# RISK AND RISK CONTROL IN FIRM GROWTH
# A SIMULATION ANALYSIS

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The importance of firm growth in agriculture is documented in agricultural statistics and in research on sources of and forces leading to growth [2]. Thus, the study of the growth process continues to be an important topic for research designed to aid individual farmers and to anticipate the future structure of agriculture.

Modern agriculture requires substantial blocks of capital. Thus, growth necessitates higher leverage positions, lower liquidity, and a greater chance of financial difficulty. Research is needed on ways of reducing growth. The W-149 project has the evaluation of strategies for reducing risks as one of its objectives. The research reported in this paper evaluates strategies for shifting risks by a firm in a growth situation. For purposes of this study, risks are measured by the variability of selected economic variables and by the chance of firm failure as specified in the study. Risk control is measured by the ability of a strategy to reduce the chance of firm failure and/or reduce the standard deviation of the variables of interest. The firm growth situation evaluated involves purchasing an additional 160 acres by a going farm business and tracing the farm's operation through 20 years. The growth effects are not large, but the analysis illustrates the potential effects of different strategies.

What strategies can be used to control risks associated with farm expansion and operation? Crop insurance, diversification, participation in government programs, and a crop share lease arrangement are considered here. Other strategies that could be tried include internal limits on liquidity or credit reserves, hedging and contracting, livestock share arrangements, pasture rental rather than livestock ownership, and combine ownership rather than using a custom operator. The results presented here are preliminary with respect to strategy formulation and evaluation.

## Growth-Investment Simulation Model

A computerized simulation model was used in the analysis [3]. Appendix A provides brief technical information about the model. The model incorporates sources of variation in farm income caused by yield and price variation. Triangularly or normally distributed, trended, and appropriately correlated prices and yields are included. Two basic kinds of information are estimated: 1) cash flow data which may be used to estimate the net present value of the firm over a specified time. Discounted cash flow includes the ending value of assets. 2) Balance sheet data which indicate the net worth of the firm in each year simulated. The model asks and answers the questions: 1) Would the investment be desirable?--e.g., is the gain in net present value positive?, and 2) Is the growth-investment plan financially feasible, given

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the farmer's consumption and debt service needs, initial financial position, and potential income distribution over planning horizon?

To initiate the model, proposed investment data and current farm resource financial and enterprise information are read as indicated in Figure 1. These data are stored along with calculated data for values which do not change in each replication of the analysis. That is, any data which are not affected by prices and yields are calculated for that replication of the analysis. After drawing and calculating stochastic prices and yields and rates of gain as appropriate, enterprise costs and returns are calculated. The data are used to determine net present value, balance sheet and firm survival statistics for the replications. Income tax depreciation schedules are based on 1978 tax tables and other key elements of cash flows and net worth are as realistic as possible. All correlations are based on time series relationships. Production coefficients, prices, family living costs, land values, and intermediate asset values and costs are trended through time at rates specified for each run.

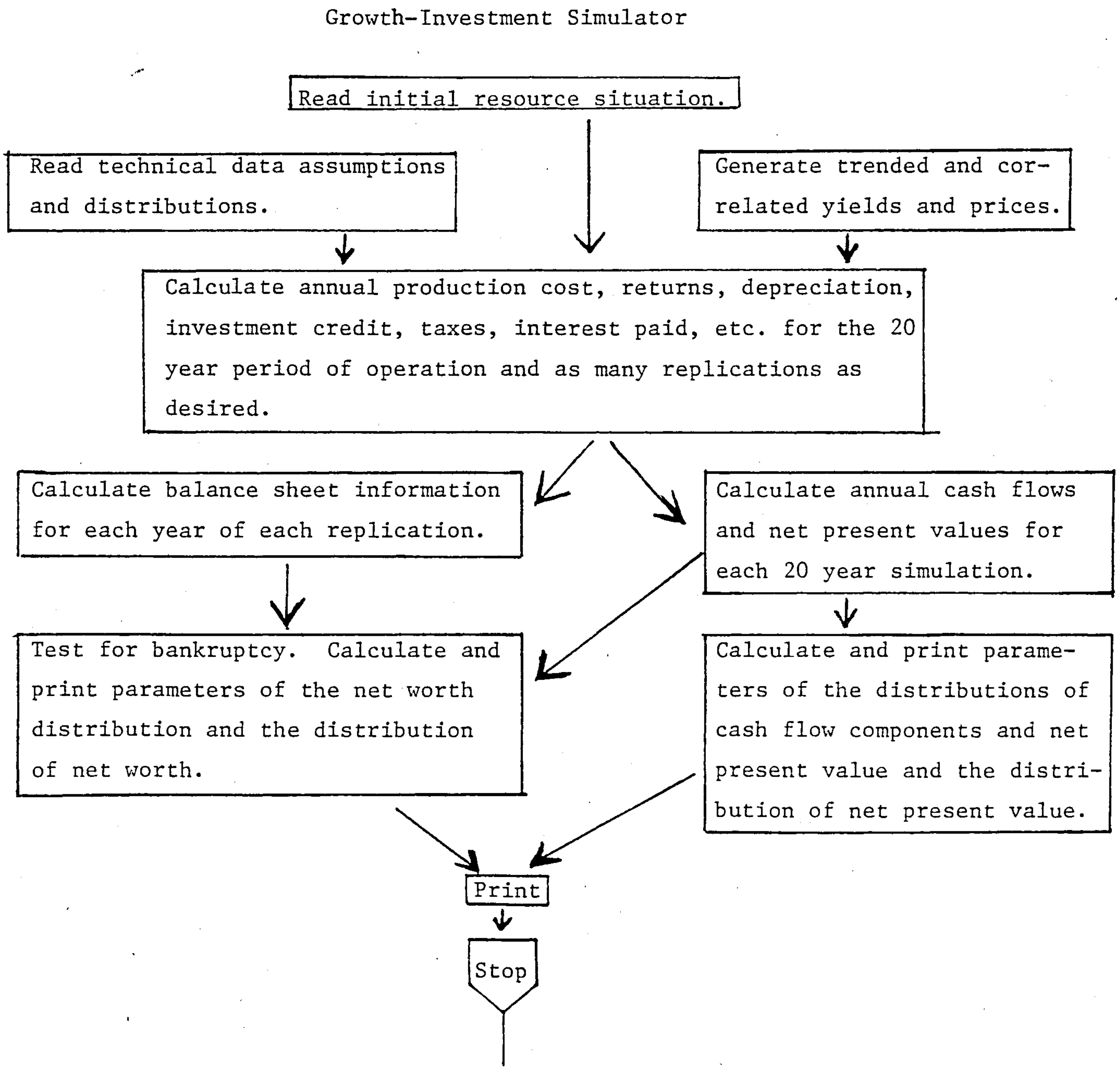
Net worth, net present value, and cash flows are calculated for each year in the planning horizon. Family living is paid and taxes are deducted. If net cash is positive, it is accumulated for future use and draws interest. If net cash is negative, the equity ratio is calculated to determine whether funds can be borrowed to meet the cash flow deficit. In the set of runs, the ratio of equity to total long-term assets must be greater than or equal to .2. If this ratio is not attained, the iteration fails the survival test. The equity ratio level necessary for borrowing is inputted as data.

With a negative annual cash flow, insufficient cash reserves and an equity ratio above the minimum, a new loan is obtained to balance the cash flow. The loan is obtained on the available net worth in long-term assets up to the ratio limit cited above. The loan is made for a 25 year period and amortized as a long-term loan. It is possible to secure a long-term loan and then experience a series of positive cash flows. The loan cannot be paid off in the model. However, the net cash surplus can be invested at 6 percent interest rate compared to 8.5 percent for the loan.

A special penalty is placed on negative cash flows used in the present value analysis and a bonus is paid for positive cash flows. When there is a negative (positive) cash flow, interest for that amount is paid (received) in cash flow in following years. The net present value estimated is more conservative when there are negative cash flows and more optimistic when there are more positive cash flows. Although it differs from the usual net present value approach, the result may reflect the way people think about penalties associated with negative cash flows.

Experiments are conducted or, in this case, strategies are evaluated with the model. No attempt is made to incorporate control theory approaches or optimizing procedures to allow adaptation of strategies or to find the optimum strategy for a given situation and set of objectives. Optimizing procedures are planned in further development of the model. Optimizing rules would permit an internal choice of the timing and amount of land purchases and other investments and selective use of strategies rather than continuous use. However, the experimental approach to simulation proves very useful.

Figure 1. MODEL FLOW



## Farm Situation Simulated

The area chosen for the study is north central Oklahoma, a part of the hard red winter wheat area of the Great Plains. The area has the reputation of being one of the more profitable farming areas in Oklahoma. The farms are highly mechanized and yields are relatively stable compared to areas to the west. The major enterprises are wheat, cattle on wheat pasture, alfalfa, and sorghum. Wheat and cattle on winter wheat pasture are used for the base farm plan in the study.

The initial resource situation is that of a farmer with 640 acres owned and 640 acres rented. He buys another 160 acres in the beginning of year one. Resources are described in Tables 1 and 2. As a result of buying the land, the farmer moves his net worth ratio from 50 percent to about 41 percent. He has a substantial net worth, over $300,000. Land is cash rented for $25 an acre. The farmer is assumed to have enough machinery to farm the additional 160 acres. In the first year, inventory of machinery is $81,165. Machinery costs are handled in a typical cash flow way, with the cost of purchases and interest in the cash flow. The family of three provides 3,328 hours of labor. Family labor is partly paid by charging a family living expense in the cash flow, $12,000 the first year inflated at a 5 percent rate each year. Intermediate term capital can be borrowed at 9 percent, long-term at 8 1/2 percent, and if money is available to loan out, the rate is 6 percent. The discount rate for the net present value analysis is 7.5 percent.

## Economic Situations Evaluated

Runs 1-5 evaluate alternative futures for agriculture as outlined in Table 3. Runs 6-10 all have the same economic assumptions but different strategies. The Base run (1) is moderately pessimistic. Each run was replicated 100 times. A Base run with several farm financial failures in the 100 runs was needed to allow a comparison of failures among runs. Two runs with no failures leave no room for comparison on the basis of that criterion. Run two assumes 100 percent equity by the farmer. Run 3 assumes a 3 percent increase in product prices each year. The fourth run uses a 7 percent land appreciation rate. Run 5 specifies a more stringent credit limitation--the farmer must have no less than a .3 ratio of equity to long-term assets.

## Risk Strategies Evaluated

Runs 6-10 evaluate alternative plans for handling risk in the farm business (Table 4).

A multiple crop (diversified) plan is used in run 6. Correlations among enterprises are shown in Table 5. In run 7, all risk crop insurance is purchased. Run 8 uses disaster provisions of the Food and Agriculture Act of 1977. Run 9 uses crop insurance and disaster payments. Run 10 uses crop share land rental rather than cash rental.

Table 1. THE FARM RESOURCE SITUATION SIMULATED

| Resource | | |
|---|---|---|
| Land | Amount | Annual Cash |
| Owned | 800 | a/ |
| Rented | 640 | $25/acre |
| Cropland | 1395 | -- |
| Machinery | $81,165 (Inventory 1st year) | b/ |
| Labor | 3328 hrs/year | $12,000 for living c/ |
| Capital | | |
| In: | | |
| Intermediate term | -- | 9% |
| Long term | -- | 8.5% |
| Out: | | |
| Short term | -- | 6.0% |
| Discount Rate | | 7.5% |

a/ Land taxes and property maintenance are part of annual cash flow.

b/ Machinery depreciation costs are handled in cash flow as machinery is replaced. In the balance sheet, machinery is depreciated and inventoried as appropriate at current (simulation time) rates.

c/ Family living costs are inflated at a 5% rate.

Table 2. THE FARM FINANCIAL SITUATION SIMULATED

| | Value |
|---|---|
| Year 0 | |
| Assets | |
| Intermediate | 81,165. |
| Long Term | 572,000. |
| Total Assets | $653,165. |
| Liabilities | |
| Machinery | 40,582. |
| Buildings and Land | 286,000. |
| Total Liabilities | $326,582. |
| Net Worth | $326,583. |
| Year 1 (Add 160 Acre Land) | |
| Total Assets | 791,165. |
| Total Liabilities | 464,582. |
| Net Worth | 326,583. |
| % Equity | 41.3 |
| Leverage Ratio | 1.42 |

Table 3. ECONOMIC FUTURES ASSUMED IN SIMULATION RUNS

| Conditions and Assumptions | Simulation Run 1 | 2 | 3 | 4 | 5 | 6–10 |
| --- | --- | --- | --- | --- | --- | --- |
| Annual % Increase in Product Prices | 2 | 2 | 3 | 2 | 2 | 2 |
| Annual % Increase in Input Prices | 4 | 4 | 4 | 4 | 4 | 4 |
| Annual % Increase in Land Value | 4 | 4 | 4 | 7 | 4 | 4 |
| % Beginning Equity | 50 | 100 | 50 | 50 | 50 | 50 |

Table 4. PRICE AND COST ASSUMPTIONS FOR ALTERNATIVE STRATEGIES USED IN SIMULATION RUNS

| Item | (Base) 1 | Run 6 | Run 7 | Run 8 | Run 10 |
|---|---|---|---|---|---|
| Rental Arrangement | $25/A | $25/A | $25/A | | 1/3 of Crop minus 1/3 of Fert.[a] |
| Crop Insurance | 0 | | $3.00/A. Payment is: (16.5 - Yield) $2.50; for Yield $\leq$ 16.5 | 0 | 0 |
| Disaster Payment | 0 | | 0 | [(Normal Farm Yield[b]) .6 - Yield] .5(3.40): for Yield $\leq$ NFY | 0 |
| Crop Mix | 100% Wheat<br>1 Steer/2 A | % Crop<br>50 Wheat<br>25 G.S.<br>25 Alf.<br>1 Steer/ 4A | 100% Wheat<br>1 Steer/2 A | 100% Wheat<br>1 Steer/2 A | 100% Wheat<br>1 Steer/2 A |

a/ For average yield and price the rental per acre for a share lease is $21.03 in the first year. Because the farmer is assuming less risk, the share rental rate probably would be greater than the cash rental rate in the market if risk averters prevail.

b/ Normal farm yield (NFY) is assumed to equal average yield for the farm.

Table 5. CORRELATIONS FOR ENTERPRISE VARIABLES INCLUDED IN THE MULTIPLE ENTERPRISE PLAN

**Yield**

Enterprise

| Stocker Gain | Wheat Yield | G.S. Yield | Alfalfa Yield |
|---|---|---|---|
| 1.0 | .17 | .14 | .33 |
| | 1.0 | .39 | .52 |
| | | 1.0 | .03 |

**Price**

Enterprise

| Wheat | G.S. | Nov. Stockers | Mar. Stockers | Alfalfa Hay |
|---|---|---|---|---|
| 1.0 | .72 | .14 | -.21 | .58 |
| | 1.0 | -.08 | -.33 | .65 |
| | | 1.0 | .76 | -.28 |
| | | | 1.0 | -.43 |
| | | | | 1.0 |

## Analysis

Results of the runs are provided in Tables 6 and 7. Ending net worth, net present value, standard deviation of each variable and number of farm failures are used to evaluate the results. The simulation model also provides data on annual cash flow variables which may be affected by risk strategies.

The base situation, with the economic conditions indicated in Table 3, gave an expected ending net worth of $372.5 thousand. The result reflects some nominal growth in net worth but a decline in the real net worth. The present value of the business is $66.9 thousand. It is possible that some highly desirable price-yield situations would occur in which the farmer would have great success. However, colossal failure is very possible. This farm failed 36 times in 100. As explained earlier, it is desirable to have a base that has a measurable number of failures so that the effects of alternative strategies can be evaluated. Tables 8 and 9 show the distribution of farm failures by years for all runs.

A higher beginning equity certainly will affect the survival of the business. Run 2, with a 100 percent beginning equity, is a drastic case. Of course, the farmer doesn't have 100 percent equity after purchase of the additional 160 acres. Moving from 50 percent equity to 100 percent equity increases ending net worth and net present value a great deal. The higher beginning equity helps to avoid failures and reduces interest paid substantially. The farmer with 100 percent equity has no farm failures as defined in the study.

The improved economic future for agriculture depicted in run 3 also has a strong effect on the survival, ending net worth and net present values of the firm. There are only 9 failures with the 3 percent product price trend, ending net worth shows real growth and the net present value is positive.

With a 7 percent land inflation rate, as in run 4, the farmer is much better off compared to the 4 percent inflation rate for the base situation. However, there was one failure. Thestandard deviation was not affected by land inflation because the land inflation simply shows up at the end of the period when the land is valued as if for sale. Land inflation may also have an effect because land is revalued each year and increases in land may increase credit available. Run 5 evaluates the effect of stringent credit wherein the equity to long-term assets ratio requirement is 0.3 rather than 0.2. Failures increased from 36 to 53. Other values remain the same.

Runs 6 through 10 evaluate the risk strategies under the same base economic assumptions as run 1. Run 6 with the multiple enterprise (diversified) plan gave surprising results. It appears that the plan with all wheat and one steer per two acres as described in Table 4 is not the most profitable plan because ending net worth and net present value both increase under run 6. However, such a statement must be carefully analyzed. Usually when a diversified plan is tried, only annual net receipts are evaluated. It is possible in individual years that the diversified plan may have lower returns and the average may be lower. However, the specialized plan may result in extremely low returns and high debt in some years. In that case, the cumulative effect of interest charges across years could be reflected in the ending net worth and net present values shown in Tables 6 and 7. The diversified plan did reduce the number of failures and the standard deviation.

Table 6. ENDING NET WORTH UNDER ALTERNATIVE ECONOMIC FUTURES AND RISK STRATEGIES, NORTH CENTRAL OKLAHOMA FARM

| Run | Ending Net Worth | | | |
|---|---|---|---|---|
| | Max. | Mean | Min. | S.D. |
| | ($1,000) | | | |
| 1. Base | 1249 | 372.5 | -421.2 | 334.2 |
| 2. 100% Beginning Equity | 1849.3 | 1318.2 | 710. | 218.3 |
| 3. 3% Product Price Trend | 1440.8 | 785.5 | 57.7 | 284.8 |
| 4. 7% Land Inflation | 2323.2 | 1446.8 | 653.1 | 334.2 |
| 5. .3 = Min. Ratio of Equity/ L.T. Assets | 1249 | 372.5 | -421.2 | 334.2 |
| 6. Multiple Enterprise Plan (Diversified Plan) | 1289.9 | 409.5 | -377.2 | 341.7 |
| 7. All Risk Crop Insurance | 1123.5 | 281.7 | -505.2 | 334.6 |
| 8. Disaster Payments | 1249.0 | 419.2 | -320.1 | 317.8 |
| 9. Crop Insurance & Disaster Payments | 1123.5 | 329.3 | -423.4 | 320.8 |
| 10. Crop Share | 1238.7 | 525.7 | -131.3 | 277.7 |

Table 7. NET PRESENT VALUE UNDER ALTERNATIVE ECONOMIC FUTURES AND RISK STRATEGIES, NORTH CENTRAL OKLAHOMA

| | Net Present Value | | | | Number of |
|---|---|---|---|---|---|
| | Max. | Mean | Min. | S.D. | Failures |
| 1. Base | 364.1 | -66.9 | -503.2 | 174.5 | 36 |
| 2. 100% Beginning Equity | 727.8 | 426.7 | 90.9 | 124.7 | 0 |
| 3. 3% Product Price Trend | 482.4 | 93.8 | -318.7 | 157.5 | 9 |
| 4. 7% Land Inflation | 617.0 | 186.0 | -250.3 | 174.5 | 1 |
| 5. .3 = Min. Ratio of Equity/ L.T. Assets | 364.1 | -66.9 | -503.2 | 174.5 | 53 |
| 6. Multiple Enterprise Plan (Diversified Plan) | 372.6 | -41.1 | -390.4 | 172.0 | 33 |
| 7. All Risk Crop Insurance | 322.6 | -105.2 | -516.8 | 173.4 | 46 |
| 8. Disaster Payments | 364.1 | -42.8 | -436.1 | 165.0 | 27 |
| 9. Crop Insurance & Disaster Payments | 322.6 | -80.8 | -449.6 | 165.8 | 41 |
| 10. Crop Share | 358.8 | -.8 | -369.5 | 147.5 | 13 |

Table 8. DISTRIBUTION OF FARM FAILURES BY YEARS FOR 100 SIMULATION REPLICATIONS OF SELECTED ECONOMIC FUTURES OF AGRICULTURE (RUNS)

| Year | Run 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | 3 |
| 3 | | | | | 1 |
| 4 | | | | | 2 |
| 5 | | | | | 1 |
| 6 | 2 | | 1 | | 4 |
| 7 | 2 | | 2 | | 2 |
| 8 | 1 | | | | 5 |
| 9 | 4 | | | 1 | 5 |
| 10 | 3 | | 1 | | 3 |
| 11 | 1 | | 2 | | 2 |
| 12 | 2 | | | | 1 |
| 13 | 2 | | | | 5 |
| 14 | 1 | | | | |
| 15 | 1 | | | | 3 |
| 16 | 3 | | 1 | | 4 |
| 17 | 4 | | 2 | | 6 |
| 18 | 10 | | | | 6 |
| 19 | | | | | |
| 20 | | | | | |
| Total | 36 | 0 | 9 | 1 | 53 |

Table 9. DISTRIBUTION OF FARM FAILURES BY YEARS FOR 100 SIMULATION REPLICATIONS OF SELECTED RISK MANAGEMENT STRATEGIES (RUNS)

| Year | Run | | | | |
|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | 1 | | | | |
| 6 | | 1 | 1 | 1 | 1 |
| 7 | 1 | 4 | 2 | 2 | 1 |
| 8 | | 1 | 1 | 2 | 1 |
| 9 | 4 | 4 | 3 | 2 | |
| 10 | 2 | 2 | 2 | 3 | 3 |
| 11 | 3 | 2 | 1 | 1 | 1 |
| 12 | | 3 | | 1 | |
| 13 | 3 | 3 | 2 | | |
| 14 | 1 | 1 | 2 | 3 | 1 |
| 15 | 2 | 2 | 1 | 2 | 1 |
| 16 | 2 | 4 | 2 | 5 | 2 |
| 17 | 7 | 8 | 2 | 4 | |
| 18 | 7 | 11 | 8 | 15 | 2 |
| 19 | | | | | |
| 20 | | | | | |
| Total | 33 | 46 | 27 | 41 | 13 |

The model provides data for building probability distributions for a large number of economic variables. Sample cumulative distributions of ending net worth are presented in Figures 2-5 for runs 1, 6, 7, and 10. One application is in using stochastic efficiency or safety-first decision rules [1].

Run 7 imposed all risk crop insurance on wheat. The assumptions concerning all risk crop insurance are in Table 4. Briefly, insurance costs $3 an acre and an indemnity was paid when yield was less than 16.5 bushels. The payment is 16.5 minus the actual yield times $2.50 per bushel. As expected, crop insurance decreases the expected net present value and the ending net worth. Apparently, partly because of the effects of insurance premiums on cash flow, the minimum was made worse and standard deviation was about the same. The maximum was made worse as a result of the crop insurance. It is hard to see why a farmer would buy crop insurance, given these results and the insurance cost and payoff assumptions.

Run 8 reflects the impact of disaster payemnts available through the present farm program on the variability of income. The disaster payment program is very much like the insurance program except that it is free to the participant. Participation raises the expected values and the minimums and reduces the standard deviation and number of failures. Insurance and disaster plans together are shown in run 9. It appears that the farmer would be better off without insurance.

Run 10 looks at the effect of having a crop share rental arrangement which shares the yield variability risk with the landlord. The terms of the lease are described in Table 4. The crop share arrangement increased the expected values, raised the minimum, and reduced the maximum to some extent. The farmer would certainly prefer a crop share arrangement to a $25 per acre cash rent arrangement if he is a risk averter or is risk neutral. If he is a strong risk taker, he might choose the cash rent arrangement.

## Summary and Conclusions

The growth-investment model looks promising as a means of analyzing growth investment under alternative futures for agriculture. The results obtained in comparisons of alternative strategies also appear reasonable. The use of simulation in comparing strategies provides interactions between years not ordinarily available in usual analyses of strategies such as crop insurance, share rental arrangements and diversification. The directional impacts of the strategies on ending net worth, net present value, minimum and maximum outcomes, and farm failures were quite consistent with expections obtained from theory. It appears that, for the study area and program provisions assumed, the disaster payment is a very important feature of the current farm program.

The results presented should be regarded as preliminary. Further studies are needed to make more definitive statements on the effects of strategies. For example, to make statements comparable to what have been made in other studies about diversification, additional variables require examination. The annual variation in returns needs study, in addition to the ending net worth and the net present value. Other all-risk crop insurance provisions need study too, as does hail insurance, Finally, several refinements of the strategies and additional strategies for living in an uncertain world need to be examined in the context of the simulation model.

## References

[1] Anderson, Jock R., John L. Dillon, and Brian Hardaker. Agricultural Decision Analysis. Iowa State University Press: Ames, 1977.

[2] Baker, C. B., P, J. Barry, W. F. Lee, C. E. Olson, E. Hochman, G. S. Rausser, and M. W. Kottke. "Economic Growth of the Agricultural Firm," Technical Bulletin 86. Washington State University: Pullman, 1977.

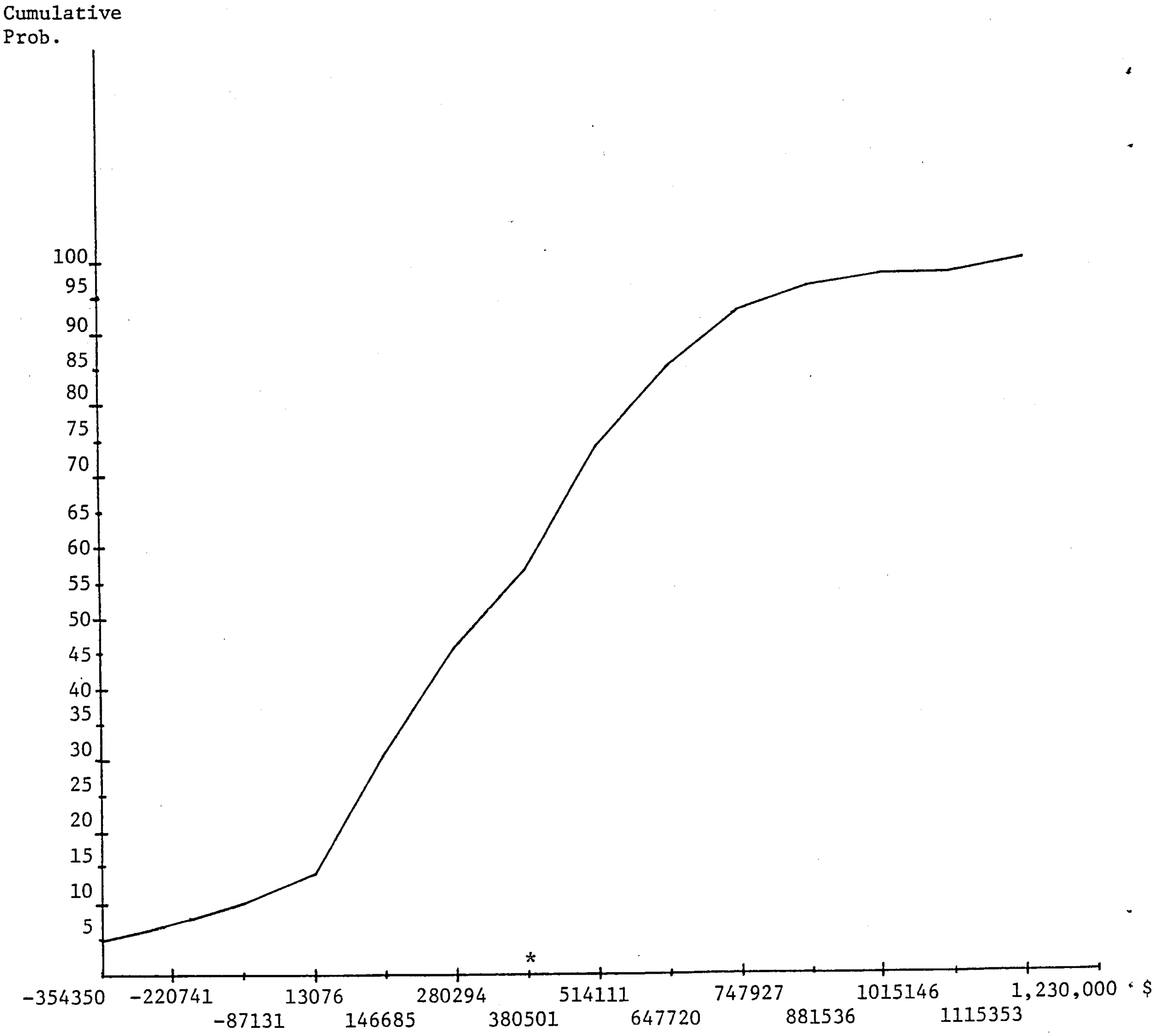
[3] Hardin, Mike L. "A Simulation Model for Analyzing Farm Capital Investment Alternatives." Unpublished Ph.D. dissertation, Oklahoma State University, 1978.

## APPENDIX A

## TECHNICAL INFORMATION: CAPITAL INVESTMENT SIMULATION MODEL, DEPARTMENT OF AGRICULTURAL ECONOMICS OKLAHOMA STATE UNIVERSITY

The program is written for FORTRAN IV level G and executes on an IBM 370 Model 158 computer. There are approximately 3,000 source statements in the main program and 10 subroutines. It is necessary to have tape or disk storage. Three small auxiliary programs are used to manipulate data files and perform statistical analyses on the variables developed from the main program and subroutine. All of the program is executed as a batch operation. The model allows for up to 20 different agricultural enterprises. The stochastic variables are product prices, livestock buy prices, product yields and rates of gain on livestock. Either a triangular or a normal distribution can be chosen. It is necessary to have variance-covariance matrices for the random variables. Due to large values of variables for such as net worth, net present value, and total cash flows, most variables are double precision. Thus there is a large core requirement of 1500K bytes. Other information can be obtained by writing the Department of Agricultural Economics, Oklahoma State University.

Figure 2- CUMULATIVE DISTRIBUTION OF ENDING NET WORTH FOR RUN NO. 1 - BASE




* Mean

Figure 3. CUMULATIVE DISTRIBUTION OF NET WORTH FOR RUN NO. 6- MULTIPLE ENTERPRISE

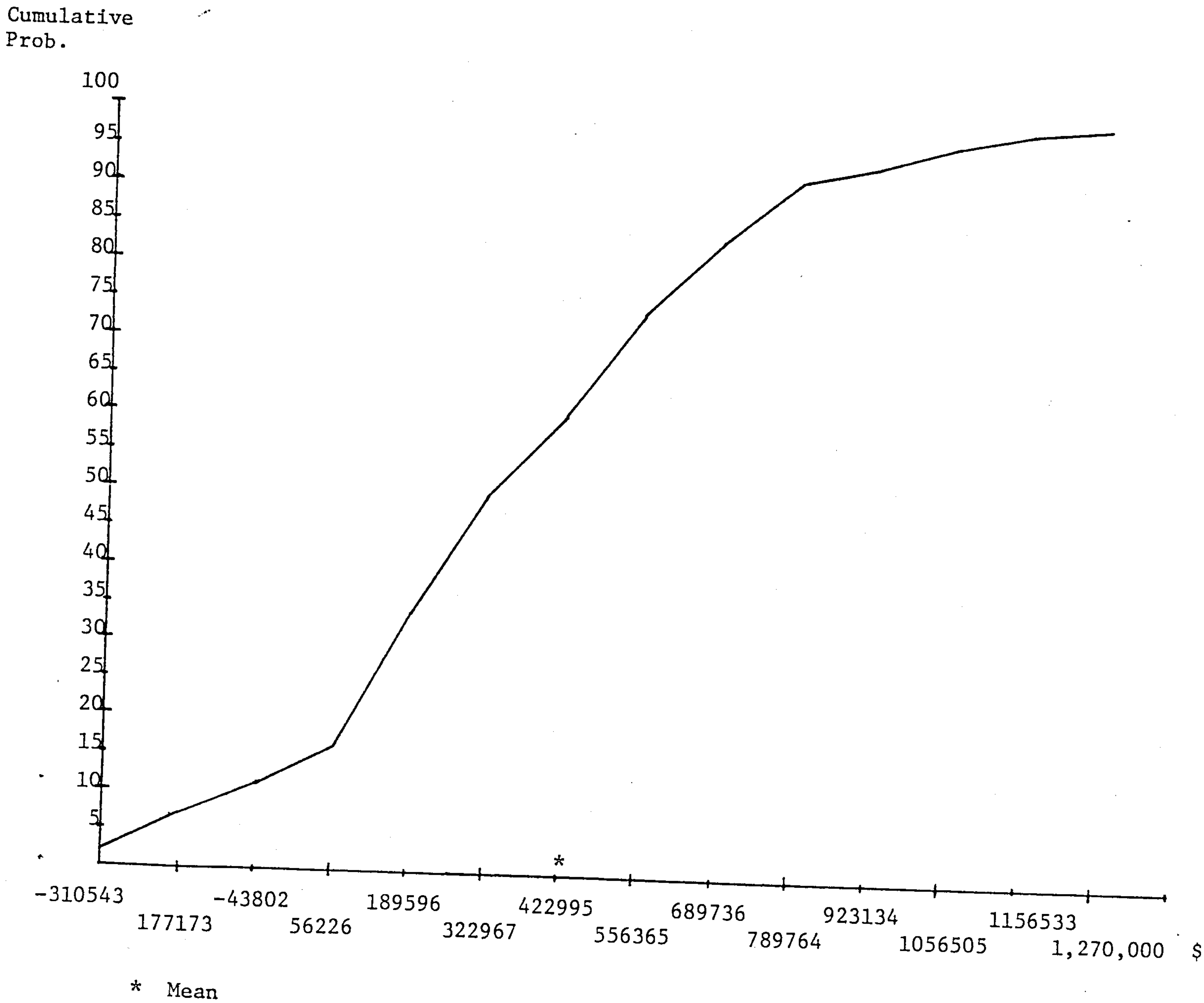


Figure 4. CUMULATIVE PROBABILITY DISTRIBUTIONS FOR RUN NO. 7- ALL RISK CROP INSURANCE

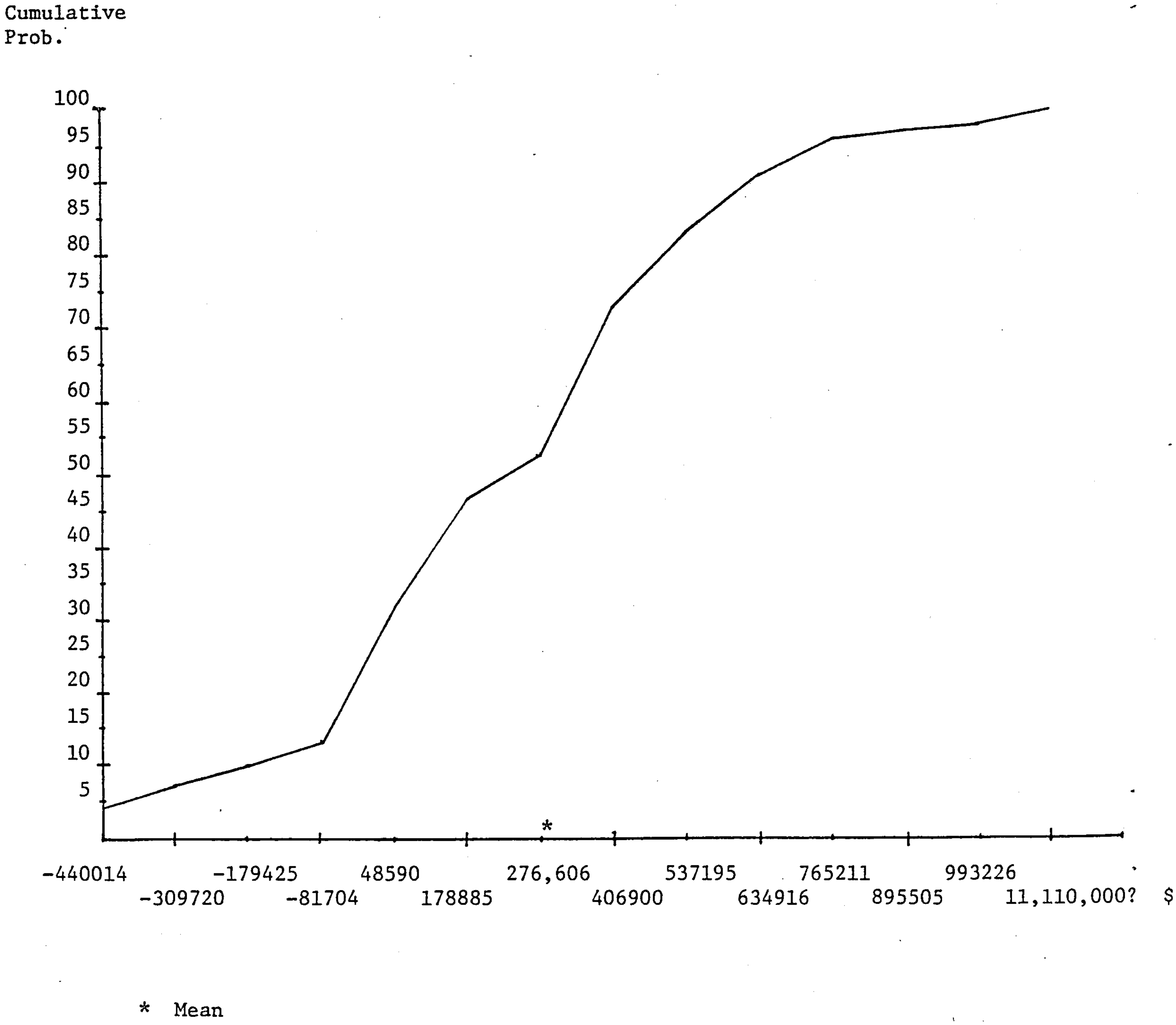
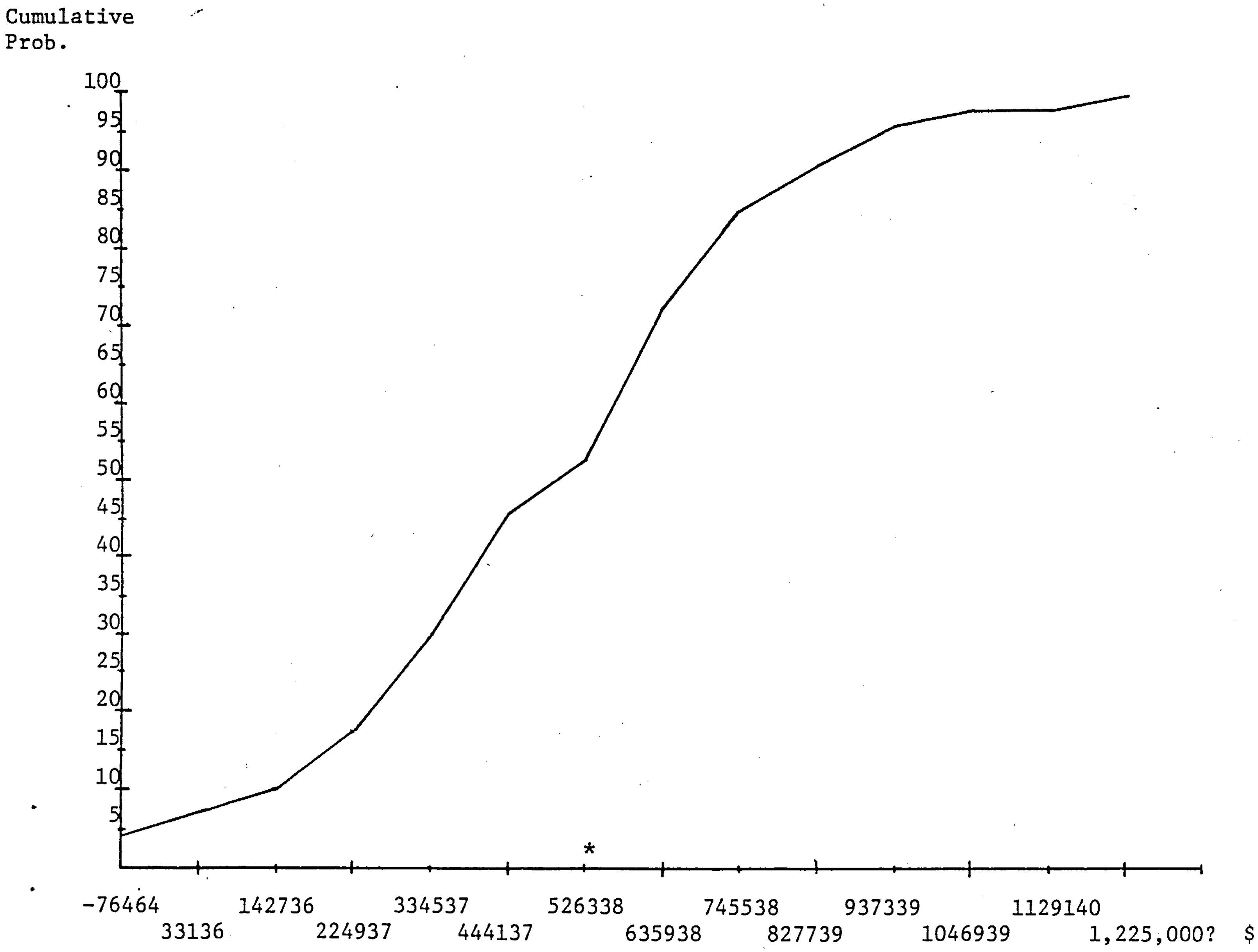


Figure 5. CUMULATION PROBABILITY DISTRIBUTIONS FOR RUN NO. 10- CROP SHARE




* Mean