ELSEVIER

Agricultural Economics 27 (2002) 175–181

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

Measuring managerial efficiency: the case of commercial greenhouse growers

G. Trip*, G.J. Thijssen, J.A. Renkema, R.B.M. Huirne

Department of Social Sciences, Wageningen University, Wageningen, The Netherlands

Received 27 March 2001; received in revised form 15 February 2002; accepted 19 February 2002

Abstract

Recently the managerial decision making process has been given new attention, both in theoretical studies as well as in empirical research explaining differences in farm results. However, while critical to explaining efficiency, managerial ability has been difficult to measure and therefore often ignored. This study attempts to measure managerial ability. It divides the decision making process into four steps: goal formulation, planning, monitoring and evaluation. The quality of each step is measured in a panel of 26 specialised flower producers. The impact of decision making on the firms' efficiencies is measured by means of a stochastic frontier production function. A one-step procedure is used in which technical and decision making parameters are jointly estimated. The results show positive associations between firm efficiency and the quality of decision making (especially monitoring and firm evaluation), indicating that this procedure has been potentially successful and is a move towards successfully measuring a critical input.

JEL classification: Q12

Keywords: Decision making process; Efficiency; Horticulture

1. Introduction

Differences in technical and economic results between comparable firms operating under similar conditions are often found to be highly significant. In explaining these differences various factors can be studied. These include the technical and biological processes used, such as use of fertiliser, labour input, mechanisation, irrigation, storage of product and crop rotations (e.g. Thijssen, 1992; Wilson et al., 1998). At a deeper level however the quality of decision making leading to input decisions can be considered. While decision making systems are given ample attention in the literature, both outside and inside agriculture (Boehlje and Eidman, 1984; Kay and Edwards, 1994), empirical studies are scarce. Recently, Wilson et al. (2001); Nuthall (2001) stressed that more detailed information about decision making should be used in explaining differences in firm efficiencies. The main reason for ignoring decision making aspects seems to be the difficulty and cost of quantifying the relevant variables (Kirkley et al., 1998; Rougoor et al., 1998).

This study addresses the question of quantifying the quality of the decision making process, as reflected in (1) producers' goals and policies, (2) the quality of their planning, (3) the quality of data recording and monitoring and (4) the quality of evaluation. The

* Corresponding author. Present address: Farm Management Group, Hollandseweg 1, 6706 KN Wageningen, The Netherlands. Tel.: +31-317-483-367; fax: +31-317-482-745.
E-mail address: ger.trip@alg.abe.wag-ur.nl (G. Trip).

0169-5150/02/$ – see front matter © 2002 Elsevier Science B.V. All rights reserved.
PII: S0169-5150(02)00035-X

stochastic frontier production function (Aigner et al., 1977) is used to estimate the effects of decision making variables on differences in firm efficiencies, through a one-step procedure in which technical and decision making parameters are jointly estimated (Battese and Coelli, 1995). The study focuses on commercial greenhouse growers in the Netherlands using a panel of 26 specialised chrysanthemum producers working under similar conditions. Several production cycles were observed in the course of a year.

2. Background

The data were collected in 1994 as part of a larger project in which other aspects of production and decision making were studied (e.g. product variety choice). Chrysanthemums are, after roses, the second most important cut flowers in the Netherlands; in 1999 the total production area was 813 ha and the number of firms was 654 (Anonymous, 1999).

The surveyed firms were randomly drawn from those located in the Westland and De Kring regions, using a membership list of the Dutch Federation of Horticultural Study Groups, an organisation to which almost all Dutch chrysanthemum growers belong. The study started with a group session in November 1993, followed by a year of (individual) bimonthly firm visits. This allowed for an extensive analysis of the decision making cycle since approximately four production cycles are carried out in 1 year (in summer total production length is about 10 weeks, in winter about 15 weeks). In addition, the firms supplied data on their production technology (capital and labour used), production processes and sales. Every grower was asked to record all sales per 4-week period, corresponding to the administrative system of the Dutch auctions. Dates of harvesting, length of vacancy, dates of subsequent planting and plant density were recorded for every production cycle in every section of the greenhouse.

The average turnover of the firms showed a large variation, from 67.1 to 126.1 guilders/m^2 per year, with an average of 90.8. The average selling price was 47.5 guilder cents (cents) per stem. One firm received 63.9 cents on average during the year, whereas the lowest average selling price was 39.2 cents. Yields varied between 163.4 and 226.4 stems/m^2 per year, with an average of 191.2.

These differences in output are to a large extent caused by differences in structural inputs. Firms with new glasshouses, using additional lighting for assimilation and a large labour input for product handling, are likely to generate a higher output than less well-equipped firms. The oldest glasshouses were built in 1970 and the youngest in 1992. Supplemental light was used on 32% of the total area. The input of labour varied between 5262 and 9247 h/m^2 per year. Furthermore, economies of scale are likely to exist for costs, but not for yields per square meter; small firms can reach similar yields as larger firms.

3. The model

The elements of the model are shown in Fig. 1. Management qualities are reflected in the process of transforming input into output. The level of turnover per square meter is used as the objective, as in the short term growers tend to think and act in terms of maximising turnover per square meter given the available firm technology.

The construction year of the greenhouse, the size of the area of supplemental lighting and the labour input are the main variables accounting for differences in firm technology. These variables also influence the level of fixed costs (interest, depreciation, and fixed labour). Variable costs, such as plant material and sales costs, are assumed to be linearly related to turnover and are therefore not taken into account.

The four elements of a firm's decision making (see Fig. 1) reflect the four main stages of a cyclical process. Given its production technology a firm will achieve a certain level of turnover as a result of the decisions made and implemented. Not included in this model are personal aspects such as age, experience, education, social skills and intelligence. These factors are likely to influence firm results (e.g. Jose and Crumly, 1993; Parikh et al., 1995), through the efficiency of the decision making (for an overview see Rougoor et al. (1998)).

To measure efficiency a stochastic production frontier approach (Fried et al., 1993) is used. Battese (1992) overviews empirical applications in the field of agricultural economics. Inefficiency is defined as the distance between a firm's actual turnover per square

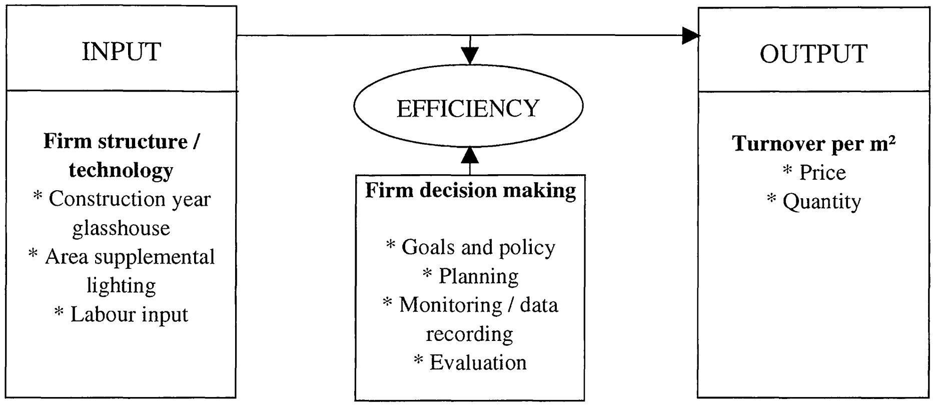

Fig. 1. Variables affecting efficiency.

meter per year and the estimated frontier turnover that corresponds to the state of its production technology (age of the glasshouses, labour input and investment in supplemental lighting). Physical output is used as the dependent variable in many studies, leading to an estimate of technical (in)efficiency. In this study, money values are used as the dependent variable (see also Battese and Coelli (1988) who uses total gross farm returns, or Aigner et al. (1977) who use value added).

In a one-stage procedure, the inefficiencies and the reasons for these inefficiencies (based on decision making and managerial practices) were estimated simultaneously. Based on Battese and Coelli (1995), and Coelli et al. (1998), the following model was used:

$$\ln(T_i) = \ln(X_i)\beta + V_i - U_i, \quad i = 1, \dots, 26$$

where T_i is the turnover per square meter per year of the ith firm, X_i the vector of technology inputs (construction year of the glasshouses (CY), area of supplementary lighting (SL) and labour input (LA)) for the ith firm, β a vector of unknown parameters, V_i the random variables which are assumed to be independently identically distributed (i.i.d.) $N(0, \sigma_{\rm v}^2)$, and independent of U_i, and U_i the non-negative random variables which are assumed to account for economic inefficiency and are assumed to be independently distributed as truncations at zero of a $N(m_i, \sigma_{\rm u}^2)$ distribution.

In this definition of U_i, $m_i = z_i\delta$ where z_i is a vector of decision making variables (goals and policy, planning system, data recording and evaluation system) which may influence the efficiency of a firm, and δ a vector of parameters to be estimated.

Pure random disturbance, V, is separated from disturbances that can be attributed to the level of the decision making, U, via δ. The level of (in)efficiency is estimated as $e^{-U(i)}$.

4. Measuring decision making

4.1. Goals and policy

Setting business goals is the basis for every organisation. The clearer are the goals, the more accurate the management can be (Kay and Edwards, 1994). The concept of critical success factors (CSFs) was used to detect the goals of the growers. CSFs were explained to the growers as the key issues that must be carried out exceedingly well for success (Rockart, 1982, p. 85). A similar approach can be found in Boyatzis (1982, p. 48), who asked managers if a certain job element differentiated between superior and average performance. The growers were asked to formulate three CSF to see if they were able to express their goals. Their answers ranged from ‘cost control’ to ‘being well motivated’. These CSF were subjectively scored on two criteria: distinctiveness and specificity. The more distinctive and the more specific, the more points were assigned (maximum four points for each factor). The scores ranged from 1 to 9 with an average of 5.15.

4.2. Planning

The focus in this study was on production planning at a tactical level. Growers were asked to provide their planned dates for harvesting and subsequent replanting. Some growers already had the production plan written down, in which case this provided the necessary data. Others had to look at the 'cultivar-card' to see on which day the cuttings had been planted and then calculate the expected harvest date (and subsequent vacancy and replanting date). This task was performed twice in winter 1993 and summer 1994.

These forecasts turned out to be rather inaccurate. The maximum absolute error (at the beginning of the next planting) in winter varied from 5 to 21 days between growers, with an average of 9.9 days, and in summer the maximum error ranged from 1 to 16 days, with an average of 6.1 days. Most growers tended to be too optimistic since their actual replanting generally took place later than planned. In winter, 17 out of the 26 growers usually had a delay in replanting, in summer 21 (out of the 26).

The deviation between plan and realisation was taken as a measure of the quality of the planning, and the growers were ranked accordingly. The total error in a planning task was calculated as the sum of three absolute deviations: the start of the harvest, the duration of harvesting and the duration of the subsequent vacancy. A ranking was made for the winter and the summer planning task. It turned out that the better planners in winter were also likely to be the better planners in summer (Spearman rank correlation $R = 0.64$; type I error $p = 0.00$). Average ranking (summer and winter) was used in the stochastic frontier approach.

4.3. Data recording and monitoring

Monitoring and data recording itself is not a sufficient requirement for making better decisions. Data alone has no value until the decision maker gives meaning to them and uses them for current or future decisions (Davis and Olsen, 1985, pp. 200–202). The hypothesis is that growers who keep extensive records have better chances of monitoring the process adequately, will make better decisions and will eventually obtain better results.

Most growers used a 'cultivar-card' for writing down data for each section of the greenhouse. A measuring device was made to score the intensity of the data recording and analysis (see Table 1). Twelve relevant items were listed and for each item that was recorded one point was given to the grower. Two of these items referred to the use of a PC for data recording and analysis.

Some items were recorded by most growers: production dates, use of growth regulator, plant density, prices and weights and use of nutrients. Labour costs and crop length were recorded by about 50% of the participating firms. Qualitative remarks, light intensity and other variable costs were recorded by a minority. PCs for recording and analysis were used by about

Table 1
Intensity of the data recording for 26 chrysanthemum growers

Does the grower record following item	Maximum score	Mean score[a]
Plant density (of each production lot)	1	0.69
Production dates (planting, short day period, interruption and harvest)	1	1.00
Crop length (at beginning, short day period and harvest)	1	0.42
Use of growth regulator (dates, dosage and crop length)	1	0.75
Additional remarks (quality of stem and leaves, etc.)	1	0.38
Light intensity (per day)	1	0.21
Prices and weights of product sold	1	0.67
Use of nutrition, disease control, energy and water (per period)	1	0.63
Labour costs (per period)	1	0.54
Other variable costs (per period)	1	0.08
Using a PC for recording and analysis of sales	1	0.33
Using a PC for recording and analysis of production data	1	0.25
Total	12	5.96

[a] Mean score: proportion of growers recording this item.

one-third. The average total score for data recording was 5.96, 50% of the maximum possible score. The individual scores ranged from 1 to 11 and were used in the stochastic frontier approach.

4.4. Evaluation

The importance of evaluation and control is obvious for keeping in touch with the desired goals (Boehlje and Eidman, 1984, pp. 662–665). During the last firm visit growers were asked to evaluate their firm results for the year. Such evaluation could be based on a comparison with the results in the previous year(s), or a comparison with the results of colleagues/peers in the same year. In line with Katona (1975, p. 297), the peer comparison was used, since it is influenced less by general cyclical fluctuations in the business. The average level of satisfaction with own results compared to peers' was 3.6 on a scale from 1 (very unsatisfied) to 5 (very satisfied). Two growers out of the 26 were not able to give a level of satisfaction because, as they said, they did not know the results of colleagues.

The number of quantitatively based measures varied from 0 to 3, with an average of 1.55. Most-mentioned measures were price (12.5 times), production (10 times), turnover (six times), labour costs (five times) and other costs (three times). Statements about these factors were scored on level of specificity. For example: a full point was given when a grower stated "my production was 173, the average production of other (comparable) firms was about 183". For responses such as "my production was 173, slightly less than others", a score of 0.5 was given, and for non-numeric answers (e.g. "the level of

Table 2
Estimated efficiency scores and decision making variables for all 26 firms

Firm	Efficiency (rank)	Decision making variables			
		G (rank)[a]	*P* (rank)[b]	*D* (rank)[c]	*E* (rank)[d]
1	0.928 (6)	6 (10)	10.25 (10)	5.5 (14.5)	1 (19)
2	0.874 (10)	5 (15)	10.5 (11.5)	7.17 (9)	1.5 (14.5)
3	0.957 (3)	8 (3)	8 (7)	11 (1.5)	3 (3)
4	0.745 (23)	1 (25.5)	15 (15)	1.5 (24)	0 (24)
5	0.715 (25)	1 (25.5)	24 (24.5)	4 (20)	0 (24)
6	0.839 (11)	5 (15)	6 (4.5)	3.67 (21)	1 (19)
7	0.779 (19)	6 (10)	2.5 (1)	7 (10)	1 (19)
8	0.713 (26)	4 (19)	17.75 (18)	3.5 (22)	2 (9)
9	0.767 (21)	5 (15)	22 (22)	5.5 (14.5)	0 (24)
10	0.787 (18)	7 (6)	6 (4.5)	8.5 (6)	1.5 (14.5)
11	0.732 (24)	6 (10)	24 (24.5)	1 (25.5)	2 (9)
12	0.768 (20)	4 (19)	10.5 (11.5)	4.5 (19)	1.5 (14.5)
13	0.918 (9)	7 (6)	7 (6)	11 (1.5)	2 (9)
14	0.803 (16)	6 (10)	15.25 (16)	5 (17)	0 (24)
15	0.823 (12)	8 (3)	8.5 (8)	9.5 (4)	3 (3)
16	0.809 (15)	5 (15)	16.75 (17)	2 (23)	1.25 (16)
17	0.809 (14)	7 (6)	23.5 (23)	5 (17)	0 (24)
18	0.927 (7)	3 (22)	13.5 (14)	10 (3)	2 (9)
19	0.950 (4)	4 (19)	19 (21)	6.17 (12)	2 (9)
20	0.762 (22)	8 (3)	25 (26)	1 (25.5)	3 (3)
21	0.924 (8)	5 (15)	18 (20)	6 (13)	3 (3)
22	0.968 (1)	3 (22)	13.25 (13)	8.5 (6)	3 (3)
23	0.822 (13)	2 (24)	9.75 (9)	5 (17)	1 (19)
24	0.796 (17)	6 (10)	3.75 (3)	8.5 (6)	2 (9)
25	0.931 (5)	9 (1)	17.75 (19)	8 (8)	2 (9)
26	0.964 (2)	3 (22)	3.5 (2)	6.5 (11)	1.5 (14.5)

[a] Goal formulating ability, based on distinctiveness and specificity of goals formulated.
[b] Planning ability, based on difference in predicted and realised production cycle.
[c] Data recording ability, based on number of items recorded (see Table 1).
[d] Evaluation ability, based on number and specificity of measures used.

Table 3
Estimated coefficients in the stochastic frontier model

Parameter	Estimate (standard error)	t-Value	Significance (p)
β_0 (constant)	−136.7 (1.1)	−124.77	<0.001
β_1 (construction year)	18.41 (0.21)	86.38	<0.001
β_2 (labour input)	0.181 (0.135)	1.34	<0.1
β_3 (suppl. lighting)	0.215 (0.040)	5.43	<0.01
β_0 (constant)	0.330 (0.084)	3.93	<0.01
δ_1 (goals)	0.003 (0.010)	0.31	NS[a]
δ_2 (planning)	−0.000 (0.004)	−0.05	NS
δ_3 (data recording)	−0.020 (0.009)	−2.32	<0.05
δ_4 (evaluation)	−0.034 (0.020)	−1.67	<0.1

[a] Not significant.

production was nearly the same"), a score of 0.25 was given.

5. Estimation results

The estimated efficiencies ($e^{-U(i)}$) varied between 0.97 (firm 22) and 0.71 (firm 8), with an average of 0.84. Table 2 lists the (in)efficiencies of all firms and also the decision making variables. Four firms (3, 13, 15 and 24) were in the top 10 on every aspect of decision making, yet two of them (15 and 24) were not in the top 10 with respect to efficiency. Five firms (4, 5, 9, 12 and 16) were not in the top 10 for any of the decision making variables. Accordingly, their rankings in the efficiency list are low.

The estimated coefficients of the model are given in Table 3. The beta's are the estimated elasticities, except for SL, which is brought into the frontier equation merely as a dummy variable, taking on values 1, 0 or close to 0 (when a firm has a few additional lights). The age of a greenhouse affects turnover; at mean values, each additional year of age reduces turnover by 0.84 guilders/m^2. The maximum effect was roughly 18 guilders/m^2 per year (22 years $\times$ 0.84). Supplementary lighting affects turnover by 21.8 guilders/m^2 per year. One hour of extra labour (per hectare) leads to an increase in turnover of 23.9 guilders (per hectare).

Beyond these effects, the level of turnover also depended on efficiency aspects of decision making. Data recording has a positive effect on the level of efficiency (see δ_3; note that the negative sign of δ_3 means a positive influence because of the negative sign attached to U in the model), as does the level of evaluation. No significant relation was found, however, between efficiency and either goal formulation or planning ability.

With respect to the lack of influence of the ability to express goals on efficiency, perhaps goals are constantly changing over time and influenced by other people besides the firm manager. For example the role of other family members, as well as external advisers, in formulating goals was not taken into account, but can be important (Gasson, 1988, 1992).

While the planning variable has an insignificant effect on efficiency, the better planners had less vacancy in their greenhouse; a positive correlation exists between planning performance and level of vacancy (Spearman rank correlation $R = 0.62$, type 1 error ($p = 0.00$)).

6. Summary, discussion and conclusion

Methods of measuring managerial ability were explored. In quantifying efficiency, goal setting, planning, implementing and controlling were included in the analysis. Operational variables suitable for quantification were collected from 26 firms during 1-year-period, consisting of about four production cycles. These decision making variables were included in a stochastic frontier production function to estimate their effects on firms' efficiencies.

The results show statistically significant associations between some decision making variables and the efficiency of firms. From the management cycle, data recording and evaluation were found to be important. Firms with a high intensity of data recording and a high level of result evaluation were less inefficient.

Goal setting and planning were not found to be associated with higher levels of efficiency. It should be noted however that transforming decision making concepts into operational variables is necessarily arbitrary to some extent. Although the variables were carefully chosen to represent the various steps in the decision making process, further research is needed to determine if better quality indicators exist. Also, the implementation stage of the decision making process could not be included in this analysis, as a satisfactory way of measuring implementation quality was not found. Including the implementation stage may increase the proportion of variation in efficiency that can be explained.

This study has made a first step towards operationally measuring managerial efficiency. Further refinement of the technique is necessary. Further progress will make it possible to classify farmers and subsequently develop managerial training systems.

Acknowledgements

Two anonymous referees are gratefully acknowledged for valuable comments.

References

Aigner, D., Lovell, C.A.K., Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. J. Econom. 6, 21–37.

Anonymous, 1999. Agricultural Census 1999. Elsevier, Doetinchem.

Battese, G.E., 1992. Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. Agric. Econ. 7, 185–208.

Battese, G.E., Coelli, T.J., 1988. Prediction of firm-level technical efficiencies with a generalised frontier production function and panel data. J. Econom. 38, 387–399.

Battese, G.E., Coelli, T.J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empirical Econ. 20, 325–332.

Boehlje, M.D., Eidman, V.R., 1984. Farm Management. Wiley, New York.

Boyatzis, R.E., 1982. The Competent Manager: A Model for Effective Performance. Wiley, New York.

Coelli, T., Rao, D.S.P., Battese, G.E., 1998. An Introduction to Efficiency and Productivity Analysis. Kluwer Academic Publishers, Boston.

Davis, G.B., Olsen, M.H., 1985. Management Information Systems: Conceptual Foundations, Structure and Development, second ed. McGraw-Hill, New York.

Fried, H.O., Lovell, C.A.K., Schmidt, S.S., 1993. The Measurement of Productive Efficiency: Techniques and Applications. Oxford University Press, New York.

Gasson, R., 1988. The farm as a family business: a review. Agric. Econ. 39, 1–41.

Gasson, R., 1992. Farmers' wives—their contribution to the farm business. Agric. Econ. 43, 74–87.

Jose, H.D., Crumly, J.A., 1993. Psychological type of farm/ranch operators: relationship to financial measures. Rev. Agric. Econ. 15, 121–132.

Katona, G., 1975. Psychological Economics. Elsevier, New York.

Kay, R.D., Edwards, W.M., 1994. Farm Management. McGraw-Hill, New York.

Kirkley, J., Squires, D., Strand, I.E., 1998. Characterising managerial skill and technical efficiency in a fishery. J. Prod. Anal. 9, 145–160.

Nuthall, P.L., 2001. Managerial ability—a review of its basis and potential improvement using psychological concepts. Agric. Econ. 24, 247–262.

Parikh, A., Ali, F., Shah, M.K., 1995. Measurement of economic efficiency in Pakistani agriculture. Am. J. Agric. Econ. 77, 675–685.

Rockart, J.F., 1982. Chief executives define their own data needs. Harvard Bus. Rev. 57, 81–93.

Rougoor, C.W., Trip, G., Huirne, R.B.M., Renkema, J.A., 1998. How to define and study farmers' management capacity: theory and use in agricultural economics. Agric. Econ. 18, 261–272.

Thijssen, G.J., 1992. Supply response and input demand of Dutch diary farms. Eur. Rev. Agric. Econ. 19, 219–235.

Wilson, P., Hadley, D., Ramsden, S., Kaltsas, I., 1998. Measuring and explaining technical efficiency in UK potato production. J. Agric. Econ. 49, 294–305.

Wilson, P., Hadley, D., Asby, C., 2001. The influence of management characteristics on the technical efficiency of wheat farmers in eastern England. Agric. Econ. 24, 329–338.