DWH 2SLS. The DWH and DWH 2SLS tests are reported in Table 5, Cols 4 and 5. The results show that exogeneity was not rejected by the DWH test, thus confirming the result obtained previously using the Hausman assumption. However, the DWH 2SLS result rejects the null, as opposed to the result obtained with the ordinary DWH test. This may be attributable to a loss of precision because of the additional instrumentation used for the IV-2SLS model. To further confirm the results obtained, a treatment effect model (TEM) was fit. This test was conducted because the potentially endogenous variable, *Tsecurity,* in the investment model is a binary variable. This implies that the outcome is observed when *Tsecurity* is 1, (that is, received treatment), otherwise, it is not observed. The test is a Likelihood Ratio (LR) test of independence of errors, which is distributed as chi-square. The null of independence was not rejected at 5% level of significance, but marginally rejected at 10% (Table 5, Row 17, Col 6). It should be noted that in the presence of a slight heteroscedastic error, the IV model is more consistent than the TEM is. Therefore, given the Hausman assumption, the DWH test, and the TEM test, there is a strong indication in support of *Tsecurity* exogeneity in the farm investment model.

The same procedure undertaken to test for *Tsecurity* endogeneity in the investment model was applied to test for farm productivity endogeneity in the investment model. Livestock

[10] The test statistics for the Hausman test is computed following the assumption that $\hat{V}(\hat{\beta}_{IV} - \hat{\beta}_{OLS}) = \hat{V}(\hat{\beta}_{IV}) - \hat{V}(\hat{\beta}_{OLS})$; where, $\hat{\beta}$ is the coefficient of the endogenous variable, and $\hat{V}$ is an estimator of the asymptotic variance

calving rate *(Calvrate)* was used as an instrument in this model. The results are shown in Table 5 (Cols 7-10). The results show that farming experience and increasing farm productivity will encourage greater composite investment on the farm. The direction of the causality is what the study seeks to establish. Firstly, the coefficient for the production parameter in both OLS and IV2SLS was compared (Table 5, Row10, Cols. 7 and 8). There was a significantly large difference between the coefficients of *Lntotprod* (about 18%). Following the Hausman assumptions, this is an indication of farm productivity endogeneity in the composite investment model. Secondly, Endogeneity tests using DWH and DWH 2SLS test statistics reject farm productivity exogeneity in the composite investment model (Table 5, Rows 15 and 16, Cols 9 and 10). It can be concluded that farmers make their production decisions based on the level of investment that they have made on the farm.

5.2.2 *Tenure security model*

This section aims to test whether composite investment and farm productivity are endogenous in a tenure security model. To achieve this, a tenure security model was fit following Equation (4), where the dependent variable y is tenure security *(Tsecurity),* x_1 is the endogenous variable (Cindex or Calvrate), and x_2 represents a vector of exogenous variables (*Age, education, household size, experience and extension support*). The composite cost of farm investment (*cindexts*) was used as an instrument for composite investment. The composite cost was computed from the PCA of investment costs, as described previously. The instrument for production, (*Calvrate*), is as explained previously.

A linear probability model LPM and the IV2SLS estimates are shown in the first two columns in Table 6. Cognisance is taken of the fact that the LPM may not be the most appropriate model for a discrete probability model because the estimates may lie outside the unit circle, or even generate a negative variance. Nevertheless, it was used for comparison with the IV2SLS, and later with the Probit model in Section 5.2.4. The results of the LPM and the IV2SLS show that exogenous variables, such as age, education, farm experience and household size, significantly influence the decision to apply for a leasehold right. For the test of endogeneity, the DWH and DWH 2SLS tests strongly reject the null hypothesis of exogeneity. This implies that composite farm investment is endogenous to tenure security. Note that, in the previous test, tenure security was found to be exogenous to composite farm investment; therefore, this result is a confirmation that there is a unidirectional causal influence between tenure security and composite farm investment, and not vice versa.

Next, the above regression procedure was repeated for farm total productivity *(Lntotprod)*. The result of the endogeneity test for farm total productivity in a tenure security model is shown in Table 6, Cols 6-9. Exogenous variables, such as age, education, and farm experience, influence the decision to apply for a leasehold right. The DWH and the DWH 2SLS reject the null hypothesis of exogeneity (Table 6, Row 16 & 17, Col. 8 & 9). This is an indication that farm productivity is endogenously determined where farmers have secure tenure rights.

5.2.3 *Productivity model*

Following the regression procedure outlined in Section 5.2.1, this section tests whether farm investment and tenure security regressors are endogenous in a farm total productivity model. The results of an OLS and IV 2SLS for this model are shown in Table 7. Following the Hausman assumption, a 12% difference was found between the OLS and IV 2SLS estimates for *cindex* (Table 7, Row 2, Cols 2 and 3). The difference is not significantly large, which is an indication that investment is exogenous to production. The result for the DWH test did not reject exogeneity. However, the DWH 2SLS rejects exogeneity. As stated earlier, this might be attributable to the loss of precision resulting from instrumentation. Notwithstanding this, the results of the Hausman assumption and the DWH tests confirm farm investment exogeneity in the farm productivity model.

The second regression model for farm productivity tests whether tenure security is endogenous to farm production. The difference between the coefficient of *Tsecurity* in OLS and IV 2SLS regression is negligible (9%). Therefore, tenure security is exogenous in the productivity model. In addition, the null hypothesis of exogeneity was not rejected by the DWH, DWH, 2SLS, and the TEM test statistics (Table 7, Row 17 & 19, Col. 8, 9, & 10). Therefore, given the result obtained in this section and that obtained in Section 5.2.2, it can be concluded that tenure security is exogenous to farm production, and that the direction of causality is unidirectional, flowing from tenure security to farm productivity, and not vice versa.

5.2.4 *Discrete dependent variable model:*

Recall that in Section 5.2.2, LPM and IV2SLS estimators were used for the discrete *Tsecurity* model to test for the endogeneity of investment and productivity variables. In this section, discrete probability models are fit to compare and confirm the results obtained previously. Firstly, a Probit model of the discrete dependent variable (*Tsecurity)* on composite investment *(cindex),* total production *(lntotprod)*, and sets of exogenous variables were fit. Secondly, two levels of an IV-Probit procedure, namely ordinary IV-Probit and IV-Probit Two-Step Sequential Estimation (2SSE), were fit. The IV-Probit is a Maximum Likelihood Estimation (MLE), whereas the IV-Probit 2SSE is an alternative procedure with a minimum chi-square estimator. Both estimators have similar distributional assumptions of multivariate normality and homoscedasticity errors. The results are shown in Table 8. Compared with the LPM and IV2SLS results in Table 6, the coefficients for the LPM, IV2SLS, the Probit, and the IV-Probit estimators are all statistically significant at 1%, which is an indication of no loss of efficiency in the models (See Table 6, Row 2. Col. 2 & 3 and Table 8, Row 2 & 9; Col 2-7). As in the LPM and IV2SLS estimations, exogenous variables, such as age, education, and farm experience, significantly influence the decision to apply for a leasehold right, when using the Probit and the IV-Probit 2SSE estimators. The test of the marginal effect of the probabilities for the Probit, IV-Probit and the IV-Probit 2SSE estimators confirm there is a significant influence exerted by these variables on the decision to apply for leasehold (See Table 8, Row 15, Cols. 2-7). The endogeneity test for investment and productivity in the Tenure security model is shown in Table 8, Rows 17-19, Cols. 4-7. The result for IV-Probit MLE is shown in Table 8, Row 19, Cols. 4 and 5, while the IV-Probit 2SSE is shown in Row 19, Cols. 6 and 7. The null hypothesis of exogeneity is rejected in all cases, implying that farm composite investment and farm productivity are endogenous in the tenure security model. This confirms the results obtained in the previous sections.

7 Conclusion

Simultaneous equation models (SEM) have been widely applied in the literature to model the relationship between farm investment and productivity, given that investors (farmers) have the potential to obtain credit under secure property rights. The assumption is that that the availability of financial credit provides leverage for farmers to increase farm investment in order to optimise farm productivity. The theoretical implication for the use of SEM in this regard is that there might be a potential causal influence amongst the variables of tenure security (enhanced by secure property rights), farm investments, and farm productivity, which is due to endogeneity amongst the variables. Hence, a single-equation method such as the OLS method will not be appropriate because of a potential estimator inefficiency and inconsistency. Analysts have often modelled the SEM without explicitly accounting for endogeneity in the regressors, which might result in mixed results.

This study aims to explicitly determine whether there is a causal influence amongst the decisions to apply for leasehold, increased farm investment, and total productivity on livestock farms in the Kavango West region of Namibia. Using a survey of 510 farms, the results show that the availability of secure tenure rights influences farmers' investment decisions. The summary statistics show that private farmers who have leasehold rights have access to credit and greater fixed farm investments than communal farmers do. This has resulted in higher productivity amongst private farmers than amongst communal farmers. The result was consistent with the regression analysis. A test of endogeneity of tenure security, investment, and farm productivity shows that tenure security is exogenous to farm investment decisions and farm productivity, whereas farm investment decisions were found to be exogenous to farm productivity. Farmers make more investment decisions when they hold a more secure tenure right, which enhances their productivity on the farm. Overall, there was no evidence to support reverse causality in any of the tests.

Table 5. Investment model: endogeneity test for tenure security and productivity in an investment model.

		Endogeneity test-Tenure security					Endogeneity test-Productivity			
1	**Regressors**	**OLS**	**IV 2SLS (EIM)**	**DWH Test**	**DWH 2SLS**	**TEM**	**OLS**	**IV 2SLS (EIM)**	**DWH Test**	**DWH 2SLS**
2	T security	5.4364*** (0.0000)	5.3691 *** (0.0000)	5.3691*** (0.0000)						
3	Age	0.1108*** (0.0000)	0.1120 *** (0.0000)	0.1120*** (0.0000)	0.1853*** (0.0000)	0.3730*** (0.0000)	0.1024*** (0.0000)	0.1210 *** (0.0000)	0.1210 *** (0.0000)	0.1210*** (0.0000)
4	Edu	0.0270 (0.4010)	0.0280 (0.4380)	0.0280 (0.4380)	0.0861*** (0.0080)	0.1159 (0.0330)	0.0326 (0.3070)	0.0451 (0.1590)	0.0450 (0.1590)	0.0451 (0.1600)
5	Hhsize	0.0502 (0.5210)	0.0489 (0.5500)	0.0490 (0.5500)	-0.0806 (0.2800)	-0.2576* (0.0530)	0.0598 (0.4160)	0.0397 (0.5910)	0.0397 (0.5910)	-0.0397 (0.5890)
6	Farmexp	-0.1775*** (0.0000)	-0.1812 ** (0.0240)	-0.1812** (0.0240)	-0.4104*** (0.0000)	-0.8225*** (0.0000)	-0.2361* (0.0384)	-0.2787*** (0.0000)	-0.2787*** (0.0000)	-0.2787*** (0.0000)
7	Extser	0.3628 (0.2010)	0.3625 (0.2090)	0.3625 (0.2090)	0.3532 (0.2250)	-0.1823 (0.6190)	0.3887 (0.1720)	0.3793 (0.1800)	0.3793 (0.1800)	0.3793 (0.1820)
8	Constant	-5.5011*** (0.0000)	-5.4555*** (0.0000)	-5.4555*** (0.0000)	-2.3216*** (0.0070)	0.2032 (0.8650)	-7.8481 (1.0000)	-6.7776*** (.0000)	-6.7776*** (0.0000)	-6.7776*** (0.0000)
9	Leasep				1.8828*** (0.0000)	11.4227 (5207.28)				
10	Lntotprod						1.9526*** (0.0000)	1.6057*** (0.0000)	1.6057*** (0.0000)	1.6057 0.2565)
11	(vhat) ρ				5.4568*** (0.0000)					0.4868 * (0.0570)
12	*F-stat*	112.94*** (0.0000)			96.73*** (0.0000)		107.81*** (0.0000)		3.6528* (0.0591)	93.69* (0.0000)
13	*Wald (chi2)*		485.22*** (0.0000)	485.22*** (0.0000)		648.94*** (0.0000)		586.71*** (0.0000)	586.71**** (0.0000)	
14	R^2	0.5742	0.5741	0.5741	0.5742		0.5895	0.5861	0.5861	0.5909
15	Score chi2 (1)			**0.0031**					**3.5612***	

		(0.9554)	**(0.0591)**
16	vhat F-test	**59.7000*** (0.0000)**	**3.65* (0.0565)**
17	LR chi2	**3.5100* (0.0610)**	

Figures in parenthesis are p-values. The signs ***, **, & *, represents 1%, 5% & 10% significant levels respectively.

Table 6 Tenure security model: endogeneity test for investment and productivity in a tenure security model

		Endogeneity Tests - Investment				Endogeneity Tests – Productivity			
1	**Regressors**	**LPM**	**IV 2SLS (EIM)**	**DWH Test**	**DWH 2SLS**	**LPM**	**IV 2SLS-(EIM)**	**DWH Test**	**DWH 2SLS**
2	Cindex	0.0329*** (0.0000)	0.0214*** (0.0000)	0.0214*** (0.0000)	0.0214*** (0.0000)				0.0329*** (0.0000)
3	Age	0.0109*** (0.0000)	0.0133*** (0.0000)	0.0133*** (0.0000)	0.0133*** (0.0000)	0.0050*** (0.0000)	0.0041** (0.0140)	0.0041** (0.0140)	0.0042*** (0.0010)
4	Edu	0.0106*** (0.0000)	0.0118*** (0.0000)	0.0118*** (0.0000)	0.0118*** (0.0000)	0.0054** (0.0110)	0.0048** (0.0370)	0.0048** (0.0370)	0.0152*** (0.0000)
5	Hhsize	-0.0173*** (0.0010)	-0.0179*** (0.0010)	-0.0179*** (0.0010)	-0.0179*** (0.0000)	-0.0053 (0.1780)	-0.0043 (0.3030)	-0.0043 (0.3030)	-0.1394*** (0.0000)
6	Farmexp	-0.0392*** (0.0000)	-0.0447*** (0.0000)	-0.0447*** (0.0000)	-0.0447*** (0.0000)	-0.0257*** (0.0000)	-0.0236*** (0.0000)	-0.0236*** (0.0000)	-0.4083*** (0.0000)
7	Extser	-0.0160 (0.4800)	-0.0121 (0.0593)	-0.0121 (0.5930)	-0.0121 (0.5890)	0.0015 (0.9320)	0.0019 (0.9100)	0.0019 (0.9100)	-0.0436* (0.0570)
8	Constant	0.7369*** (0.0000)	0.7157*** (0.0000)	0.7157*** (0.0000)	0.7157*** (0.0000)	-0.0578 (0.3570)	-0.1103 (0.1300)	-0.1103 (0.1300)	1.5518*** (0.0000)
9	Lntotprod					0.2380*** (0.0000)	0.2550*** (0.0000)	0.2550*** (0.0000)	
10	(vhat) ρ				0.0238*** (0.0010)				0.1955*** (0.0000)
11	*F-stat*	329.48***				618.95***	3290.34 ***	3290.34***	292.17***
12	*Prob> F*	(0.0000)				(0.0000)	(0.0000)	(0.0000)	(0.0000)
13	*Wald (chi2 (6))*		1915.12***	1915.12***				3290.34	
14	*Prob > chi2*		(0.0000)	(0.0000)				0.0000	
15	R^2	0.7431	0.7361	0.7361		0.8472	0.8464	0.8464	0.7425
16	Score chi2(1)			**12.4551*** (0.0004)**				**1.1376 (0.0862)**	

17	Vhat F-test	**11.12***** **(0.0009)**	**157.66** **(0.0000)**

Figures in parenthesis are p-values. The signs ***, **, & *, represents 1%, 5% & 10% significant levels respectively

Table 7 Productivity model: endogeneity test for investment and tenure security in a productivity model

		Endogeneity tests: Investment				Endogeneity tests: tenure security				
1	**Regressors**	**OLS**	**IV 2SLS (EIM)**	**DWH Test**	**DWH 2SLS**	**OLS**	**IV 2SLS (EIM)**	**DWH Test**	**DWH 2SLS**	**TEM**
2	Cindex	0.1069*** (0.0000)	0.0945*** (0.0000)	0.0945 (0.0000)	0.0591*** (0.0000)					
3	Age	0.0316*** (0.0000)	0.0342*** (0.0000)	0.0342 (0.0000)	0.0415*** (0.0000)	0.0156*** (0.0000)	0.0189*** (0.0000)	0.0189*** (0.0000)	0.2453 (0.2586)	0.3855*** (0.0000)
4	Edu	0.0251*** (0.0000)	0.0263*** (0.0000)	0.0263 (0.0000)	0.0300*** (0.0000)	0.0060 (0.3190)	0.0086 (0.1530)	0.0086 (0.1530)	0.0189*** (0.0044)	0.1081* (0.0620)
5	Hhsize	-0.0523*** (0.0010)	-0.0530*** (0.0010)	-0.0530 (0.0010)	-0.0549*** (0.0000)	-0.0170 (0.1960)	-0.0206 (0.1080)	-0.0206 (0.1080)	0.0086*** (0.0062)	-0.3020** (0.0320)
6	Farmexp	-0.0719*** (0.0000)	-0.0778*** (0.0000)	-0.0778 (0.0000)	-0.0946*** (0.0067)	-0.0047 (0.5620)	-0.0151 (0.2010)	-0.0151 (0.2010)	-0.0206* (0.0127)	-0.8467*** (0.0000)
7	Extser	-0.0630 (0.3420)	-0.0588 (0.3720)	-0.0588 (0.3720)	-0.0470 (0.3870)	-0.0164 (0.7500)	-0.0174 (0.7340)	-0.0174 (0.7340)	-0.0151** (0.0118)	-0.2067 (0.6090)
8	Constant	3.2812*** (0.0000)	3.2585*** (0.0000)	3.2585 (0.0000)	3.1941*** (0.0000)	1.6310*** (0.0000)	1.7584*** (0.0000)	1.7584*** (0.0000)	-0.0174* (0.0515)	0.3867 (0.7590)
9	Tsecurity					2.1504*** (0.0000)	1.9621*** (0.0000)	1.9621*** (0.0000)	1.9621 (0.1962)	
10	leasep									11.9170 (2482.34)
11	(vhat) ρ				1.8852*** (0.0000)				0.2453 (0.2025)	
12	*F-stat*	135.68***			260.11***	321.7***			276.48***	
13	*Prob> F*	(0.0000)			(0.0000)	(0.0000)			(0.0000)	
14	*Wald (chi2)*		698.71***	698.71	260.11***		1041.11***	1041.11***		1707.78***
15	*Prob > chi2*		(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)		(0.0000)
16	R^2	0.6454	0.6442	0.6442	0.7620	0.7813	0.7795	0.7795	0.7818	

17	Score chi2(1)	**1.5961** **(0.2065)**		**0.9159** **(0.3385)**	**0.90** **(0.3433)**	
18	vhat F-test		**163.90***** **(0.0000)**			
19	LR chi2					**1.22** **(0.2690)**

Figures in parenthesis are p-values. The signs ***, **, & *, represents 1%, 5% & 10% significant levels respectively

Table 8 Discrete dependent variable model: Investment and productivity endogeneity test in a tenure security model

	DEPENDENT VARIABLE : (T security)	PROBIT		IV-PROBIT		IV-PROBIT 2STEPS	
1	Regressors	Investment	Productivity	Investment	Productivity	Investment	Productivity
2	Cindex	0.4188*** (0.0000)		0.2483*** (0.0010)		0.2790*** (0.0010)	
3	Age	0.1046*** (0.0000)	0.1485 (0.1770)	0.1149*** (0.0000)	0.0545 (0.5000)	0.1291*** (0.0.000)	0.0751 (0.4810)
4	Edu	0.1369*** (0.0000)	-0.0181 (0.6460)	0.1394*** (0.0000)	-0.0434 (0.1610)	0.1566*** (0.0000)	-0.0598 (0.5140)
5	Hhsize	-0.0450 (0.5220)	0.0706 (0.3330)	-0.0644 (0.3410)	0.0892 (0.1260)	-0.0724 (0.3380)	0.1231 (0.4420)
6	Farmexp	-0.3428*** (0.0000)	-0.4668** (0.0270)	-0.3595*** (0.0000)	-0.2636 (0.1060)	-0.4040*** (0.0000)	-0.3638 * (0.0710)
7	Extser	-0.1971 (0.5040)	0.2232 (0.6150)	-0.2153 (0.4350)	0.1964 (0.5390)	-0.2419 (0.4280)	0.2710 (0.7480)
8	Constant	1.8813** (0.0140)	-15.1687*** (0.0010)	1.5447** (0.0300)	-13.9301*** (0.0000)	1.7359** (0.0430)	-19.2224*** (0.0050)
9	lntotprod		5.6687*** (0.0000)		5.2860*** (0.0000)		7.2942*** (0.0030)
10	**<u>Diagnostics:</u>**						
11	**Wald Test:**						
12	*Wald (chi2 (6))*	103.03***	32.5***	92.76***		68.88***	11.47*
13	*Prob > chi2*	(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0750)
14	*Pseudo R2*	0.8566	0.9712				
15	**Marginal effect:**	0.0774*** (0.0000)	0.1534 (0.6950)	0.2483 *** (0.0010)	5.2860 *** (0.0000)	0.2790 * (0.0850)	7.2942*** (0.0030)
16	**Endogeneity Test:**						
17	Wald chi2 (1)			**12.16*** **	**9.46**	**4.39** **	**2.00**

18	Prob > chi2		**(0.0005)**	**(0.0210)**	**(0.0361)**	**(0.0569)**
19	Rho		**0.4926*** (0.0000)**	**-0.8462*** (0.002)**		

Figures in parenthesis are p-values. The signs ***, **, & *, represents 1%, 5% & 10% significant levels respectively

Conflict of Interest: The authors do not have any conflict of interest.

Acknowledgement

This research was financed by the Ministry of Land Reform through the Programme for Communal Land Development in Namibia.

References

Alchian, A.A., and H. Demsetz., (1973). The property right paradigm*. Journal of Economic History* 33: (1) 16–27.

Alemu, T., (2000). Insecure land tenure regimes and soil conservation. Sweden: Göteborg University, Department of Economics.

Atwood, D.A., (1990). Land Registration in Africa: The Impact on Agricultural Production. *World Development Vol. 18: 659-71*

Awudu, A.; Victor, O. & Renan, G., (2010). Land tenure differences and investment in land improvement measures: Theoretical and empirical analysis. *Journal of Development Economics*, 96 (2011): 60-79.

Besley, T., (1995). Property rights and investment incentives: Theory and evidence from Ghana. *Journal of political economy, Vol. 103 (5):903-937*

Brasselle, A.S., Gaspart, F., & Platteau, J.P., (2002). Land tenure security and investment incentives: puzzling evidence from Burkina Faso. *Journal of Agricultural Economics, Vol. 67(2): 373–418.*

Bruce, J.W., (1988). A Perspective on Indigenous Land Tenure Systems and Land Concentration. In Land and Society in Contemporary Africa, edited by R. E. Downs and S. P. Reyna. Hanover, N.H.: Univ. Press New England.

Davidson, J., (2000). Econometrics theory. Oxford: Blackwell.

Deininger, K., Ali, D., Holden, S.T., & Zevenbergen, J., (2008). Rural land certification in Ethiopia: process, initial impact, and implications for the other African countries. *World Development, Vol. 36(10): 1786–1812.*

Deininger, K. & Jin, S., (2006). Tenure security and land-related investment: evidence from Ethiopia. *European Economic Review, Vol. 50: 1245–1277.*

Demsetz, H., (1967). Toward a theory of property rights. *American Economic Review, Vol. 57(2): 347–359.*

Dercon, S. & Ayalew, D., (2005). Property rights in a very poor country: Tenure insecurity and investment in Ethiopia. *Economics Series Working Papers GPRG-WPS – 021*. Oxford: Oxford University, Department of Economics.

Dlamini, D.D. and Masuku, M.B. (2011). Land tenure land productivity: A case of maize production in Swaziland. *Asian Journal of Agricultural Science, Vol. 3 (4): 301-307*

Do, Q.T., & Lyer, L., (2008). Land titling and rural transition in Vietnam. Economic Development Cultural Change 56(3), 531–579.

Dube, L. and Guveya, E., (2013). Land tenure security and farm investment amongst small commercial farmers in Zimbabwe. *Journal of Sustainable Development in Africa, Vol. 15 (5)*

Feder, G. & Onchan, T., (1987). Land ownership security and farm investment in Thailand *American Journal of Agricultural Economics, Vol. 69 (2): 311-320.*

Gavian, S. & Ehui, S., (1999). Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia. *Agricultural Economics*, 20(1999): 37-49.

Gebremedhin, B. & Swinton, S.M., (2003). Investment in soil conservation in northern Ethiopia: The role of land tenure security and public programs. *Agricultural Economics*, 29: 60-89.

Graham, A.W. & Darroch, M.A.G., (2001). The relationship between the mode of land redistribution, tenure security and agricultural credit use in KwaZulu-Natal. *Development Southern Africa*, 18(3): 295-307.

Gujarati, D.N. & Porter, D.C., (2009). Basic econometrics. 5th ed. ISBN 978-007-127625-2, NY USA.

Hayes, J., Roth, M., and Zepeda, L., (1997). Investment and productivity in Gambia agriculture: A generalised probit analysis. *American Journal of Agricultural Economics, Vol. 79 (2): 369-382.*

Holden, ST., and Ghebru, H., (2016). Land tenure reforms, tenure security and food security in poor agrarian economies: Causal linkages and research gaps, *Global Food Security, Vol. 10: 21-28.*

Jacoby, H.G., Minten, B., (2007). Is land titling in Sub-Saharan Africa cost-effective? Evidence from Madagascar. *World Bank Economic Review.21(3),461–485.*

Kabubo-Mariara, J., (2004). Poverty, property rights and social-economic incentives for land conservation: The case for Kenya. *African Journal of Economic Policy*, 11(1): 35-68.

Kabubo-Mariara, J., (2007). Land conservation and tenure security in Kenya: Bosemp's hypothesis revisited. *Ecological Economics*, 64: 25-35.

Lawry, S., Samii, C., Hall, R., Leopold, A., Hornby, D. & Mtero, F., (2014). The Impact of Land Property Rights Interventions on Investment and Agricultural Productivity in Developing Countries: A Systematic Review.

Migot-Adholla, S.E., Place, F., & Oluoch-Kosura, W., (1994). Security of tenure and land productivity in Kenya. In: Bruce, J.W., Migot-Adholla, S. E, S.E. (Eds.), Searching for Land Tenure Security in Africa. Kendall/Hunt, IA, US.

Ministry of Lands and Resettlement, (2009) (Unpublished). Fact-finding mission on the availability of farm land in Oshikoto and Ohangwena regions. Windhoek: Republic of Namibia.

Ministry of Land and Resettlement, (2015) (Unpublished). Integrated regional land use plan for the Kavango West region baseline report (volume 1).

Mwakubo, S.M., (2002). *Land tenure and natural resource management in semi-arid Areas, Kenya*. Beijer Research Workshop on Property Rights, May 2002, Durban, South Africa.

Norton, G. & Alwang, W., (1993). Introduction to Economics of Agricultural Development. McGraw-Hill International edition. *ISBN 0-07-112759-3*

Place, F. & Hazell, P., (1993). Productivity Effects of Indigenous Land Tenure Systems in Sub-Saharan Africa. *American Journal of Agricultural Economics, Vol. 75: 10-19.*

Place, F. & Migot-Adholla, S.E., (1998).The economic effects of land registration on smallholder farms in Kenya: Evidence from Nyeri and Kakamega districts

Place, F., & Otsuka, K., (2001). Tenure, agricultural investment, and productivity in the customary tenure sector of Malawi. Economic Development Cultural Change, Vol. (50): 77–99

Roth, M., Barrow, R, Carter, M & Kanel, D., (1989). Land ownership security and farm investment: Comment. *American Journal of Agricultural Economics, Vol. 71 (1): 211-214*.

Sherborne, R., (2017). Guide to the Namibian Economy. *ISBN 978-99945-60-66-0*. Windhoek.

Smith, R.E., (2004). Land tenure, fixed investment, and farm productivity: Evidence from Zambia's Southern Province. *World Development*, 32(10): 1641-1661.

The Republic of Namibia, (2002) (Unpublished). *Communal Land Reform Act (Act No 5 of 2002)*. Windhoek: Republic of Namibia.

Werner, W.; Adams, F. & Vale, P. (1990) (Unpublished). *The land issues in Namibia: An Inquiry*. Windhoek: the University of Namibia, Institute for Social and Economic Research.