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Relationships between Farmer Psychological Profiles and Farm Business Performance amongst Smallholder Beef and Poultry Farmers in South Africa

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Abstract: Beef cattle and poultry are critically important livestock for improving household food security and alleviating poverty amongst smallholder farmers in South Africa. In this paper, our goal is to examine the relationships between farmer psychological profiles and farm business performance of commercially oriented beef cattle and poultry smallholder farmers in South Africa. We employ a multipronged interdisciplinary approach to test the theory of planned behaviour and its relationship to farm business performance. First, a behavioural science-informed survey instrument was employed to collect data from randomly selected farmer participants in two major beef and poultry projects undertaken by the authors. Second, a latent profile analysis was used to identify the psychological profiles of those farmers. Third, traditional and estimated indicators of farm business performance were obtained using descriptive and econometric-based approaches, including logistic regression and stochastic frontier analyses. The estimated farm business performance indicators were correlated with the psychological profiles of farmers. Results from the latent profile analysis showed three distinct profiles of beef and poultry farmers clearly differentiated by their ability to control and succeed in their farm business enterprises; criteria included attitude, openness to ideas, personality, perceived capabilities, self-efficacy, time orientation, and farm- and personal-related concerns. Profile 1 ('Fatalists') scored themselves negatively on their ability to control and succeed in their business enterprises. The majority of farmers were generally neutral about their ability to control and succeed in their businesses (Profile 2, 'Traditionalists'), while a relatively small group of farmers were confident of their ability to succeed (Profile 3, 'Entrepreneurs'). We found evidence of significant differences in farm business performance amongst the different profiles of farmers. As far as we can determine, this is the only study to have assessed farm business performance based on a differentiation of farmers' psychological profiles. Our results provide a framework to further investigate whether particular types of on-farm interventions and training methods can be customised for different segments of farmers based on their preferred learning styles.

Keywords: smallholder beef and poultry farmers; farm business performance; farmer psychological profiles

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1. Introduction

Since the end of apartheid in South Africa in 1994, successive South African governments have invested strongly in smallholder farmer support schemes, including land, financing, and infrastructure costs as well as information and marketing infrastructure. However, livestock production amongst smallholder farmers remains consistently low. Therefore, development of smallholder livestock farmers is a very high priority for the South African government.

Around 70% of South Africa's total land area of 1.2 million km^2 is suitable only for livestock production. Accordingly, South Africa's "Integrated Sustainable Rural Development

Strategy" [1] identified livestock farming as the agricultural enterprise with the greatest chance of improving household food security and addressing poverty alleviation in small-scale and communal farming areas of South Africa. A subsequent policy known as the "National Development Plan" (NDP) was implemented in 2013, aimed at eliminating poverty and reducing inequality by 2030 [2]. According to the NDP, South Africa will realise those goals by growing an inclusive economy, building capabilities, enhancing the capacity of the state, and promoting leadership and partnerships throughout society. Agriculture and livestock farming in particular are vital components of the process of South Africa's economic development through the NDP.

1.1. South Africa's Beef Industry

South Africa's beef industry is segregated into three 'economies' [3]: (i) a commercial sector comprising mainly white-controlled businesses with a well-developed farm–feedlot–abattoir–retailer value chain and industry infrastructure and production systems equivalent to those of most developed countries; (ii) a sector comprising smallholder black farmers who own or lease land and are commercially oriented but generally lack the training, infrastructure, and production systems available to the commercial sector and who farm either individually or as part of legally registered farming cooperatives and are known in South Africa as 'emerging' or 'smallholder' farmers; and (iii) a sector comprising farmers who do not own or lease land but graze their cattle on communally owned land and operate mainly as subsistence farmers. They are known in South Africa as 'communal' farmers. The main differences between emerging/smallholder farmers and communal farmers are the degree of control that individual farmers have over access to their farming land and the extent to which they are commercially oriented. Our study was undertaken entirely in conjunction with emerging/smallholder farmers who were part of a project known as "High Value Beef Partnerships" (HVBP).

In 2016, there were 13.6 million head of cattle in South Africa, with 42% (5.7 million head) owned by emerging and communal farmers [3]. The total number of cattle slaughtered annually has averaged 3 million head over several years [3]. However, cattle marketed by emerging and communal farmers varies between 7.5% and 10% and is significantly lower than the estimated 25% marketed by the commercial sector. So, while cattle owned by emerging and communal farmers represent an important asset for South Africa, they currently contribute only 5% to South Africa's GDP from beef [3].

A major reason for the discrepancy evident across the commercial and smallholder beef sectors is that the South African commercial beef market continues to be dominated by high-input production systems focused on grain-fed beef, with feedlots supplying the great majority of beef reaching retail shelves. Feedlots primarily source weaner cattle from South Africa's commercial beef farmers or by importing weaner calves from Namibia [3]. Although some emerging/smallholder farmers supply weaners to the feedlots, many have strong social and cultural preferences for keeping animals until they are mature and ready for slaughter. In addition, many of the breed types managed by smallholder farmers are not suitable for feedlot finishing due to their slower growth rates and lower mature sizes. Cattle from emerging and communal herds also generally fail the current feedlot induction specifications for weight, fatness, age, and frame score, primarily due to poor herd management [3].

1.2. South Africa's Poultry Industry

Smallholder poultry production is recognized as one of the important tools for poverty reduction and also contributes positively to the nutritional status of low-income farming communities across South Africa [4]. Poultry production offers strong opportunities to create employment and income for many people in remote South African villages and communities, because providing appropriate training and support and critical infrastructure (portable broiler and layer houses, local feed suppliers, etc.) means that new production sites can be readily established in the backyards of poor people with no previous background in farming.

The poultry industry is the largest single contributor to the agricultural sector in South Africa. In 2019, about 20.0% of total agricultural gross value and 41% of animal product gross value stemmed from poultry production [4]. The 20.0% contribution from poultry products represents 16.4% from poultry meat and 3.6% from eggs. Approximately 75% of the birds in the South African poultry industry are used for meat production, while the remaining 25% are used in the egg industry. Poultry's nearest competitor, the South African beef industry, contributed 12.4% to the turnover of all agricultural production and 25.6% of animal products in 2019 [4].

The poultry industry provides direct and indirect employment to over 110,000 people, is the second-largest consumer of maize, and supports many peripheral businesses (including the feed industry) and those downstream in the value chain [4].

As with the South African beef industry, South Africa's poultry industry comprises small-scale, emerging, and larger commercial poultry farmers [4]. Farmers in our study were small-scale and emerging broiler and egg farmers participating through a South African government-funded project known as the "High Value Poultry Partnerships" (HVPP) project.

1.3. Rationale for This Study

In an attempt to identify the factors accounting for the persistent low levels of productivity amongst smallholder farmers in South Africa, Nengovhela [5] investigated the barriers and promoters of individual change considered essential for improving the well-being of individual smallholder beef farmers in one South African province (Limpopo). Results from that study showed a need to build human, social, financial, and psychological capital amongst smallholder farmers. Critically, when farmers had equivalent access to land, water, infrastructure, knowledge, and financing, psychological capital had the greatest impact on adoption of practices needed to improve the business performance of smallholder cattle farmers [5]. It has been argued that understanding farmers' psychological attributes regarding their goals and actions, in addition to the impact assessment of farm physical and financial performance, is an important step towards the achievement of efficient outcomes for targeted groups [6,7]. Considering the psychological and behavioural profiles of farmers can help in the design of communication and policy strategies that are targeted to the requirements of specific groups [8].

Based on those findings, this study uses three groups per industry of South African smallholder beef and poultry farmers that were shown by Bhullar et al. [9] to have similar behavioural profiles and additionally evaluates those farmers' business performance. The aim is to specifically determine whether those farmers' behavioural profiles are associated with their farms' business performance. This approach extends the work of [8], which used a profiling method to identify the psychological drivers and barriers of farmers' adoption of low-emission agricultural practices in Australia, by adding an additional step of evaluating the relationship between the farmers' psychological profiles and their farm business performance. A separate study [7] employed a segmentation technique to examine the link between segmented groups and their related physical, financial, and managerial qualities. Understanding whether farmers' psychological profiles are associated with their farm business performance is imperative for designing appropriate intervention strategies that could potentially be designed, implemented, and evaluated amongst smallholder farmers with the aim of improving their farm business performance.

2. The Theoretical Link between Psychological Profiles and Farm Business Performance

The conceptual link between farmers' psychological profiles and farm business performance in this study hinges on the theory of planned behaviour (TPB) [10,11] and on the empirical expositions provided in existing studies that focus on the association between farmers' psychological attributes and farming practices. According to the TPB, three psychological/cognitive elements influence a farmer's decision to adopt a particular innovative agricultural method to improve farm business performance. These elements include attitude towards the behaviour (ATT), subjective norms (SNs), and perceived behavioural control (PBC). ATT relates to a

farmer's likelihood of possessing a favourable or unfavourable propensity towards a behaviour, SNs are the extent to which farmers' significant others influence them to adopt a particular innovation, and PBC is associated with the farmers' perceived difficulty or easiness of adopting an innovation [10,12,13]. Putting the three psychological elements together results in a positive or negative intention to adopt an innovation. Farmers who possess enough actual behavioural control (ABC) will carry out their intention. ABC represents the availability of required behavioural prerequisites such as capital, skills, knowledge, and opportunities. The implication of this is that a farmer's positive intention may not always lead to adoption of an innovation due to a perception of insufficient ABC (see Figure 1).

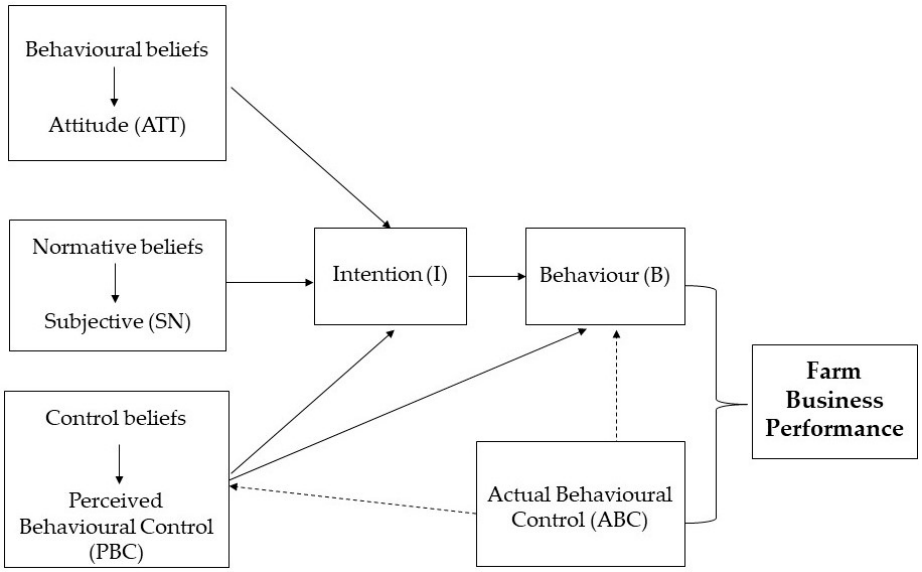

Figure 1. The theory of planned behaviour (Source: Authors' construct adapted from [10,13]).

Closely linked to the TPB is the "Big Five" model of personality, which suggests that a farmer's thoughts and actual behaviour are informed by five personality characteristics: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism [14]. Other researchers [8,15,16] also found that farmers' conviction in their capability to undertake an activity (self-efficacy) is linked to the eventual adoption of a particular climate change technology. Studies that have considered farmers' psychological orientations and their actions based on the theories above have also incorporated expectations about profit and cost targets, which are known to play diverse roles in informing farmers' decisions [8]. With the decisions also being informed by farmers' psychological characteristics, we hypothesize that farmers' psychological profiles are related to their farm business performance.

3. Materials and Methods

3.1. Study Area and Respondents

This study is based on baseline behaviour change surveys completed by 480 smallholder beef farmers and 435 smallholder poultry farmers (with a mix of egg and broiler producers) as reported by [9]. Data were cleaned for completeness of information and missing observations. Thus, 471 beef farmer and 426 poultry farmer respondents were used for subsequent analyses. The smallholder farmers were selected amongst beef and poultry farmers in seven provinces in South Africa from those who had agreed to participate in the HVBP and HVPP projects. The beef farmers were located within a 250 km radius of Cradock Abattoir (Eastern Cape Province) and a similar radius of Cavalier Meats (which sources supply from Gauteng, Mpumalanga, Limpopo, North West, and Free State Provinces), with both abattoirs supplying cattle to the free-range markets promoted by Woolworths to middle- and high-income consumers as part of the HVBP project. Additionally, farmers from the Northern Cape Province were sampled, although their locations subsequently proved too distant for them to cost-effectively supply

to either of the abattoirs. Poultry farmers were from the same provinces as the beef farmers and were also selected from farmers engaged in the HVPP project. Approximately 92% of the respondents were full-time beef producers, and 91% were full-time poultry producers. Only 24% of our beef respondents were female farmers, with 54.48% of poultry respondents being female. Most beef and poultry respondents had completed at least a high school certificate. The ethnic composition and language background of respondents were almost the same for beef and poultry farmers. Basic characteristics of respondents in this study are presented in Table 1.

Table 1. Profile of farmer respondents.

Item	Beef (% of Responses) All	Poultry (% of Responses) All
No. of respondents	471	426
Farming engagement		
Full-time	92.4	91.78
Part-time	7.6	8.22
Reasons for keeping cattle		
Wealth	6.6	
Sale	66.9	
Home consumption	7.0	
Mixed reasons *	19.5	
Cultural reasons	54.1	
Farmers who actually sell	71.3	58.69
Demographic characteristics		
Male farmers	76.3	45.5
Female farmers	23.8	54.5
Age of farmer *	54.19	47.28
Farming experience (years) *	17.48	4.37
Household size *	5.6	5.49
Education		
No school	6.0	3.05
Primary	20.8	20.89
Secondary/high school	53.8	57.28
College/university	19.4	18.78
Language		
Sepedi	15.3	36.49
Setswana	22.3	24.41
Isizulu	13.9	8.77
Isixhosa	24.2	10.66
Others **	24.4	19.67
Race		
Black	98.8	99.06
White	0.4	0.78
Coloured	0.8	0.23

* Where appropriate, for continuous variables; ** includes Swati, Ndebele, Afrikaans, English, Venda.

3.2. Survey Instrument

A survey questionnaire was designed to collect the data through personal interviews of farmer respondents. The survey instrument comprised two sections. The first section comprised information supplied by farmers about their demographics and aspects of farm business performance. Questions were framed in structured, open-ended, and close-ended formats and included information on farm and farmer characteristics. Those questions were designed by the project team in consultation with beef and poultry experts and calibrated through pretesting and pilot surveys. The second section included farmers' self-scores on a range of psychological aspects, described below. Development of these questions was informed by several sources including [8,17–20]. Responses to the latter component of the survey instrument were analysed and grouped to generate psychological profiles of the smallholder beef and poultry farmers, with profile results reported by [9].

The survey instrument was developed in English to avoid potential errors of translation into the multiple other languages used by smallholder farmers across South Africa. However, those surveys were administered by trained enumerators who were also fluent in the local language where the research occurred. The survey instrument was initially administered to selected beef and poultry farmers across several provinces by 15 project enumerators who

had been trained to administer the survey. Responses from the preliminary surveys were then checked for consistency and to ensure that the questions were not misinterpreted. Based on those initial responses, some minor amendments were made to the questionnaire. The revised questionnaire was then transferred to electronic format using KoboCollect, and the 15 enumerators were further trained to gather the survey data electronically. Collected data were processed and analysed using Stata [21].

3.3. Ethical Issues

To ensure adherence to ethical standards, the research instruments were submitted to the Human Research Ethics Committee of the University of New England for ethical clearance, with approval number HE19-081. Informed consent to participate and to publish were obtained from all individual participants before administering the instrument. The consent was documented in the completed questionnaire.

3.4. Farmer Psychological Variables

To identify farmer behavioural profiles, latent profile analysis (LPA) was applied to 14 psychological attributes that were selected based on theory and their potential to explain both the farm business performance and the decision-making processes of South Africa's commercially oriented smallholder farmers. LPA is a categorical latent variable approach that focuses on identifying latent subgroups or profiles within a population based on a certain set of variables [22]. LPA combines the different psychological variables for each individual and then examines the variables for patterns of similarity to obtain profiles.

As reported by [9], the behaviour change component of the survey instrument comprised farmers' self-rated scores on their attitudes, subjective norms, perceived behavioural control, personality (openness to new experience, conscientiousness, extraversion, agreeableness, and neuroticism), time orientation (present or future), self-efficacy (the farmers' belief that they can succeed in the tasks they are faced with), perceived benefits of engaging in farming and personal capacity, and farm-related concerns. Development of the survey instrument was informed by the existing literature to find appropriate measurement scales for these psychological attributes. Questions on key psychological variables were informed by various theories such as the theory of planned behaviour constructs [17]: attitudes, subjective norms, and perceived behavioural control on the new self-efficacy scale [18]; the Big Five Inventory–10 (BFI-10) [19]; and the Zimbardo Time Perspective Inventory [20]. Descriptions of these attributes are provided and discussed in [9].

Consistent with previous studies [19], we employed a 5-point Likert scale for all questions and ensured internal validity amongst the set of Likert scale questions using Cronbach's alpha (α). Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. Measurements were taken for attitudes (5 items; $\alpha = 0.70$), subjective norms (3 items; $\alpha = 0.80$), perceived behavioural control (2 items; $\alpha = 0.80$), self-efficacy (11 items; $\alpha = 0.86$), expected benefits (8 items; $\alpha = 0.87$), farming concerns (29 items; $\alpha = 0.89$), and personal capability concerns (12 items; $\alpha = 0.90$). For personality traits using a brief version of the "Big Five" inventory, we employed 2 items for each component. Regarding time perspective, we used 2 subscales: present (8 items; $\alpha = 0.74$) and future (13 items; $\alpha = 0.73$).

Items retained after the preliminary data validation tests were averaged to compute an overall composite score for each final psychological attribute, with high scores indicating positive endorsement of the psychological attribute towards cattle and poultry farming. Using the generated scores from the retained items, the LPA was carried out using Mplus (v.7.3) to categorise respondents based on shared patterns of their answers on a variety of psychological traits [23,24].

To determine the appropriate number of profiles, several model fit indices were employed (Table 2) including the Bayesian Information Criterion (BIC) and its adjusted versions, Vuong–Lo–Mendel–Rubin (VLMR), the Bootstrapped Likelihood Ratio Test (BLRT), and entropy. A combination of the least BIC and adjusted BIC values with the

maximum number of profiles indicates the favoured model. If the *p* values for LMR and BLRT are significant, model *k*-1 should be rejected in favour of model *k* [5]. Considering the entropy value in addition to the model fit indices resulted in the choice of 0.87, since the values close to 1 are considered ideal [25]. For the grouping of farmers into different profiles, grouping values of 1–3 were used. All 14 psychological profiling measures were normalised to a mean of 0 with a standard deviation of 1 to make profile interpretation easier. Additional details of profile construction are provided in [9].

Table 2. Model fit indices for solutions for Profiles 2–5 poultry farmers.

Profiles	BIC	*Adj* BIC	VLMR	BLRT	Entropy
2	16,465.28	16,328.83	<0.001	<0.001	0.8
3	16,234.72	16,050.66	0.06	<0.001	0.87
4	16,177.68	15,946.82	0.02	<0.001	0.89
5	16,157.07	15,877.81	0.262	<0.001	0.86

Note: *N* = 426. BIC = Bayesian Information Criterion; VLMR = Vuong–Lo–Mendel–Rubin adjusted test; BLRT = Bootstrapped Likelihood Ratio Test.

3.5. Farm Business Performance

Three sets of indicators were used in this study to measure the performance of a business enterprise. First, key on-farm indicators were used to depict the performance of farmers in terms of number of cattle/poultry stock holdings and number of stock sold. On-farm performance may also include cost and return indicators. As prices and income from cattle and poultry sales were difficult to obtain at the farmer level, we were unable to compute the costs and returns for either cattle or poultry production. Our decision to use the number of animals kept is based on evidence that in rural Lesotho and amongst black South Africans more generally, livestock is a kind of property that is not freely interconvertible with cash, whereas the reverse is easy [5,26].

Second, we measured the likelihood of farmers engaging in a market as a performance indicator. Several studies suggest that formal market participation of smallholder beef farmers in South Africa is low [27,28]. Market participation amongst smallholder poultry farmers was also low, with the few farmers who did participate selling only in the informal market [29]. Another study [30] indicated that market participation amongst smallholder poultry farmers in South Africa was low and was primarily focused on informal markets. The lower participation was because the formal or commercial value chain requires high production volumes and higher quality standards, which usually cannot be met by the smallholder farmers [31]. The distribution of farmers according to market choices is provided in Table 3.

Table 3. Distribution of beef farmers according to place and number of market outlets.

Market Outlet	Beef		Poultry	
	Number of Responses	% of Farmers	Number of Responses	% of Farmers
Informal	182	43.03	220	68.75
Auction	184	43.50		
Feedlot	25	5.91		
Abattoir	19	4.49		
Other	13	3.07	100	31.25

Smallholder farmers in this study raised livestock for various cultural (e.g., weddings and funerals and as symbols of wealth) and economic reasons. Of the total cattle sample, 86.42% of producers raised cattle with the intention to sell for home consumption (20.18%) and for savings (indicator of wealth, 15.29%). However, only 71% of farmers actually sold cattle during the study period. There were also 54% of respondents who kept cattle for cultural reasons. There was evidence that market participation remained relatively low, especially for those selling to auctions, feedlots, abattoirs, and commercial markets.

Decisions about whether to participate and the level of market participation are generally attributed in the scientific literature to several factors including herd sizes and cultural reasons, and these influence farmers' willingness to liquidate animals through different market outlets [31–35].

The decision to sell is estimated using the binary logit model, as follows:

$$P_i(j) = F(Z_i) = \frac{e^{Zi}}{(1+e^{Zi})} = \frac{1}{(1+e^{-Zi})} \quad (1)$$

where $Zi = \sum_{j=1}^{k} X'_{ij}\beta_j$ and where P_i is the probability that the ith farmer participates in the market and is regressed against the set of explanatory variables (X_i). X_i is the ith row of the $n \times k$ matrix of explanatory variables, β_j is the $k \times 1$ vector of parameter coefficients, and k is the number of coefficients. The coefficient measures a 1-unit change in the explanatory variable based on the logarithm of the probability ratio of the producer choosing to sell and measures the likelihood of farmers to engage in the market. The marginal change in probability of the ith farmer engaging in the market resulting from a change in the kth explanatory variable was also computed. The independent variables used to measure the probability to sell and subsequent results are provided in Table 4 (beef farmers) and Table 5 (poultry farmers).

Third, our remaining indicators of business performance were productivity and technical efficiency. Productivity is measured the same as partial productivity measures (hereafter referred to simply as productivity), which provides a similar measure as long as all farmers have access to the same production technologies and there are no scale economies. Examples of productivity indicators are number of calves per year, number of cattle sold per household, and number of stocks sold per cycle. On the other hand, technical efficiency measures the performance of farmers based on their existing resources and shows the capacity of farmers to reach the maximum attainable output from those resources. A farm is technically efficient when it achieves the maximum possible output for a given set of inputs used in production. A technically inefficient farm can increase output without requiring any more inputs. Several studies have used technical efficiency and productivity as performance indicators of smallholder farmers. For example, Ref. [36] examined the efficiency of production of small-ruminant systems in Ghana, Refs. [37,38] analysed the productive performance of extensive beef cattle farms in Botswana, Ref. [39] assessed the performance of livestock farming households in the northern Eastern Cape communal areas of South Africa, and Ref. [40] examined the technical efficiency of milk-producing households in Tanzania. In this study, we estimated the technical efficiency of cattle farmers as an indicator of farm business performance using a stochastic production frontier framework. We used the survey data for cattle to obtain the above indicators. Because there are some missing data, the number of observations varies depending on the completeness of information used. We did not obtain technical efficiency and productivity for poultry farmers due to a lack of data on key inputs required for their estimation.

We assumed that farmers had access to the same set of production technologies, although they may not all have made the same use of them. Following [41], satisfactory estimates were made of the stochastic frontier production functions of farmers that enabled calculation of individual technical efficiency indices for each farm. The general representation of the stochastic frontier model is:

$$lnY_i = \beta_0 + \sum_{j=i}^{4} \beta_j lnX_i + v_i - u_i \quad (2)$$

where ln is a natural logarithm, Y represents the number of cattle owned (in n), X_1 is the farm size (in ha) for cattle production, X_2 is labour input (total of hired and family labour), and X_3 represents the total costs (in rands) for cattle production, with a dummy included for those farmers who do not spend on supplementary feed and veterinary costs and those

farmers who do not own or lease their own area for grazing. A flexible specification of the production function using translog has been estimated; however, a Cobb–Douglas stochastic frontier model specification is used in this study following a likelihood-ratio test, LR test statistic 11.29. The subscripts j and i refer to jth input and ith farmer, respectively, whereas v_i denotes the noise error term, and u_{i} is a nonnegative random variable associated with technical inefficiency.

Table 4. Determinants of the number of beef cattle sold and propensity to sell per household.

	Log (Actual Number of Cattle Sold)	**Probability to Sell**
		ME
Access to credit (0/1)	0.469 **	0.100 *
	(0.182)	(0.058)
Access to agric info (0/1)	0.107	0.014
	(0.106)	(0.045)
Age of farmer	0.008 **	0.003 **
	(0.004)	(0.002)
Educational Status (Base = Tertiary)		
No school	−0.169	−0.011
	(0.237)	(0.093)
Primary	−0.383 **	−0.083
	(0.153)	(0.057)
Secondary	−0.419 ***	−0.106 *
	(0.155)	(0.055)
High school	−0.275 *	−0.041
	(0.142)	(0.047)
Farming not on basis of culture (0/1)	0.025	−0.141 ***
	(0.106)	(0.040)
Log (number of hired labourers)	0.331 ***	0.075 ***
	(0.071)	(0.024)
Log (total exp on electricity)	−0.022	−0.016 ***
	(0.016)	(0.006)
Female famer (0 = male; 1 = female)	−0.151	−0.079 **
	(0.093)	(0.040)
Years of farming	0.008 **	0.004 **
	(0.004)	(0.001)
Household size	0.000	0.003
	(0.013)	(0.005)
Log (exp on veterinary purchases)	0.124 ***	0.030 ***
	(0.014)	(0.005)
Province (Base= Eastern Cape)		
Limpopo	0.582 ***	0.165 ***
	(0.139)	(0.059)
Free State	0.608 ***	0.118 *
	(0.174)	(0.071)
Mpumalanga	0.228 **	0.075
	(0.114)	(0.059)
North West	0.567 ***	0.220 **
	(0.214)	(0.090)
Gauteng	0.455 ***	0.085
	(0.147)	(0.057)
Northern cape	0.234	0.049
	(0.218)	(0.079)
Constant	−0.185	—
	(0.292)	—
Observations	471	471
R-squared	0.505	0.350

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 5. Determinants of the number of broilers sold and propensity to sell per household.

Variables			Willingness to Sell (WTS)	
			Market	
	Log (Actual Number of Broilers Sold)	Probability to Sell Broiler	WTS in Informal Market	WTS in Formal Market
Access to credit (0/1)	−0.569 *	−0.067 **	0.059	−0.059
	(0.296)	(0.034)	(0.051)	(0.051)
Access to agric info (0/1)	0.211	0.044	−0.092 *	0.092 *
	(0.347)	(0.034)	(0.052)	(0.052)
Educational status (base = no school)				
Primary	−0.157	−0.069 *	−0.136	0.136
	(0.339)	(0.035)	(0.092)	(0.092)
Secondary	−1.231 ***	−0.115 ***	−0.073	0.073
	(0.446)	(0.040)	(0.084)	(0.084)
High school	−0.646 *	−0.083 **	−0.055	0.055
	(0.382)	(0.036)	(0.082)	(0.082)
Tertiary	−0.751	−0.085 **	−0.119	0.119
	(0.456)	(0.040)	(0.093)	(0.093)
Log (number of broiler houses)	1.183 ***	0.133 ***	0.153 ***	−0.153 ***
	(0.408)	(0.024)	(0.048)	(0.048)
Log (number of broilers owned now)	0.754 ***	0.034 ***	0.018 *	−0.018 *
	(0.081)	(0.005)	(0.010)	(0.010)
Log (number of hired labourers)	−0.146	−0.018	−0.001	0.001
	(0.167)	(0.017)	(0.027)	(0.027)
Log (total exp on electricity)	0.044	0.007 **	−0.008	0.008
	(0.037)	(0.003)	(0.006)	(0.006)
Log (years of farming)	0.373 *	0.031 *	0.083 **	−0.083 **
	(0.191)	(0.019)	(0.035)	(0.035)
Female famer (0 = male; 1 = female)	−0.096	0.004	0.004	−0.004
	(0.308)	(0.028)	(0.045)	(0.045)
Years lived in current location	−0.060	−0.011	−0.024	0.024
	(0.142)	(0.019)	(0.026)	(0.026)
Age of farmer	−0.039 ***	−0.002	−0.002	0.002
	(0.012)	(0.001)	(0.002)	(0.002)
Household size	0.044	0.008	0.014	−0.014
	(0.058)	(0.005)	(0.009)	(0.009)
Province (Base = Eastern Cape)				
Free State	1.430 **	0.106 **	−0.049	0.049
	(0.556)	(0.051)	(0.095)	(0.095)
Mpumalanga	0.867 *	0.130 ***	−0.111	0.111
	(0.489)	(0.043)	(0.082)	(0.082)
North West	0.784 **	0.084 *	−0.055	0.055
	(0.391)	(0.047)	(0.061)	(0.061)
Gauteng	0.267	−0.004	0.069	−0.069
	(0.738)	(0.080)	(0.078)	(0.078)
Constant	2.893 **	—	—	—
	(1.234)	—	—	—
Observations	325	325	325	325
R-squared	0.720	0.660	0.256	0.256

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

4. Results

4.1. Determinants of the Number of Stock Sold and the Propensity to Sell

The independent variables used to measure the probability to sell and subsequent results are provided in Table 4 (beef farmers) and Table 5 (poultry farmers). We found that cattle farmers' likelihood to sell was highly influenced by access to credit, age of farmer, education, hired labourers, years of farming, expenditure on tertiary services, and location of farmer (Table 4). Farmers who had access to credit were 10% more likely to sell their cattle. Older farmers had a 0.3% higher probability of selling cattle, likely reflecting increased experience. Farmers who had attained tertiary levels of education were more likely to sell than those with any other level of education. Those who kept cattle for cultural

reasons were 14.1% less likely to sell. Also, increasing the number of hired labourers by one person increased the likelihood of selling by 7.5%. This is expected, because a hired labourer is associated with higher per unit output, which increases the intention to sell. In addition, the findings indicated that selling through informal markets was positively influenced mainly by farming experience (years of farming). On the other hand, the decision to sell at auction markets and abattoirs was influenced favourably by the number of hired labourers, expenditure on veterinary services, and location and education. The role of education and training in regard to the benefits of selling in these market outlets was crucial for farmers. Thus, appropriate information dissemination strategies and the role of extension workers are fundamental in this aspect.

The decision by farmers with regard to the number of broilers sold is influenced by a number of demographic and socioeconomic variables (Table 5). As expected, the more broiler houses and the larger numbers of broilers, the higher the likelihood of selling broilers. The results for having access to credit are counterintuitive, and the same is true for educational attainment. However, we found that greater access to agricultural information improved the likelihood of farmers engaging and being willing to sell in the formal market.

4.2. Profiles of Farmers

The results of LPA as reported by [9] identified three distinct profiles for both beef and poultry farmers. The psychological features of individual profiles of farmers are depicted in Figures 2 and 3 for beef cattle and poultry farmers, respectively. The horizontal axes of these figures indicate the standardized predicted mean values for each attribute. Most beef cattle farmers (54%) perceived personal capability and farm-related concerns as a deterrent to their business. However, a high proportion of beef cattle farmers (40%) in Profile 3 had positive attitudes and beliefs and a perception of their ability to thrive in their business while showing some concerns about their propensity to work in groups and collaborate.

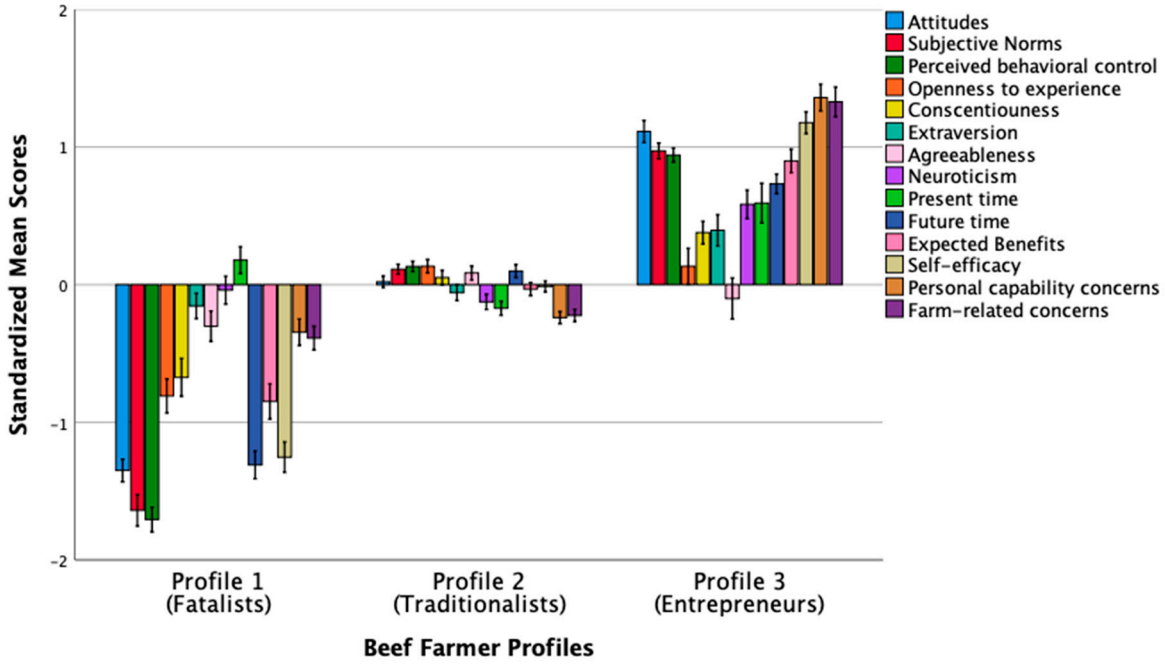

Figure 2. Profile of beef cattle farmers (Profile 1, n = 67; Profile 2, n = 329; Profile 3, n = 75; Reprinted with permission from [9]. 2023. Bhullar et al.

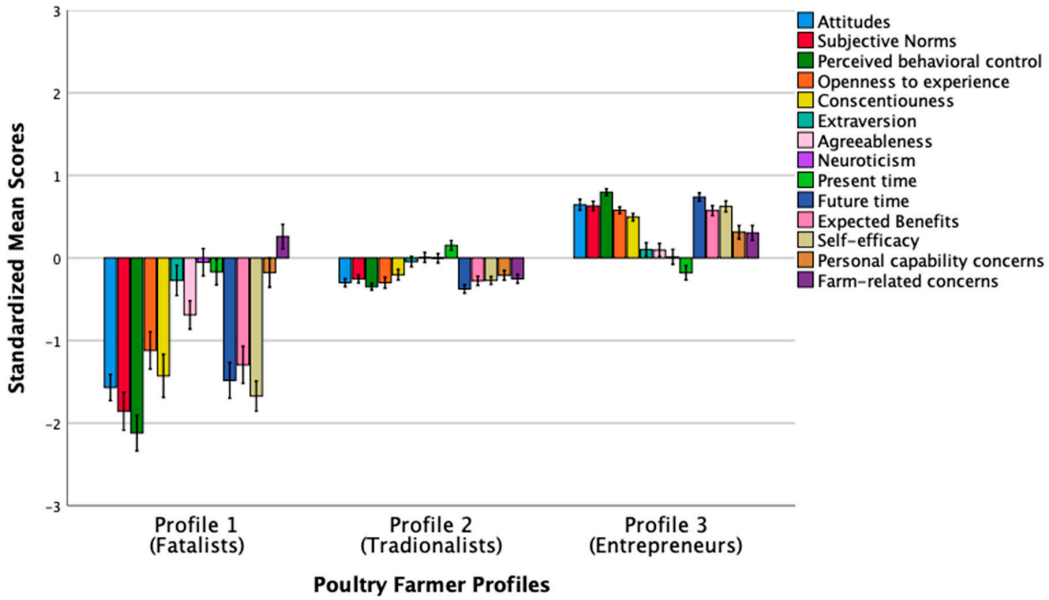

Figure 3. Profile of poultry farmers (Profile 1, n = 26; Profile 2, n = 230; Profile 3, n = 170; Reprinted with permission from [9]. 2023. Bhullar et al.

Following the results of [9], the distribution of farmers according to different profiles is shown in Figure 4. The results showed (1) a relatively small proportion of farmers who scored themselves negatively on their ability to control and succeed in their business enterprises (Profile 1, 'Fatalists'); (2) a group comprising the majority of farmers who were generally neutral about their ability to control and succeed in their businesses (Profile 2, 'Traditionalists'); and (3) a relatively small group of farmers who were confident of their ability to succeed (Profile 3, 'Entrepreneurs').

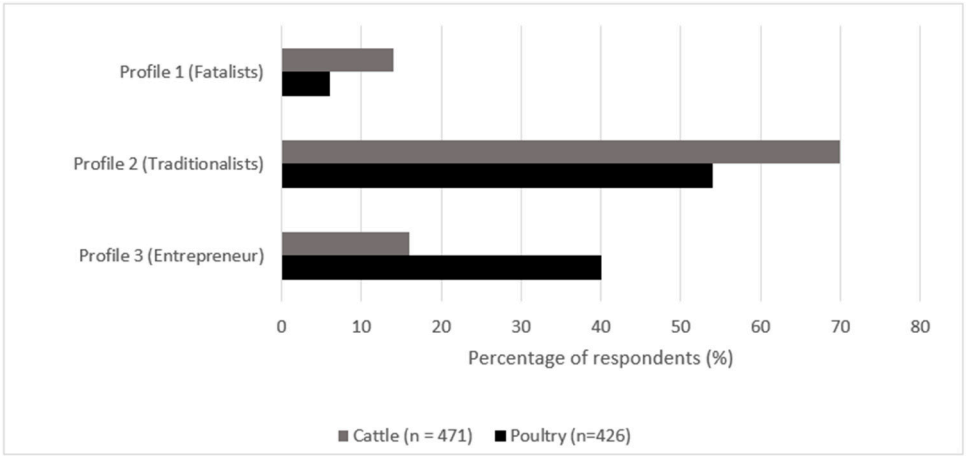

Figure 4. Distribution of smallholder cattle and poultry farmers based on their psychological attributes.

Selected features of farmers in each profile are presented in Table 6. (These characteristics are presented here to provide context in the discussion of the relationship between farmers' psychological profiles and farm business performance.) Most farmers were engaged in full-time beef cattle and poultry farming. Some farmers grew cattle purely for sale, while most raised cattle for cultural and other reasons. The proportion of farmers who raised beef cattle specifically for selling was highest in Profile 3. There were significant differences between farmer profiles in terms of educational attainment, language, and ethnic composition, as summarised in Table 1.

Table 6. Characteristics of beef and poultry farmers by psychological profile.

Item	Beef (% of Responses)			Test		Poultry (% of Responses)			Test	
	Profile 1	**Profile 2**	**Profile 3**	**Chi-Square/Anova ***	***p*-Value**	**Profile 1**	**Profile 2**	**Profile 3**	**Chi-Square/Anova ***	***p*-Value**
Farming engagement										
Full-time	94	91.19	96			80.8	92.2	92.9		
Part-time	6	8.81	4	2.315	0.314	19.2	7.8	7.1	4.53	0.104
Reasons for keeping cattle										
Wealth	4.5	6.7	8	1.885	0.390					
Sale	71.6	64.4	73.3	6.084	0.048					
Home consumption		8.5	6.7	5.061	0.080					
Mixed reasons	23.9	20.4	12	18.735	0.044					
Cultural reasons	59.7	52.3	57.3	1.601	0.449					
Farmers who actually sell	71.6	69.6	78.7	2.456	0.293	38.5	56.1	65.3	8.089	0.018
Demographic characteristics										
Female farmers	28.4	21.6	30.7	3.582	0.167	46.2	57.4	51.8	2.018	0.365
Age of farmer *	55.94	52.92	58.07	4.49	0.012	49.56	48.13	45.8	1.82	0.163
Farming experience (years) *	17.4	17.21	18.71	0.3	0.738	3.73	4.29	4.59	0.26	0.774
Household size *	5.03	5.55	6.33	1.61	0.003	4.73	5.5	5.59	1.32	0.27
Education										
No school	7.5	4.9	10.7			3.9	3.9	1.8		
Primary	32.8	22.2	6.7			30.8	24.4	14.7		
Secondary/high school	50.7	53.5	54.6			61.6	58.3	55.3		
College/university	9	19.5	28	22.2	0.001	3.9	13.5	28.2	34.012	0.001
Language										
Sepedi	14.9	11.4	32			26.9	39	34.5		
Setswana	23.9	24.3	13.3			26.9	18.9	31.6		
Isizulu	17.9	15.1	6.7			23.1	7.9	7.7		
Isixhosa	20.9	30.2	4			11.5	12.7	7.7		
Others **	22.4	19.1	44	80.32	0.001	11.5	21.5	18.5	39.356	0.001
Race										
Black	100	98.2	100			96.1	99.1	99.4		
White		0.6				3.9	0.9	0.6		
Coloured		1.2		2.623	0.623				6.46	0.167

* Where appropriate, for continuous variables and tested with ANOVA; ** includes siSwati, Ndebele, Afrikaans, English, Venda.

4.3. Correlations between Farmers' Psychological Profiles and Traditional Measures of Farm Business Performance

Selected business performance indicators for the different profiles of farmers are presented in Table 7. For beef cattle farmers, ownership per household, number of calves born, and number of cattle deaths were significantly different amongst the three profiles. Cattle owned per household was highest in Profile 3 and lowest in Profile 1.

Table 7. Selected performance indicator by different farmers' profiles.

Variable	Profile 1	Profile 2	Profile 3	F-Value	*p*-Value
Beef Farmers					
Cattle owned/household	24.82 (27.91)	44.84 (73.03)	58.19 (65.36)	4.42	0.013
Cattle sold/household	4.67 (9.21)	9.49 (27.48)	13.45 (18.52)	2.29	0.102
Number of calves born	6.53 (8.88)	13.54 (27.22)	19.76 (24.25)	4.88	0.008
Number of cattle deaths	1.74 (2.59)	3.65 (6.03)	2.21 (2.38)	5.02	0.007
Feed and veterinary cost (R)	6746 (9917)	22,937 (75,704)	44,181 (74,332)	3.73	0.025
Likelihood to sell	0.65 (0.21)	0.67 (0.21)	0.88 (0.10)	30.57	0.001
Technical efficiency	0.49 (0.15)	0.52 (0.15)	0.49 (0.17)	2.30	0.102
Poultry Farmers					
No. of broilers sold/household	1223.08 (2491.19)	5987.70 (37,132.10)	16,580.90 (81,040.13)	1.94	0.145
Likelihood to sell	0.53 (0.18)	0.59 (0.25)	0.73 (0.22)	3.46	0.036

Values in parentheses are standard deviations.

The number of cattle sold per household was not significantly different across the profile of farmers, but the likelihood to engage and sell was significantly different and highest in Profile 3 (Table 7). Most farmers sold to either informal or auction markets. Of the total farmers selling, more than 16% were engaged in selling to multiple markets (Table 3).

Amongst poultry farmers, on average there were no significant differences between farmer profiles in the number of broilers sold per household. However, when considering the propensity to engage in formal markets, we found significant differences amongst the different profiles of farmers, with the highest propensity to sell in Profile 3 at 0.73. The number of broilers sold and the probability to sell are presented in Table 7. As expected, the number of broilers sold and the probability to sell were influenced by the holding capacity of the farms (number of poultry houses), investments in capital (feed and electricity), and the experience of farmers. The negative relationship between farmers' access to credit was not expected, but it is not possible to determine whether credit was directly used for poultry production or for other purposes.

4.4. Correlations between Farmers' Psychological Profiles and Productivity and Efficiency

The maximum-likelihood estimates of the stochastic frontier model are presented in Table 8 (Model 1). As expected, all production factors had a significant effect on improving productivity of cattle production. More importantly, those farmers who invested in supplementary feeding and veterinary expenses had the greatest improvement in production. The estimated stochastic frontier model was used to obtain measures of technical efficiency for individual farmers. The results showed that technical inefficiency was present amongst the sampled farmers. The average technical efficiency score was 0.51, indicating a significant potential for all farmers to improve their current productive performance. There was a relatively high coefficient of variation

(30%), indicating that some farmers operated very close to the maximum potential, but most performed below 50%. As reported in Table 7, the average estimated technical efficiency was not significantly different amongst profiles of farmers. This implies that all farmers, regardless of their profile, had a strong potential to increase and potentially maximise output from their existing resources. There is an opportunity to target and provide interventions to nonperforming farmers so they can improve and also to all farmers so they can reach their maximum attainable target output. As the number of cattle owned per household differed significantly across the farmers' profiles, it is imperative that they also improve market participation.

Table 8. Maximum-likelihood estimates of the Cobb–Douglas function.

Variable	Model 1—Base Model			Model 2—With Psychological Variables		
	Coef.	**Std. Err.**	***p*-Value**	**Coef.**	**Std. Err.**	***p*-Value**
Constant	0.679	0.291	0.020	0.523	0.321	0.104
Area	0.070	0.021	0.001	0.074	0.217	0.001
Labour	0.195	0.068	0.004	0.176	0.069	0.011
Total Cost [a]	0.317	0.028	0.000	0.325	0.030	0.000
Dummy—Cost [b]	2.218	0.261	0.000	2.242	0.269	0.000
Dummy—Area [c]	0.055	0.147	0.707	0.097	0.150	0.517
ln σ_v	−0.610	0.169	0.000	−0.549	0.176	0.002
ln σ_u	0.120	0.245	0.624			
Attitudes				0.067	0.236	0.778
Norms				0.347	0.242	0.151
Perceived behavioural control				−0.065	0.257	0.800
Openness				0.135	0.136	0.322
Conscientiousness				0.131	0.141	0.354
Extraversion				0.212	0.109	0.051
Agreeableness				−0.193	0.107	0.072
Neuroticism				−0.076	0.104	0.468
Expected benefits				−0.045	0.179	0.800
Self-efficacy				−0.624	0.263	0.018
Present time orientation				0.092	0.171	0.590
Future time orientation				−0.224	0.330	0.497
Personal capability concerns				0.188	0.227	0.408
Farm-related concerns				0.246	0.216	0.255
Constant				−0.711	1.116	0.524
σ_v	0.737	0.062		0.760	0.067	
σ_u	1.062	0.130				
σ^2	1.671	0.213				
Λ	1.441	0.183				
LLF	−640.1			−620.9		
N	461					

[a] Includes the cost of supplementary feeds and veterinary costs; [b] dummy for those with feed and veterinary costs; [c] farmers without owned area.

The correlations between technical efficiency scores and predicted probability of selling amongst cattle farmers are presented in Figure 5. The horizontal axis is the estimated technical efficiency, and the vertical axis shows the probability of selling. The distribution of these scores is divided into four quadrants: (I) Low efficiency/low probability to sell; (II) High efficiency/low probability to sell; (III) Low efficiency/high probability to sell; and (IV) High efficiency/high probability to sell. Most farmers (55%) are located in quadrant IV, while 35% are located in quadrant III, and 5% are located in both quadrants II and I.

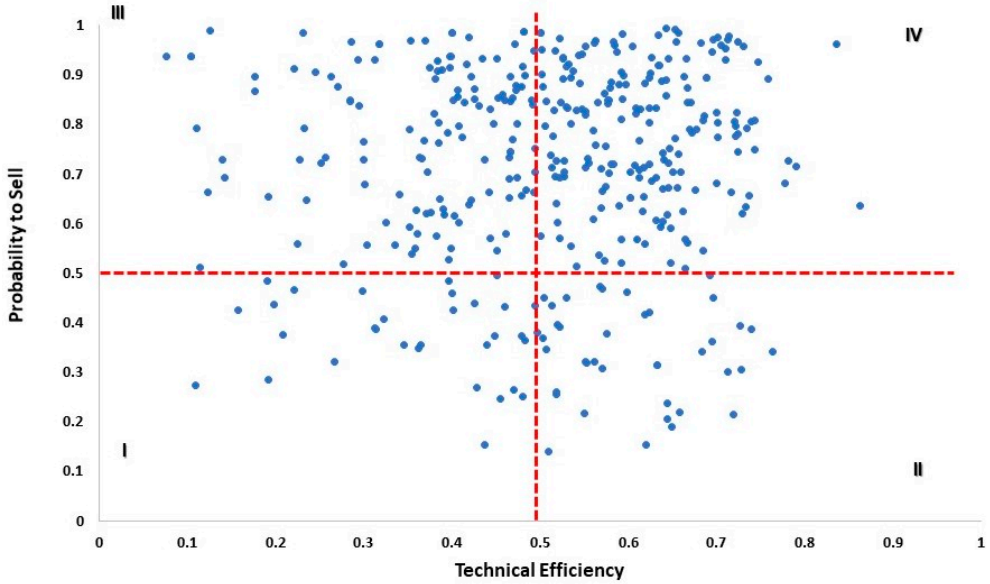

Figure 5. Correlation between technical efficiency scores and probability of selling.

We examined the distribution of the different profiles of beef farmers in the four quadrants. Profile 1 farmers were distributed across the different quadrants, with 42% in quadrant IV, 37% in quadrant III, and 5% and 16% for quadrants II and I, respectively. The distribution for Profile 2 farmers exhibited a similar pattern, with 56% in quadrant IV, 33% in quadrant III, and the rest in quadrants II and I. Finally, 60% of Profile 3 farmers were in quadrant IV, and 40% were in quadrant III. These results indicate the need to define intervention strategies based on the different typologies of farmers. This is most important for those Profile 3 farmers who were confident of their ability to succeed and engage in the market but had low technical efficiency and for those Profile 2 farmers who were neutral about their ability to control and succeed in their businesses and who performed well in terms of their technical efficiency but were unlikely to engage in the market.

The influence of psychological variables on the levels of technical efficiency are presented in Table 8 (Model 2). The negative sign indicates a reduction in the level of inefficiency, thus improving technical efficiency. While we found no significant differences in the average technical efficiency estimates amongst different profiles of cattle farmers, the most significant psychological attributes likely to influence the level of efficiency were extraversion, agreeableness, and self-efficacy. The negative sign on the coefficient of agreeableness endorsed the positive effect of being cooperative and trusting. Additionally, the ability of farmers to perform and engage and make decisions on cattle farming improved the level of technical efficiency. The level of extraversion appeared to negatively affect the performance of farmers, which may indicate that farmers are influenced by social and/or cultural factors that impede their overall performance.

To further study the divergence in performance of farmers across different profiles, we examined the expected value of income accruing from the enterprise. In the absence of actual prices received by farmers, we estimated the average income for individual groups of farmers using an average price for broilers and cattle sold. Assuming an average price of ZAR 8000 per animal for cattle and an average price of ZAR 60 per broiler, the estimated average income of farmers is provided in Table 9. Clearly, the expected value of the selected performance indicators increased with the different profiles of farmers.

Table 9. Expected income of farmers by different profiles.

Cattle	Number of Cattle Sold	Income (in Rand) [a]
Profile 1	5	40,000
Profile 2	9	72,000
Profile 3	13	104,000
Poultry	Number of broilers sold	Income (in Rand) [b]
Profile 1	1223	73,380
Profile 2	5988	359,280
Profile 3	16,581	994,860

[a] Assuming average price of ZAR 8000 per animal; [b] assuming average price of ZAR 60 per broiler.

We also examined the marginal change in the expected value of key performance indicators if farmers were classified under each category, and we used a simple regression to estimate the magnitude of these changes in expected values. The number of cattle owned and sold improved as the farmers' profiles changed from Profile 1 to Profile 3 (Table 10). In cattle farming, the number of cattle owned per household was 42% lower if farmers were classified in Profile 1, relative to farmers in Profiles 2 and 3. The number of cattle owned per household was approximately 38% higher if farmers were classified in Profile 3. Average supplementary feeding and veterinary costs were significantly higher for Profile 3 farmers, relative to Profile 1 and 2 farmers. The same pattern was observed for the number of broilers sold per household, with Profile 3 farmers having the highest marginal change in the expected value.

Table 10. Relationship between profile of farmers and performance indicators.

Indicator	Profile 1	Profile 2	Profile 3
Beef Farmers			
Log (Cattle owned/household)	−0.429 *** (0.136)	0.007 (0.119)	0.379 *** (0.155)
Log (Cattle sold/household)	−0.356 ** (0.139)	−0.219 * (0.125)	0.668 *** (0.159)
Feeding and veterinary cost (R/household)	−0.992 * (0.571)	−0.710 (0.441)	2.060 *** (0.492)
Observations	471	471	471
Poultry farmers			
No. of broilers sold/household	−1.851 ** (0.770)	−0.650 (0.400)	1.116 *** (0.406)
Observations	426	426	426

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

5. Discussion and Implications

In this study, smallholder farmers' market participation through their likelihood and propensity to sell cattle and poultry products was driven by several socioeconomic and demographic variables. Our findings indicate that smallholder beef and poultry farmers in South Africa are faced with the option of selling in either informal or formal markets (including supermarkets) that have characteristics identical to those found in many high-income economies. These results imply the need to generate enabling environments and policy frameworks that support and enhance smallholder beef and poultry farmers' participation in formal markets that reward farmers on the basis of the quality of the products delivered to market. A number of livestock development interventions have been implemented in South Africa to increase smallholder awareness and participation in formal markets because informal outlets are known to offer relatively lower prices [42].

However, to improve the uptake of those programmes, especially those that encourage market participation in higher-priced formal markets, the programmes need to be designed and implemented with consideration of the different psychological profiles and preferred

learning styles of the farmers. Consideration of different psychological profiles in the design of policies is supported by previous studies that have adopted the TPB together with other psychological theories to explain how business performance of farmers is affected by differences in attitudes, subjective norms, perceptions, self-efficacy, and expectations [7,8,10,15].

The results for productivity and efficiency from this study suggest that there is strong potential to improve production, with outputs per household being strongly and favourably influenced by physical (area), human (labour), and economic (investment) capital. The average technical efficiency of farmers in our study was low, suggesting that a strong potential exists to increase output per household. While these levels of technical efficiency were not significantly different across the different groups of farmers' psychological profiles, it is clear that self-efficacy and agreeableness played important roles in improving the performance of farmers. This implies the need to increase the ability of farmers to perform their farming operations based on improved education and training. This activity is envisaged to improve the knowledge and understanding of different farming operations, such as meeting formal market specifications. As agreeableness is likely to influence technical efficiency, this also indicates that agreeable farmers will be open to new and innovative ideas. Hence, interventions aimed at improving farmers' physical and psychological capabilities and generating new opportunities are imperative for improving not only market participation but also the overall business performance of the farms.

Finally, our results show that farm business performance of poultry and beef farmers differs significantly amongst the different groups of farmers' psychological profiles. The psychological profiling affirmed the value of positive attitudes, personality, and beliefs towards improved farm business performance. The increasing trajectories found in the marginal expected values of key farm business performance indicators in this study suggest that very strong benefits would accrue if extension programmes, social capital, and policy supports were specifically designed to target individual farmers based on their psychological profiles. The analysis presented herein suggests that psychological profiling may prove useful as a mechanism for targeting specific group of farmers. Thus, to accelerate the uptake of intervention strategies aimed at promoting a commercial market orientation of farmers, new mechanisms could be designed and implemented to specifically encourage farmer engagement and learning opportunities across psychologically and culturally diverse farmer groups.

6. Conclusions and Areas for Further Study

As far as we can determine, this is the only study that has attempted to differentiate farmers and their farm business performance based on farmers' psychological profiles, particularly as applied to agriculture and more specifically to livestock agriculture. In this study, we found that there were favourable relationships between farmers' psychological profiles and their farm business performance. These results support Nengovhela's finding that "when farmers had equivalent access to land, water, infrastructure, knowledge and finance, psychological capital had the greatest impact on adoption of practices needed to improve the business performance of smallholder cattle farmers" [5]. Our findings also complement the hypotheses suggested by [7,8] based on their development of psychological profiles for farmers whose farming management practices needed to change in response to climate change.

This study also showed the importance of a multipronged interdisciplinary approach to understanding the decision-making process of smallholder farmers. Previous studies focused on the importance of key factors including human, physical, social, infrastructure, and financial capital. Our study showed the importance of analysing farm business performance through behavioural and psychological lenses. Other earlier nonagricultural studies showed that employee psychological well-being was favourably related to both work and personal life outcomes but without specifically evaluating business performance as part of their studies. For example, Wright et al. [43–46] demonstrated a positive relationship between psychological well-being and performance in the workplace, but those studies did not explore the theoretical mechanisms underpinning the relationship. Subsequently, [47,48] specifically examined the positive psychological indicators of efficacy, hope, optimism, and resilience

(which they referred to as "positive psychological capital") and reported that these specific indicators underpinned the relationship between psychological capital and worker performance. However, they also emphasized the need for ongoing research to conclusively understand the theoretical mechanisms that result in the favourable relationships reported in their studies.

More recently and in the context of agricultural practice change, two separate studies examined the role of farmers' psychological capital on aspects of farm practice change in Australia and Thailand. Zhang et al. [49] examined three dimensions of wheat yield gaps in Australia (i.e., farm management practices, farm characteristics, and grower characteristics). Their results showed that significant differences between farms with smaller and greater yield gaps were related to both farm and grower characteristics, demonstrating intertwined dynamics between biophysical factors, grower sociopsychological characteristics, and farm management practices. Sociopsychological factors were found to not only directly contribute to yield gaps but also influence farm management practices that in turn contribute to yield gaps.

Suksod et al. [50] examined the roles of psychological capital and agricultural extension knowledge in improving farmers' self-perceived farm performance. They found that positive psychological capital acted as a significant mediator between the association of agricultural extension knowledge and farmers' perceptions of farm performance.

The results of our analyses provide important lessons and insights with regard to designing research for development projects. During development of the HVBB and HVPP projects from which the data for this study were derived, we examined the results presented by [5], particularly his recommended solution that individual coaching of farmers should be investigated as a method of improving levels of livestock production amongst South Africa's smallholder farmers. However, our projects aimed to target thousands of smallholder farmers across multiple South African provinces, and availability of business coaching expertise for those smallholder farmers was almost nonexistent. We therefore chose to include a behaviour change research component in both projects, where the main aim was not to understand the drivers of the farmers' psychological capital, as was the focus of the earlier papers cited above. Rather, the aims of the behaviour change components of the HVBP and HVPP projects were to:

- Determine whether smallholder cattle and poultry farmers could be differentiated based on their psychological profiles [9];
- Determine whether farmers' psychological profiles were correlated with their farm business performance (this paper);
- Determine, assuming that the previous two issues are in the affirmative (as they are), whether the farmers' psychological profiles could then be used to customise farmer training methods to best recognize the farmers' individual and preferred learning styles, thereby improving farm business performance by all farmers.

Hence, results reported in this paper and by [9] represent the first stages of the HVBP and HVPP projects. Two additional papers are envisaged in this series. One additional paper will report results on our efforts to validate a shorter psychological profiling survey form. Development of the initial profiles reported in this paper and by [9] required farmers to fill out a survey form that took at least 30 min for them to complete. We therefore developed a considerably shorter survey form based on our current results, but that shorter survey now needs to be validated on psychology-discipline criteria prior to wider use. The shortened version has subsequently been completed by a range of livestock enterprises (beef and dairy cattle, sheep and goats, broiler and layer poultry) across smallholder farmers in several southern African countries. Assuming that the shortened version of the survey form is appropriately validated, our aim will then be to develop a simplified scoring system that could enable extension officers and other support workers to identify the psychological profiles and preferred learning methods of individual farmers without consulting statistical experts to undertake the complex latent profile analysis currently used to develop psychological profiles. A simple scoring system would empower trained

extension and support officers to directly implement training methods that are customised for their farmers.

The second additional paper will investigate the effectiveness of developing and implementing training methods for smallholder poultry farmers who have been customised to their behavioural profiles. Results will be compared to those of HVPP poultry farmers undergoing traditional training programmes. Only poultry farmers were targeted for this component of the research due to the frequency of their product sales (daily for egg producers and 6–8-week cycles for broiler producers, whereas cattle farmers sometimes only sell once every 1–2 years). Use of poultry data will deliver results much more quickly than waiting for sufficient data from beef businesses. Assuming that the customised training is shown to work amongst poultry farmers, it could then be readily adapted for farmers across different livestock species. The customised training now being implemented with poultry farmers was designed using the Behaviour Change Wheel approach developed by [51] and successfully tested in two domains of human behaviour change, namely tobacco control and obesity. The intervention design model proposed by [51] is a 'behaviour system' involving three essential conditions: capability, opportunity, and motivation. Those conditions form the hub of the Behaviour Change Wheel around which nine intervention functions aimed at addressing deficits in one or more of those conditions are considered. Around the intervention functions are seven categories of policy that could enable those interventions to occur. Michie et al. [51] also define and provide excellent examples of how the different interventions and policies can be used to identify methods to change human behaviours.

Interventions designed using the Behaviour Change Wheel are currently being experimentally evaluated amongst smallholder poultry farmers in the HVPP project. They are designed specifically to build farmers' self-efficacy through a combination of strategies targeting mastery, modelling, mentoring, and 'mood-fit' (if it feels right, do it). Farmers forming the control treatment groups are receiving technical training only, reflecting South Africa's traditional approach to farmer capacity building.

Finally, this paper provided us the opportunity to assess and evaluate data needs and requirements to establish appropriate assessments of the relationship between farmers' behaviour and their farm business performance. Our analysis would have benefited from the availability of more complete and detailed information about income sources, enterprise-based costs and returns, and gender-based and disaggregated information. These are areas for further consideration and will further enhance the efficacy of the approach as an intervention design and development tool.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy considerations.

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