CASH FLOW BUDGETING INCORPORATING MONTE CARLO SIMULATION.

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ABSTRACT

Cash flow budgeting remains one of the tried and tested management techniques available to farm management personnel. BUDGET GENERATOR (BG) is a computerised farm management aid which has been developed to calculate farm cash flow budgets using variable prices and yields. BG combines the traditional gross margin with a crop husbandry calendar to generate a cash flow budget. BG has a static mode which calculates cash flow budgets using pessimistic, expected and optimistic yield and price forecasts. BG also has a dynamic mode which uses Monte Carlo simulation to calculate the cash flow budget based on yield and price distribution estimates and assumptions on distribution characteristics.

With BG an estimate of the cash flow of a single enterprise plan or a whole farm plan can be calculated as well as the variability associated with that cash flow.

INTRODUCTION

Malcolm (1990) surveyed and reviewed fifty years of farm management in Australia and, in his overview stated 'Throughout this time the farm management professionals, and the managers of farms, battled on with the simple budgeting techniques whose chief virtue was that they were general enough to allow a comprehensive picture of all the important aspects of the problem and the full ramifications of the solution(s) to be weighed in the decision. [The writer goes on to extol the virtues of computer spreadsheets in association with these simple budgeting techniques to 'enable the risks, time and dynamic aspects of problem to be analysed more practically and fully than ever before'.]

Chudleigh (1991) when discussing Future Farm Management Education in Australia, stated 'The cash flow budget is the only technique which has achieved reasonably wide acceptance in practice, ...'.

The inclusion of the inherent variability in yield and price in budgets can be facilitated by the use of computer spreadsheets as noted by Malcolm. Another approach is that of incorporating Monte Carlo simulation in the development of the cash flow budget.

This paper outlines the development of a computer program to enable preparation of cash flow budgets by the use of simulation after allocating probabilities to a range of expected yields and prices for each of the crops to be grown during the budget period.

PROGRAM FEATURES

1. Overview

The aim of BUDGET GENERATOR (BG) is to provide a fast, simplified and accurate method of formulating farm cash flows budgets. BG simplifies the budgeting by incorporating a method of linking gross margins to cash flow budgets via a type of crop husbandry calendar. In addition, BG incorporates a method of accounting for risk by employing the Monte Carlo simulation technique.

When planning a cropping program, enterprises with the highest gross margins are commonly selected first (depending on the objectives of the planner). Mill and Longworth (1975) describe the average pay-off received and the variability attached to that pay-off as the two main components of the desirability of any given enterprise. In the static mode, BG calculates cash flows using point estimates of yields and prices, while in the dynamic mode it provides a measure of the whole farm risk.

Using the stochastic mode of BG, the risk associated with each enterprise included in a budget is effectively pooled to formulate a level of whole farm risk. The risk component is calculated in BG by first deciding on a level of confidence and then calculating a bound around the mean simulation result for each month's cumulative cash flow.

The values of price and yield for each possible enterprise will usually be unknown at the time decisions are made. Managers will however, know an expected range of these variables which can be summarised in the form of a subjective probability distribution. The spread and shape of each distribution is defined by a low (pessimistic), a median (most likely), and a high (optimistic) value. BG provides the choice of four types of continuous distributions to use in generating random values for yield and price.

Figure 1 illustrates a simplified flow chart of the BG program logic.

2. Random Variate Generators

BG does not provide the capability to select random variables from empirical distributions. However, four different types of theoretical distributions are provided which can be used to imitate most unimodal probability distributions. These include versions of the normal, linear, exponential distributions and the triangular distribution. These are all capable of being skewed in either direction. All distributions are defined by three parameters, namely low, median and high population estimates (excluding the triangular distribution whose second parameter is a mode rather than a median).

Shannon (1975, p347-366), Watson (1981, ch5) and Law (1982, p157-188) presented summaries of theoretical distributions and their random variate generators. However, apart

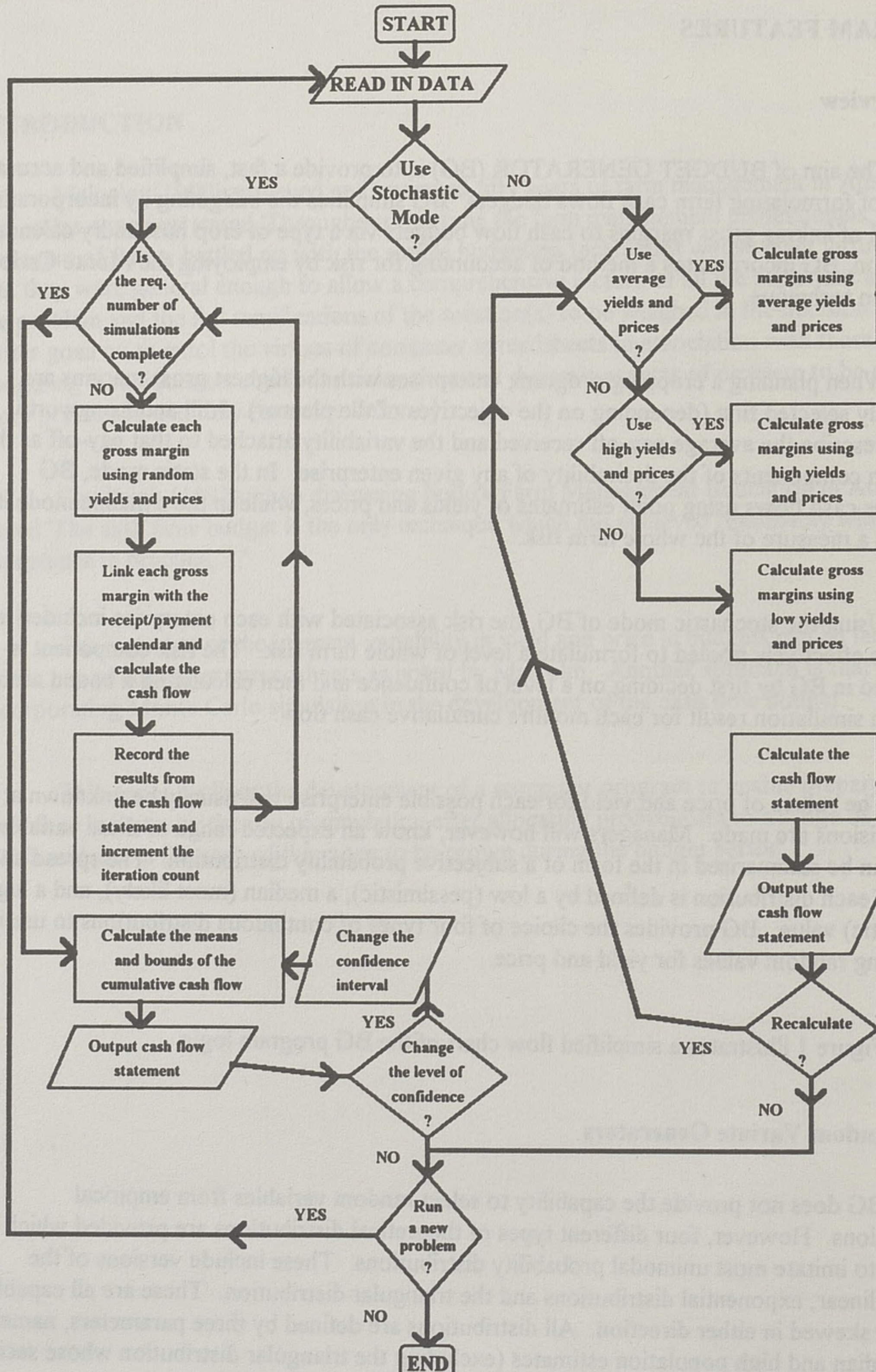

Figure 1. A simplified flow chart of the BUDGET GENERATOR program.

from the triangular distribution, none of these were considered satisfactory for use in BG because they were all limited to populations that were symmetrical, discrete or defined by obscure parameters. Consequently, random variate generators were developed by Davison (1990) and endorsed by Bruce *pers comm.*(1990) and Tisdell *pers comm.*(1990). Appendix 1 provides detail of the random variate generators.

3. Gross Margin and Receipt/Payment Calendar

A gross margin is simply the gross income less the variable costs of the particular enterprise, usually quoted on an area basis for crops. A whole enterprise gross margin is simply the gross margin per area times the enterprise area. The whole farm gross margin is the sum of all whole enterprise gross margins.

The gross margin screen in BG contains gross income and variable cost items, expressed on a one hectare area basis, adjacent to a receipt/payment calendar which specifies the months of receipt or payment. Also included in the gross margin screen is the enterprise area and the whole enterprise gross margin. When estimates of yield and price are entered, the appropriate probability function can be selected.

The receipt/payment calendar is similar to a husbandry calendar except that it represents the months in which the receipt/payment occurs rather than the actual timing of the activity. In order to use computer memory efficiently, receipts and payments can only be spread equally between different months ie. if receipts occur over a three month period each month receives one-third of the total receipts. (BG is programmed in Microsoft C and this allows one bit as the smallest data type which requires one-eighth of a character or byte. The trade-off of this saving is the inability to allocate different proportions of receipts/payments to different months.)

4. Calculating bounds on skewed distributions

The distribution of the cumulative cash flow could not be assumed to be normally distributed. Therefore the conventional method of placing a bound around the mean was rejected. In addition the method of formulating a discrete frequency distribution for the simulation results was rejected because this would require allocating enough computer memory to store the results of each simulation.

An alternative method was devised by Davison (1990) which involved recording the maximum, minimum, sum and sum squared for each month's cumulative cash flow result. At the end of the simulation the mean and standard deviation could then be calculated.

The resultant distribution from each month's cumulative cash flow result was assumed to follow a shape similar to the normal type of distribution, but could be skewed one way or the other. The method used to calculate a bound for this skewed distribution involved proportioning the standard deviation relative to the distance which the highest and lowest values occurred from the mean and then multiplying the two. The terms given to these two values suggested by Tisdell (1990) are the skewed lower deviate (S_{LD}) and the skewed upper deviate (S_{UD}).

S_{LD} = Standard deviation x (mean-low) / (high-low) x 2.

S_{UD} = Standard deviation x (high-mean) / (high-low) x 2.

The bounds of the confidence interval are therefore calculated:

Lower bound = Mean - S_{LD} x Z.

Upper bound = Mean + S_{UD} x Z.

When the mean is equal to the mean of the high and low, then the resultant bound is identical to that which would be calculated using the conventional method (bound = $\mu \pm \sigma . z$) Tisdell *pers comm.* (1990) considered this method of placing a bound on a skewed distribution appropriate for the application.

DISCUSSION and CONCLUSION

The farm budget simulation program presented allows farm managers to address the uncertainty in decision making by using a probabilistic approach. Some farm managers may be uncomfortable with forecasts that represent a range rather than a point estimate. Obviously an accurate point estimate forecast would be ideal in any planning situation. However Campbell and Madura (1989) stated that inaccurate point estimates usually result in wrong planning decisions.

Farm managers may also have difficulty in understanding some of the concepts inherent in BG, including the type of distribution to attach to particular yield and price estimates.. Consequently, BG could be considered to have more value in the hands of farm management consultants/advisers working closely with farm managers. These consultants could educe the necessary information from the farm manager to allow the selection of an appropriate distribution.

The simulation process in BG accounts for the whole farm risk by pooling the risk associated with each enterprise. Although this method doesn't always allow for a clear planning decision, it can indicate the probability that any particular farm plan will fail. The shortcomings associated with the simulation process includes the lack of association (dependence) between yield and price as frequently occurs. (However this is being addressed in further development of the program.) A further shortcoming is the inability to link different paddocks having enterprises whose price expectations are positively or negatively related. The requirement to allocate costs and returns equally in chosen months of the crop husbandry calendar is a further limitation (this is also being addressed, but will require extra computer memory.)

Nevertheless, BG could be used to prepare a 'quick and dirty' budget using standard industry gross margins or by customising these to reflect a farmers own individual farming practices. Farm managers and consultants could use BG to formulate a farm plan which combines the best mixture of enterprises with varying degrees of risk and pay-off while maintaining the whole farm risk at an acceptable level. The level of confidence used to set the bounds can be varied to suit an individuals risk profile.

Rural loan assessors should find the program useful when examining a loan application by allowing assessment of the risk of a farmers ability to repay. It would also allow the structuring of the loan so that repayments are scheduled when they are most likely to be repaid.

Farm Management students would benefit from the use of BG as a practical introduction to cash flow budgeting and Monte Carlo simulation. Using BG would allow students more time to learn more important management skills including thorough investigation of decision situations, rather than spending most of the time on tedious budget calculation and recalculation.

Many farm plans could be quickly examined using this approach, by changing enterprises, areas, yields, prices, etc. This allows fine-tuning of the farm plan.

It is concluded that techniques employed by BG are applicable for projecting farm cash flows, especially when yields and prices are uncertain, and the process of farm planning and budgeting is considerably simplified without compromising accuracy.

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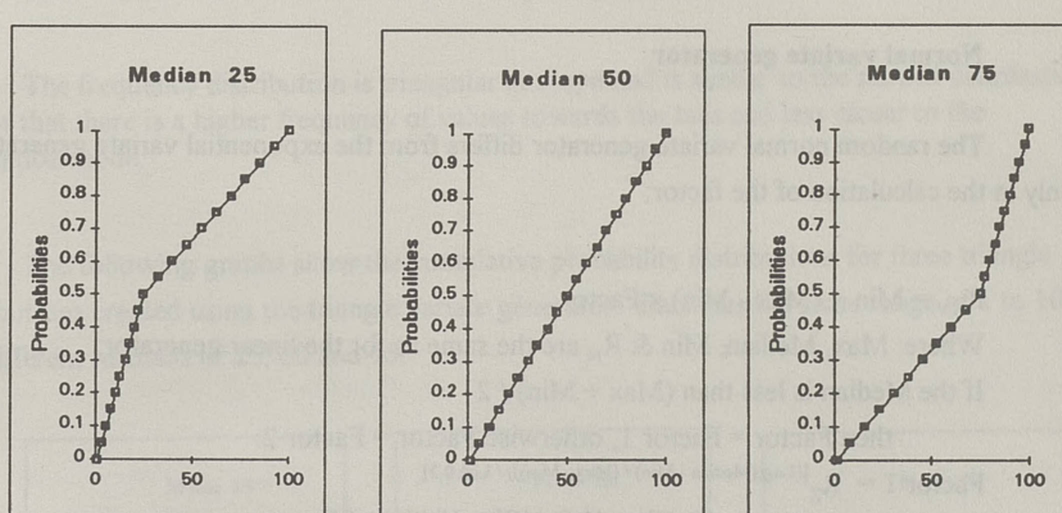
APPENDIX 1

1. Linear variate generator

The random linear variate (R_{LV}) generator is defined as follows:

If R_N is less than 0.5 then R_{LV} = Min + R_N / 0.5 x (Median - Min)
otherwise R_{LV} = Median + (R_N - 0.5) / 0.5 x (Max - Median)
where: R_N = a random number between 0 and 1
Min = estimate of the minimum value in the population
Max = estimate of the maximum value in the population
Median = estimate of the middle value in the population

The following graphs show the cumulative probability distributions for three linear distributions created using the linear variate generator. Each has the same range of 1 to 100, but different medians of 25, 50 and 75. When the median value assumed is equal to the mean of the maximum and minimum values, then the resultant distribution will be equal to the uniform distribution defined by Watson (1981, p100-102).



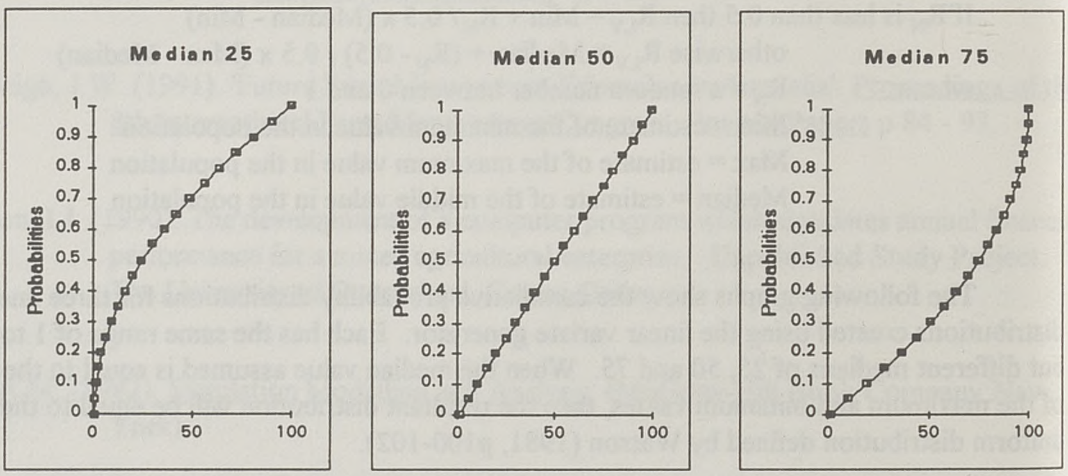
2. Exponential variate generator.

The random exponential variate (R_{EV}) is defined as follows:

R_{EV} = Min + (Max - Min) x Factor
Where: Max, Median, Min & R_N are the same as for the linear generator;
If the Median is less than (Max + Min) / 2
then Factor = Factor 1, otherwise Factor = Factor 2.
Factor 1 = $R_N^{[(\text{Log}((\text{Median - Min}) / (\text{Max - Min}))) / \text{Log } 0.5]}$

Factor 2 = 1 - $(1 - R_N)^{[(\text{Log}((\text{Max - Median}) / (\text{Max - Min}))) / \text{Log } 0.5]}$

The following graphs show the cumulative probability distributions for three exponential distributions created using the exponential variate generator. Each has the same range of 1 to 100, but different medians of 25, 50 and 75.



3. Normal variate generator

The random normal variate generator differs from the exponential variate generator only in the calculation of the factor:

R_{NV} = Min + (Max - Min) x Factor
Where: Max, Median, Min & R_N are the same as for the linear generator;
If the Median is less than (Max + Min) / 2
then Factor = Factor 1, otherwise Factor = Factor 2.
Factor 1 = $R_Z^{[(\text{Log}((\text{Median - Min}) / (\text{Max - Min}))) / \text{Log } 0.5]}$
Factor 2 = 1 - $(1 - R_Z)^{[(\text{Log}((\text{Max - Median}) / (\text{Max - Min}))) / \text{Log } 0.5]}$
R_Z = 0.5 + ((12 random numbers between 0 and 1) - 6) / 6
but if R_Z is less than 0 then $R_Z = 0$
and if R_Z is greater than 1 then $R_Z = 1$
and assume 6 standard deviations in the range.

This random normal variate generator uses a normalised random number between 0 and 1 rather than a random number between 0 and 1 like the exponential variate generator. The routine for generating R_Z is based on a random Z generator defined by Watson (1981, p107). 0.26% of normalised random numbers generated in the above manner will in theory lie outside the 0 and 1 limits. Because negative numbers cannot be raised to non integer powers it was decided to limit the normalised random number range to between 0 and 1 and therefore limiting the random variate to within the high and low population estimates.

When the median is equal to the mean of the maximum and minimum population estimates, the resultant distribution will be identical to the true normal distribution, apart from a slight distortion at the extremities of the range.

4. Triangle variate generator

The method used to calculate a random triangle variate R_{TV} defined by Watson (1981, p110-113) is as follows:

If $R_N >= (Mode - Min) / (Max - Min)$

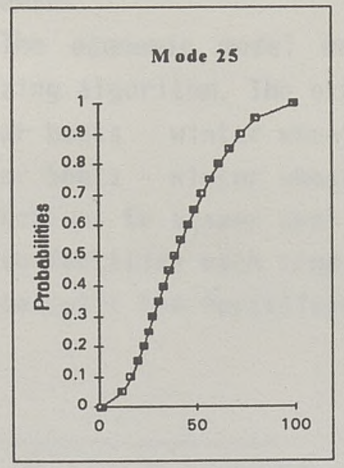
then $R_{TV} = Max - ((1 - R_N) \times (Max - Mode) \times (Max - Min))^{\wedge 0.5}$

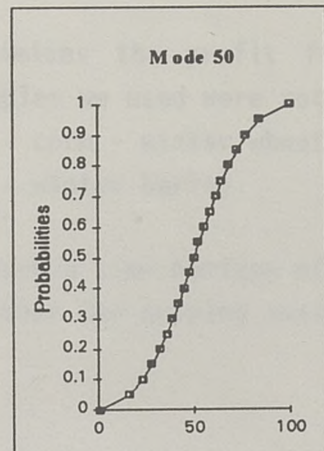
otherwise $R_{TV} = Min + ((R_N \times (Mode - Min) \times (Max - Min))^{\wedge 0.5}$

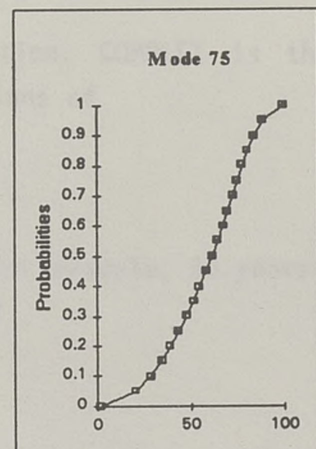
Where: Max, Median, Min & R_N are the same as for the linear generator; and Mode is the estimate of the most frequent population value.

The frequency distribution is triangular in shape and is similar to the normal distribution except that there is a higher frequency of values towards the tails and less closer to the population mode.

The following graphs show the cumulative probability distributions for three triangle distributions created using the triangle variate generator. Each has the same range of 1 to 100, but different medians of 25, 50 and 75.







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