DERIVING RISK-INCOME RELATIONSHIPS FOR PRODUCTION-MARKETING DECISIONS BY SIMULATION

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The objectives of this paper are twofold: 1) to present risk-income relationships for combined production-marketing decisions and 2) to discuss the use of simulation as a tool in developing risk-income relationships.

The EV frontier setting of quadratic programming forms a framework in which utility decisions relating to risk and income can be viewed (Lin, Dean, and Moore). In such a context income variance represents risk. Alternatives to quadratic programming are a linearizing approximation (Thomas, Blakeslee, Rogers, and Whittlesey), focus-loss (Boussard and Petit), minimization of total absolute deviation (Hazell) and marginal risk (Chen and Baker). A modified setting is one where a linear programming-risk simulator is used in discounting gross margins (Driver and Stackhouse).

The study reported here is one of outcome research generated through simulation. An objective of this research was to present risk-income relationships in an easily understood manner. Net income is contrasted to relative variability represented by the coefficient of variation. This method of contrasting net income to relative variability is shown in research by Johnson and Tefertiller. It can be argued that relative variability is a more acceptable method of contrasting the risk of various alternatives compared to income variance. Still another risk measure is survivorship. This criterion may represent the basic goal of avoiding variable income for purposes of maintaining the farm business. The use of simulation in farm firm risk research lends itself well to investigating survivorship (Held and Helmers).

This research investigates the financial performance of combinations of production and marketing alternatives over time in crop farming. The choices of activity combinations are arbitrary rather than optimally selected. A growth framework is assumed such that ending net worths of the firm can also be examined.

Joint investigations of production-marketing decisions related to risk-income relationships are rare. It would not be assumed that an optimal crop selling strategy is independent of the type of crop produced. Variability of both yield and product price is examined here. The crops examined are corn, soybeans, and wheat. A study examining risk-income relationships for corn and soybeans in Illinois is reported by Bolen, Baker, and Hinton; however, the scope of that study was confined to marketing alternatives.

It can be hypothesized that some crops are more stable than others from a yield and/or product price standpoint. It has long been suggested that diversification can lead to increased stability depending upon the nature of income variability between production alternatives. Such relationships could result from income variability differences resulting from product price movements or yield relationships. In recent years it has been suggested that diversified selling of crops over a crop marketing year may result in increased price stability. Finally, hedging of crop prices has been suggested as a technique to reduce price variability.

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Production and Marketing Alternatives

Production Alternatives (PROD)

A variety of production alternatives were investigated including both diversified (PROD 1, 2, and 5) and specialized production (PROD 3-4).

PROD 1. Alternative 1 corresponded to historical production in the county (46.05% corn, 11.9% wheat, and 42.76% soybeans).

PROD 2. 50% row crop and 50% small grain as
25% corn
25% soybeans
50% wheat

PROD 3. 100% wheat

PROD 4. 100% corn

PROD 5. 50% corn, 50% soybeans

Marketing Alternatives (MKT)

The range of marketing alternatives studied included selling on the cash market at various times during the year to hedging. The hedging alternatives were nonselective: that is, they were routinely placed using July futures for corn and soybeans and May futures for wheat.

MKT 1. Sell all production at harvest.

MKT 2. Sell one-third of production at harvest and store two-thirds with one-half of stored grain to be sold in February and one-half to be sold in April on the cash market.

MKT 3. Store the entire crop and sell on the cash market, one-third in February, one-third in April, and one-third in May.

MKT 4. Sell one-third at harvest storing the remainder and hedging (selling futures) for two-thirds of the production with one-half to be liquidated in February and one-half in April.

MKT 5. Hedge the entire crop at harvest time storing the crop and hedging (selling futures) with one-third of the crop to be liquidated in February, April, and May, respectively.

Model[1]

The five production strategies and five marketing strategies were simultaneously examined for 100 trials. The 100 trials represented 100 unique 15-year yield patterns for the crops. Each trial was investigated for the 25 combinations of production and marketing alternatives.

It was assumed that yields were randomly distributed in a normal distribution. Wheat yields were found to be unrelated to corn yields; hence wheat yields were randomly chosen. Soybeans were found to be related to corn yields. Soybean yields were estimated as a function of corn yields; however, the standard error of the regression coefficient was used to generate a set of

[1] The model is described in greater detail in Lutgen.

standard errors for soybean yields. Thus, corn and soybean yields while having a general yield relationship each contained individual yield variability tendencies.

The basic time dimension was for the 1961-75 time period. Commodity and commodity futures prices were taken from historical monthly prices for 1961-75. Thus while the model used historical commodity price movements, the yield distributions were developed for a wide range of possible distributions.

Saunders county in East-Central Nebraska was selected as the study area. The firm was assumed to have the same starting net worth (approximately $100,000) for all production alternatives except for production alternative 3 which required less machinery investment. The farm firm was assumed to have 304 acres of cropland. An 80 percent financial equity position was chosen as a starting point. This in conjunction with a conservative borrowing policy allowed the firm to easily survive price and yield variability such that outcomes for each alternative could be readily compared.

The simulation program simulated the financial performance for each production/marketing alternative including production costs, grain sales, machinery replacement, land purchases, capital borrowing and repayment, payment of taxes, and family consumption. Net farm income is defined as net cash farm income minus depreciation plus or minus changes in values of grain inventories. Land prices followed a historical index of land values. The model farm was allowed to purchase an 80 acre tract in four randomly chosen years (2, 6, 8, and 10) if the farm debt-equity ratio did not exceed two. Family consumption was assumed to be $6,304 in year 1 and increased by the rate of economic inflation over the period. Initial grain storage capacity was assumed for an average year's production with commercial storage available at 1.8¢ per month per bushel.

Machinery was routinely traded and depreciation schedules maintained. Variable costs were calculated for each machinery operation and updated each year by an index of costs. Interest, borrowing, and repayment of loans were handled in the customary manner. Interest rates paid on long-term, intermediate-term and short-term loans were 7, 7.25 and 7.56 percent, respectively. Income and self-employment taxes were based upon historical tax schedules.

Results

The simulated income results for the model farm are presented in Table 1. The income results by production alternatives are dependent upon the specific area yields and cost budgets assumed. Of more general applicability are the results by marketing strategy.

Wide differences exist among production alternatives. Soybeans were found to be a high income crop for this farm while corn was found to be a low income crop. Wheat was an intermediate income crop.

Less difference in net farm income exists among marketing alternatives compared to production alternatives. Selling at harvest resulted in the highest average net farm income for the period studied. The storage strategy (MKT 3) resulted in a lower average income than the pure hedging strategy (MKT 5). The other strategies involving partial harvest selling were in intermediate positions. It can be concluded that harvest selling resulted in 1) commodity sales at higher levels than for later seasonal prices or 2) increases in later seasonal prices over harvest prices but not at high enough levels to offset storage cost.

Table 1. Average net farm income for alternative production and marketing strategies based upon 100 15-year trials under historical prices. (1961-75).

		Dollars					
		PROD 1 46% C* 42% SB 11% W	PROD 2 25% C 25% SB 50% W	PROD 3 100% W	PROD 4 100% C	PROD 5 50% C 50% SB	AVE.
MKT 1	Harvest	16,945	16,492	15,032	8,741	17,378	14,918
MKT 2	Harvest and Store	14,984	15,090	14,642	6,098	15,347	13,232
MKT 3	Store	14,040	14,052	13,101	4,448	14,467	12,022
MKT 4	Harvest and Hedge	15,514	14,431	12,418	7,084	16,216	13,133
MKT 5	Hedge	14,999	13,601	10,802	6,203	15,811	12,283
AVE.		15,296	14,733	13,199	6,515	15,844	13,118

* C - Corn, SB - Soybeans, W - Wheat

Harvest selling was found to yield a higher average net farm income than other marketing strategies for all production strategies. However, the ranking of other marketing alternatives was not consistent among all production alternatives. Hedging was found to be a better strategy for soybeans compared to other crops. For wheat, hedging tended to perform poorly. For corn and soybeans harvest selling was a relatively good alternative while the storage alternative performed very poorly.

The performance of production and marketing alternatives showed little difference from the above results when growth in net worth was observed rather than net farm income. These results are presented in Table 2. Production alternatives 2 and 3 performed best with respect to growth in net worth where production alternatives 1 and 5 were best with respect to net income. The reasons for the improved performance of alternatives 2 and 3 when growth in net worth was measured are twofold. First, production alternatives 2 and 3 which are either 50 percent wheat or 100 percent wheat, respectively, started operations at a slightly lower net worth than other production alternatives. This was because wheat was considered already planted, and for alternative 3, a lower starting net worth was assumed due to less machinery investment. Second, alternatives 2 and 3 with greater wheat production had a greater level of stability thus less income taxes were paid.

Examining marketing alternatives, harvest and hedging (MKT 4) secured the greatest growth in net worth but only slightly higher than for harvest selling (MKT 1). The hedging alternatives again performed relatively better for corn and soybeans compared to wheat. For wheat, harvest sales were clearly the strategy leading to most growth in net worth.

The risk implications of each production and marketing alternative are presented in Table 3. Risk is represented by the coefficient of variation.

Comparing production alternatives, it can be seen that the inclusion of wheat as well as diversification acts to reduce risk. Both elements enter production alternative 2 which results in the lowest coefficient of variation of all production alternatives. Dramatically higher than all other alternatives is production alternative 4 (100 percent corn).

Harvest sales resulted in the lowest level of variability among marketing alternatives. This is in contrast to conventional hypotheses that diversified sales throughout the year (MKT 3) and hedging (MKT 5) reduce variability. Complete hedging was less risky than storage for later sales but both had greater average variability than other marketing alternatives. Little interaction between production alternatives exist with respect to the risk performance of alternative marketing strategies. In production strategies 2 and 3 complete hedging resulted in more variability than storage for later sales. This is opposite to the average results across all production strategies and is caused by the inclusion of wheat in those alternatives. This suggests that hedging is more successful in reducing risk in corn and soybeans compared to wheat even though both strategies are inferior to harvest sales. It should be noted that wider differences in risk occur among production alternatives compared to marketing alternatives. This suggests that risk reduction in agriculture must place a primary emphasis on yield variability for different crops.

The income results from Table 1 can be combined with the variability results from Table 3. These are presented for the marketing alternatives in Figure 1. The income results are averages across all production alternatives. With respect to marketing alternatives, no trade-offs exist

Table 2. Average yearly rates of growth in net worth for alternative production and marketing strategies based upon 100 15-year trials under historical prices. (1961-75).

	PROD 1 46% C* 42% SB 11% W	PROD 2 25% C 25% SB 50% W	PROD 3 100% W	PROD 4 100% C	PROD 5 50% C 50% SB	AVE.
	Dollars					
MKT 1 Harvest	11.41	11.72	12.13	9.66	11.42	11.27
MKT 2 Harvest and Store	11.36	11.62	12.07	9.51	11.41	11.19
MKT 3 Store	11.24	11.51	11.82	9.04	11.29	10.98
MKT 4 Harvest and Hedge	11.61	11.62	11.72	9.89	11.73	11.31
MKT 5 Hedge	11.64	11.61	11.49	9.69	11.77	11.24
AVE.	11.45	11.62	11.85	9.56	11.52	11.20

* C - Corn, SB - Soybeans, W - Wheat

Table 3. Coefficients of variation of average net farm income for alternative production and marketing strategies based upon 100 15-year trials for 1961-75.

	PROD 1 46% C* 42% SB 11% W	PROD 2 25% C 25% SB 50% W	PROD 3 100% W	PROD 4 100% C	PROD 5 50% C 50% SB	AVE.
MKT 1 Harvest	0.212	0.142	0.179	0.653	0.230	0.283
MKT 2 Harvest and Store	0.239	0.158	0.193	0.927	0.261	0.356
MKT 3 Store	0.260	0.170	0.215	1.252	0.282	0.436
MKT 4 Harvest and Hedge	0.240	0.165	0.205	0.830	0.255	0.339
MKT 5 Hedge	0.256	0.180	0.230	0.956	0.270	0.378
AVE.	0.241	0.163	0.204	0.924	0.260	0.358

* C - Corn, SB - Soybeans, W - Wheat

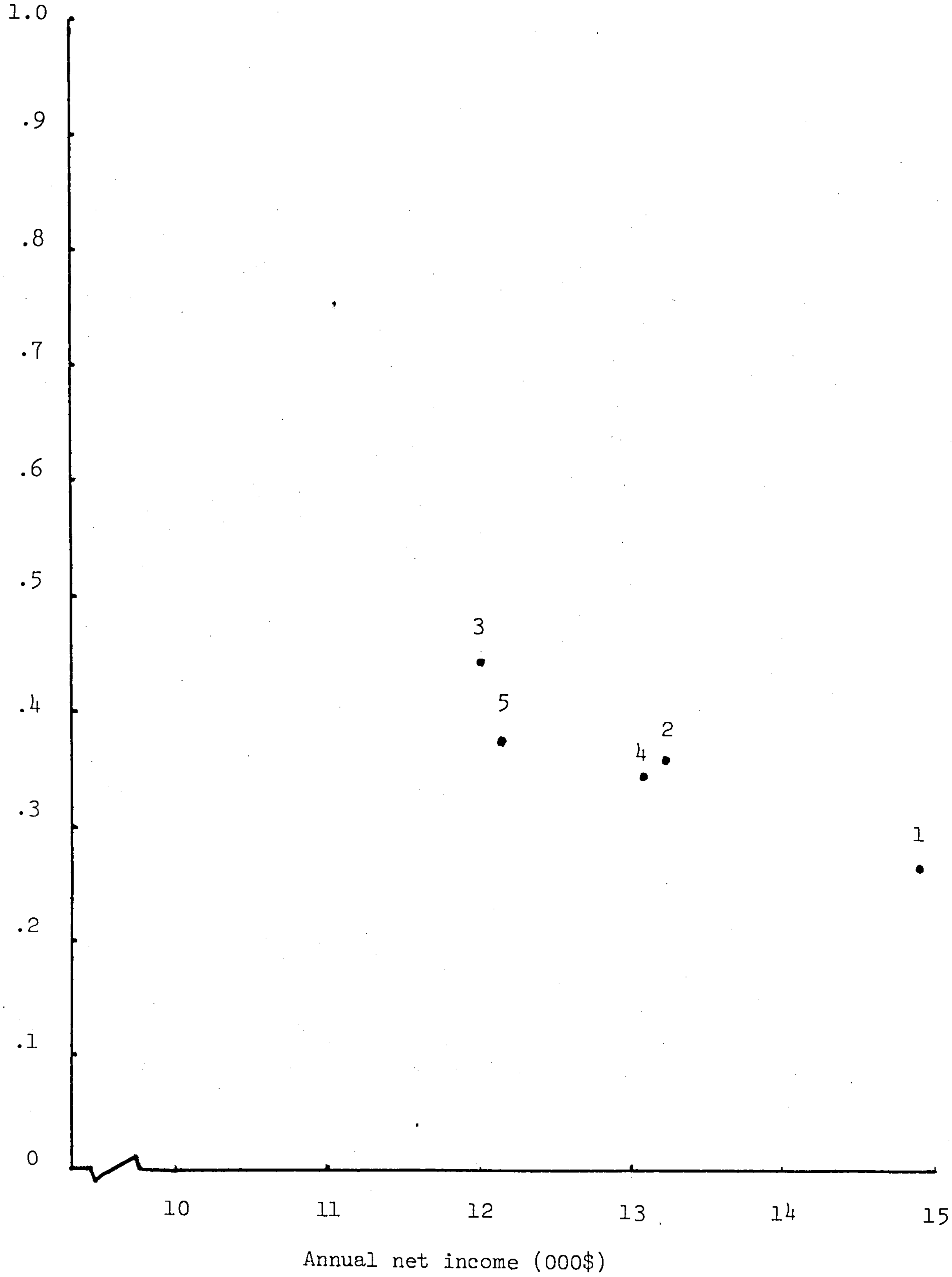

Fig. 1. Average risk-income relationships for alternative marketing strategies for the 1961-75 period.

between increased income and risk since marketing alternative 1 has the lowest coefficient of variation and highest net income of all alternatives.

In Figure 2 risk-income relationships for production alternatives are presented as averages across all marketing alternatives. In this case a segment of the risk-income relationship represents a trade-off situation. For production alternatives 2, 1, and 5 respectively, higher net incomes are accompanied by higher coefficients of variation. Consequently this range represents a choice framework. The higher income moving from alternatives 2 to 1 to 5 results from increased soybean production in the crop mixes. This is accompanied by higher relative variability.

Conclusions

The results of the study generally support the principle of risk reduction by diversification or the use of an enterprise with low variability in income. The marketing results suggest that spreading sales over a marketing year does not reduce variability. Similarly hedging did not lower risk compared to harvest sales. Boehlje and Trede found that spreading sales throughout the year did not necessarily reduce coefficients of variation although their results found that single month sales in July resulted in the lowest coefficient of variation compared to other months and compared to spreading sales.

The simulation model employed in this study has some advantages and some limitations in generating risk-income relationships. The alternatives chosen are, of course, not selected in an optimum method. A large number of production or marketing alternatives can be investigated. Some knowledge of risk relationships between alternatives can be used toreduce the number of variables examined.

Simulation is readily adaptable to other measures of risk, particularly financial ones such as survivorship. This becomes more cumbersome in optimizing models.

While not necessarily characteristic of a simulation model, the use of the coefficient of variation may be a more useful manner to gauge risk than variance. More research on the issue of alternative risk measures is in order. This would range far beyond income variability measures.

A simulation model such as the model presented here can track growth which can be an important element to decision making. In fact, it could be argued that financial alternatives which result in wide income-growth trade-offs are more important to modern firm decision making compared to income variance considerations.

Specific alternative distributions of yields or prices can easily be investigated with simulation while general statistical variability relationships are used in current optimizing models. Similarly, alternative financial settings and financial linkages can be easily changed with simulation while the incorporation of financial alternatives becomes more complex in programming models.

Finally, in agricultural areas where risk is a severe problem, few production alternatives often exist. Hence, elements other than diversification principles form the setting in which risk is viewed. Thus, income variability - income trade-offs are somewhat irrelevent under these conditions. In these cases, longer-run decisioms must form the focus of the risk framework such as investment and financial alternatives.

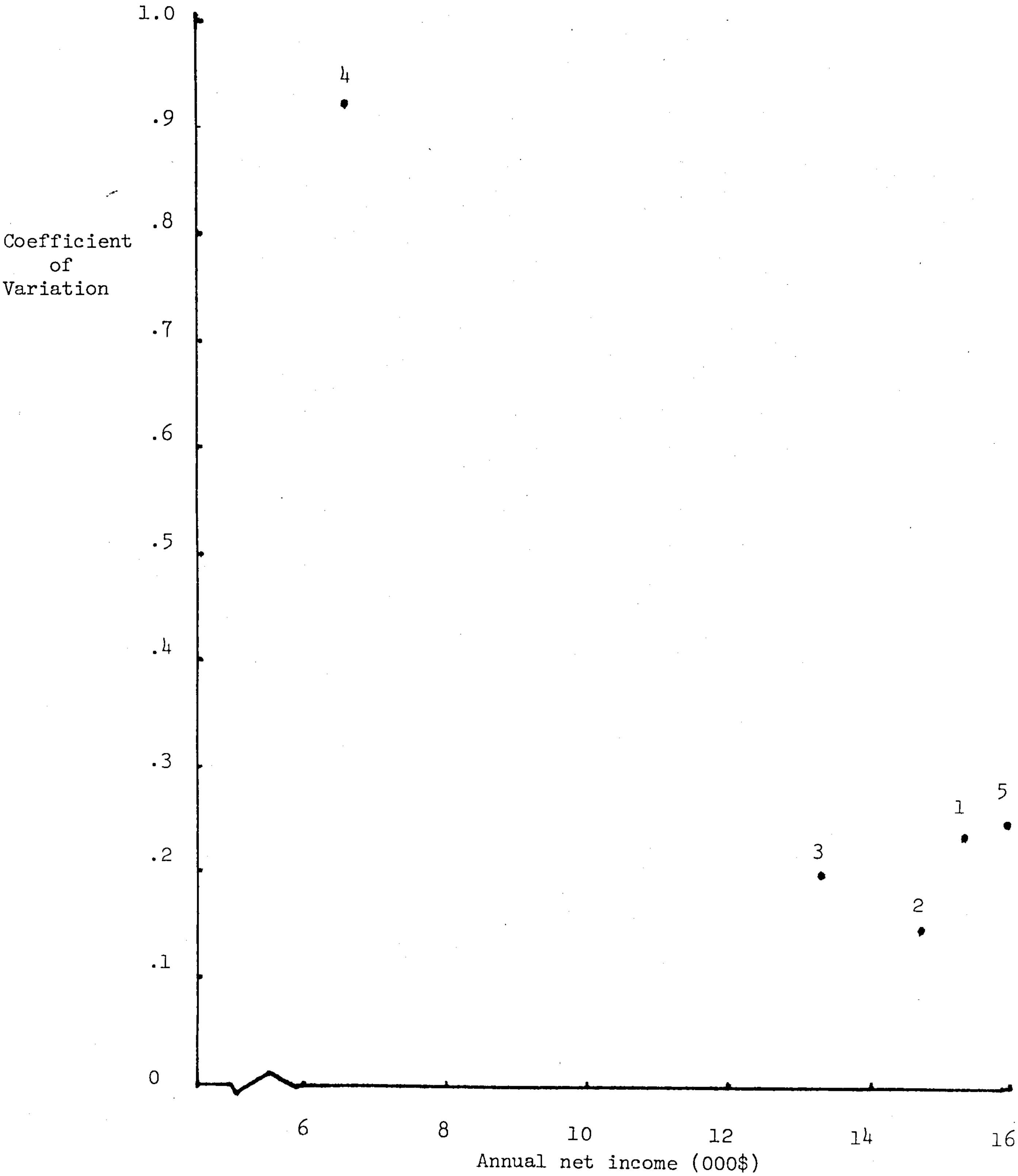

Fig. 2. Average risk-income relationships for alternative production strategies for the 1961-75 period.

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