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Clustering of the self-organizing map reveals profiles of farm profitability and upscaling weights

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ABSTRACT

Profitability and other economic aspects of farming in Finland are analyzed using clustering of the self-organizing map. The analysis of profitability bookkeeping data reveals several interesting relationships between the monitored financial variables. Economic profiles of farms are presented based on the clustering, and the findings are confirmed with statistical tests. A weight optimization system is proposed for upscaling financial figures of the sample of profitability bookkeeping farms to the whole country level. The system output is analyzed, and it is confirmed that the most important large and medium-sized enterprises are represented well by the sample. Furthermore, it seems that the utilized arable area is the key factor in guiding the weight optimization process. These findings may turn out to be useful in developing the sampling of bookkeeping farms in the future.

1. Introduction

Profitability of farm enterprises is very important as it makes it possible for the farms to stay in business in the long run and, thus, be a part of a stable food supply chain. Farm profitability has been fluctuating strongly in Finland during the recent years [1]. This may complicate the farmers' planning for the future.

In this paper, clustering of the self-organizing map (SOM) is used to analyze financial data of agricultural and horticultural enterprises. The data are collected from a sample of bookkeeping farms, and they are the source of many figures characterizing Finnish agriculture in the EconomyDoctor service of Agrifood Research Finland [2]. In addition, a weighted upscaling system for obtaining country-level results based on the sample is analyzed using the SOM. The goal is to discover interrelations between financial variables and find out how different kinds of farms are represented by the sample based on the weighting, cf. [3].

The SOM has been successfully used in financial analysis, e.g., benchmarking of industrial companies [4,5]. The SOM has recently been applied in the field of agricultural science for predicting losses induced by typhoons [6], land cover identification [7], soil analysis [8], detection of potential alien pests [9], and evaporation estimation based on meteorological variables [10]. Agriculture-related use of the SOM can also be found in the literature with the aim of assessing the importance of farm ponds for biodiversity [11,12], disease detection [13], apple mealiness detection [14], and plant species detection [15].

In the field of agricultural economics, the SOM has been applied less frequently. Simpler SOM analyses of the relationships within the bookkeeping farm data have been recently published [16,17]. Hypotheses presented in these earlier studies are tested in this paper. The bookkeeping data have also been analyzed with the aim of understanding input substitution and technological development of farms [18] and finding changes in productivity [19,20]. In addition, neural networks have been used in predicting the sufficiency of internal financing of farms [21].

The organization of the rest of the paper is as follows: in the next section we present the data, in Section 3 the structure of the weighting system is introduced, in Section 4 the SOM, clustering of the SOM, and related parameters are explained, the results are shown in Section 5, and conclusions drawn in Section 6.

2. Profitability bookkeeping data

Annual profitability figures for Finnish agricultural and horticultural enterprises showing the average results of over 60 000 enterprises are calculated from the profitability bookkeeping organized by MTT Agrifood Research Finland. Profitability of

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Table 1
Numbering of economic size classes, types of farming, and support areas.

No.	Economic size (€)	Type of farming	Support area
1	$e_i < 2000$	Cereal farms	A
2	$2000 \le e_i < 4000$	Other crop farms	B
3	$4000 \le e_i < 8000$	Horticulture, indoor	C1
4	$8000 \le e_i < 15\,000$	Horticulture, outdoor	C2
5	$15\,000 \le e_i < 25\,000$	Dairy farms	C2P
6	$25\,000 \le e_i < 50\,000$	Cattle farms	C3
7	$50\,000 \le e_i < 100\,000$	Sheep, goats and other grazing livestock	C4
8	$100\,000 \le e_i < 250\,000$	Pig farms	
9	$250\,000 \le e_i < 500\,000$	Poultry farms	
10	$500\,000 \le e_i < 750\,000$	Non-classified	
11	$750\,000 \le e_i < 1\,000\,000$		
12	$1\,000\,000 \le e_i < 1\,500\,000$		
13	$1\,500\,000 \le e_i < 3\,000\,000$		
14	$e_i \ge 3\,000\,000$		

Finnish farms is monitored using a sample of approximately 1000 farms yearly. Data from the year 2010 are used in this study. In 2010 there were 940 bookkeeping farms. The original aim has been to represent the 40 000 largest enterprises of Finland, which is why the sample contains only a few small farms.

The form of bookkeeping data is similar to the data in the Farm Accountancy Data Network (FADN) [22]. There are thousands of variables in the bookkeeping data bank. The variables used in this study were selected by an expert. The aim was to select variables that have potential of providing a diverse picture of the economic performance – especially solvency and profitability – of farm enterprises. The following variables are used to characterize each bookkeeping farm i: economic size e_i, utilized arable area a_i, support payments, total gross return, entrepreneur's profit, livestock units, interest claim, equity ratio, return on assets, entrepreneurial income, profitability ratio, return on equity, hourly earnings, total assets, equity, interest rate, wage and interest claim, liability pay-back period,[1] debt-%, working hours, rented arable area, type of farming, and support area.

The wage cost of own labor in 2010 is calculated using an hourly wage claim of 14€. The interest cost of equity is calculated on the basis of a farm-specific interest rate, which is the sum of the risk-free interest rate and a farm-specific risk premium. The risk premium depends on the temporal variation of equity ratio, return on assets, and debt-%. When the compensations for labor input and own capital are deducted from entrepreneurial income, we obtain the entrepreneur's profit. The profitability ratio is defined as $E/(W+I)$, where E is the entrepreneurial income and W and I are the wage and interest claims, respectively [23]. When the profitability ratio is 1, all production costs have been covered and the entrepreneur's profit is zero [2].

In addition, structural data of agriculture containing the total number of farms and total utilized areas in the support areas, size classes, and types of farming have been calculated based on farm register data obtained from Information Centre of the Ministry of Agriculture and Forestry Tike.

According to a Regulation of the European Commission, there are 14 economic size classes of farms. In the EU farm production is divided into about 60 types. Ten types of farming are present in Finland, some of which are combinations of more specific EU farm types. In addition, there are seven support areas in Finland. Table 1 shows the economic size classes, types of farming, and support areas from south (A) to north (C4). The geographical locations of the support areas are shown in Fig. 1.

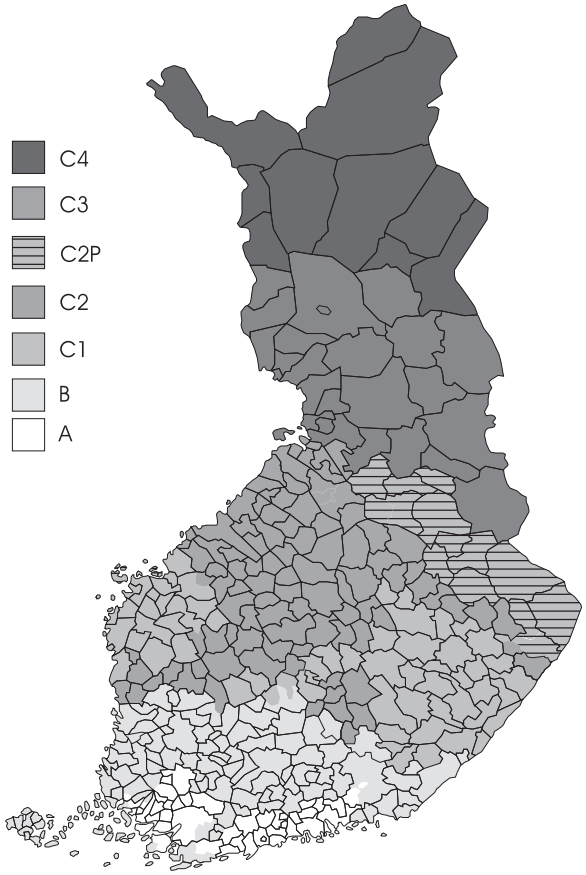

Fig. 1. Map of support areas in Finland. Source of the image: Agency for Rural Affairs (Mavi).

Areas are reported in hectares in the data and the currency unit is €. Livestock units are defined as grazing equivalents of dairy cows, i.e., small animals count for less than one livestock unit. See [24,2,21] for more information on the calculation of financial variables, and [25,24] on the determination of types of farming.

3. Weighting system

MTT Economic Research calculates annually the result and profitability development of Finnish agriculture and horticulture. In this total calculation the results for the whole country are obtained by summing up the weighted results of the bookkeeping farms [26]. A weighting system is presented in this section for obtaining reliable upscaling results based on the bookkeeping farms.[2] The total results for the country's over 60 000 farms are, thus, calculated by summing up the weighted figures of the bookkeeping farms.

Weighting coefficients are calculated annually for each bookkeeping farm by numeric optimization so that when multiplied by the weighting coefficients and summed up the number of farms and cultivation areas correspond to the total number of farms and cultivation areas both in the whole country and in each support area. Within the support areas the weighting based on the number of farms is done according to farm size classes. By weighting

[1] Liability pay-back periods above 50 years were considered uninformative and were, therefore, truncated.

[2] See [27,28] for similar approaches of upscaling the FADN data to the sectoral scale.