THE ECONOMIC EFFECT OF AVERSION TO RISK DURING TACTICAL PLANNING IN POT PLANT PRODUCTION

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Abstract

Two risk avers strategies are applied during tactical planning in pot plant production. Production risk should be reduced by an extra optional week added to the cultivation-schedule and price risk should be reduced by a staggered selling-schedule. However, the effect of these risk avers strategies after a simulated implementation of tactical plans is limited. The first strategy results in a lower financial result. And with respect to the second strategy no significant difference can be proved. Therefore other approaches should be developed and attention should be directed to operational management. Futhermore, the present study shows the relation between the financial result and the efficiency of space utilization.

1. Introduction

Pot plant production in Western Europe is characterized by a complex organization of labour and greenhouse space (Krijgsman and Achter, 1973). Therefore tactical production planning, i.e. planning before the start of the cultivation, is required. Tactical planning in pot plant production is not only problematic because of the changing demand for labour and greenhouse space during the cultivation, but also because of uncertainty with respect to crop growth and price formation.

In this study the effect of simple risk avers strategies during the tactical production planning on the Net Farm Income (NFI) is determined by means of simulation. Linear Programming (LP) is applied to develop several tactical production plans, the implementation of which is simulated with a deterministic model of a standard Dutch pot plant nursery. The results of the simulations are statistically analysed and discussed.

2. Description of method and model

The characteristics of a standard Dutch pot plant nursery are described in a linear programming model of a compartment with an area of 3840 m^2. This model disregards uncertainty and is representative for a risk neutral manager. The first tactical plan (PLAN1) is determined by maximization of the expected NFI of the model. Subsequently three additional tactical production plans are developed. In these plans, however, uncertainty is taken in consideration, i.e. risk avoiding strategies are included in the model. In the second plan (PLAN2) all cultivation schedules are extended with one optional week at the end of the cultivation to avoid problems due to unforeseen delays of crop growth. With respect to the uncertainty of price formation no precautions are applied. In PLAN3 the opposite is the case. The number of plants per batch is restricted to stagger sales and reduce the risk of low prices. The cultivation schedules in this plan are not extended as in PLAN2. Finally in PLAN4 both risk avoiding strategies are applied. The cultivation schedules are extended and the number of plants per batch is restricted.

The implementation of each of the four plans is simulated under uncertain exogenous conditions. The simulation model describes the business process of the nursery from a organizational and economic point of view. A special submodel for the simulation of the crop growth of *Schefflera arboricola* 'Compacta' (Leutscher and Vogelezang, 1990) is included in the model to simulate unforeseen situations of crop growth depending on the exogenous conditions radiation and starting weight of the crop. The submodel is a simplified version of SUCROS (Penning de Vries and Van Laar, 1982).

Unforeseen developments of the selling-prices are simulated by a special submodel for price formation, which consists of two parts. In the first part a price is simulated for a standard saleable pot plant, which size is in optimal proportion to the size of the pot. Prices are based on ex ante tactical price forecasts and exogenous random deviational variables for long term (at least a year) and short term (one week at the most) effects. Seasonal influences are implicitly taken into account in the price forecasts. The Mean Absolute Percentage Error (MAPE), as formulated by Makridakis and Wheelwright (1978), of the price forecasts is in the present study 20 percent. In the second part of the submodel the price reduction is simulated, which should be applied when a non-standard product is sold. Due to organizational and economic reasons the manager may decide to sell pot plants with a size significantly deviating from the optimal size of the standard product. For these situations four classes of plant length are distinguished, in order to calculate the percentage of reduction. Figure 1 shows the minimum and maximum percentage of reduction for each class. Prizes of plants over 65 cm are also reduced, because the length of these plants is not in proportion to the size of the pot, which reduces the ornamental value of these plants. The minimum price reduction percentage is applied at the maximum price level. The price reduction percentage increases inversely proportional with the price level to the maximum value at the minimum price level. This negative correlation between the price level and the price reduction percentage is based on the market principle that there are better opportunities to sell non-standard products when the demand exceeds the supply on the market and the price level is relative high, than in the opposite situation.

During the implementation of the tactical production plan the availability of greenhouse space and labour is restricted, although temporary labour can be hired up to a certain amount. When an organizational problem arises, due to a deviation of crop growth, the original tactical production plan is executed exactly. This strategy is promoted nowadays by extension employees and producers of management supporting software.

The exogenous conditions, which cause the unforeseen situations of crop growth and price formation, have been simulated randomly and saved in a record of 25 independent scenarios of a period of one year. The financial results of the implementation of the tactical production plan are determined in 25 parallel simulations per plan.

3. Results

The average results of the simulated implementation of the four tactical production plans are presented in table 1. For each variable the standard deviation over all 25 scenarios is also presented. Analysis of variance shows that the effect of the tactical plans and the scenarios on the presented output variables is significant. The Weighted Average Price Reduction over all batches (WAPR) varies from 2.74 percent up to 4.48 percent. The differences between the plans are significant (T-test, significance probability < 0.05), except for the difference between the WAPR-values of PLAN1 and PLAN3, as indicated by the types in table 1. With respect to the greenhouse Space Utilization Efficiency (SUE) each plan is significantly different from all other plans. The standard deviation of the SUE of PLAN1 and PLAN3 are equal to zero, because the tactical production plan is executed exactly. In PLAN2 and PLAN4 the optional week is added to the cultivation schedules, which is only utilized in situations of unforeseen delays of crop growth. In the same situations during the implementation of PLAN1 and PLAN3 the plants are sold at reduced prices, which results in higher WAPR-values. The average values of the Total Cost year^{-1} (TC) are also significantly different from each other. Remarkable is the difference between the standard deviations of the TC in comparison to the standard deviations of the average Total Earnings year^{-1} (TE) and the average Net Farm Income year^{-1} (NFI). This difference should be attributed to the fact that only the selling-prices are simulated randomly. Due to this random simulation of selling-prices PLAN1, PLAN3 and PLAN4 are not significantly different with respect to the average TE. Only the average TE after implementation of PLAN2 differs significantly from the values of the other implemented plans. With respect to the average NFI the same remark has to be made. The average NFI year^{-1} varies from Dfl. -12.19 m^{-2} after implementation of PLAN2 to Dfl. 1.51 m^{-2} after implementation of PLAN3. The standard deviation varies from Dfl. 8.03 m^{-2} up to Dfl. 11.82 m^{-2}. The variance of the results of the implementation of the individual tactical plans is too large to find significant differences between PLAN1, PLAN3 and PLAN4.

It is not clear that the risk avoiding strategies applied in the present study result in a higher annual NFI. On the contrary, extending every cultivation schedule with one optional week results in an even lower annual NFI. It seems that this optional week is most of the time not utilized, which results in a lower SUE. Although the average results of the TE and NFI are not significantly different from each other in PLAN1, PLAN3 and PLAN4, it seems that there is a relation between these two variables and the SUE. Theoretically the TE should be zero when the SUE equals zero. In such a situation no plants are potted at all, no space is utilized and no plants are sold. Thus linear regression is applied to determine the relation between TE and SUE with an intercept equal to zero (equation 1).

$$TE = 7323\ SUE \qquad (1)$$
$$(S.E. = 47.2)$$

The parameter is tested for the H_0-hypothesis that it is equal to zero. With a significance probability smaller than 0.05 the H_0-hypothesis is not accepted. In addition a test has been applied for the H_0-hypothesis that the intercept is equal to zero. This H_0-hypothesis should be accepted since the significance probability exceeds 0.05. With the acceptance of equation 1 the conclusion should be that in the simulated situation the maximum average TE amounts up to Dfl. 732 300 $year^{-1}$, which is equal to Dfl. 190.70 m^{-2} $year^{-1}$. The NFI depends theoretically indirectly on the SUE through TE. An intercept lower than zero is expected because the fixed costs will weigh upon the NFI even when no plants are produced and the SUE equals zero (equation 2).

$$NFI = -590952 + 6644\ SUE \qquad (2)$$
$$(S.E.=103293.1) \quad (S.E.= 1179.3)$$

Both parameters are tested for the H_0-hypothesis that they equal zero. For both parameters this hypothesis is not accepted with significance probabilities smaller than 0.05. Theoretically the intercept of equation 2 should correspond with the fixed costs. The intercept of Dfl. 153.89 m^{-2} $year^{-1}$, is relative close to the average TC values presented in table 1. The relative low (negative) intercept is due to the fact that equation 2 is based on simulation results with high values of SUE. From a theoretical point of view the intercept should be fixed at the value of the fixed costs. From a more practical point of view, however, it is justifiable to base equation 2 only on results with realistic values of SUE. The consequence of which is a limited range (SUE> 80%) in which equation 2 could be applied.

4. Discussion

In general managers of Dutch pot plant nurseries aspire to a maximum SUE. The relation between the NFI and the SUE demonstrated in the present study indicates that this strategy contributes to the economic success of pot plant production in The Netherlands. With respect to the analysed risk avers strategies it is clear that from an economic point of view the strategy to avoid the consequences of delays of crop growth is not interesting. The small SUE-value indicates that this type of problem does not occur very often. A significant effect of the application of the price risk avers strategy could not be proven. In pot plant production sales are often already spread over the year, due to short cultivation-periods and the urge to attain a high SUE in the restricted space of the greenhouse.

Thus, the contribution of risk avers strategies, tested in the present study, to an improvement of the tactical planning is limited. In addition alternative strategies or planning methods may be designed and tested. More information about possible events could help to reduce uncertainty. A different approach to avoid problems due to uncertainty is to eliminate the disturbing conditions. Artificial growth conditions can forestall crop growth delays and delivery contracts lead to fixed selling-prices. It is, however, unlikely that it will be economical to eliminate uncertainty totally. Furthermore, despite of all efforts to improve the tactical planning in pot plant production, unforeseen developments will occur during the implementation of tactical plans. Therefore it is interesting to direct the attention to operational management. Operational management, i.e. management during the production, does not prevent all problems, but should resolve these problems with the best possible solution at the time (Steffen, 1989). During the implementation of the tactical plan uncertainty is reduced because of the fact that information with respect to crop growth and price formation is becoming available. The development of operational management supporting systems appears therefore a promising approach to improve production management on pot plant nurseries.

With respect to the simulation approach applied in this study some remarks should be made. Uncertain conditions are recorded in scenarios, which are applied one by one as input for simulation runs. The model of the pot plant nursery simulates the implementation of tactical plans under these input conditions. In general a model never covers the real system exactly and annoying, unaccountable results may be simulated. In this study, however, the simulated results correspond very well to the average financial results nowadays in Dutch pot plant production. The simulation approach opens the opportunity to analyse and appraise management strategies ex ante. Not only strategies with respect to risk aversion, but also other types of management strategies on the tactical and operational level. Further research will be concentrated on operational management in pot plant production. The simulation approach, described in this study, will also be applied in this future research.

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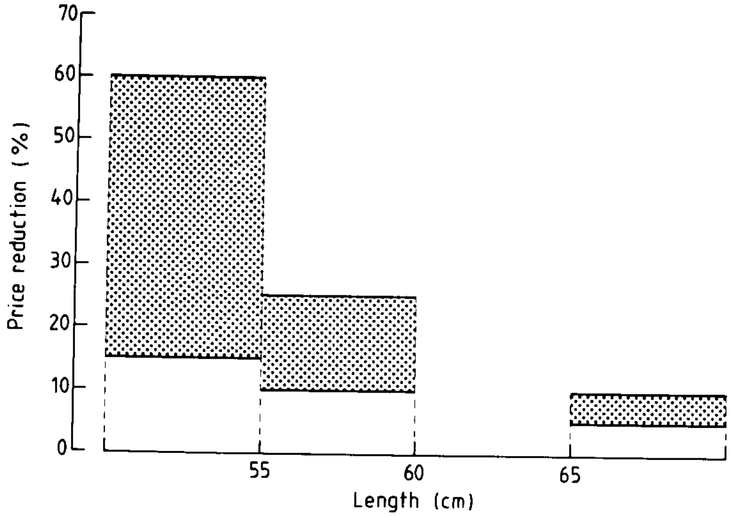

Figure 1 - Representation of the maximum and minimum percentage of price reduction in four classes of plant length.

Table 1 - Average results and standard deviation of the main variables.

PLAN	WAPR (%)	SUE (%)	TC (Dfl.)	TE (Dfl.)	NFI (Dfl.)
1	4.48 (a) (1.67)	89.30 (a) (0.00)	655114 (a) (3443)	659423 (a) (48614)	4309 (a) (45391)
2	3.12 (b) (0.62)	82.10 (b) (0.57)	632548 (b) (2688)	585728 (b) (33304)	-46820 (b) (30843)
3	4.18 (a) (1.43)	90.11 (c) (0.00)	659368 (c) (3033)	665173 (a) (41258)	5805 (a) (38438)
4	2.74 (c) (0.40)	88.61 (d) (0.69)	653097 (d) (2900)	652317 (a) (38431)	-780 (a) (35839)

WAPR : Weighted Average Price Reduction
SUE : Space Utilization Efficiency
TC : Total Costs
TE : Total Earnings
NFI : Net Farm Income