Furkan YIGIT*, Timo SIPILÄINEN* and Leena RANTAMÄKI-LAHTINEN*

Farm Characteristics and Resources: The C5.0 Classification Tree as a Means Towards Understanding Finnish Family Farmers' Perceptions of Success

This study investigates the classification of the family farmers' perceptions of success, based on characteristics and resources. The empirical analysis was undertaken on primary data collected via a questionnaire completed by family farmers in Finland. The most important variables in the classification are identified using the C5.0 decision tree algorithm. The algorithm performs with an approximately 16% error rate. In the classification of family farmers' perceptions of success, farm characteristics are of minor importance, whereas the most important variables relate to resources and skills. The most important variables classifying perceptions of success are skills for exploiting opportunities, funding opportunities, and technology, machinery and equipment. The importance of the factors of resources (capital, capability, organisational, skills) are interpreted, together with factors of success (financial, self-realisation, growth and family). This study provides a further indication of the potential of the methodology to highlight the role played by farm characteristics and resources in family farm success.

Keywords: family farm, success, farm characteristics, resources, classification

JEL classification: Q12.

* Department of Economics and Management, University of Helsinki, PL 28 (Koetilantie 5), 00014 - Helsinki, Finland. Corresponding author email: furkan.yigit@helsinki.fi.

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Introduction

Successful strategies are a driving factor for economic and social sustainability, and this is especially so for family farms. The entrepreneurial strategies implemented by family farms can also contribute to the development of sustainable rural entrepreneurship. Determining what accounts for the success of family farmers is important for theoretical and practical discourses, as well as for understanding future-oriented strategies such as those related to innovation, sustainability and succession (Suess-Reyes and Fuetsch, 2016). Knowledge of the dynamics of successful farming is vital for the sustainability of the rural population.

However, not all farms are the same. Farms are considered to have a range of characteristics and individual farmers have distinct perceptions of success. Likewise, resources used in a strategy for success vary from farm to farm, as farms and farmers have been in a fundamental transitional period requiring resources and trade-offs between efficiency and adaptability with a view to the farm sustainability (Darnhofer *et al.,* 2010). Small farms in particular are considered to be in need of vital policy support to avoid sociological risks affecting the future of rural areas (Hazell *et al.,* 2010). In general, the agricultural sector has its own unique characteristics and structures that distinguish it from other sectors in most parts of the world. Identifying the profile of a typical successful farmer is challenging because the sector is so heterogeneous (McElwee, 2008).

Rather than there being a broad goal of business success, farmers have different objectives and motivations, prioritised in ways that match the characteristics and resources of the farm. Internal and external relations of production have also shaped the definition of business structures and farm typologies (Whatmore *et al.,* 1987). The farm typologies in Europe have been studied from various perspectives (Weltin *et al.,* 2017; Guiomar *et al.,* 2018; Guarin *et al.,* 2020), mostly considering specific farm characteristics. For example, heterogeneity among farmers has been explained from an identity perspective (Vesala *et al.,* 2007; Vesala and Vesala, 2010; Stenholm and Hytti, 2014), comparing entrepreneurial identities rather than creating a new typology of farmers. The focus has been more on behaviour than characteristics, which Gartner (1988) also suggested might be a useful approach in small business and entrepreneurship research.

In the agricultural sector, the most typical business type is family farming. Family farms account for more than 90% of the agricultural businesses in the world (FAO, 2014; Lowder *et al.,* 2021) and in Europe (Eurostat, 2022). In Finland, approximately 84% of agricultural and horticultural enterprises with a financial size exceeding €2,000 are family-operated (LUKE, 2024). In the literature, family firm identification has been mostly based on ownership and self-definition (Casillas *et al.,* 2021) or reliance on family labour more broadly (Garner and De la O Campos, 2014).

A farm business comprises two main elements: the farm and the farm family, inseparably. However, the family farming concept is distinct from conventional farm business terminology (Gasson *et al.,* 1988). What does success mean for family farmers, and what is a successful family farm? Addressing these questions requires a special research setting, by taking the perspective of the farm as a family business into account. The heterogeneity of family businesses and the interrelation between goals and resources at the firm level has been discussed from both entrepreneurship and strategic management perspectives (Chrisman *et al.,* 2013). Farmers value the image of a 'successful farmer' (Walter, 1997). Additionally, Etumnu and Gray (2020) demonstrate the diverse perceptions of success among farmers, highlighting the need for multidimensional measurements, despite their research not focusing on the family unit as such.

Success is usually interchangeably used with such concepts as performance. However, success does not reflect only

objective measures, but can also include subjective perceptions (Wach *et al.,* 2020; Fisher *et al.,* 2014; Baron and Henry, 2011; Gorgievski *et al.,* 2011), especially for family farms (Mäkinen *et al.,* 2009). It is not always possible to conceptualise and measure objective performance for family farms, for which the perception of success is more focused on continuity in the family and survival, unlike in other sectors. In addition, objective indicators are not always available. It is of interest to this study how farm characteristics and resources are related to multidimensional perceptions of success, specifically with taking the subjective perceptions of farmers into consideration as a novelty in its theoretical framework.

Besides traditional methods such as regression and correlation-based analysis, there are recently-developed data-driven methods and techniques. Classification algorithms are among those which current developments in data science allow to be used as the techniques of data mining and machine learning. These techniques have been applied in agricultural research (Liakos *et al.,* 2018). There has been a trend in the usage of the techniques by studies focusing on the management of crops (Van Klompenburg *et al.,* 2020), water (El Bilali *et al.,* 2021), soil (Diaz-Gonzalez *et al.,* 2022), livestock and dairy farms (Shine and Murphy, 2022), aquaculture and fisheries (Gladju *et al.,* 2022), agricultural and biological engineering (Huang *et al.,* 2010), and supply chain (Sharma *et al.,* 2020; Kumari *et al.,* 2023). Even though there have been studies from an economic and sociological perspective on risk management (Ghaffarian *et al.,* 2022), decision-making (Attonaty *et al.,* 1999), and farmer typology (Graskemper *et al.,* 2021), the literature is limited in respect of strategic management and successful farm entrepreneurship. The range of studies in the agricultural economics literature that use these techniques with primary datasets has not been wide, except for those models which have been applied on panel datasets (Hyvärinen, 2016). The literature thus far on strategic management and successful entrepreneurship in family farm research lacks studies which outline classification algorithms in detail.

Family farms have unique characteristics and resources in creating a strategy, especially through exploiting the clusters of opportunities (De Rosa *et al.,* 2019). The most important characteristics of family businesses in general also relate to the resources (Alonso and Austin, 2016). And in defining what makes a farm successful in comparison to their counterparts strategically, one of the most common frameworks that has been used in family farm business research is resource-based theory (RBT), which considers the farm as a set of resources that may or may not count as being strategically relevant to its success. RBT has been a trending framework since the early 2000s (Chrisman *et al.,* 2010), but the origin of the theory dates back to Penrose's 'Theory of the Growth of the Firm' in 1959 (Penrose, 2009), and thereafter it has developed further explanations of the critical resources for competition (Wernerfelt, 1989), in addition to the capabilities (Peteraf and Barney, 2003; Teece, 2007), and strategic resources (Barney, 1991) that are considered to be valuable, rare, imperfectly imitable, and non-substitutable. Ultimately, some resources are strategically significant, and this is especially so for family farms. While resources are vitally important for successful strategies, an abundance of resources does not necessarily guarantee that a given business will have a competitive advantage (Mosakowski, 2017; Armstrong and Shimizu 2007). Acknowledging the non-linear and complex nature of the relationship between farm success and resource availability, this study employs an exploratory approach to identify the resources most salient to farmers' perceptions of success.

The aim of this study was to determine whether family farmers can be classified according to how they perceive their success, using farm characteristics and resources as classification variables in machine learning models. In our case, success and resource variables include farmers' perceptions, in other words, their own assessment of success in relation to physical, financial, organisational and skill resources in comparison to their counterparts. In addition to empirical results, our aim with this study was to provide insights into the potential use of machine learning and data mining techniques in the family farm context. As these techniques have not yet been widely used in farm management research, this study introduces a new approach for classification purposes in this area. It also aims to evaluate the efficacy of machine learning as a tool for discerning structures within large datasets of family farm data.

Material and Methods

The questions processed in this study were formulated so as to integrate concepts from both farming and business domains. We updated the questions regarding farm characteristics, which were originally developed by Vesala and Peura (2002) and further specified by Rantamäki-Lahtinen (2009) along with the resources as being suitable for reflections on family farms in Finland. Farm characteristics constructed in this study included several concepts and were grouped into two for each for classification procedure to be more efficient. The characteristics are the use of external labour, whether the type of farm is private or is a company, whether farm was handed down by the family or purchased from a non-family source, whether the farm size under cultivation is lower or higher than the average in Finland, whether there are other business activities, whether the primary production is grain farming, whether there is another family member (aged over 18) in the household, whether there is a child(ren) in the household, whether the current situation of the farm business is stable, whether there is consideration of a long term exit or generational change, whether the farm has organic farming, whether the farmer's education is related to agriculture, whether the farm is located in southwestern or central Finland, and whether the education level is practical experience/short courses or academic-level education.

Resources were considered to be based on European and Finnish farmers' perspectives, and were derived mainly from Forsman (2004), Rantamäki-Lahtinen (2009) and de Wolf *et al.* (2007), which have been constructed as potential resources to lead to a competitive advantage of the farm in the resources of buildings, funding opportunities, profitability, business competence, technology, machinery and equipment, customer relationship management, networks of entrepreneurs, professionalism and networks of other family members, cooperation partners, quality of products and services, organisational culture, production technical skills, financial management skills,

skills for exploiting opportunities, strategic planning and implementation skills and collaboration/networking skills.

Subjective perceptions of success were constructed using suitable measures of small businesses derived from Reijonen and Komppula (2007). These are the perceptions of the best possible financial result, maintaining an adequate standard of living for the farmer and farmer's family, financial profitability of the operation, self-determination in farmer's work, pride in what the farmer does, personal satisfaction, reputation, using the latest technology, keeping the farm business under family control, transferring the business to the next generation, farm size growth and revenue growth. The construction of the variables in the concepts of farm characteristics, resources and success are presented in Appendix 1.

The data were gathered through an electronic survey responded to by Finnish farmers, and the respondents were chosen by the random sampling method. The family farm dataset was filtered with self-assessment of the farmers to the question 'Which of the following best describes your farm business?' with 'We have a family business in which two or more family members are responsible for running the farm'. After data processing, observations from 910 responses from family farmers were included in the analysis. Since there was a high variance for variables about the farm characteristics, they were aggregated into two-level categories before the analysis. Resources and success variables were constructed with 5-point Likert scale (self-assessment of resources between 'much worse' and 'much better', self-rating of skills between 'weak' and 'excellent', and self-assessment of success between 'not at all' and 'very well').

Table 1 presents the distribution of the percentages regarding the farm characteristics of the sample. External labour is hired by 20.8% of family farms, while 79.2% do not hire. The business form of 93.9% of the family farms is the private type and 88.4% of family farms were acquired from the family, as a continuation of the operation of the family business. About 63.5% of family farms are of a smaller size than the average farm size in Finland, which is 51.15 ha (LUKE, 2021), whereas 36.5% are larger than the average. No other business activity is carried out in 70.8% of family farms, but in 29.2% there is. Cereal, grain and other crop production are the main production lines in 56% of family farms, while 44% have other agricultural production such as dairy, milk or other cattle or animal, mixed production, or open field horticulture. There is no other family member(s) (aged over 18 years) in the household in 70.8% of family farms, where 29.2% have at least one other family member(s) (aged over 18 years) in the household. There is no child in the household in 58.2% of family farms, but there is at least one child in the household in 41.8%. The current situation of 54.4% of family farms is stable, while 45.6% of family farms have different situations, such as being in a starting, changing, growing or declining phase. In 67.8% of family farms, there is no consideration of stopping farming or generational change in the next 5 years, while 32.2% consider. 86% of family farms do not practise organic farming, but 14% practise it. Vocational training of 62.4% of farmers in family farm is related to the current business, whereas 37.6% of farmers' education is not related. Over 79% of family farms are located in the provinces in southern or central Finland, while 20.8% are located elsewhere in Finland.

Table 1: Descriptive statistics regarding the farm characteristics.

Variable	Levels	Frequency	Percentage (%)
External labour	Yes	132	20.8
	No	504	79.2
Private or company	Private	597	93.9
	Company	39	6.1
The farm was handed down by the family or purchased from a non-family source	Family	562	88.4
	Elsewhere	74	11.6
The farm size under cultivation	Smaller	404	63.5
	Larger	232	36.5
Other business activities	No	450	70.8
	Yes	186	29.2
Primary production	Cereal, grain and other crop production	356	56.0
	Other agricultural production (dairy, milk or other cattle or animal, mixed production, or open field horticulture)	280	44.0
Other family member(s) (aged over 18 years) in the household	No	450	70.8
	Yes	186	29.2
Child(ren) in the household	No	370	58.2
	Yes	266	41.8
Current situation of the farm business	Stable	346	54.4
	Other (starting, changing, growing or declining)	290	45.6
Long term exit or generational change	No	431	67.8
	Yes	205	32.2
Organic production	No	547	86.0
	Yes	89	14.0
Relatedness of education	Yes	397	62.4
	No	239	37.6
Location	Southwestern and Central Finland	504	79.2
	Elsewhere	132	20.8
Education	At least at practical/short courses or higher	395	62,1
	Academic	241	37.9

Source: own composition

Table 2: Descriptive statistics regarding family farmers' perceptions of their resources in comparison to their counterparts.

Variable	Mean	Standard Deviation
Buildings	3.0	1.1
Funding opportunities	3.4	1.0
Profitability	3.2	0.9
Business competence	3.5	0.9
Technology, machinery and equipment	3.0	1.0
Customer relationship management	3.5	0.8
Networks of entrepreneurs	3.4	0.9
Professionalism and networks of other family members	3.4	0.9
Cooperation partners	3.4	0.7
Quality of products and services	3.6	0.8
Organisational culture	3.4	0.8
Production technical skills	3.8	0.6
Financial management skills	3.7	0.7
Skills for exploiting opportunities	3.5	0.8
Strategic planning and implementation skills	3.5	0.8
Collaboration/networking skills	3.5	0.8

Source: own composition

Table 3: Descriptive statistics regarding family farmers' perceptions of success.

Variable	Mean	Standard Deviation
Best possible financial result	3.0	0.9
Maintaining an adequate standard of living for farmer and farmer's family	3.2	1.1
Financial profitability of the operation	3.1	1.0
Self-determination in farmer's work	3.9	0.9
Pride in what the farmer does	3.8	1.0
Personal satisfaction	3.6	1.0
Reputation	3.6	1.0
Using the latest technology	2.7	1.0
Keeping the farm business under family control	4.0	1.1
Transferring the business to the next generation	3.3	1.3
Farm size growth	2.9	1.3
Revenue growth	2.9	1.2

Source: own composition

The education level of 62.1% of the family farmers is at least at practical/short courses or higher, and 37.9% have academic levels of education.

Additionally, Table 2 and Table 3 represents the mean values and standard deviations regarding the variables of resources and success. In general, family farmers assess their resources and success as being above average.

Classification of the multiple success items is handled using classification algorithms based on data mining and machine learning techniques. The most influential classification algorithms have been discussed in Wu *et al.* (2008). To group the perceptions of success according to farm characteristics and resources, decision tree learning algorithms (Kotsiantis, 2014) were considered. The most common classification methods are Classification and Regression Trees (CART) (Breiman *et al.,* 1984; Loh, 2014), Chi-squared Automatic Interaction Detector (Kass, 1980), C4.5 and C5.0 (Quinlan, 1996) and Random Forest (RF) (Breiman, 2001; Biau and Scornet, 2016). Among the options offered by the algorithms, we used C5.0 algorithm in this study. C5.0 has similarities with other algorithms, but it differs in the splitting procedure of categorical variables, and the objective of the algorithm is to develop a single tree. In addition, the C5.0 algorithm has multiway splitting technique instead of binary. This algorithm was chosen in line with the initial analysis of Hodges-Lehmann Median differences (Hodges and Lehmann, 1963) on error rates, comparing the performance of such algorithms (Appendix 2) and its suitability for the context of this study including the multiplicity of items. For our dataset, C5.0 performed significantly lower error rates comparing to, for example, CHAID and RF.

C5.0 is a decision tree-based classification algorithm, an extended version of C4.5 presented by Quinlan (1996). The algorithm follows the split selection process based on the information gain (Forman, 2003). The aim of the algorithm is to maximise the information gain. Information gain is obtained by the calculation of expected information requirement (Quinlan, 1986), which, in contrast, is minimised to reach the aim. The formula for information gain (1) and entropy (2) is presented as follows:

$$Information\ Gain(Sample, Attribute) = H(Sample) - H(Sample|Attribute) \quad (1)$$

$$Entropy(Sample) = H(Sample) = -\sum_{i=1}^{m} p_i log_2^{p_i} \quad (2)$$

We evaluated the accuracy of the classification using the indicators of error measured in the algorithms, where p_i denotes the proportion of the number of those values occurred in the class *i*. In line with other algorithms, the indicators of error (error rates hereafter), which correspond to the proportion of misclassified observations in the estimations, are calculated to evaluate the accuracy of the algorithm:

$$Accuracy = (TP/TI) \times 100$$
$$Error\ rate_i = (1 - Accuracy_i)$$

where *TI* is the number of total instances, and *TP* is the number of correctly classified instances. In other words, the robustness criterion for the algorithm was set as the error rates in the classifications.

In the estimation, farm characteristics and resource variables were identified as features, and success variables as targets. For each target, C5.0 built one tree. We also examined the structure of the classification and the role that features play in the classification of each target. We formulated the features, farm characteristics, and resources together in the classification procedure. There was only one exception that to avoid overfitting, as also they have very similar meanings in survey language, the profitability resource was excluded

from the classification procedure of the first three success variables. The ratios of the trained datasets located in the terminal nodes were calculated, and the feature variables were sorted by their percentages to determine the variables that have the highest importance in the classifications. For further implications, the cross-validation process was held to gain insights on the generalisability of the classification. The process includes the splitting of the data as training and test subgroups (Quinlan, 1996), which in our case, were set to be 70% to 30%, respectively. The algorithm was run in R Project (Version 4.2.3) using *C50* package (Kuhn and Johnson, 2013).

Results

Error rates of the classifications of success variables are presented in Table 4. Success based on farm characteristics and resources is misclassified, with the percentages varying from 13.2% to 18.9%. The lowest error rate results in the classification of the success perception in the operation's financial profitability. The highest error rate is in the classification of the perception of success in keeping the farm business under family control. In general, there are no remarkable differences between the accuracy of the classifications of the perceptions of success of family farmers based on the farm characteristics and resources. Around 84% of the cases are classified correctly using the C5.0 algorithm.

Table 4: Error rates regarding the classifications of success variables.

Success variable	Error rate (%)
Best possible financial result	16.4
Maintaining an adequate standard of living for farmer and farmer's family	16.7
Financial profitability of the operation	13.2
Self-determination in farmer's work	17.3
Pride in what the farmer does	16.5
Personal satisfaction	17.3
Reputation	15.3
Using the latest technology	15.1
Keeping the farm business under family control	18.9
Transferring the business to the next generation	15.9
Farm size growth	17.1
Revenue growth	17.6

Source: own composition

Variables' levels of importance of farm characteristics and resources in classification of family farmers' perceptions of success are reported in Appendix 3. In general, farm characteristics have minor importance in classifications of family farmers' perceptions of success.

Table 5 presents the variables' levels of importance regarding the classification of family farmers' perceptions of success. The five highest and lowest levels of importance are sorted for each success variable. The best possible financial result is classified mostly by production technical skills, skills for exploiting opportunities, technology, machinery and equipment, private or company type of the farm, professionalism and networks of other family members, while in classification of best possible financial result, whether there are other business activities, whether the location of the farm is southwest and central Finland, collaboration/networking skills, whether the current situation of the farm business is stable, quality of products and services have the lowest levels of importance. Maintaining an adequate standard of living for the farmer and farmer's family is classified mostly by skills for exploiting opportunities, funding opportunities, technology, machinery and equipment, collaboration/networking skills, production technical skills, while the lowest levels of importance in classification corresponds to cooperation partners, whether the education level is practical experience/short courses or academic-level education, existence of children in the household, whether the primary production is grain farming, organisational culture. Financial profitability of the operation is classified mostly by funding opportunities, strategic planning and implementation skills, collaboration/networking skills, skills for exploiting opportunities, production technical skills, but the lowest levels of importance in classification belong to buildings, whether there are other business activities, private or company type of the farm, whether the farm has organic farming, whether the primary production is grain farming.

Self-determination in a farmer's work is classified mostly by production technical skills, funding opportunities, organisational culture, collaboration/networking skills, whether there is consideration of long term exit or generational change, while the variables with the lowest levels of importance are customer relationship management, whether there are other business activities, whether a farm was handed down by the family or purchased from a non-family source, private or company type of the farm, existence of children in the household. Pride in what the farmer does is classified mostly by collaboration/networking skills, organisational culture, skills for exploiting opportunities, quality of products and services, funding opportunities, but the lowest levels of importance correspond to whether there is a consideration of long term exit or generational change, whether the farm has organic farming, whether the farmer's education is related to agriculture, existence of children in the household, whether the primary production is grain farming. Personal satisfaction is classified mostly by collaboration/networking skills, quality of products and services, cooperation partners, strategic planning and implementation skills, financial management skills, while the lowest levels of importance in classification belongs to whether the location of the farm is southwest and central Finland, professionalism and networks of other family members, whether there is a consideration of long term exit or generational change, whether the current situation of the farm business is stable, whether the farm size under cultivation is lower or higher than average in Finland. Reputation is classified mostly by funding opportunities, quality of products and services, organisational culture, collaboration/networking skills, strategic planning and implementation skills, but the lowest levels of importance come from

Table 5: Variables with the highest and lowest variable levels of importance for classification of success.

Success variable	Highest	%	Lowest	%
Best possible financial result	sk1	100	c5	0.9
	sk3	89.5	c13	3.0
	r5	61.8	sk5	3.5
	c2	36.7	c9	3.9
	r8	35.5	r10	5.0
Maintaining an adequate standard of living for farmer and farmer's family	sk3	100	r9	0
	r2	91.4	c14	2.0
	r5	74.4	c8	4.4
	sk5	68.1	c6	6.8
	sk1	52.7	r11	6.9
Financial profitability of the operation	r2	100	r1	1.6
	sk4	85.69	c5	2.2
	sk5	76.26	c2	3.6
	sk3	47.64	c11	4.7
	sk1	38.84	c6	9.1
Self-determination in farmer's work	sk1	100	r6	1.26
	r2	91.82	c5	1.42
	r11	91.82	c3	1.73
	sk5	37.74	c2	1.89
	c10	36.64	c8	1.89
Pride in what the farmer does	sk5	100	c10	0.63
	r11	88.99	c11	3.77
	sk3	85.69	c12	4.09
	r10	65.72	c8	6.13
	r2	45.6	c6	7.39
Personal satisfaction	sk5	100	c13	0
	r10	92.3	r8	0
	r9	82.08	c10	2.2
	sk4	78.77	c9	2.67
	sk2	68.87	c4	3.62
Reputation	r2	100	r8	0.94
	r10	97.33	r4	2.04
	r11	83.96	c9	4.87
	sk5	82.7	c12	5.19
	sk4	59.12	c14	7.55
Using the latest technology	r5	100	c11	2.52
	sk3	100	sk1	2.83
	r2	67.14	c8	3.14
	r4	55.19	c12	3.93
	r8	46.7	c14	3.93
Keeping the farm business under family control	sk5	100	c2	0
	r8	84.75	c3	1.26
	r11	57.7	c6	1.57
	r4	43.87	sk3	2.67
	sk2	41.35	c10	3.46
Transferring the business to the next generation	sk1	100	c8	2.36
	sk5	96.86	c8	3.93
	sk3	87.58	r9	4.4
	r3	84.91	r10	8.18
	c11	58.81	c1	9.28
Farm size growth	r3	100	c11	0
	r5	79.72	sk4	3.3
	sk1	75.31	c9	5.5
	r4	56.29	r11	5.82
	r8	53.14	c10	7.23
Revenue growth	sk3	100	c12	0.94
	r3	91.35	c8	1.1
	r9	75.47	sk4	1.1
	r2	75.16	sk1	1.26
	r8	60.22	c8	3.14

Note: c1: existence of external labour, c2: private or company type of the farm, c3: whether a farm was handed down by the family or purchased from a non-family source, c4: whether the farm size under cultivation is lower or higher than average in Finland, c5: whether there are other business activities, c6: whether the primary production is grain farming, c7: existence of other family member(s) (aged over 18 years) in the household, c8: existence of children in the household, c9: whether the current situation of the farm business is stable, c10: whether there is a consideration of long term exit or generational change, c11: whether the farm has organic farming, c12: whether the farmer's education is related to agriculture, c13: whether the location of the farm is southwest and central Finland, c14: whether the education level is practical experience/short courses or academic-level education. r1: buildings, r2: funding opportunities, r3: profitability, r4: business competence, r5: technology, machinery and equipment, r6: customer relationship management, r7: networks of entrepreneurs, r8: professionalism and networks of other family members, r9: cooperation partners, r10: quality of products and services, r11: organisational culture, sk1: production technical skills, sk2: financial management skills, sk3: skills for exploiting opportunities, sk4: strategic planning and implementation skills and sk5: collaboration/networking skills
Source: own composition

professionalism and networks of other family members, business competence, whether the current situation of the farm business is stable, whether the farmer's education is related to agriculture, whether the education level is practical experience/short courses or academic-level education.

Using the latest technology is classified mostly by technology, machinery and equipment, skills for exploiting opportunities, funding opportunities, business competence, professionalism and networks of other family members, while the variables with the lowest levels of importance are whether the farm has organic farming, production technical skills, existence of children in the household, whether the farmer's education is related to agriculture, whether the education level is practical experience/short courses or academic-level education.

Keeping the farm business under family control is classified mostly by collaboration/networking skills, professionalism and networks of other family members, organisational culture, business competence, financial management skills, but the lowest levels of importance correspond to private or company type of the farm, whether a farm was handed down by the family or purchased from a non-family source, whether the primary production is grain farming, skills for exploiting opportunities, whether there is a consideration of long term exit or generational change. Transferring the business to the next generation is classified mostly by production technical skills, collaboration/networking skills, skills for exploiting opportunities, profitability, whether the farm has organic farming, while the lowest levels of importance come from existence of children in the household, existence of children in the household, cooperation partners, quality of products and services, existence of external labour.

Farm size growth is classified mostly by profitability, technology, machinery and equipment, production technical skills, business competence, professionalism and networks of other family members, while the lowest levels of importance belong to whether the farm has organic farming, strategic planning and implementation skills, whether the current situation of the farm business is stable, organisational culture, whether there is a consideration of long-term exit or generational change. Revenue growth classified mostly by skills for exploiting opportunities, profitability, cooperation partners, funding opportunities, professionalism and networks of other family members, while the variables with the lowest levels of importance are whether the farmer's education is related to agriculture, existence of children in the household, strategic planning and implementation skills, production technical skills, existence of children in the household.

Methodological Implications

This study provides a classification framework using the C5.0 algorithm among machine learning and data mining techniques. The results of the semi-supervised estimations were interpreted in accordance with the error rates, reflecting the accuracy of the algorithms, and therefore, how the algorithm performed in turn.

The algorithm might be further developed. Accuracy of the algorithm might be increased by further supervision, by bagging (Breiman, 1996), and boosting (Freund and Schapire, 1997) using C4.5 algorithm (Quinlan, 1996), winnowing or other approaches in training the data and building trees (Kuhn and Johnson, 2013). It must be noted that while the training accuracy is high, cross validation accuracy is low, which addresses the lack of generalisability of the conceptual model, due to potential overfitting issues. For similar data to that used here, which has somewhat concentrated frequencies in favour of some levels or medians, or variables that have more levels, a particular algorithm might be developed by weighting options (Ting, 2002) or adjusting misclassification costs. In that case, one might consider adjusting the error-based classifiers so that they become more cost-sensitive (Breiman *et al.,* 1984; Domingos, 1999). Likewise, as offered by the software, tuning options could be used. Alternatively, algorithms other than C5.0 could be employed – indeed, a comparison between alternative algorithms would be insightful.

Implications for Success Factors of Family Farmers

As indicated in the results, elements of perceptions of success in our study are concentrated within dimensions. To improve the classification performance, we used dimension reduction by applying Confirmatory Factor Analysis (Kline, 2023) as an alternative approach to pre-process the target variables to be used in classification procedure.

The factor structure was used in line with the same conceptualisation used by Yigit *et al.* (2024), whereby perceptions of success of family farmers are conceptualised as latent variables identified as economic, self-realisation, growth and family control, as are resources, taken to be capital, capability, organisational and skills (Figure 1). All success factors were found to be significant in the model, whose composite reliability and average variance extracted scores indicate that the model is reliable and valid. In the next step, the standardised loadings of each latent success variables were categorised into three; to be low, medium and high. It was determined that interpretation of the classification of latent success constructs would be also changed. Since the target variables are not observed but are constructs, and the categorisation explains the level of determination of the variance in those constructs, this procedure can be explained as the classification of the different levels of varying success constructs based on the characteristics and resources.

This study used a classification method which explored the relationships between variables from a non-causal perspective. This means that the interpretation of the analysis might show similarities, especially with correlation analysis. However, there are differences as well. To begin with, this method was more flexible compared to correlation analysis, an approach that requires assumptions such as linear dependency. However, this method does not indicate the direction of the relationships as simply as correlation method would, which makes the explanation of the results more complicated. Furthermore, interpretation of the results would be more complex if the data were pre-processed, even if there

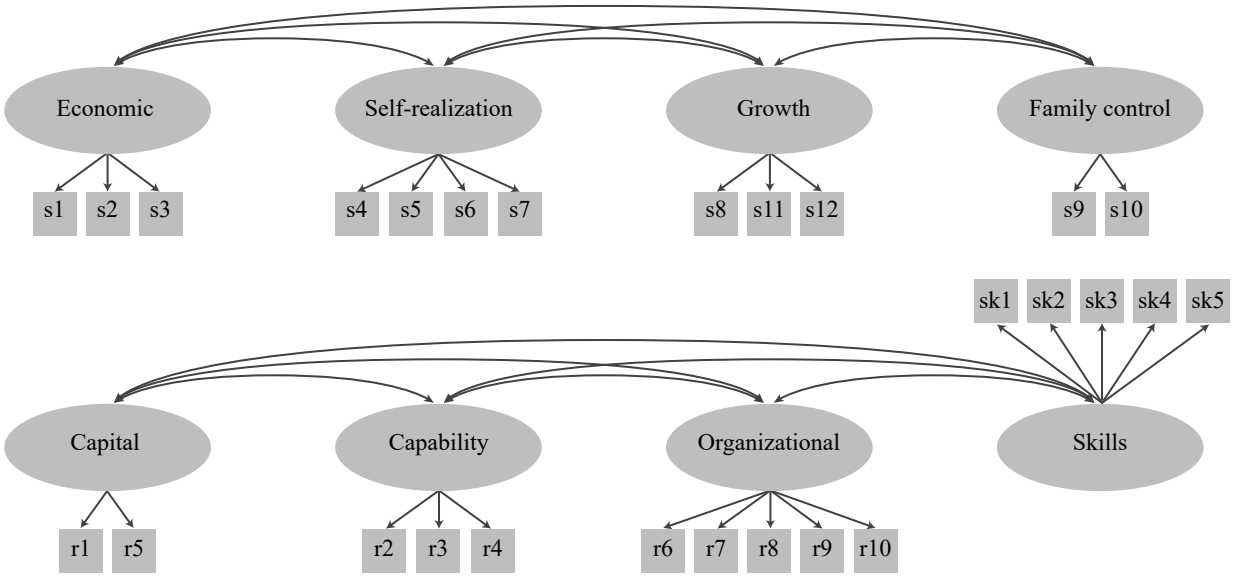

Figure 1: Factors of resources and success.

r1: buildings, r2: funding opportunities, r3: profitability, r4: business competence, r5: technology, machinery and equipment, r6: customer relationship management, r7: networks of entrepreneurs, r8: professionalism and networks of other family members, r9: cooperation partners, r10: quality of products and services, r11: organisational culture, sk1: production technical skills, sk2: financial management skills, sk3: skills for exploiting opportunities, sk4: strategic planning and implementation skills and sk5: collaboration/ networking skills, s1: best possible financial result, s2: maintaining an adequate standard of living for the farmer and farmer's family, s3: financial profitability of the operation, s4: self-determination in farmer's work, s5: pride in what the farmer does, s6: personal satisfaction, s7: reputation, s8: using the latest technology, s9: keeping the farm business under family control, sl0: transferring the business to the next generation, s11: farm size growth and s12: revenue growth.

Source: own composition

was a development in cross validation, as occurred in this study (Appendix 4). Further factorisation could simplify the classification process using the most important variables in the initial analysis, which in our case related to resources and skills, and in our case the simplification results in the observation that the most important factors are capabilities and capital (Appendix 5). However, it must be noted that we noticed a trade-off caused by the simplification, namely that it still increases the cross validation (Appendix 6) but it also limits the information to be interpreted.

Making it different from correlation analysis, this method provides performance measures. Instead of testing only the significance of the correlational relationship, this method provides the potential to monitor and develop the performances. Eventually, the data mining techniques could be challenging when using categorical data, such as in this study. However, the continuation of the efforts to develop the performance of the estimation is required in the literature (Maione *et al.,* 2019), especially when working with social data. Even though the overall performance of the classification algorithm in this study is still far from perfect, a fact which limits the generalisability of the results, we think it would be important to monitor the performance of the method of analysis.

Implications for Farm Characteristics and Resources

Most of the farm characteristics have only lower levels of importance in the classification of family farmers' perceptions of success. Although the characteristics of the farm and farmer influence management (Rikkonen *et al.,* 2013), we found that the characteristics in our study were not very important when classifying family farmers' perceptions of success. The existence of external labour and private or company type of farm are of minor importance, but they are involved in classification of several perceptions of success.

The existence of external labour has relatively low but a wide range of levels of relevance with the perceptions of success of family farmers. Hired external labour is an indicator of heterogeneity of goals among family farms, as it is a catalyst of technical efficiency especially in dairy sector in Europe (Garcia-Covarrubias *et al.,* 2024). The demand to use technological innovations, enhance the production capacity, support the family labour and intention to grow seem to diversify the perceptions of success and strategies of Finnish family farmers for hiring external labour.

Similarly, private or company type of the farm is relevant to several perceptions of success with minor importance, especially with farm size growth. Whether there is consideration of a long-term exit or generational change is of little importance in classification of self-determination. This touches on the potential structural changes related to the different decision-making processes in family farms, about which we can point out the discrepancy between the subjective perceptions of entrepreneurs on short-term changes in wellbeing and long-term plans (Dijkhuizen *et al.,* 2018). Speaking of structural changes, whether the farm has organic farming has moderate importance in the classification of transferring the business to the next generation, and in general in family control success. This is in line with Väre *et al.* (2021) on the succession plans of organic farms in Finland. And for all family farms in Finland, we found that whether the location of the farm is in the southwest or central part of

the country is also of little importance in the classification of using the latest technology. Whether a farm was handed down by the family or purchased from a non-family source has also low importance in several perceptions of success, especially revenue growth, which would be of interest to new entrants to the agricultural sector who already have a family background in farming.

In addition, this study found that some characteristics are not important in the classification of perceptions of success. Whether the farm size under cultivation is lower or higher than average in Finland, whether there are other business activities, whether the primary production is grain farming, the existence of other family member(s) (aged over 18 years) in the household, the existence of children in the household, whether the current situation of the farm business is stable, whether the farmer's education is related to agriculture, whether the education level is practical experience/short courses or academic-level education, are the characteristics that were not found to be important in the classification of family farmers' perceptions of success. These results would bring reconsideration of the framework that family characteristics could be implemented as dimensions of RBT (Habbershon and Williams, 1999), perhaps by using family capital (Danes *et al.,* 2009). It can also be suggested that more agrobusiness-related characteristics of family farms can be included as factors such as investments and variety of plant cultivation in more agriculture related decisions such as the use of fertilisers (Besuspariene and Niskanen, 2020), especially to give insights in addition with an agricultural policy dimension.

In a way other than the farm characteristics, most of the resources are important in classifying family farmers' perceptions of success. The most important variables in classification of success are found to be skills for exploiting opportunities, funding opportunities, and technology, machinery and equipment. To start with, the most vital resource feature in classification is skills for exploiting opportunities. Skills for exploiting opportunities are especially important in all economic and self-realisation related success, along with using the latest technology, revenue growth, pride in what as farmer does, transferring the business to the next generation, and a little in personal satisfaction and reputation. Unlike simply identifying opportunities (Pindado *et al*., 2018), 'skills for exploiting opportunities' imply a proactive managerial approach crucial for family farm success, emphasising the need for further research into farmers' strategic thinking (Mäkinen, 2013). Within this study, we define success as reflecting both the micro level, which is the profitability of individuals and households, and conversely, the macro level, which is business growth and achievement, as demonstrated by the skills for exploiting opportunities. We label this interpretation as 'having a profitability resource in the family farm while at the same time having the skills to exploit opportunities in the outside/business world'.

Funding opportunities are crucial for economic success, reputation, and revenue growth. They also contribute to reputation and self-determination, though to a lesser extent, economic stability. This suggests farmers may leverage funding opportunities as a form of social capital, as noted by Sutherland and Burton (2011), providing both practical resources and a sense of security. However, it is important to note that, while funding is important for self-realisation, it has limited impact on growth success beyond revenue.

Technology, machinery, and equipment are crucial for adopting the latest technology and maintaining family control of the farm business. This finding aligns with research highlighting the link between sustainable family business innovation and technological integration (Labaki and Haddad, 2019). For family farms, this underlines the importance of generational involvement and leveraging knowledge gained both from the market and from within the family (Fuetsch, 2022). Overall, technology significantly contributes to economic and growth-related success.

This study found that technical production skills, profitability, organisational culture, and collaboration/networking skills significantly impact multiple success perceptions. Notably, profitability plays a complex role in family-related success: it predicts the intention to transfer the business but not to maintain family control, and it contributes to general growth success while not to self-realisation. This seeming contradiction can be explained by the socioemotional wealth (SEW) perspective (Gomez-Mejia *et al*., 2011; Berrone *et al*., 2012), which prioritises non-economic values, a concept particularly pertinent in agricultural (Gómez-Mejía *et al*., 2007) and family farm research (Dressler and Tauer, 2015).

Technical production skills are important in self-determination in farmer's work, transferring the business to the next generation, farm size growth, maintaining an adequate standard of living for the farmer and farmer's family, but also important with the best possible financial result. Even though small-scale family farms are considered to use less machinery in arable farming (Yagi and Hayashi, 2021), technical capital still seems decisive in shaping perceptions about farm growth and survival. In this perspective, new insights on the technical and growth and survival relationship can be studied, using the efficiency of the farm business (Bojnec and Latruffe, 2008), or the conceptualisation of the farmer's concept of a farmer, entrepreneur, rural entrepreneur or a contractor (McElwee, 2008) by focusing on technical and strategic orientation of the family. We note in this study that perceptions of expanding family farms are associated with both financial and technical dimensions. In fact, we argue that technical production skills are vital, as also shown to be important in classification of factors of economic, growth and family control.

Organisational culture significantly influences maintaining family control of the farm, and to a lesser degree, impacts business transfer, revenue growth, and self-realisation. We attribute this to the concentric nature of family farming. While this study cannot determine causality, we propose further investigation through the lens of self-determination theory, exploring the relationship between autonomy, well-being (Markussen *et al*., 2018), and trade-offs with financial rewards (Ocean and Howley, 2023). This finding also provides a foundation for examining family farm resilience, including the intergenerational transfer of culture and experience (Hanson *et al*., 2019; Nuthall, 2009), and the potential for strategic adaptability.

Collaboration and networking skills are essential for emotional and family-related success, with a supporting role

in financial outcomes. This reinforces the need to prioritise social relationship development to address farmer stress, well-being, and family-work balance (Kallioniemi *et al*., 2008, 2016; Janker *et al*., 2021; Melberg, 2003; Gorgievski *et al*., 2010; Paskewitz and Beck, 2017). Historically, collaboration has been central to agricultural activities, especially family farming, making social interaction skills critical for emotional success. Meanwhile, other resources, while relevant, have a more focused importance. Buildings primarily classify living standards and profitability. Entrepreneurial networks classify farm expansion and revenue. Professionalism and family networks classify family control along with revenue and pride. Cooperation partners classify personal satisfaction and revenue, with minor importance in farm growth and technology adoption.

Some resources are important in classification of only some perceptions of success, and these resources are business competence, quality of products and services, financial management skills and strategic planning and implementation skills. Business competence is important in farm size growth, using the latest technology and keeping the farm business under family control. Quality of products and services is especially highly important in self-determination and pride, reputation, and a little in keeping the farm business under family control. Financial management skills are moderately important in personal satisfaction. Strategic planning and implementation skills are especially highly important in personal satisfaction, but they are also important in transferring the business to the next generation, and in general, in economic and self-realisation senses of success.

Customer relationship management showed no significant importance in the classification of family farmer success. While the majority of resources were impactful, their importance varied greatly. Some were highly influential in a small number of success measurements, while others provided small amounts of influence across many measurements.

Practical Implications for Successful Family Farming, Agricultural Policy and Rural Development

Classification of the family farmers' perceptions of success vary between success items. We note that the perceptions of success have not been studied widely, so it would be useful to provide some interpretation of the results on the classification. These concepts might be different from other measures, such as performance. In general, perceptions of success are classified most importantly by the resources and skills. Our main interpretation of the results revealing the importance of skills in classification of family farmers' perception of success is that successful family farming is highly related to agricultural entrepreneurship, entrepreneurial skills, plus economic flexibility/opportunities afforded to family farmers, and the development of innovation and technology at a rural level. From a broader perspective, this study also underlines that successful family farming is especially closely related to human and social capital, and capabilities. The two points that we think are important in enhancing the success of family farmers further are summarised below, to provide implications for family farmers, researchers of family farming, and stakeholders in agricultural policy and rural development.

This study measures the perceptions of success of family farmers, in which the dynamics of successful farming are considered in the strategic management of the family farm. Success elements might have different meanings when perceived by the farmers, based on subjective perceptions, such as eliminating obstacles while developing the farm business (Hansson and Sok, 2021), and might be at different levels according to the strategies that farmers have. This may be taken into account when thinking about, monitoring and making policies on strategies for the development of family farms.

The interplay between financial and psychological factors is evident (Heo *et al*., 2020). Integrating the family concept into success classifications introduces greater complexity, yet provides a more nuanced understanding. The query, 'Is success optimised by a particular strategy?' gains a distinct significance when evaluated through the lens of family farm management, given their unique goals, resources, and skills.

Conclusions

Perceptions of success of Finnish family farmers were classified mostly by resources and skills, because farm characteristics do not play key roles in the classification of these. Skills for exploiting opportunities, funding opportunities, and technology, machinery and equipment are among the more important classifiers in perceptions of success of family farmers. While some farm characteristics are important in some of the classifications (such as external labour, private or company type of the farm, consideration of long-term exit or generational change, organic farming etc.), some resources are found to be important in several classifications (e.g. technical production skills, profitability, organisational culture, collaboration/networking skills). Although this study's results are not generalisable, as indicated by the classification algorithm's performance, they highlight the intricate nature of family farmer success perceptions and strategies, where resource influence varies significantly across different success factors.

We hope that the interpretations from the results will be useful for considering perceptions of success of family farmers, and the process of resource development in family farms in line with business strategy, and resource use efficiency. In a broader perspective, this study provides insights to be used in academic and practical efforts in enhancing sustainable rural economic development. As implied in this study, we highlighted the importance of strengthening the social capital of family farmers and farmer groups, as a policy recommendation.

This study has limitations. As mentioned in methodological implications, firstly, that the accuracy rates when classifying the family farmers' perceptions of success are not high. Besides, we employed farm characteristics, resources and skills to classify perceptions of success, which are mostly

internal to the farms and farmers. However, some externalities that might classify the perceptions of success importantly as well, such as the influence of climate change and the change in the livelihood on the farm typologies. Besides, we focused on profit maximisation in measuring economic and financial success. However, the framework could be extended by including success measures regarding cost minimisation and survival strategies, which are also important for family farmers. Lastly, this study lacks insights on execution of strategy into practice in family farms.

Further research could perhaps enrich our understanding of the dynamics of family farmers' perceptions of success and farm characteristics and resources. We propose that an interesting approach could be to add characteristics unique to the country's agricultural sector. Studies from a different vision of natural resource management research could focus on, for example forest and water, livestock, forage quality and production, animal welfare, ecotourism, dairy and fisheries. More broadly, changes in socioeconomic, rural, and ecological structures could be considered as well. Furthermore, countries with different socioeconomic conditions and empowerment, institutional conditions, cultural aspects, and different norms in intensity of participation to collective/collaborative actions could be interesting to study. Lastly, a deeper approach considering family structure and the quality of health and wellbeing could also be insightful.

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Appendices

Appendix 1: Construction of the variables.

Variable	Construct
Farm characteristics	2 levels
External labour	use of external labour or not
Private or company	whether the farm is the private or company type
The farm was handed down by the family or purchased from a non-family source	whether farm was handed down by the family or purchased from a non-family source
The farm size under cultivation	whether the farm size under cultivation is lower or higher than average in Finland
Other business activities	whether there are other business activities
Primary production	whether the primary production is grain farming
Other family member(s) (aged over 18 years) in the household	whether there is another family member(s) (aged over 18 years) in the household
Child(ren) in the household	whether there is a child(ren) in the household
Current situation of the farm business	whether the current situation of the farm business is stable
Long-term exit or generational change	whether there is a consideration of long-term exit or generational change
Organic production	whether the farm has organic farming
Relatedness of education	whether the farmer's education is related to agriculture
Location	whether the location of the farm is in southwest or central Finland
Education	whether the education level is practical experience/short courses or academic-level education
Resources	5-levels
Buildings	self-assessment of the buildings of the farm company in relation to other farm companies in the same field
Funding opportunities	self-assessment of the funding opportunities of the farm company in relation to other farm companies in the same field
Profitability	self-assessment of the profitability of the farm company in relation to other farm companies in the same field

Variable	Construct
Business competence	self-assessment of the business competence of the farm company in relation to other farm companies in the same field
Technology, machinery and equipment	self-assessment of the technology, machinery and equipment of the farm company in relation to other farm companies in the same field
Customer relationship management	self-assessment of the customer relationship management of the farm company in relation to other farm companies in the same field
Networks of entrepreneurs	self-assessment of the networks of entrepreneurs of the farm company in relation to other farm companies in the same field
Professionalism and networks of other family members	self-assessment of the professionalism and networks of other family members of the farm company in relation to other farm companies in the same field
Cooperation partners	self-assessment of the cooperation partners of the farm company in relation to other farm companies in the same field
Quality of products and services	self-assessment of the quality of products and services of the farm company in relation to other farm companies in the same field
Organisational culture	self-assessment of the organisational culture of the farm company in relation to other farm companies in the same field
Production technical skills	self-rating of the skills of the people responsible for your farm company as a whole in the production technical skills
Financial management skills	self-rating of the skills of the people responsible for your farm company as a whole in financial management skills
Skills for exploiting opportunities	self-rating of the skills of the people responsible for your farm company as a whole in the skills for exploiting opportunities
Strategic planning and implementation skills	self-rating of the skills of the people responsible for your farm company as a whole in the strategic planning and implementation skills
Collaboration/networking skills	self-rating of the skills of the people responsible for your farm company as a whole in the collaboration/networking skills
Success	5-levels
Best possible financial result	self-assessment of how well the farm has managed to implement the best possible financial result in the farm business
Maintaining an adequate standard of living for farmer and farmer's family	self-assessment of how well the farm has managed to implement the maintaining an adequate standard of living for the farmer and the farmer's family in the farm business
Financial profitability of the operation	self-assessment of how well the farm has managed to implement the financial profitability of the operation in the farm business
Self-determination in farmer's work	self-assessment of how well the farm has managed to implement the self-determination in farmer's work in the farm business
Pride in what the farmer does	self-assessment of how well the farm has managed to implement pride in what the farmer does in the farm business
Personal satisfaction	self-assessment of how well the farm has managed to implement personal satisfaction in the farm business
Reputation	self-assessment of how well the farm has managed to implement a good reputation in the farm business
Using the latest technology	self-assessment of how well the farm has managed to implement using the latest technology in the farm business
Keeping the farm business under family control	self-assessment of how well the farm has managed to implement keeping the farm business under family control in the farm business
Transferring the business to the next generation	self-assessment of how well the farm has managed to implement transferring the business to the next generation in the farm business
Farm size growth	self-assessment of how well the farm has managed to implement farm size growth in the farm business
Revenue growth	self-assessment of how well the farm has managed to implement revenue growth in the farm business

Source: own composition

Appendix 2: Hodges-Lehmann Median Differences.

		Confidence Interval	
	Estimate	**Lower**	**Upper**
CHAID-C5.0	0.25	0.18	0.305
RF-C5.0	0.3	0.23	0.335
RF-CHAID	0.05	0.04	0.06

Source: own composition

Appendix 3: Variables' levels of importance of farm characteristics and resources in classification of perceptions of success.

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12
c1	9.75	26.57	26.57	17.45	13.52	25.16	13.05	11.32	17.45	9.28	26.57	31.13
c2	36.64	19.81	19.81	1.89	35.38	29.56	34.59	25.47	0	37.89	49.21	7.86
c3	10.85	16.19	16.19	1.73	41.19	15.57	32.39	32.7	1.26	11.48	11.95	43.08
c4	9.12	13.36	13.36	10.38	12.58	3.62	9.12	16.82	6.6	11.16	24.06	8.49
c5	0.94	16.67	16.67	1.42	11.48	12.74	27.83	9.59	19.65	25.16	8.96	12.58
c6	5.03	6.76	6.76	20.6	7.39	5.66	13.68	8.65	1.57	20.91	29.25	4.87
c7	10.85	4.4	4.4	23.27	6.13	6.29	16.67	6.45	10.22	3.93	9.59	1.1
c8	7.7	13.05	13.05	1.89	12.58	9.43	11.01	3.14	8.49	2.36	7.23	3.14
c9	3.93	10.69	10.69	5.19	8.02	2.67	4.87	7.55	6.13	10.85	5.5	9.59
c10	5.82	9.59	9.59	36.64	0.63	2.2	16.04	4.09	3.46	20.6	7.23	8.65
c11	16.19	27.83	27.83	10.53	3.77	6.29	11.01	2.52	21.54	58.81	0	12.89
c12	13.05	8.81	8.81	7.55	4.09	8.96	5.19	3.93	12.89	9.91	8.49	0.94
c13	2.99	6.92	6.92	3.77	16.67	0	21.38	43.08	20.44	9.75	20.28	10.38
c14	17.45	2.04	2.04	9.59	22.48	12.11	7.55	3.93	12.89	12.74	9.12	20.6
r1	22.17	26.73	26.73	25.16	11.95	39.31	12.11	13.21	7.55	14.78	30.66	32.23
r2	34.28	91.35	91.35	91.82	45.6	27.04	100	67.14	20.13	21.54	21.38	75.16
r3	*	*	*	7.86	41.51	10.69	35.22	18.24	37.11	84.91	100	91.35
r4	10.69	35.22	35.22	32.55	24.37	25.16	2.04	55.19	43.87	11.01	56.29	25.47
r5	61.79	74.37	74.37	21.54	13.52	33.33	28.62	100	15.72	35.85	79.72	35.22
r6	26.89	23.27	23.27	1.26	16.67	14.47	9.12	13.99	8.33	19.5	9.91	9.59
r7	17.45	26.73	26.73	5.5	18.71	13.05	0.94	10.22	8.65	19.34	53.14	60.22
r8	35.53	34.75	34.75	6.92	27.67	82.08	30.66	40.25	18.87	4.4	42.45	75.47
r9	27.2	0	0	5.66	65.72	92.3	97.33	22.01	30.03	8.18	9.75	46.54
r10	5.03	18.4	18.4	91.82	88.99	15.41	83.96	37.89	57.7	41.98	5.82	40.09
r11	18.24	6.92	6.92	31.76	41.67	0	23.74	46.7	84.75	37.58	30.19	55.66
sk1	100	52.67	52.67	100	43.87	21.23	18.55	2.83	9.91	100	75.31	1.26
sk2	33.96	22.33	22.33	3.3	37.89	68.87	13.99	27.36	41.35	12.11	7.86	26.89
sk3	89.47	100	100	11.79	85.69	41.82	38.36	100	2.67	87.58	12.11	100
sk4	16.35	31.92	31.92	22.96	38.99	78.77	59.12	24.84	8.81	41.67	3.3	1.1
sk5	3.46	68.08	68.08	37.74	100	100	82.7	12.42	100	96.86	14.31	37.89

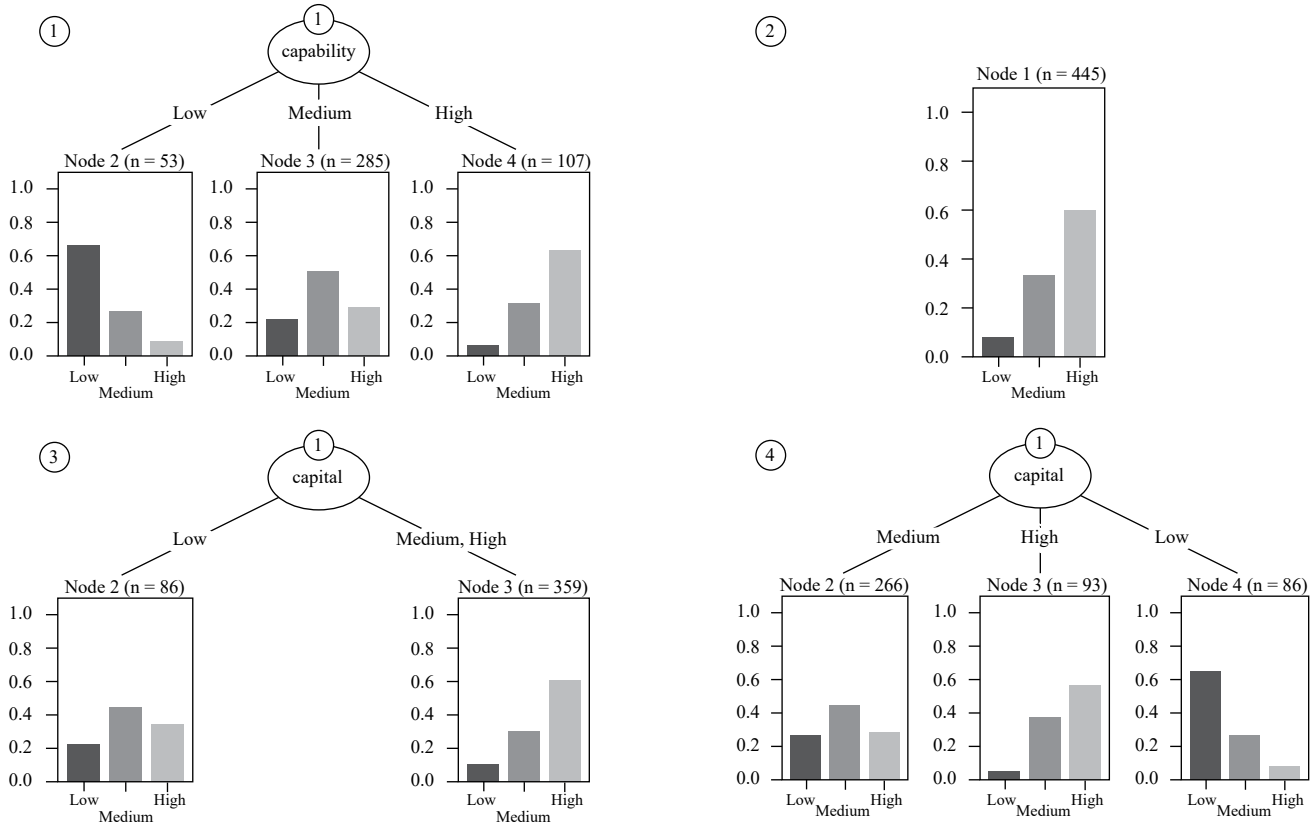
Note: c1: existence of external labour, c2: private or company type of the farm, c3: whether a farm was handed down by the family or purchased from a non-family source, c4: whether the farm size under cultivation is lower or higher than average in Finland, c5: whether there are other business activities, c6: whether the primary production is grain farming, c7: existence of other family member(s) (aged over 18 years) in the household, c8: existence of children in the household, c9: whether the current situation of the farm business is stable, c10: whether there is a consideration of long term exit or generational change, c11: whether the farm has organic farming, c12: whether the farmer's education is related to agriculture, c13: whether the location of the farm is southwest and central Finland, c14: whether the education level is practical experience/short courses or academic-level education. r1: buildings, r2: funding opportunities, r3: profitability, r4: business competence, r5: technology, machinery and equipment, r6: customer relationship management, r7: networks of entrepreneurs, r8: professionalism and networks of other family members, r9: cooperation partners, r10: quality of products and services, r11: organisational culture, sk1: production technical skills, sk2: financial management skills, sk3: skills for exploiting opportunities, sk4: strategic planning and implementation skills and sk5: collaboration/networking skills. s1: best possible financial result, s2: maintaining an adequate standard of living for the farmer and farmer's family, s3: financial profitability of the operation, s4: self-determination in farmer's work, s5: pride in what the farmer does, s6: personal satisfaction, s7: reputation, s8: using the latest technology, s9: keeping the farm business under family control, s10: transferring the business to the next generation, s11: farm size growth and s12: revenue growth
*: excluded from the classification
Source: own composition

Appendix 4: Accuracy rates of the classification of success factors for the cross-validation.

Success factor	Accuracy rate (%)
Economic success	46.60
Self-realisation success	55.50
Growth success	49.21
Family control success	47.64

Source: own composition

Appendix 5: Decision trees for the success factors based on resource factors.



Decision tree plots for the factors of 1: economic success, 2: self-realisation, 3: family, 4: growth
Source: own composition

Appendix 6: Accuracy rates of the classification of success factors using resource factors for the cross-validation.

Success factor	Accuracy rate (%)
Economic success	53.93
Self-realisation success	59.69
Growth success	59.69
Family control success	53.40

Source: own composition