Expectations, Project Appraisal and Financial Sustainability in Protected Horticulture: New Models for Decision Support Systems

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Abstract

From a financial point of view, one of the most important problems for almost any horticultural farmer is to predict the future, profit expectations, above all, if the investment is very high as happens in greenhouses. In this situation, operations and resource management are basically under a controlled risk. On the other hand, production and resource prices could be considered properly as uncertain parameters. Project appraisal using simulation and multicriteria methods is a useful technique to analyse both different feasible alternatives and critical parameters for financial sustainability. Our software PRAPPIS v2.0 has been developed combining Monte Carlo and Goal Programming techniques and has shown satisfactory results in this context. However, some methodological problems appeared because of the technical relationship between agricultural activities and the financial items that describe them. For example: low production always means a decrease in part time hand labour in harvesting operations. In order to design an easy-to-use tool, an inference engine based on fuzzy logic has been developed for the PRAPPIS system. Users can introduce their financial parameters and then relate them using five options: very positive, positive, neutral, negative and very negative relations. For example, a neutral relation between parameter A and B has five inference rules, for example: if A increases, B must increase. This paper shows the statistical differences between traditional simulation, where parameters vary freely, and simulation using controlled relations. The statistical distribution in every financial result is a powerful tool for decision makers in horticulture where uncertainty is so high. In order to test our model, a standard subtropical greenhouse was selected. Green beans and cherry tomatoes were chosen in a 1 ha plastic "parral" structure. Theoretical and real technical and financial items were used for a five year project appraisal in an uncertain environment.

INTRODUCTION

The financial appraisal of investment projects is one of the most appropriate fields for simulation (Goodwin & Wright, 1998), particularly in horticulture. This is because this analysis is based on a cash flow estimation that needs to determine future revenues, costs and investments, almost always uncertain. In horticulture, these basic parameters depend strongly on farming –for example, fertilizer and pesticide treatments- and external factors like market prices, agricultural policies and so on.

Choosing the appropriate statistical distributions for each financial parameter is a very big problem in horticulture. Financial parameters can be grouped into three main sets (Fabre, 1997): investment costs, operating costs and benefits. Every set have many financial items like, for example, fixed capital, pre-production charges and working capital, all of them related, in this case, to investment costs. This choice –the appropriate statistical distribution for them- is a decision maker's problem that needs a deep knowledge of the project and its environment. Sometimes it is very difficult to obtain enough previous real data to base the choice, and we cannot always consider independent the statistical distributions chosen.

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Depending on the project description –more or less financial items detailed or grouped- and the life span considered –that includes the investment period-, project financial appraisal of horticultural projects can need a lot of computer resources because of the number of iterations needed for simulation. In order to reduce this number, some convergence algorithms (Ross, 1999) based on the standard error of, for example, the Net Present Value (NPV) of the project, can be used.

In conclusion, simulation in project financial appraisal is not a technological problem. We have methodology and enough computer resources. But there is an additional difficulty to approach: the management of dependence relationships between financial items, that is directly related to the independence of statistical distributions. Many of our financial items like, for example, sale revenues and harvesting salaries are closely related in real horticultural projects. Many methods have been proposed for approaching the dependence relationships between financial items (Goodwin & Wright, 1998): conditional sampling, correlating coefficients and more.

In this paper a new way to model dependence relationships in horticultural investment projects is proposed. In order to have a greater precision in financial appraisal a fuzzy inference engine is designed, developed and tested. Fuzzy logic is an appropriate methodology to approach the way decision makers have to explain dependence relationships between financial items in a cash-flow table. Using an every-day language, based on their own knowledge, users can design the structure of their relationships and the computer system can interpret it in a simulation process.

An artificial greenhouse project is designed to show the differences between standard simulation results -Monte Carlo method- and those obtained using the new model.

MATERIALS, METHODS AND EXPERIMENTAL PROCEDURES

PRAPPIS v2.0 PRoject APPraisal Information System is now being tested in risky and uncertain horticultural environments and in other contexts (García and Amador, 2001). The simulation process is controlled using a standard Monte Carlo method (Ross, 1999). Different statistical distributions can be chosen to adjust any of the project financial items. Certainty can also be considered an option. Statistical distributions of simulation results are studied automatically using nonparametric statistical methods (Kolmogorov-Smirnov-Lilliefors. Sheskin, 2000) in a financial context.

Financial items can be related in a semi-semantic way using every-day language that is as similar as possible to a decision maker’s explanation. First of all, users must previously define the financial items that are related. There are to basic structures for modelling their dependence relationships: simple and inverse multiple (García & Amador, 2002) but it is also possible to combine them in a most complicated or mixed structure (Figure 4). On the left hand side of the relation, there is always a unique parameter that is called “dominant” while, on the right hand side, there could exist one o more called “dominated”.

A set of financial items related among themselves is properly called a dependence relationship. Once its structure is defined by the user, five intensity options can also be chosen for it: very positive –for example, dominated parameters increase a lot if the dominant one increases a little-, positive -for example, dominated items increase a little bit more than the dominant one, if it increases-, neutral -for example, dominated parameters increase a similar amount compared to the dominant one if it increases-, negative –that is the opposite of the positive intensity option- and, finally, very negative –that is the opposite of a very positive intensity option-. There are five fuzzy rules like the examples for each intensity option.

A fuzzy inference engine (Mizumoto, 1995) has been designed and developed to manage both the intensity option chosen and the relationship structure designed. Depending on the statistical distribution chosen, the simulation process calculates first the value of the dominant parameter. PRAPPIS v2.0 automatically makes five triangular membership functions for it, and then this calculated value is analysed using the fuzzy inference engine (García & Amador, 2002). The membership functions transform the real value of the dominant parameter into words (this value increases a little, so much, is on the average, decreases a little, and so on) that include some ambiguity. Values of the dominated parameters (if there are more than only one) are finally determined by the fuzzy inference engine using the centre-of-gravity method (Mizumoto, 1995). In addition, a slight degree of uncertainty can also be included in the application of the inference rules.

A standard 1 ha. "parral" greenhouse (minimum investment required: 6.61 euros/m^2, estimated maximum investment: 10.82 euros/m^2, uncertainty conditions) is chosen to test the fuzzy inference engine (García & Amador, 2001). Two different crops are considered in a five year span of time: short cycle cherry tomatoes and green beans. Both real -Tables 6 and 7-, survey based data from AGROS system (García & Amador, 2001), and theoretical data, from many interviews with agro-technicians (García & Amador, 2001), -Tables 1 to 5- are used to determine the cost structure of this project. One uncertain investment, 37 cost items –risky partial hand labour in harvesting costs (PHLH, triangular distributions) and uncertain other costs (partial hand labour except PHLH –PHL- and other production costs –PC-)- and 14 uncertain revenue items in a five year project are tested with and without selected dependence relationships. The iteration number was fixed at 10,000.

A "simple-neutral" (García and Amador, 2002) dependence relationship between sale revenues and partial hand labour costs in harvesting (PHLH) is established for testing the inference engine and financial results. Net Present Value (NPV) is chosen as the main financial indicator, but also the investment payback period (IPB), profit/investment ratio (PIR) and the Internal Rate of Return (IRR) are considered.

RESULTS AND DISCUSSION

The main results in both cases (with and without dependence relationships) are shown in Tables 8 and 9. After 10,000 iterations, the NPV average of the situation "without" dependence relationships is slightly greater than that "with" (1.12%), but the difference is not significant. Of course, the NPV averages are identical in both cases but their standard deviations are not. The one "without" is greater than its opposite to a very significant degree (7.51%). The inner risk of our project is really lower than the standard Monte Carlo simulation process shows us.

Recovering the investment takes longer in the "with" dependence relationship situation (Table 9) where it takes between 2.65 and 3.80 years compared to the interval "without" located between 2.57 and 3.51 years. It is also interesting to note both spans of time: 1.15 years in the "with" situation and 0.94 years in that "without". Finally, the real IPB is longer and located in a time interval slightly greater that the standard Monte Carlo method also shows us. The variability coefficient (standard deviation divided by the mean) and its range in the "with" situation are lower (0.31-0.36) than in the other (0.34-0.40).

There is no difference between the two situations analysed considering the PIR (NPV divided by the investment). Only the standard deviation is slightly greater in the one "without". This result is absolutely obvious because after 10,000 iterations, the average of this ratio remains constant and both NPV and investment parameters are identical to the limit.

Identical behaviour is shown by the IRR. In both situations, this ratio is not significantly different but also the variability is greater in the "without" situation. In this case, this greenhouse project is very profitable.

Figures 1 and 2 show us the absolute frequency diagrams of the NPV in both analysed situations. Both distributions are very similar to a Normal one but we cannot prove that they are. This is because the cash-flow structure of the project, that shows us non-Normal distributions in almost four of its five years life span.

The probability of a negative NPV –financial losses- is between 3.80%-3.95% in the "with" dependence relationships situation. On the other hand, in the "without" situation, it is located in the 6.36%-6.58% range, which is a 67% greater for the same project (Figure 3). This parameter can be considered a measure of the inner financial risk of our horticultural greenhouse. Using dependence relationships, this financial risk decreases greatly. The real financial risk of the project is lower than the standard Monte Carlo method shows us, considering that every parameter is independent.

Also the slopes of the distribution curves (Figure 3) are different in the two situations. The two intersect at a point approximately located at (50050 –NPV-, 0.41 –cumulative probability-). At this point, the "with" dependence relationships curve has a greater slope that the "without" one. This means that, from this point, the cumulative probability of a given NPV is greater in the "with" situation.

CONCLUSIONS

The standard Monte Carlo simulation method has many limitations. In an uncertain horticultural context, where decision makers want to analyse different technical alternatives and processes, these limitations increase the statistical risk in financial appraisal. This is due to a mistaken understanding of business rules: dependence relationships between financial items.

Dependence relationships can be modelled using semi-every-day language in a decisional context. Fuzzy logic is an appropriate methodology for their interpretation and to design an inference engine to manage complicated business rules.

Considering a medium scale horticultural project, the computer system efficiency is really good, also if we force an unnecessarily high iteration number, because the statistical error of the NPV average usually decreases very quickly. Using dependence relationships, the results of financial appraisal are more realistic and, due to that, decision makers can use them in a more precise way.

The statistical distributions of NPV and other financial statements and indicators obtained from simulation processes cannot be considered as Normal ones in this context, with or without dependence relationships. This problem must be studied to adjust other methodologies based on mathematical programming.

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Tables

Table 1. Year 1 cost structure (euros) of the selected greenhouse. Theoretical data.

	PHLH (euros)	PHL (euros)	PC (euros)
Cherry tomatoes SC year	6380.90	11831.94	13617.40
Green beans	15498.00	0.00	5829.46
Total	21878.91	11831.94	19446.85

Table 2. Year 2 cost structure (euros) of the selected greenhouse. Theoretical data.

	PHLH (euros)	PHL (euros)	PC (euros)
Cherry tomatoes SC year-1	14888.77	1314.66	716.71
Cherry tomatoes SC year	6380.90	11831.94	13617.40
Green beans	15498.00	0.00	5829.46
Total	36767.68	13146.60	20163.56

Table 3. Year 3 cost structure (euros) of the selected greenhouse. Theoretical data.

	PHLH (euros)	PHL (euros)	PC (euros)
Cherry tomatoes SC year-1	14888.77	1314.66	716.71
Cherry tomatoes SC year	6380.90	11831.94	13617.40
Green beans	15498.00	0.00	5829.46
Total	36767.68	13146.60	20163.56

Table 4. Year 4 cost structure (euros) of the selected greenhouse. Theoretical data.

	PHLH (euros)	PHL (euros)	PC (euros)
Cherry tomatoes SC year-1	14888.77	1314.66	716.71
Cherry tomatoes SC year	6380.90	11831.94	13617.40
Green beans	15498.00	0.00	5829.46
Total	36767.68	13146.60	20163.56

Table 5. Year 5 cost structure (euros) of the selected greenhouse. Theoretical data.

	PHLH (euros)	PHL (euros)	PC (euros)
Cherry tomatoes SC year-1	14888.77	1314.66	716.71
Cherry tomatoes SC year	6380.90	11831.94	13617.40
Green beans	15498.00	0.00	5829.46
Total	36767.68	13146.60	20163.56

Table 6. Cost and income structure of cherry tomatoes short cycle. Real surveyed data.

Values	Productivity (t/ha)	Total costs (euros/ha)	Total HL (euros/ha)	PHL (euros/ha)	PHLH (euros/ha)	Revenue (euros/ha)
max.	80.00	52318.10	30050.61	28731.38	17526.14	86545.74
min.	16.00	17561.57	3966.68	3792.54	2313.45	6731.34
modal	58.00	29129.06	9135.38	8734.34	5327.95	40868.82

Table 7. Cost and income structure of green beans. Real surveyed data.

Values	Productivity (t/ha)	Total costs (euros/ha)	Total HL (euros/ha)	PHL (euros/ha)	PHLH (euros/ha)	Revenue (euros/ha)
max.	56.82	25388.35	18418.11	14169.05	14169.05	68296.83
min.	7.40	7551.22	2826.98	2174.80	2174.80	5216.79
modal	15.00	12530.63	6339.25	4876.78	4876.78	18591.31

Table 8. Financial results after 10,000 iterations without dependence relationships.

	NPV (euros)	IPB (year)	PIR	IRR (%)
Mean	59121.87	2.57-3.51	0.65	26.57
Standard deviation	38345.45	1.02-1.20	0.45	12.26

Table 9. Financial results after 10,000 iterations with dependence relationships.

	NPV (euros)	IPB (year)	PIR	IRR (%)
Mean	58460.07	2.65-3.60	0.64	26.49
Standard deviation	35465.03	0.96-1.11	0.42	11.44

Figures

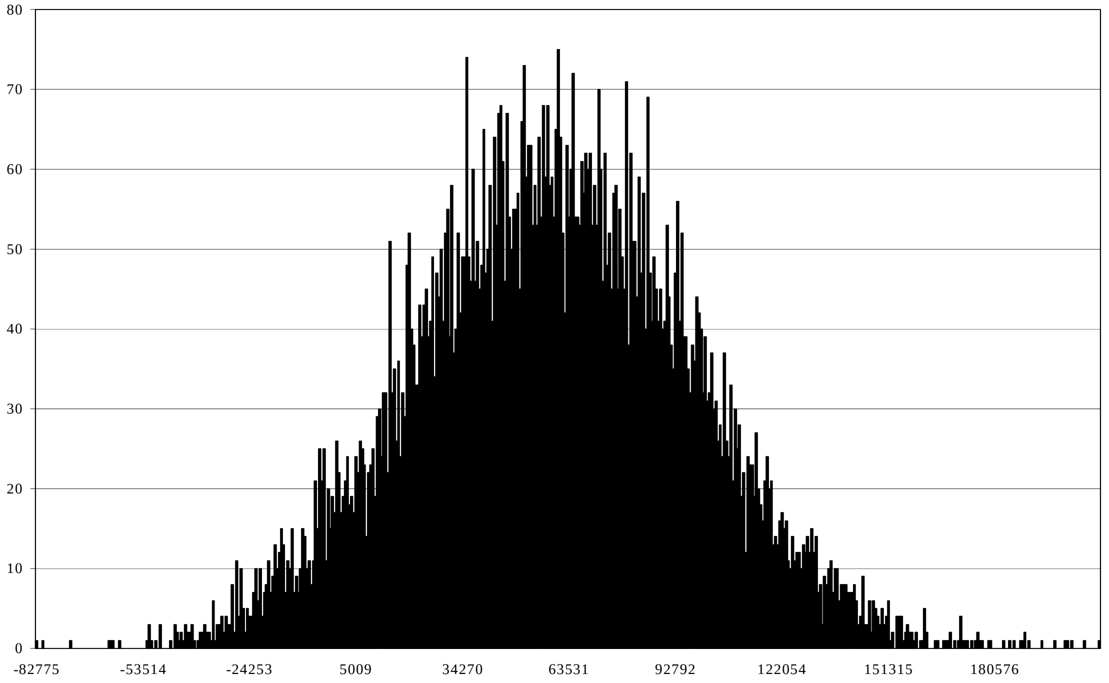

Fig. 1. Net Present Value absolute frequencies without dependence relationships.

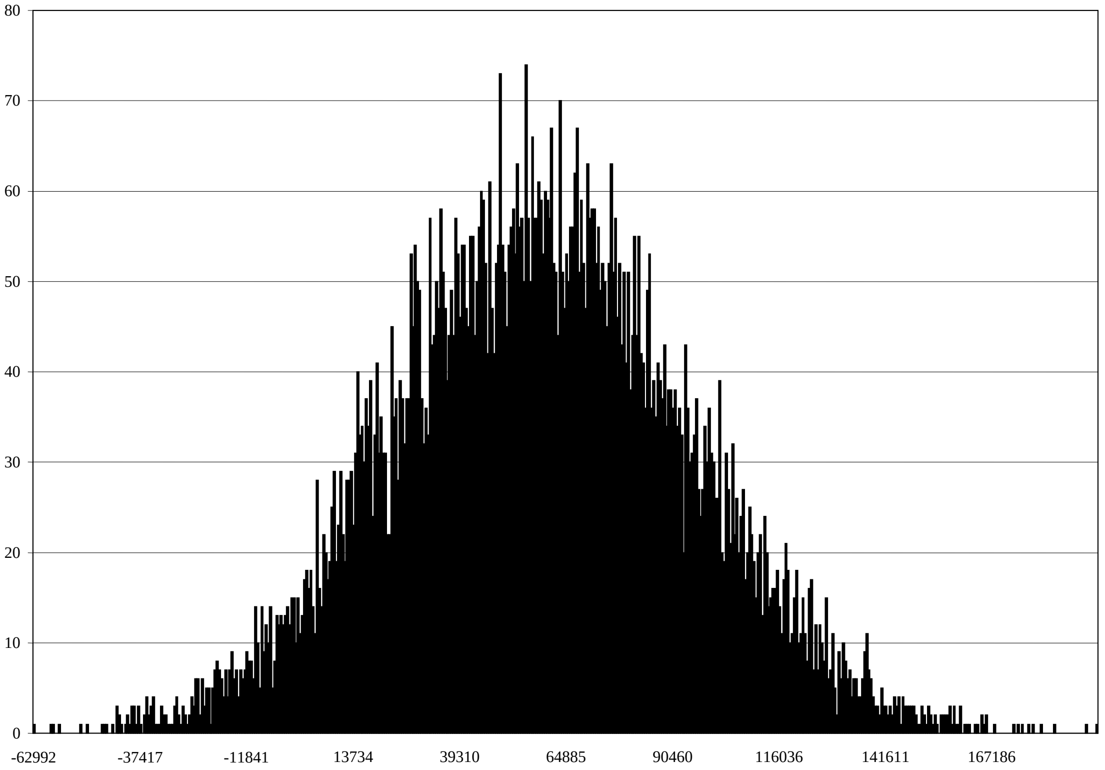

Fig. 2. Net Present Value absolute frequencies with dependence relationships.

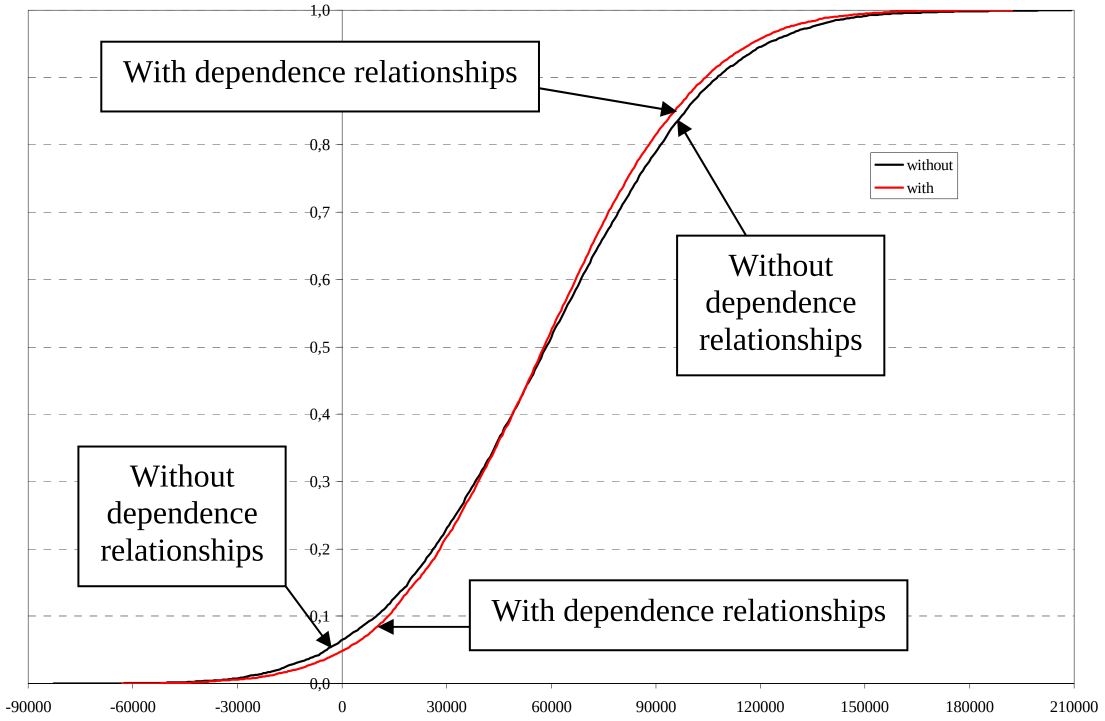

Fig. 3. Net Present Value cumulative probability with and without dependence relationships.

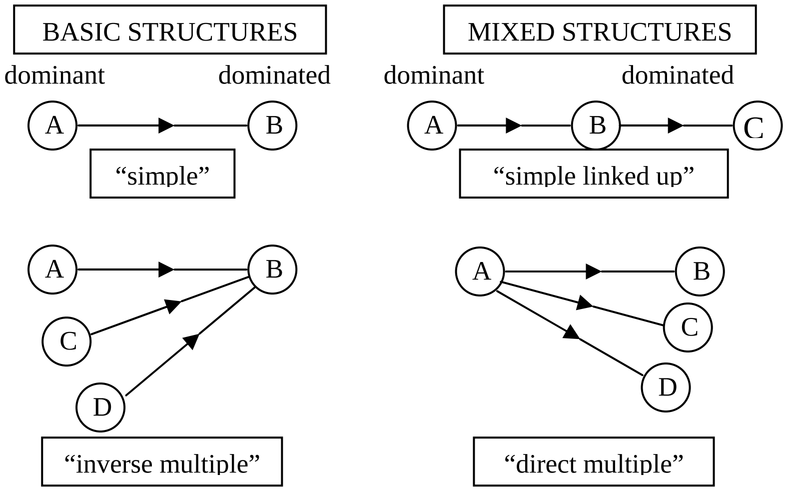

Fig. 4. Structural types of dependence relationships.