

Article

Modelling Investment Decisions on Dairy Farms

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Abstract

Farmers' investment decisions can shape their capacity to implement practices consistent with sustainable development objectives. The article identifies the declarative structure of investment decisions on Polish dairy farms based on a survey and diverse theoretical frameworks (resource-based view, institutional approach, real options theory, behavioural theory, and the theory of planned behaviour). The purpose is to identify the determinants of the extent and structure of declared agricultural investments. The authors determined the relationships between declared investments and groups of variables and identified investment axes and interdependencies. Investment decision predictions are founded on logistic regression, an SEM model for relationship structuring, and residual correlation analysis for mapping relationships and evaluating the correlation demasking effect, according to which raw correlations between investment axes may hide underlying residual associations between them. We found that declared farmland investments were associated with milk production volume and appeared to be linked to long-term farm development objectives. The respondents became less keen on investing in livestock production as they aged, whereas older farmers showed a greater propensity to undertake energy-related investments. These results suggest that farmers' declared investment intentions may be consistent with conditions conducive to achieving sustainable development objectives through their potential association with farm viability, resource-use efficiency, and rural economic development. Our findings may have potential policy relevance by informing the design of public measures aimed at strengthening farms' adaptive capacity in the context of sustainability transitions.

Keywords: structure and axes of investment decisions; dairy investments; logistic regression; SEM



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1. Introduction

Many agricultural sectors worldwide exhibit an investment gap. There is a difference between the expected (optimal) level of farms' fixed assets and the actual level achieved through capital investments. This is true for Poland as well. Polish farms have the lowest ratio of CAPEX to production value and to gross added value compared to those in other EU countries [1]. This leads to the following questions: what drives investment decision-making on Polish farms, and what guides farmers' behaviour when choosing specific investment axes?

Investments are also necessary in agriculture to offset declining farm revenue. Dairy farmers can improve their farms' economic performance by increasing milk production [2,3],

particularly by improving cow milk yield. In this way, they can temporarily alleviate problems caused by the decline in the number of dairy farms, although some expenditure is necessary [4].

The level of capital investment on farms is a different but equally important problem. A propensity to invest depends primarily on the farm's revenue [5,6]. Another variable affecting capital expenditure is the availability of the necessary capital. Farms may use their own funds (the so-called retrospective model) or engage external capital (the so-called prospective model) [7]. Our literature review has demonstrated that decisions to seek external financing hinge primarily on production scale. The larger the farm, measured by milk volume, the greater the propensity to use external funds [8]. When investment decisions depend solely on the availability of internal capital, the growth of dairy farms is severely affected [9].

Other milk production challenges involve labour availability. Worker shortages imply the necessity to modernise production, mechanise the farm, or even invest in digital systems [10]. Digitalisation exhibits a beneficial impact on husbandry costs. For example, precision feeding reduces fodder costs and helps tailor it to specific animal needs, thus improving feeding performance [11].

Climate change also affects farmers and their investment decision-making. Ongoing environmental and social pressures on agricultural production are particularly conspicuous on dairy farms, forcing farmers to engage in adaptability efforts such as improving animal welfare (including cowshed air conditioning and ventilation) but also reducing farms' susceptibility to weather conditions, such as pasture irrigation or using fodder crops resistant to water shortages [12].

The dairy sector offers a highly relevant context for analysing investment decisions because of dairy farms' high capital intensity, strong integration with processing and advisory institutions, significant exposure to market and environmental risks, and long investment cycles. Compared with many other agricultural sectors, dairy production requires continuous modernisation and adaptation, making it a useful empirical setting for studying relationships between farm resources, institutional support, diversification-related activities, and factors relevant to rural development in the context of sustainability transitions.

Dairy farms are facing dynamic changes: modernisation trends, growing production costs, and market and policy pressures that require investment. Investment decisions are critical because they determine the scale of production, competitive position, and survival of farms, especially mid-sized ones, which must grow to remain viable. This is why an investigation into the investment plans of milk producers provides better insight into the sector's growth trajectory, the factors that determine its stability, and its future competitive position.

The problem is also highly relevant in the context of sustainability transitions in agriculture, as evidence on stated investment intentions may provide insights relevant to the design of policies supporting farm adaptation to climate and policy pressures.

The primary purpose of the article is to identify the determinants of the level and structure of agricultural investments. It is pursued with the following objectives: (1) to determine the relationships between declared investments and independent variables—tangible (TFs) and intangible factors (IFs)—and (2) to identify investment axes and their interrelationships while evaluating the effect of demasking investment tendencies.

Studies to date have typically analysed agricultural investments either at the level of specific investment categories or through observable correlations among variables. However, latent residual associations among investment domains, after accounting for the structural and institutional characteristics of farms, remain insufficiently explored. Therefore, the study addresses a research gap concerning the patterns of stated investment

intentions and their residual associations across investment domains. So far, most studies have relied mainly on raw correlations and standard regression approaches, which are not fully suited to capturing conditional patterns of association among investments after accounting for the structural and institutional characteristics of farms.

The novelty of this study lies in combining logistic regression, multivariate SEM probit modelling, and residual correlation analysis to examine relationships among investment domains and to identify residual associations conditional on farm characteristics. The proposed approach distinguishes between associations that remain after controlling for observable factors and those that become weak or disappear under multivariate specification. This contributes to a more nuanced understanding of observed investment patterns under conditions of economic and institutional heterogeneity.

2. Literature Review and Hypotheses

Farmers' investment decisions can be analysed from several complementary theoretical perspectives. In this study, the theoretical framework is organised around four main analytical dimensions: (1) farm resources and structural conditions, (2) institutional and behavioural determinants, (3) investment decision-making under uncertainty, and (4) individual adaptive strategies. This structure helps integrate economic, institutional, and behavioural approaches into one coherent explanatory framework for analysing investment decisions on dairy farms (Figure 1).

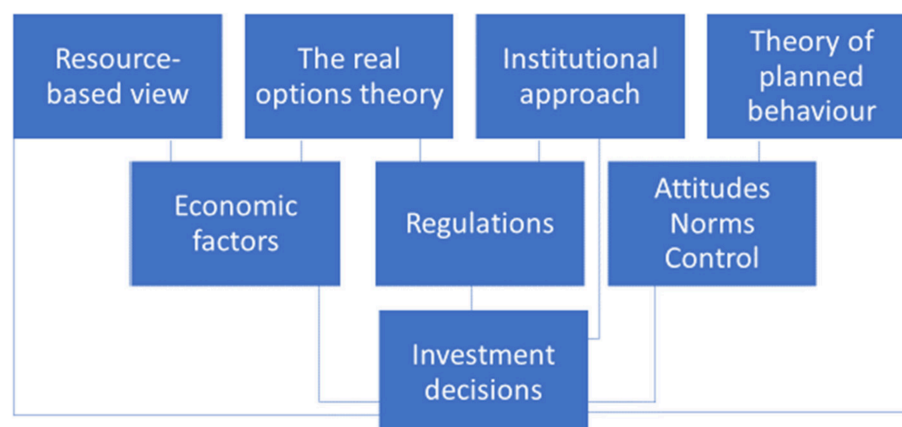


Figure 1. Review of theories and factors for investigating farmers' investment plans. Source: original work.

2.1. The Resource-Based View (RBV), Focused on Farms' Resources

According to the RBV [13], investment potential and innovation pathways emerge from a combination of available production resources, capital, labour, and farm size. Research [14] shows that the structure of resources affects the types of innovations and modernisation directions chosen by farmers. Our analyses involve the theory of accumulation and economies of scale. In this study, the RBV serves as the primary framework for breaking down how tangible farm resources shape investment capacity and long-term development strategies. The approach is particularly useful in dairy farming, where production scale, herd size, and land resources strongly determine modernisation opportunities and investment potential.

2.2. The Institutional Approach

The institutional approach [15] assumes the influence of advisors, the market, dairy plant organisations, and network relationships on farmers' investment decisions. Research [16] shows that engagement in information acquisition, interaction with agricultural

advisory centres, and cooperation with dairy plants significantly increase the propensity to invest. Within the institutional approach, the problem of farmers' investment decision-making is explored as follows.

2.2.1. Behavioural Decision Theories

Behavioural decision theories [17–21] take into account attitudes, emotions, values, quality of life, intuition, and social and psychological circumstances of decision-making [22]. As a result, behavioural theories emphasise that farmers' decisions emerge not only from economic reasoning, which other researchers corroborate [23,24].

2.2.2. The Bounded Rationality Concept

The bounded rationality concept [17] assumes that decision-makers have only limited access to information and operate under uncertainty, satisficing rather than maximising payoffs. Farmers also make decisions based on incomplete information and in a highly complex production environment [25–27]. The institutional perspective complements the RBV by explaining how external advisory systems, market organisations, and social interactions reduce uncertainty and stimulate investment activity.

2.3. The Real Options Theory

The real options theory [28] concerns the evolution of investments under uncertainty conditions because farmers carry out investments in stages (e.g., first the herd, then buildings, then technology) and they adapt the order of their decisions to unfolding circumstances (milk prices, EU policy, and regulatory uncertainty) [29,30]. Research shows that when uncertainty is high, farmers can invest step by step, wait, or postpone their decisions [31]. This perspective is especially relevant to dairy farming due to high investment irreversibility, long investment cycles, and exposure to market and policy uncertainty.

2.4. A Psychological Theory of Decision-Making

A psychological theory of decision-making, specifically Icek Ajzen's theory of planned behaviour (TPB) [32], is an extension of the theory of reasoned action (TRA). It originates from social psychology and explains intentions through three critical constructs: attitudes, social norms, and perceived behavioural control. The TPB is widely employed across disciplines, such as marketing, public health, and consumer and behavioural analysis [33]. It is complementary to the RBV and the institutional approach. Studies have demonstrated that it can be combined with economic theories, including the technology acceptance model (TAM)—a model for investigating acceptance of technology innovation—and technology and innovation adoption models [34,35]. The study employs the TPB framework mainly to explain how subjective attitudes and perceived behavioural control may influence investment intentions beyond purely economic considerations.

2.5. Individual Farmers' Attitudes

Beyond structural and institutional determinants, the farmers' investment decisions may also reflect individual adaptive behaviour. Behavioural approaches emphasise that farmers differ in their willingness to respond to market pressures, climate risks, labour shortages, and technological change [17,19,22]. Previous studies also indicate that investment decisions may be influenced by farmers' preferences, values, quality-of-life considerations, and subjective perceptions of risk [29,36]. Consequently, investment strategies may vary between development-oriented and adaptive approaches depending on farm resources, perceived uncertainty, and external pressures.

Taken together, these approaches suggest that farmers' investment decisions result from the interplay of structural resources, institutional conditions, behavioural factors, and adaptive responses to uncertainty.

2.6. Hypotheses

The following hypotheses are based on the theoretical background outlined above.

Hypothesis 1. *Farms' tangible resources are more relevant to farmers' declared investments than institutional cooperation.*

Hypothesis 2. *Farmers tend to invest in on-farm (crop and livestock) production rather than off-farm activities.*

Hypothesis 3. *Farmers' investment strategies are more individual (independent in their responses to economic stimuli) than adaptive (externally driven).*

Hypothesis 4. *Farmers more frequently declare substitutive rather than complementary investments.*

Hypothesis 1: Farms' tangible resources are more relevant to farmers' declared investments than institutional cooperation (intangible resources). This hypothesis assumes that farms' tangible resources (such as land or dairy cow herd size) are stronger determinants of declared farmer investments than intangible institutional resources (such as support from advisory centres or dairy cooperatives). It is grounded in empirical studies (2023–2026) that demonstrate the decisive role of tangible assets in investment decision-making, whereas institutional factors have intermediate, weaker, or fixed-asset-dependent effects [37].

Research shows that farmers who have above-average land and machinery at their disposal also declare investments in machines and land as their priorities. Institutional cooperation is not associated with investment declarations to the same degree [38]. Polish farms with more extensive machinery resources tend to declare higher fixed-asset investments, even at the expense of income performance [38]. When planning development towards either conventional or precision agriculture, farmers focus on securing machinery rather than institutional cooperation [39,40]. Similarly, Gelgo et al. [41] identified only a weak institutional influence on agricultural value added (AVA) in seven Eastern African countries. Tangible economic resources, including farm income, directly drive the agricultural value added of investments much more than institutional cooperation does. Although regulatory and normative institutions improve farms' entrepreneurial positioning, their impact on investments is indirect. At the same time, tangible resources directly fuel investment preferences [37].

Hypothesis 2: Farmers tend to invest in on-farm (crop and livestock) production rather than off-farm activities. The literature review has demonstrated that farmers prioritise investments linked to on-farm (crop and livestock) production because the level of availability of fixed assets related to on-farm production and the quality of the assets contribute to competitive advantage and resilience [42]. Additionally, Gołębiewska [43] has demonstrated that as Polish farms grow more interconnected with their surroundings, the impact of off-farm production investments also increases while still remaining below the level of on-farm production investments. A study of Swiss dairy farms emphasised limited investment in off-farm activities due to the high level of capital tied up in milk production [44]. Moreover, when Swedish farmers diversify their businesses, they tend to focus more on milk production, while investments in off-farm activities hinge on external incentives [45]. Ashfield et al. [46] reported similar findings and emphasised the necessity of educating farmers and encouraging off-farm investments. This would help diversify

income sources, particularly during milk oversupply shocks. Based on their study of Italian milk producers, Salvioni et al. [47] reached similar conclusions, indicating a positive impact of investments on the economic performance of both on-farm and off-farm production on dairy farms. Investments are perceived as a way to reallocate capital, diversify agricultural income, and mitigate risks associated with economic instability.

Hypothesis 3: Farmers' investment strategies are more individual (independent in their responses to economic stimuli) than adaptive (externally driven). Farmers' investment decisions are determined by a variety of premises. They want to invest along development axes that deliver economic outcomes and improve their production potential [39,48]. The literature contains numerous studies indicating that investment decisions are driven by the need to adapt to evolving farm environments [39,49]. Interestingly, some researchers report that a pressure towards an adaptive approach in farming investment decision-making could be detrimental to outcomes. Vallury et al. [50] claim that behavioural and structural factors affect both engagement in and perseverance with investments. Therefore, some authors investigate the degree and scope of individualisation and adaptability in investment strategies.

According to Wang et al. [51], farmers' investment decisions are shaped by diverse economic, social, and institutional factors, and this abundance of influences naturally leads to individualised strategies. Commenting on changes in the Common Agricultural Policy and the allocation of its funds to investments, Paloma et al. [52] noted that decisions varied with farm resources and producers' characteristics and also pointed out the individualisation of strategies.

An experiment among a thousand cereal producers in Hubei Province, China, yielded interesting results. The authors investigated farmers' preferences for deploying specific environmental protection investments. Their primary conclusion was that the farmers' decisions and incentives regarding specific actions were heterogeneous [53].

Hypothesis 4: Farmers more frequently declare substitutive rather than complementary investments. Fares [54] provided a formal proof of complementarity between crop and livestock systems, including dairy farming, using the concept of supermodularity of the income function. The results show that integrated crop–livestock farming activity increases farm income beyond the mere sum of outcomes for specialised farms, while providing a buffer against climate and price volatility risks. Wolfart et al. [55] expanded the systemic approach proposed by Fares [54], focusing on the microeconomic level of investment decision-making on dairy farms. The results indicated a strong association between investment performance and the structure and integration of the entire farm. Still, Monte Carlo simulations confirm a relatively low risk of financial failure, which supports the argument for the importance of investment complementarity in the long run. De Herde et al. [56] indicated that the choice of the dairy cooperative model may be substitutive or complementary vis-à-vis other investment decisions because it affects terms of sale and profitability of production investments on dairy farms. In particular, diversity of cooperative models facilitates diversification of sales channels without causing a direct market conflict.

Results reported in international publications indicate a diversified spectrum of investment relationships on dairy farms. Monge et al.'s [57] New Zealand study demonstrated that investments in dairy farming and forestry could be explicitly complementary, generating shared economic value across the supply chain while exerting environmental impacts.

A review by Palma et al. [58] focused on production micro-decisions. It demonstrated the dominance of substitutive relationships in herd optimisation models, where the replacement of dairy cows serves to maximise short-term profitability. Although useful in terms of

technical performance, this approach disregards the broader systemic and organisational context, as emphasised by Monge et al. [57] and Polish authors.

Polish empirical studies confirm the duality of investment relationships. A report by Portal Mleczarski [Association of Polish Dairy Processors] [59] and analyses of dairy farm competitiveness indicated that investments are often treated as substitutes when capital is limited, especially among smaller farms. At the same time, studies by Karolewska [60] and Wiza-Augustyniak [61], along with analyses by Pietrzak [62] and Polska Agencja Pozyskiwania Funduszy Unijnych Sp. z o.o. [Polish Agency for EU Funding Acquisition, a private company] [63] demonstrated that investments in livestock, automation, logistics, and the organisation of production are complementary, especially on larger farms or in cooperatives, leading to increased productivity and improved market positioning. Taken together, the literature indicates that the type of relationship among dairy farm investments depends on the scale of activity, sector integration, and the development strategy employed, which is consistent with international reports.

3. Materials and Methods

For the purposes of the study, a dairy farm investment is an expenditure aimed at permanent or long-term improvement of the farm's resources, including the acquisition, modernisation, or expansion of infrastructure, technology, and means of production. The investments are intended to increase future productivity, technological performance, and economic outcomes of the farm, improve livestock well-being, or reduce future production costs [64–67]. We define a cow-milk producer's propensity to invest as their readiness to make decisions to invest in the modernisation, expansion, or improvement of their farm's resources. This definition is consistent with the literature, which indicates that farmers' investment decisions are driven by a combination of economic, technical, behavioural, and market factors [30,68,69]. We acquired the data necessary for our analysis of investment decisions on dairy farms through a survey. It was conducted in the first half of 2025 among dairy farms in Podlaskie Voivodeship, Warmińsko-Mazurskie Voivodeship, and Podkarpackie Voivodeship. The first two voivodeships are important for the Polish dairy industry, while the latter is a region of significant agrarian fragmentation dominated by declining animal husbandry. The substantial variation in agricultural structures across the regions expanded the analytical perspective and strengthened the robustness of the conclusions. We employed a standardised pen-and-paper interview (PAPI) questionnaire approved by the Ethics Committee for Human Research of the University of Agriculture in Kraków. The survey was administered by dairy plant milk reception operators. The survey questionnaire was developed by university staff and subsequently submitted for validation to employees of the entities responsible for collecting data from farmers. The feedback helped clarify certain issues; however, the revisions were minor.

Participation was voluntary and anonymous. The farms included in the survey were selected by plant employees based on their knowledge of and experience with individual vendors. Thanks to the diverse conditions of milk production and the variety of farms across the regions involved, the study can capture a broad perspective in evaluating the reasoning behind investment decisions.

The questionnaire consisted of 39 questions. Some of them were open-ended, while most were closed-ended. The respondents were asked about the structures of resources available to them, farm management activities, financial standing, investment decision circumstances, institutional cooperation, and operational conditions. The response rate was approximately 75 per cent, with 1000 distributed questionnaires. Questionnaires with unreliable answers were rejected during preliminary verification. Next, we completed and corrected the data as needed. This procedure was applied to about 5 per cent of the returned

questionnaires, in which we found simple miscalculations or internally contradictory answers that could nevertheless be corrected based on other answers on the specific questionnaire. The remaining 768 questionnaires were of sufficient quality. A logistic regression model of the propensity to invest was estimated using data from 768 dairy farms. Among them, 501 reported undertaking investments ($INV = 1$). The multivariate SEM probit model of investment areas was subsequently estimated for this subsample of investing farms. We acknowledge the limitations of the sampling method.

To identify farm investment models, we first had to define the variables for the research. The dependent variables are various investment axes declared by the farmers.

As the initial number of investment types was relatively large (17), it was necessary to aggregate them into more general categories. We reduced the investment intentions into five specific domains: (1) livestock investments (such as the construction or modernisation of livestock infrastructure): INV_{live} ; (2) renewable energy investments (such as the purchase of energy storage systems): INV_{ener} ; (3) land investments: INV_{land} ; (4) investments in other activities still related to the farm (such as the construction of other farm buildings): INV_{other} ; and (5) investment in off-farm activities (such as building modernisation to expand the scope of business): INV_{off} . The classification into the five dependent variables was based on methodological grounds; the investment axes constitute internally consistent paradigms that are at the same time distinct and independent of one another. We decided to treat land investments as a separate group because of their special role in livestock activities as a source of fodder. Importantly, each category reflects a different type of investment, technical, and legal processes in the Polish agricultural environment, further facilitating their logical and pragmatic separation. An excessive level of detail would impede thorough observations and statistical analyses, particularly given logistical constraints and sample size. This problem was confirmed in field research, where the authors emphasised the necessity of adapting the mix of variables to the practical conditions of the study [70]. Moreover, the literature indicates that agricultural typologies require fewer categories to capture actual differences across groups and to avoid problems with minute data subsets hindering interpretation [71]. Additionally, investment models based on empirical data typically operate along several broad investment axes, as excessive detail impedes accurate estimation [72]. In light of the above, it was necessary to aggregate investment categories to ensure methodological consistency and stable, comparable results. This process reduced the number of farms involved in further analysis.

The scope of the explanatory variables was limited by the scope of the research tool used in the survey. Numerous authors emphasise that qualitative data are starting points for model building, such as agent-based models (ABMs), where interviews are used to calibrate decision rules [73], TPB-based models [74], typological and classification models based on qualitative input [75], and scenario models for public policies [76]. The independent variables were selected in line with the logic presented in the grounds for the hypotheses (Section 2). The process involved the assumptions for the analysis (including parameter significance and elimination of multicollinearity). This procedure identified nine variables related to tangible resources, human resources, financial standing, and institutional cooperation among the variables describing the farms. They are summarised in Table 1.

The employed analytical methods (logistic regression for predicting investment probability; SEM model to determine the structure of latent relationship networks; and residual correlation analysis to detect latent relationships, control for main effects, and evaluate the demasking effect) are consistent with the character of the survey data and complexity of farmers' decision-making [77–79].

Table 1. Variables for the logistic regression model and the SEM probit model of investment axes.

Variable Category	Variable Designation	Data Type
Dependent variables	5-year investment plans	binary
	5-year investment plans: livestock investments (INVlive)	binary
	5-year investment plans: renewable energy investments (INVener)	binary
	5-year investment plans: land investments (INVland)	binary
	5-year investment plans: investments in other activities still related to the farm (INVother)	binary
	5-year investment plans: off-farm activities investments (INVoff)	binary
Independent variables, tangible factors (TFs)	Farm size	continuous
	Herd size	continuous
	Farmer's age	continuous
	Successor	categorical
	Farm income self-assessment (Income)	categorical
Independent variables, intangible factors (IFs)	Support from agricultural advisory centre consultants (SAACs)	binary
	Support from private consultants (SPriv)	binary
	Support from consultants of the dairy plant (SDairy)	binary
	Self-evaluation of the current terms of business with the dairy plant (Satisfaction)	categorical

Source: original work.

4. Results

4.1. Sample Profile

The average area of agricultural land in the sample was 47.0 ha, with 28.5 ha of owned land and 18.5 ha of leased land. All the investigated farms primarily used their own agricultural land, but most decided to lease additional areas. The farms varied significantly in terms of size. The smallest covered 4 ha, while the largest spanned 375 ha. On average, the dairy farms needed three people for milk production. Two of them were employed permanently, and one was a casual worker. Labour needs also varied significantly across the sample. The number of permanent workers ranged from 1 to 10. Some farmers declared no need to use casual labour, while others employed up to four additional people during the high season. The average herd size in the sample was 36 cows, indicating that the production scale, measured by head count, was 2.5 times higher than Poland's average. Again, the sample varied significantly in terms of herd size; the smallest farms had two milk cows, while the largest kept 320.

4.2. Logistic Regression Model

A logistic regression model of the propensity to invest was estimated based on a sample of 768 dairy farms. Among these farms, 501 reported undertaking investments ($INV = 1$), whereas 267 reported no investment activity ($INV = 0$). The logistic regression model indicates an association between the exogenous descriptive variables and propensity to invest.

The logistic regression model exhibited a moderate explanatory power. McFadden's pseudo- R^2 reached 0.149, while the Nagelkerke coefficient was 0.242, indicating a satisfactory fit for behavioural and economic decision models. The likelihood-ratio statistic ($G^2 = 147.98$) confirmed that the full model significantly improved over the null model.

The intercept is negative and statistically significant, indicating a relatively low base-line for propensity to invest within the population (Table 2). The model identifies clear-cut differences between tangible factors and intangible factors affecting investment decisions. Herd size has a significant positive impact on the probability of investment, meaning that as

production scale grows, the propensity to invest increases as well, which is consistent with the accumulation theory and the economies of scale in agriculture. Conversely, agricultural land has a significant negative impact. Farms with more land are significantly less likely to make new investments. This may indicate capital saturation (indirectly consistent with the RBV theory, where saturation is a limitation), lower modernisation pressure, and an orientation towards stability rather than expansion. This result may also suggest that farmers treat land as a long-term asset and a value deposit rather than as a factor directly stimulating further investment activity (which confirms hypothesis 1 that tangible resources affect declared investments more than institutional support). Income exhibits a strong positive impact. Farms with higher incomes are more willing to engage in new investments, which may reflect a greater need to adapt and openness to risk. Higher income levels may additionally improve creditworthiness and financial liquidity, thereby increasing farmers' ability to fund investment projects. Support from agricultural advisory centres also exhibits a significant positive effect. This means that relationships with advisory institutions significantly increase the probability of investment by providing access to information, reducing uncertainty, and facilitating decision-making. This finding suggests that institutional support plays informational as well as motivational and organisational roles, driving farmers towards development-oriented activities under conditions of uncertainty. The results of this part of the analysis are relevant to hypothesis 1 concerning the impact of tangible factors (TFs) and intangible/institutional factors (IFs) on declared investments. The significant positive and negative impact of tangible factors driving investment declarations outweighed the effects of intangible factors. This confirms hypothesis 1 (H1), as tangible (non-institutional) factors more often influenced farmers' investment declarations. Herd size (TF), income (TF), satisfaction with business with the dairy plant (IF), and support from AAC (IF) were positively associated with investment decisions. Land (TF) had a negative impact. Overall, the results indicate that dairy farmers' investment decisions are shaped primarily by production scale and economic capacity, while institutional factors mainly strengthen or facilitate already existing development potential.

Table 2. Parameters and statistical significance of the logistic regression model.

Variable	β	SE	z	p	OR	CI 0.025	CI 0.975
(Intercept)	−1.668	0.553	−3.015	0.002 *	0.19	0.062	0.55
Cows	0.021	0.0049	4.36	0.000 *	1.02	1.01	1.03
Age	−0.006	0.0073	−0.86	0.391	0.99	0.98	1.01
Successor	−0.060	0.0630	−0.96	0.338	0.94	0.83	1.07
Land	−0.284	0.0767	−3.70	0.000	0.75	0.65	0.87
Satisfaction	0.252	0.092	2.753	0.006	1.29	1.08	2.42
SAAC	0.568	0.176	3.22	0.001	1.77	1.25	2.50
SPriv	0.491	0.205	2.39	0.017	1.63	1.10	2.45
SDairy	−0.367	0.214	−1.72	0.085	0.69	0.46	1.05
Income	0.463	0.105	4.388	0.000	1.59	1.30	1.96

Note: OR denotes odds ratio. OR values greater than 1 indicate an increase in the probability of investment, while values less than 1 indicate a decrease. Confidence intervals (CI) are reported at the 95% level. * $p < 0.01$. Source: original work.

The low variance inflation factor (VIF) values confirm that the exogenous variables exhibit no multicollinearity (Table 3).

Table 3. Multicollinearity statistics for explanatory variables.

Variable	VIF
Cows	1.122
Age	1.008
Successor	1.130
Land	1.087
Satisfaction	1.074
SAAC	1.080
SPriv	1.146
SDairy	1.047
Income	1.084

Note: All VIF values are far below the threshold of five, which indicates no multicollinearity in the model. Source: original work.

4.3. Multivariate SEM Probit Model of Investment Axes

The multivariate SEM probit model of investment areas was estimated based on 501 complete cases of dairy farms ($INV = 1$). The multivariate probit model with residual correlations among the axes can evaluate the interdependence of decisions to invest in specific domains through correlations of residuals in a model of latent variables across the declared investment axes. Regression coefficients indicate the associations between the exogenous descriptive variables and the propensity to invest in specific domains. Correlation coefficients reveal associations among the investment axes, controlled for the exogenous descriptive variables. Table 4 presents estimates from a multivariate SEM probit model for the five investment axes, interpreted on the plane of latent investment tendencies. The results suggest a significant variability of decision-making mechanisms across the investment approaches.

The multivariate probit structural equation model was estimated using the diagonally weighted least squares estimator (DWLS), which is recommended for models with categorical or ordered endogenous variables. The DWLS estimation relies on polychoric/tetrachoric correlations and uses a diagonal weight matrix, providing more stable parameter estimates and standard errors than maximum likelihood methods when binary outcomes are analysed. Model optimisation was based on the NLMINB algorithm, a quasi-Newton numerical optimisation procedure implemented in R's lavaan library. The multivariate probit structural equation model was estimated in R using the lavaan package (version 0.6-20). The algorithm iteratively minimises the fitting function while accounting for parameter constraints and the complexity of the covariance structure.

Because the dependent variables were defined as ordered binary indicators, the DWLS estimator, combined with probit-link parameterisation, provides parameter estimates on the latent continuous response scale. Therefore, standardised coefficients reflect relationships between predictors and latent propensities toward specific investment approaches rather than direct effects on observed binary responses. The results suggest a significant variability of decision-making mechanisms across the approaches.

The estimated multivariate probit SEM model is saturated ($df = 0$), meaning that the number of freely estimated parameters equals the number of observations in the covariance structure. Consequently, global goodness-of-fit indices such as RMSEA, CFI, TLI, or the chi-square test are not informative because the model reproduces the observed covariance matrix perfectly by design. For this reason, model evaluation focused on local explanatory performance rather than global fit statistics. In particular, the analysis relied on the coefficient of determination (R^2) estimated for each endogenous investment axis on the latent probit scale. These coefficients indicate the proportion of latent variance explained by observed farm characteristics and provide a substantive assessment of how strongly each

investment strategy is structurally determined by the model's predictors. The reported R^2 coefficients represent explained variance on the latent probit scale estimated within the SEM framework.

Table 4. Estimation of the multivariate SEM probit model for five investment axes.

Dependent Variable	Predictor	Est.	SE	z	p-Value	Std. Est.
INVoff	Cows	−0.004	0.006	−0.59	0.553	−0.108
	Age	−0.054	0.105	−0.47	0.642	−0.407
	Successor	−0.109	0.091	−1.20	0.230	−0.145
	Land	0.063	0.121	0.52	0.605	0.063
	Satisfaction	0.031	0.111	0.21	0.836	0.021
	SAAC	0.147	0.297	0.49	0.622	0.062
	SPriv	0.344	0.249	1.38	0.167	0.141
	SDairy	−0.779	0.505	−1.54	0.123	−0.258
	Income	−0.105	0.141	−0.746	0.456	−0.105
INVland	Cows	0.009	0.002	4.17	0.000	0.259 ***
	Age	0.004	0.005	0.75	0.456	0.033
	Successor	−0.078	0.041	−1.87	0.061	−0.108 †
	Land	−0.161	0.054	−2.97	0.003	−0.169 **
	Satisfaction	−0.244	0.078	−3.13	0.002	−0.244 ***
	SAAC	0.226	0.125	1.81	0.071	0.100 †
	SPriv	0.206	0.136	1.52	0.129	0.088
	SDairy	0.031	0.154	0.20	0.842	0.011
	Income	0.141	0.074	1.87	0.061	0.141
INVener	Cows	0.001	0.002	0.65	0.515	0.046
	Age	0.013	0.006	2.14	0.033	0.121 *
	Successor	0.028	0.054	0.51	0.611	0.042
	Land	−0.001	0.068	−0.02	0.988	−0.001
	Satisfaction	0.183	0.086	2.123	0.034	0.183 *
	SAAC	−0.122	0.148	−0.83	0.408	−0.060
	SPriv	−0.016	0.161	−0.10	0.921	−0.008
	SDairy	−0.065	0.180	−0.36	0.719	−0.025
	Income	−0.049	0.087	−0.56	0.573	−0.041
INVlive	Cows	−0.000	0.002	−0.13	0.899	−0.007
	Age	−0.011	0.006	−2.00	0.045	−0.109 *
	Successor	0.034	0.040	0.86	0.389	0.052
	Land	−0.063	0.053	−1.19	0.233	−0.073
	Satisfaction	0.195	0.076	2.569	0.010	0.195 **
	SAAC	0.111	0.121	0.92	0.356	0.054
	SPriv	0.165	0.130	1.27	0.206	0.077
	SDairy	−0.329	0.145	−2.27	0.023	−0.125 *
	Income	0.088	0.073	1.208	0.227	0.080
INVother	Cows	−0.001	0.002	−0.45	0.650	−0.030
	Age	0.005	0.007	0.65	0.515	0.044
	Successor	−0.041	0.041	−1.01	0.312	−0.063
	Land	0.054	0.054	1.00	0.316	0.063
	Satisfaction	−0.001	0.074	−0.013	0.989	−0.001
	SAAC	0.317	0.126	2.51	0.012	0.156 *
	SPriv	0.113	0.137	0.83	0.409	0.054
	SDairy	−0.031	0.154	−0.20	0.838	−0.012
	Income	0.074	0.072	1.18	0.309	0.074

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$. Standardised coefficients (Std.) concern the latent scale. Source: original work.

The explained variance differed substantially across investment axes. Off-farm investments exhibited the highest variance, $R^2 = 0.305$, followed by land investments ($R^2 = 0.193$). Energy investments reached $R^2 = 0.041$, livestock investments, $R^2 = 0.083$, and other investments, $R^2 = 0.030$. These findings suggest that some investment approaches are structurally determined, whereas others depend primarily on latent, contextual, or adaptive mechanisms.

1. Off-farm investments (INVoff): None of the predictors reach the conventional level of statistical significance. This suggests that the propensity to engage in off-farming activities is determined by observable characteristics of the farm and farmer only to a limited degree. Relatively high, although still insignificant, coefficients for private consulting and the negative effect of dairy plant support indicate that the decisions are strategic and context-based rather than stemming directly from the current production circumstances. In practice, this means that off-farm investments play an adaptive instead of a developmental role. The absence of statistically significant predictors may indicate that such investments are undertaken mainly in response to external uncertainty and income diversification needs rather than as part of a standard farm development pathway.
2. Land investments (INVland): The land investment model exhibits the strongest power to identify explanatory factors. The propensity to invest in land increases significantly with the scale of production, measured by herd size. Simultaneously, the negative impact of currently available land suggests saturation of this resource. The significant negative effect of business relationships with dairy plants suggests that investments in land are not simply a function of the current cooperation; instead, they are part of a long-term development strategy. These results confirm the traditional role of land investments as a structural strategy, rooted in the farm's production underpinnings. The strong association between herd size and land investments additionally suggests that land expansion serves specifically to maintain production scale and feed security in dairy farming systems. The negative relationship with already owned land may further indicate diminishing marginal utility of additional land acquisition among larger landholders.
3. Energy investments (INVener): Demographics and subjective factors have a strong influence on energy investments. The positive impact of the farmer's age indicates that energy-related decisions are more common among experienced producers, who potentially enjoy a more stable economic position. The parallel positive influence of satisfaction with business relationships with dairy plants suggests that energy investments could be a response to diversification needs. Energy investments do not simply emerge from agricultural development, because there are no significant effects of production variables (herd size) and income variables. Instead, they are a distinct axis aimed at adaptation. This pattern may reflect considerations related to operating costs and adaptation to changing environmental and market conditions, which are often discussed in the context of sustainability transitions. However, the present findings do not provide direct evidence regarding the motivations behind investment intentions or their sustainability outcomes.
4. Livestock investments (INVlive): The propensity to invest in livestock production declines with the farmer's age, which is consistent with the high capital intensity and long return horizon typical of such investments. A significant positive influence of satisfaction with cooperation with the dairy plant could suggest that farms with strong contractual links find it easier to expand in this area. This result may indicate that stable market relationships and perceived security of milk sales encourage

farmers to undertake highly capital-intensive livestock investments despite their long payback period.

5. 'Other' investments (INVother): The only significant predictor in this category is support from agricultural advisory centres, which suggests that 'other' investments are initiated mainly by institutional factors rather than emerge from autonomous farmers' decisions. The lack of identified impact from structural or economic factors indicates that this category should be considered a flexible 'investment fallback' used in response to external advice or incentives. This finding confirms that this investment category is relatively heterogeneous and may include projects implemented opportunistically, depending on the availability of advisory support or temporary development programmes.

The results indicate that different investment areas are subject to distinct decision-making mechanisms and that there is no single universal investor profile. Some strategies (investments in land and livestock production) are structural and individual in nature and are strongly linked to farm resources and long-term development strategies, whilst other investment areas (energy, non-agricultural investments, and others) primarily serve an adaptive function. This demonstrates that farmers simultaneously pursue two partially overlapping investment behavioural mindsets: a structural-developmental logic aimed at strengthening production capacity and a diversification-adaptive logic aimed at improving resilience to economic and institutional uncertainty. Therefore, the results suggest a heterogeneous nature of farmers' investment strategies, which means that hypothesis H3 has been confirmed only partially. It cannot be unequivocally stated that investment strategies are exclusively individual or exclusively adaptive in nature, as both mechanisms co-occur, varying depending on the specific investment axis. This heterogeneity warrants further analysis of residual correlations, enabling us to determine whether these strategies co-occur as complementary investment decisions or remain substitutable.

4.4. Residual Correlation Analysis

Our residual correlation analysis concerns (latent) residual correlations among tendencies to opt for specific investment axes, controlling for all explanatory variables. They are latent components of the propensity to invest in specific domains, controlled for exogenous variables. A positive correlation indicates complementarity of the propensity to invest in specific domains (co-occurrence in addition to the explanation provided by exogenous variables). A negative correlation suggests substitutability between investments in specific domains (a trade-off, controlled for independent factors). An insignificant correlation indicates no systemic association between investment axes after controlling for exogenous variables.

Table 5 presents residual correlation estimates of the 'net' latent propensities to engage in specific investment axes, controlling for exogenous variables. The correlations reflect the co-occurrence of investment strategies, controlled for observable farm characteristics such as resources, income, or institutional cooperation. As opposed to raw correlations, these associations can be interpreted as purely strategic decision-making dependencies instead of the results of common determinants.

According to the data summarised in the table, off-farm and energy investments are complementary, as their correlations are the strongest (positive) and significant. This means that farms with an above-average propensity to invest in energy projects are also more open to off-farm activities, regardless of their production system and financial standing. This association may be consistent with a pattern of co-occurrence between stated investment intentions across domains. However, given the cross-sectional nature of the data, it should be interpreted as a statistical association rather than evidence of a deliberate investment strat-

egy. This relationship remains after controlling for observed farm characteristics and may reflect unobserved heterogeneity influencing stated investment intentions across domains.

Table 5. Residual correlations (latent) among propensities to invest in various domains.

Strategy 1	Strategy 2	Est.	SE	z	p-Value	Std. Est.	Type of Association Among Investment Strategies
INVoff	INVland	0.109	0.104	1.05	0.295	0.109	no systemic association among investment axes
INVoff	INVener	0.269	0.085	3.17	0.002	0.269 **	complementarity
INVoff	INVlive	−0.083	0.107	−0.77	0.439	−0.083	no systemic association among investment axes
INVoff	INVother	−0.251	0.109	−2.31	0.021	−0.251 *	substitutability
INVland	INVener	0.130	0.086	1.51	0.131	0.130	no systemic association among investment axes
INVland	INVlive	0.089	0.073	1.22	0.222	0.089	no systemic association among investment axes
INVland	INVother	−0.048	0.073	−0.66	0.512	−0.048	no systemic association among investment axes
INVener	INVlive	0.102	0.085	1.20	0.231	0.102	no systemic association among investment axes
INVener	INVother	−0.142	0.086	−1.65	0.098	−0.142 †	substitutability
INVlive	INVother	−0.234	0.071	−3.27	0.001	−0.234 ***	substitutability

Note: Residual correlations were estimated with a multivariate SEM probit model (WLSMV). Positive values mean complementary strategies. Negative values mean substitutive strategies. All controlled for observable variables. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$. Source: original work.

We have also identified the substitutability of ‘other’ investments and other strategies. Clearly negative and significant correlations were found between ‘other’ investments and three other axes, i.e., energy investments, off-farm investments, and livestock production investments. These results indicate residual negative associations that may reflect inverse relationships between stated investment intentions across domains. Farms that engage in investments grouped as ‘other’ rarely combine them with investments that require high capital and organisational effort. This can be interpreted as an allocation mechanism. ‘Other’ investments compete with more demanding development strategies for farms’ resources.

We found that land, energy, and livestock production investments lacked strong associations with production strategies. Any relationships are positive but weak and statistically insignificant. This means that, controlled for structural variables, investments in land are not systemically combined with investments in livestock. Energy investments are relatively independent of classical production-related decisions. This suggests that their co-occurrence in the raw data is mainly due to shared determinants (farm size, income) rather than to a conscious strategy to combine investment axes. Conclusions from this part of the analysis provisionally support Hypothesis 3. However, the analysis of residual correlation patterns suggests that stated investment choices exhibit systematic patterns of association rather than being fully independent. Therefore, Hypothesis 3 is only partially supported, as residual associations among investment domains remain present after controlling for observed farm characteristics.

Our analysis of co-occurrence of investment strategies identified statistically significant correlations between off-farm and energy investments, off-farm and ‘other’ investments, and livestock production and ‘other’ investments. Although the associations are both positive and negative, the statistically significant ones are dominated by two types. The first are correlations concerning ‘other’ investments, which are significant for relationships with (1) off-farm investments, (2) livestock investments, and (3) energy investments. For the other type, namely correlations involving off-farm investments, the relationships are significant for (1) energy investments and (2) ‘other’ investments. Therefore, we reject

hypothesis 2 that farmers' investments are more strongly related to on-farm production than off-farm activities.

4.5. Evaluation of Correlations Among Investment Axes and Investment Strategy Demasking Effect

The 'demasking effect' refers to the idea that raw correlations among investment strategies may obscure the actual underlying association among them. At the raw level, two investment axes can appear positively associated simply because they are both driven by the same external conditions. For example, larger farms may invest simultaneously in land, livestock, and energy because wealthier farms may have easier access to multiple investment opportunities, and subsidies or institutional support may stimulate several types of investments simultaneously. As a result, the observed correlation conflates genuine strategic relationships among investments, shared dependence on farm characteristics, and broader contextual influences.

The SEM model 'removes' the part explained by observable predictors (farm size, income, support, satisfaction, etc.). What remains are residual latent correlations, that is, relationships between investment strategies that cannot be explained by the observed covariates. The demasking effect occurs when these residual correlations differ substantially from the raw correlations. It can take three primary forms: (1) attenuation when the adjustment weakens a strong raw correlation, which means the original association was mainly caused by shared external conditions rather than by a real strategic link; (2) sign reversal when a positive raw correlation becomes negative (or vice versa), which reveals an overt trade-off or overt complementarity that was previously masked by common farm characteristics; and (3) the emergence of a latent dependence as a weak raw correlation becomes strong after adjustment, which suggests that a strategic relationship existed but was obscured by noise or confounding factors.

Figure 2 compares raw tetrachoric correlations (Raw) among the investment axes (inter-investment relationships before 'demasking') with latent correlations (Lat) estimated using the multivariate SEM probit model, controlled for farm structural variables (inter-investment relationships after 'demasking'). All the data points lie below the $y = x$ line, indicating that the latent correlations are systemically weaker than the raw correlations. Therefore, a significant portion of the observed correlations among investments in specific domains are spurious. In general, the associations are driven by structural factors (such as farm size, income, and available land) rather than by direct strategic relationships.

The grey points denote stable relationships and pairs of strategies in which the sign of the correlation remains unchanged, and the relationship weakens when controlled for descriptive variables. These are the land and energy, energy and livestock, and off-farm and land investment pairs. This means that these strategies exhibit a moderate investment integrity. Still, their intensity hinges primarily on the farms' shared economic standing, indicating that the farms' resources influence the co-occurrence of investment strategies.

The black points represent strategy 'demasking' where the correlation's sign changes (positive to negative) when controlled for descriptive variables. Spurious complementarity shifts towards strategic substitutability (a latent trade-off). The strongest pairs include off-farm and 'other' investments, energy and 'other' investments, and off-farm and livestock investments. Raw correlations for these associations suggest co-occurrence of strategies, while latent (Lat) correlations reveal competition for resources or farms' absorptive capacity. These points represent the strongest 'demasking of investment strategies'.

The point size reflects the difference: $|\Delta| = |r_{\text{Lat}} - r_{\text{Raw}}|$. Large points indicate relationships in which the raw correlation is strong but disappears almost entirely when controlled for descriptive variables. This means that empirically observed interdependency does not reflect strategic behaviours but identical exposure to structural factors. Further-

more, the figure demonstrates that ‘other’ and off-farm investments are buffer strategies, and their relationships with other axes are mostly substitutive rather than complementary.

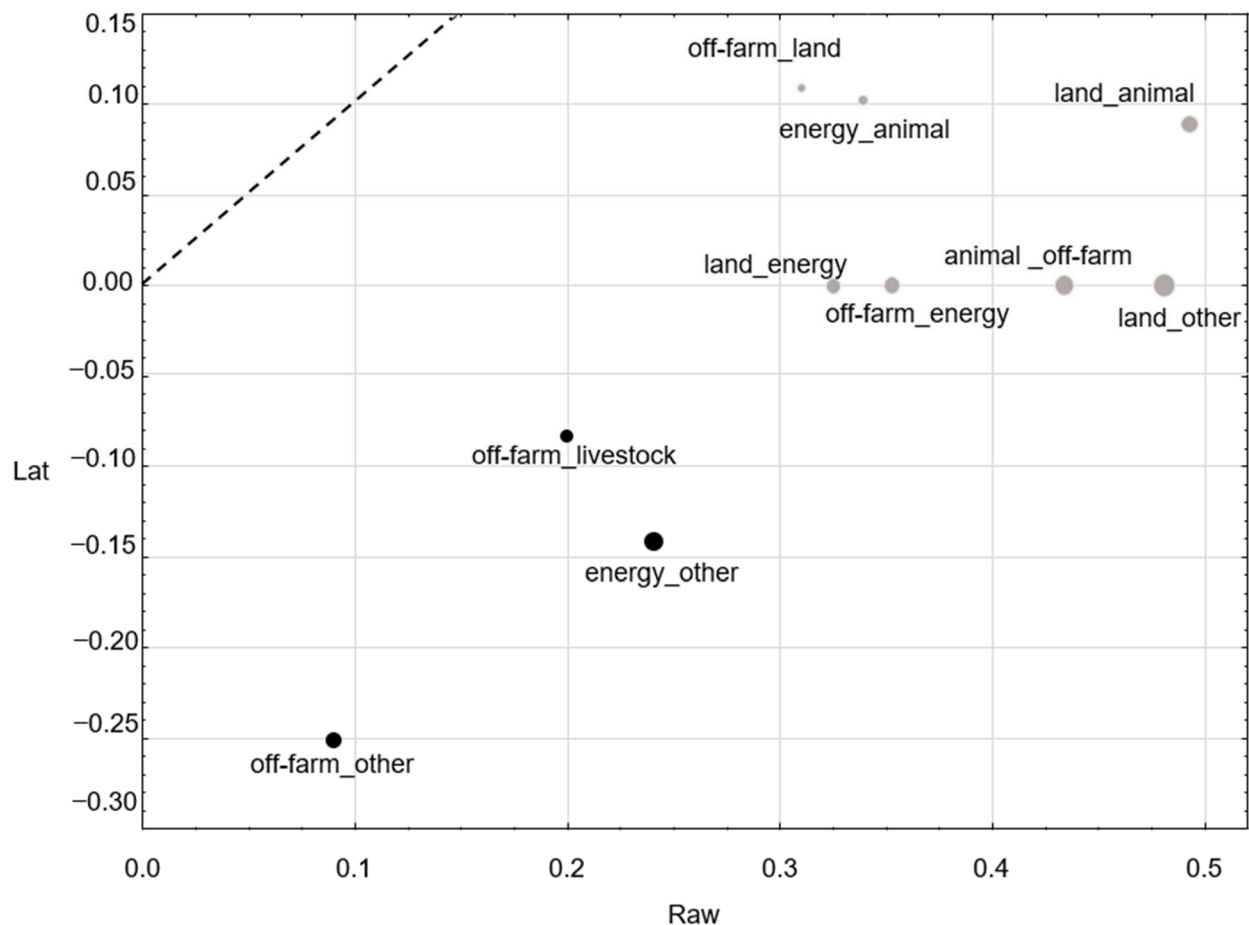


Figure 2. Investment strategy demasking effect. Note: the dashed line represents a reference line corresponding to equal values of the Lat and Raw parameters. The grey points denote stable relationships and pairs of strategies in which the sign of the correlation remains unchanged, and the relationship weakens when controlled for descriptive variables. The black points represent strategy ‘demasking’ where the correlation’s sign changes (positive to negative) when controlled for descriptive variables. Source: original work.

Large delta $|\Delta|$ indicates spurious complementarity of investment axes. The highest values were found for the land and ‘other’, livestock and ‘other’, and land and livestock pairs. High delta values mean that most raw correlations were spurious. They vanished when controlled for farm structure, resources, and economic circumstances. This demonstrates that traditional analysis, founded solely on correlation, could significantly overestimate the integrity of investment strategies.

In some cases, positive raw correlations become negative latent correlations after controlling for explanatory variables: energy and ‘other’ investments, off-farm and ‘other’ investments, and off-farm and livestock investments. The sign change suggests potential relationships of substitutability. When controlled for the farm’s resources, the investments compete for capital, time, or absorptive capacity. Note that these associations are not evident from raw data and can be revealed as latent investment propensities.

Only a few pairs of investment axes remain positive when controlled for variables, although even then they grow weaker (for example, energy and livestock investments or land and livestock investments). This indicates that there are not many complementary

relationships among the investment strategies, and the investment system as a whole is not uniform.

When juxtaposed, the raw and latent correlations yield three key conclusions:

1. Most of the observed correlations are spurious and driven by common characteristics of the farms.
2. There are a few actual strategic dependencies. They are either explicitly complementary or substitutive.
3. The analysis of latent investment axes reveals the structure of the investment portfolio, which is unavailable to raw correlation analysis.

As a result, surveyed farm investments should be interpreted as a system of conditional decisions, where some strategies are mutually reinforcing while others compete for limited resources, rather than a set of co-occurring activities. Based on Markowitz's theory of investment portfolio [80], as quoted by Lindquist et al. [81], we propose a farm investment portfolio diagram (Figure 3).

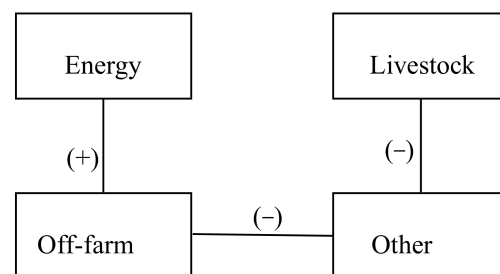


Figure 3. Farm investment portfolio diagram. The plus sign (+) means diversification, and the minus sign (−) means competition for resources. Source: original work.

The pattern of residual correlations suggests two broad configurations of associations among stated investment intentions across domains. The observed positive residual association between off-farm and energy investments may reflect a pattern of co-occurrence between these stated investment intentions. This association is consistent with the joint reporting of income-diversification activities and energy-related investment intentions.

Another configuration is characterised by negative residual associations among several investment domains, indicating inverse relationships in stated investment intentions. In this case, limited resources may be associated with differences in reported investment choices across domains.

Land investments exhibit very low residual correlations, suggesting that stated investment intentions in this domain are primarily associated with structural factors such as farm size, resources, and income rather than with residual associations among other investment domains.

These findings suggest that stated investment intentions across domains are not entirely independent after controlling for observed covariates but instead exhibit a pattern of residual interrelationships. This structure is identified through the combined use of sequential modelling, multivariate SEM, and correlation-based analysis. Logit models indicate that production resources, economic circumstances, and institutional support play a significant role in reported investment choices across domains. However, most raw correlations substantially weaken or disappear after controlling for farm characteristics, suggesting that a large part of the observed co-occurrence is attributable to shared structural conditions rather than residual associations.

At the same time, residual correlations reveal a small number of positive and negative associations, particularly among off-farm, energy, and other investments, indicating latent associations among selected domains. Overall, the results suggest that farm invest-

ments across domains may be interpreted as interconnected patterns of stated investment intentions rather than entirely independent responses to economic stimuli.

5. Discussion

5.1. Overall Drivers of Propensity to Invest

Our logistic regression analysis has revealed relationships between declarations to invest in specific domains and variables related to tangible and intangible factors on the farms. We identified both positive and negative influences, which suggest the co-occurrence of mechanisms described by the resource-based view (RBV) and the institutional approach. The results indicate that both farm production resources and relationships with institutional actors jointly affect farmers' propensity to invest in specific domains. They furthermore demonstrate a positive impact of herd size (production resources), support from advisory institutions, and business relationships with dairy plants on the propensity to invest in specific domains. Land resources have a negative impact. The negative relationship between land resources and propensity to invest in specific domains may indicate a saturation effect; however, it may also imply greater investment caution among larger farms operating under conditions of economic and regulatory uncertainty. Cooperation with the dairy plant was treated more on a market (contractual) basis than as an investment. Other authors, such as Gelgo [40], confirm the beneficial impact of support from advisory institutions. The positive influence of satisfaction with the dairy plant and income on the propensity to invest may indicate the importance of behavioural factors, such as subjective perceptions of economic stability and security of cooperation. This finding is partially consistent with the theory of planned behaviour (TPB), according to which investment intentions depend not only on available resources but also on perceived behavioural control and positive attitudes towards action.

No significant influence of the farmer's age or the availability of a successor on overall investment plans indicates that social factors play a role in line with theories of behavioural decision-making and bounded rationality. This may suggest that some stated investment intentions across domains are associated with considerations related to farm continuity and adaptation to changing market conditions rather than solely economic efficiency considerations. Our results also suggest that decisions to invest in specific domains may be partly associated with individual perceptions of risk and expectations regarding future farming conditions, which is consistent with behavioural approaches and the bounded rationality theory.

The results largely support hypothesis H1. Tangible resources, especially herd size, demonstrated a stronger and more stable influence on investment propensity than most institutional variables. At the same time, the significance of advisory support and relationships with dairy cooperatives indicates that institutional factors play a complementary rather than marginal role in shaping investment intentions.

5.2. Investment Axes (Multivariate SEM Probit Model)

The results of the SEM probit model offered an in-depth insight into the propensity to invest in specific domains. They identified relationships among the five investment axes (off-farm, land, energy, livestock production, and 'other') and exogenous variables (herd size, farmer's age, successor, land, income, satisfaction with the dairy plant, and support from three advisory institutions). The results confirmed that some investment axes were more strongly associated with farm resources and structural characteristics (consistent with the RBV), whereas others depended more heavily on institutional relationships and advisory support, which supports the assumptions of the institutional approach. Land investments were associated with the scale of milk production and appeared to be linked to

longer-term development considerations. The propensity to invest in livestock production declined with farmers' age. On the other hand, the older they were, the more readily they embraced energy investments. We identified dependency on external institutional factors for 'other' investments (similarly to Nasalski & Juchniewicz [39]). This broadened the perspective on investment propensity evaluation, and not all the overall results of logistic regression analyses were confirmed for the five investment axes. Differences in the impact of farmers' age on particular investment directions may suggest that investment decisions are associated not only with economic calculation but also with individual perceptions of risk and expectations regarding the future of the farm, which is consistent with behavioural approaches and TPB.

The results do not confirm hypothesis H3. Some stated investment intentions across domains were primarily associated with farm characteristics, while the significant role of advisory support and institutional cooperation suggests the importance of institutional factors in explaining variation in reported investment choices.

5.3. Complementarity and Substitutability of Investments (Interdependence of Investment Decisions): Residual Correlation Analysis

Our analysis of the co-occurrence of investment domains identified statistically significant correlations between off-farm and energy investments. These results may be interpreted as patterns of association that are broadly consistent with perspectives from the literature on investment under uncertainty, including real options theory and portfolio-based approaches (e.g., Salvioni et al. [47]). However, these theoretical frameworks are used here as interpretative lenses rather than as hypotheses formally tested in this study. Although the associations are both positive and negative, the statistically significant ones are mainly correlations among off-farm, energy, and other investments. Therefore, we reject hypothesis 2 (H2) that investments are more strongly related to on-farm than off-farm production.

Our residual correlation analysis indicates the complementarity of off-farm and energy investments. This means that farms with an above-average propensity to invest in energy projects are also more open to off-farm activities, regardless of their production system and financial standing. This conclusion is consistent with findings reported by Ashfield et al. [46] and Salvioni et al. [47]. The association may be interpreted as a pattern of co-occurrence between stated investment intentions in energy and off-farm domains. Our results do not confirm the dominance of substitutive investments; therefore, hypothesis H4 was rejected.

On the other hand, the substitutability of 'other' investments with three investment axes (off-farm, energy, and livestock production) is consistent with the allocation mechanism: 'other' investments are an alternative way to consume resources, competing with more demanding development strategies.

We found that land, energy, and livestock production lacked strong associations with production strategies (positive and statistically insignificant). This means that, when controlling for structural variables, investments in land are not systemically combined with investments in livestock. Energy investments are relatively independent of classical production-related decisions. This suggests that their co-occurrence in the raw data is mainly driven by common determinants such as production scale and income rather than residual associations between investment domains. These findings provide only partial support for H3, indicating that observed relationships are largely explained by structural farm characteristics, while a smaller part reflects residual associations and contextual factors.

5.4. Demasking of Latent Investment Associations

Our final conclusions regarding farmers' investment strategies are founded on a demasking analysis following a series of preliminary analyses: (1) logit models, which

demonstrated the strong impact of tangible resources on investment decisions; (2) the SEM probit model, which confirmed the role of tangible factors depending on the investment axis; (3) the residual correlation analysis, which identified associations among the investment axes; and (4) finally, the combined analysis of raw and model-based correlations, which provided evidence of residual associations among investment domains.

The first part of the observed raw correlations became weaker. They are stable, have not changed sign, and are complementary (the land and livestock, energy and livestock, and off-farm and land pairs), which means that the strategies emerge from common economic circumstances and are conditioned by the farm's resources. The second portion of the correlations among the investment axes changed sign from positive to negative. These include off-farm and 'other' investments, energy and 'other' investments, and off-farm and livestock investments. This indicates that initial positive associations between investment domains become weaker or negative after controlling for farm characteristics, suggesting that observed co-occurrence is largely driven by shared structural factors rather than residual correlations. The third group of correlations among the investment axes is defined by their disappearance following control for farm characteristics (land and 'other' investments, livestock and 'other' investments, off-farm and energy investments, and land and energy investments).

This suggests that part of the co-occurrence of declared investments in specific domains may primarily result from shared structural conditions of farms rather than from stable strategic relationships between investment axes.

Our findings partially modify the assumptions of the resource-based view (RBV) because tangible resources alone do not fully explain investment axes. The significance of advisory support and dairy cooperative relationships indicates that investment decisions are co-shaped by the institutional environment. At the same time, the results do not indicate a clear dominance of any single pattern of associations among investment domains, suggesting heterogeneity in observed investment choices. These findings are consistent with the theory of planned behaviour (TPB), according to which investment intentions depend not only on available resources but also on subjective perceptions of opportunities, risks, and social relationships. Furthermore, the co-occurrence of complementary and substitutive investments supports the assumptions of the real options theory, according to which farms adjust investment structures gradually under conditions of uncertainty.

The analyses largely confirmed H1, rejected H2 and H4, and only partially supported H3. We determined the following:

1. Tangible factors are stronger drivers of overall investment plans for farmers—H1.
2. Off-farm investments displace on-farm activities—H2.
3. Farmers' investment strategies are heterogeneous—some are structural and individual in nature, while others are adaptive; therefore, H3 is confirmed only partially.
4. Farmers declared both complementary and substitutive investments, with neither achieving clear dominance, which constitutes the basis for rejecting H4.

6. Conclusions

Our results show that farmers vary in how they make investment decisions. Therefore, it is not possible to identify a single universal farmer investor profile. The structural image of land and livestock production investments suggests that their purpose is to ensure long-term farm potential. Meanwhile, energy, off-farm, and 'other' investments appear to be more strongly associated with institutional, contextual, and non-production-related factors. Their occurrence may reflect exposure to changing economic and regulatory conditions. This means that any farmer support instruments need to be diversified and adapted to the various motives and decision horizons of investor groups to be effective. In

practical terms, larger farms are more likely to undertake investments because they have greater production potential and stronger economic capacity to absorb investment risk and long-term financial commitments. These conclusions may have potential relevance for public policy by providing insights into patterns of stated investment intentions that could be considered when designing measures to support rural development in the context of sustainability transitions.

7. Recommendations

The results may inform the development of policy scenarios and the specification of alternative empirical models in future research. Future investment models could incorporate additional explanatory factors. We recommend considering variables such as attitudes, values, and motivations; social relationships and influence networks; and perceptions of risk and uncertainty as potential factors influencing variation in stated investment choices.

8. Proposed Future Research

The present analysis does not address the identification or evaluation of factors associated with the observed residual correlations. In particular, it does not take into account institutional, behavioural, and context-dependent variables (such as access to subsidies, risks, and farm-specific preferences). An important direction of future research is to employ the dynamic approach to evaluate the stability of cross-strategy relationships. In-depth modelling of interaction and relationship non-linearity (such as SEM with moderation effects or dynamic network models) could also be pursued to analyse the structure of the farms' investment decisions in more detail. Another issue to analyse is the reasons for the lack of investment decision-making. It would be interesting to understand the motives and characteristics of farmers who do not have investment plans for the coming years.

9. Limitations

The findings presented in this study are derived from survey data collected among dairy farmers. As the responses were declarative in nature, they may have been influenced by subjectivity, temporary emotional states, or social desirability bias. The main conclusions rely on self-reported assessments, which naturally increases measurement sensitivity and the possibility of classification inaccuracies. Although the sample was extensive and heterogeneous, it was not randomly selected. Furthermore, the study covered only three distinct regions of Poland. While this enhanced the analytical comparison, it also limits the extent to which the results can be generalised to the whole country.

The methods employed in the study are burdened with significant limitations due to the internal characteristics of survey data and the complexity of decision-making on farms. Logistic regression is susceptible to model misspecification and issues with proper modelling of cross-sectional data. SEM models require high-quality indicators and are susceptible to specification errors and cross-loading. Residual correlation analysis is restricted to linear relationships and is highly sensitive to confounders. Confounders may affect the observed relationships. The identification of residual associations depends on adequate control for unobserved factors, which is inherently limited in cross-sectional settings.

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Informed Consent Statement: Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time. Information regarding the anonymity of the study and the possibility of withdrawing from participation at any stage was included as an integral part of the questionnaire. Completion of the anonymous questionnaire was considered to imply informed consent. No personal or identifiable information was collected during the data collection process.

Data Availability Statement: The datasets generated and analysed during the current study are not publicly available to preserve research participants' privacy but are available from the corresponding author on reasonable request.

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