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CASH FLOW IMPLICATIONS OF FIXED VERSUS
VARIABLE INTEREST RATE DEBT STRUCTURES

by

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I. INTRODUCTION

Problem Statement and Overview

"They still grow corn, beans, wheat, cotton, or forage, feed cattle and hogs or milk dairy cows. But their real business is raising, nurturing, conserving, handling, and marketing money. They are the new money farmers. Money is their ultimate commodity because from year to year the survival of their operation and how well their family lives depends solely on farm profits."

Successful Farmer, April 1984, p.13
"The New Money Farmers"

"Generally you want to see interest as a percent of total expenses between 14-16%... When interest exceeds 20% it's likely that you will run into financial problems."

Successful Farmer, Feb 1984, p.8
"Interest Costs Cripple"

"Operating, machinery, and equipment loans will likely be up in '84."

Successful Farmer, Machinery Management Issue, Feb. 1984, p.8
"Credit Outlook Improving Slightly"

These three quotations from a popular farm magazine highlight the increased attention being given financial issues. Farmers have long been assumed to be rational profit maximizers, and now they are being encouraged to explicitly develop their financial skills.

As rational profit maximizers, farmers have long sought to stay

abreast of current economic trends.

In the early 1970s the concept of 'leverage' was promoted as a means of raising the rate of return on the farmer's equity (provided that the overall rate of return on assets was greater than the average interest rate on debt outstanding). Farmers heeding that advice borrowed to expand their operations. Also during this time, rising real estate prices made expansion appear to be a wise investment as well.

Relatively stable interest rates during most of this period allowed accurate projection of interest expenses. But beginning in the late 1970s, interest rates began to climb, up 192% in the four years from 1978 to 1981.[1] Lending institutions were by this time making increasing use of variable (or flexible or renegotiated) rate loans, in which the interest rate is not fixed over the length of the loan, but fluctuates with the prime rate (or some other indicator). The variability (and its associated risk) were passed on from the lending institution to the farmer. This has in recent years placed additional financial pressure on farmers in years of generally low revenue. This increased financial pressure increases the farm operator's risk. Given a choice between two types of loan instruments, the rational farm manager will seek to chose the option with both the smallest financial burden as well as the least financial risk. (Financial risk is the probability of incurring relatively greater losses as the proportion of borrowed capital relative to

[1] see Table A, section III.A.3.

equity capital increases. This is not to be confused with farm business risk in general, which is the variation in earnings due to weather, disease, and price changes.)[2] This study is an attempt to quantify the risk transfer through the use of variable interest rate loans for four prominent southern Minnesota farm types.

The objective of this study was to discover the magnitude of the effect variable rate loans have on net operating cash flow over the period from 1968 to 1981. This was done by comparing a variable rate loan model with a fixed rate loan model under varying debt loads for four farm types. Historical data over the period from 1968 to 1981 provided the source material. The difference in mean operating cash flows (as well as in variability of cash flows) between the two models provides the desired measures of interest rate risk associated with a movement from fixed to variable interest rates.

The background data which is the basis of this study is from the Southeastern and Southwestern Minnesota Farm Management Associations. Income and asset information is provided by the members for research use. Interest rate, land valuation, and debt ratio information was supplied from published and unpublished material from private and University sources.

Types of simulations include comparisions of a fixed rate model and a variable rate model, and an adjusted fixed rate model (which is contrasted with the same variable rate model). Within these two comparisons, four debt levels are simulated. These debt levels are

[2] Nelson, Aaron G., Warren F. Lee, and William G. Murray, Agricultural Finance, 6th ed., Iowa State University Press, Ames, 1973, pp 55-57.

composed of representative mixes of short, intermediate, and long term debt. Also simulated is a level of debt composed of only long term liabilities. Initial debt levels are also tied each year to the amount of total assets, so that a constant debt level is maintained as old debt is paid off and farm operations expand from year to year. These five debt level simulations per interest rate model create a total of ten comparisons between farm types.

II. METHODOLOGY

This section of the paper is divided into descriptions of the data sets and the development and formulation of the simulation model employed, including the various equations and mathematical relationships utilized. In the first subsection, the origins of the basic income, expense, asset, interest rate, land valuation, and debt ratio data are discussed. In the second subsection, the mathematical relationships of the cash flow, interest expense, tax liability, principal repayment, and detrending (where interest expense means are equalized and de-trended over the fourteen year period in order to facilitate comparisons) variables are developed in detail.

A. Data Sets

1. The Farm Records

The historical farm record data on which this study is based is from the Southwestern and Southeastern Minnesota Farm Management Associations. Members of these associations provide basic balance sheet and income statement data, which are used to compile net worth and net income statements, as well as livestock and crop enterprise earnings statements. 350 of these data items for each selected farm were retrieved from magnetic data storage tapes. Prior to 1967, the records were compiled manually (making retrieval for computer studies much more difficult), consequently the study begins with 1967 and continues through 1981.

Since a time series study was prefered, the 250-300 farmers who

annually submit their records were screened down to "survivors" who submitted records in each of the 15 years under consideration. This sample was further subdivided into groups on the basis of farm type. Farm type was determined by the percentage of total receipts contributed by enterprise. For single enterprise farms the percentage of total sales contributed by the major enterprise was 70% or more. For dual enterprise farms the combined percentage of sales accounted for by the two largest enterprises was 80% or more. These type designations were then tallied so that farms with a single designation for eight or more years were permanently assigned that type. This was done to prevent farms from shifting across type boundaries, and to prevent minor income fluctuations from one source or another to influence type designations. These restrictions reduced the sample to 47 farmers in the following four enterprise groups: cash crop farms (6), dairy farms (10), dairy-cash crop farms (10), and hogs (all types)-cash crop farms (21).

The emphasis on "survivability" (in reference to case farms that submitted records in each of the years between 1967 and 1981 inclusive) biases the sample toward the more successful farms (or at least the better record managers), or who did not retire during the period. Since the liability and interest expense data are generated by the model, however, the impact of such bias is mitigated somewhat, although survivability may still be evidence in favor of efficiency.

2. Land Values

In order to make the total asset valuations comparable across

farms, (as well as for ratio analysis, etc.), land was valued at market value, instead of historical cost as recorded in the data set. This was done by multiplying acres owned by the value per acre. Acreage valuations were obtained from annual surveys made by the University of Minnesota of real estate brokers, agricultural loan specialists, and bankers.[1] Their estimates of land values were used (instead of actual farm sales) because of the greater homogeniety over time in the land valuations. (Actual sales figures vary widely due to spotty sales, local price competition, distress sales, topography and soil type of specific parcels sold in a particular year, etc.) These market-based land values were used in the compilation of total asset valuation used in debt calculation (see section III.A.4. for details). The total asset valuations in turn were multiplied by the different debt ratios for the various simulations to provide the calculated debt levels. These debt levels in turn, along with interest rates, became the factors determining the interest expense and principal repayments applicable to each farm unit.

3. Interest Rates

The interest rates used were drawn from several sources.

Long term (farm real estate debt) rates were St. Paul District Federal Land Bank (FLB) rates which were adjusted for loan fees, stock purchase requirements, and for compounding effects. (See Table A for

[1]Data was obtained from unpublished per county surveys courtesy of Dr. Philip Raup and Matt Smith, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul.

Table A. INTEREST RATES APPLIED IN STUDY

Year	Minneapolis Short term[1]	Minneapolis Intermediate term[1]	Minneapolis Long term [2]
1967	6.99	7.09	6.91
1968	7.31	7.41	7.48
1969	7.73	7.78	8.97
1970	8.32	8.44	9.07
1971	8.22	8.31	8.04
1972	8.04	8.16	7.51
1973	8.23	8.33	7.99
1974	8.74	8.94	8.98
1975	9.03	9.28	9.08
1976	9.12	9.36	9.08
1977	9.18	9.48	8.82
1978	9.33	9.62	8.82
1979	10.80	11.21	10.29
1980	14.82	15.10	11.36
1981	17.87	17.98	12.90

[1]Agricultural Finance Databook MPLS FRB - with 1967 and 1968 extrapolated from Chicago Federal Reserve feeder cattle series.

[2]Actual St. Paul Federal Land Bank Rates - correspondence St. Paul FLB.

rates used.) Time weighted averages were used when rates changed during the year.

Short and intermediate term rates were taken from Agricultural Finance Datebook, Quarterly Series, Oct 1982. For 1969-1981 short and intermediate term farm loan rates were directly taken from the Minneapolis Federal Reserve series for short and intermediate non-real estate loan series. (These rates are derived from a survey of commercial banks in the Ninth Federal Reserve District that have significant agricultural lending involvement.) Annual averages of the four quarterly reports were constructed from this source.

Intermediate term rates for 1967 and 1968 were estimated based upon an index relationship to feeder cattle loan rates of the Chicago Federal Reserve District for the 1967 to 1972 period,(same source). (This was due to the Minneapolis series 1969 commencement.)

Short term rates for 1967 and 1968 were likewise based on an index relationship of the Minneapolis short term rate to the complete Minneapolis intermediate term rate series.

4. Debt Ratios

Since this investigation centers on the difference in interest expense and principal repayment between fixed interest rate loans and variable interest rate loans, considerable attention was paid to the debt ratio assumptions. Standardized debt ratios were constructed in order to hold liability conditions constant across years as well as across farm types. This allowed uniform comparison of the simulations. Standardized debt ratios were also employed in order to

explore the impact of alternative leverage levels on the fixed and variable rate models.

The debt mix was broken down into current, intermediate, and long term (real estate) liabilities. The first differentiation was between long term liabilities and combined short and intermediate term liabilities. Balance Sheet of the Farming Sector statistics[1] reveals the proportion of real estate debt to total debt to be 54%, with the remaining 46% being composed of current and intermediate term liabilities. The division of current from intermediate liabilities was complicated by the lack of published data. Unpublished data furnished by the Federal Land Bank Associations (FLBA) allowed the differentiation of current from intermediate liabilities by FLBA district. (FLBA districts are multi-county areas served by local FLB associations. There are eight such districts in southern Minnesota.) This differentiation by district allowed the debt ratios to reflect local agricultural and lending practices as well as to reflect financial differences across geographic areas where certain farm types predominate. Individual farmers were classed by county of residence into the corresponding FLBA district and that (current liability)/(current and intermediate liability) proportion applicable to their FLBA district was assigned to their case farm.

According to Economic Indicators of the Farming Sector[2], the

[1]Economic Research Service, USDA, Balance Sheet of the Farming Sector, 1979, p.32 and 1980, p.158.

[2]Economic Research Service, USDA, Economic Indicators of the Farming Sector, 1982, p.157.

Table B. EXAMPLE OF DEBT RATIOS USED AT A DEBT RATIO OF 25.0%

Expressed in %	Northfield	Worthington	Windom	St.James	Blooming Prairie	Rochester	Redwood Falls	Mankato
Short term liabilities/ total assets	1.8	5.6	8.0	4.9	4.4	2.7	5.6	5.6
Intermediate liabilities/ total assets	9.7	6.0	3.5	6.7	7.2	8.7	6.0	6.0
Long term liabilities/ total assets	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Total debt/total assets	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0

Note: Current and intermediate liabilities are generally similar except for Northfield, Rochester, and Windom. Northfield and Rochester are located in areas in which dairy operations are prominent. The regularity of cash flows from dairy operations may prompt less short term borrowing. Windom, due to local meat packing, may finance more feeder cattle loans and thus experience relatively more use of short term credit.

debt to asset ratio for Minnesota farms for the period 1979 to 1982 was approximately 20%. We selected 15, 20, and 25% mixed debt levels as a basis for our investigation. A 40% mixed debt level was also chosen in order to represent more aggressively leveraged operations. (For an example of the rates used, see Table B.) (Also, two simulations were made with 20% debt levels which was totally composed of real estate debt. These were done to study the effects that longer term debt might have on residual net of debt servicing cash flows.)

B. Formulations

1. Introduction and Overview

Basic income, expense, and asset (except for land valuation) data from the farm management associations became the foundation of the analysis. Tax, interest, and principal repayment expenses for each farm unit were derived for both variable and fixed rate models, allowing accurate comparison of the effects of the two different types of interest rate models.

For each of the four farm types, a total of ten comparisons between a fixed rate model and a variable rate model were performed. Five of these comparisons were made between the variable rate model and a simple (unadjusted) fixed rate model. Of these five comparisons, four were made with a representative mix of short, intermediate, and long term debt (see previous section for debt mix details) at debt ratios of 15, 20, 25, and 40%. The fifth comparison was composed of a debt structure initially consisting only of real estate liabilities at a debt ratio of 20%. It was anticipated that

any inherent differences between the models would be emphasized in the real estate debt simulation, since a slower than "normal" principal repayment would cause a slower turnover of the original debt, and therefore, of the original interest rate structure connected with that debt. The slower turnover would result in a greater contrast to the variable rate model.

The remaining five comparisons were between the variable rate model and a fixed rate model which was indexed to flatten the interest rate trend. The overall (grand average across farm types and years) interest expense between the variable and adjusted fixed rate models were then equalized. (These adjustments are described in detail in section III.B.3.) This allows focusing on variability differences only. Four of these comparisons were made with the standard short, intermediate, and long term debt mix specified above at debt to asset ratios of 15, 20, 25, and 40%. The last model comparison was made between simulations initially containing only real estate debt at a 20% debt to asset ratio.

In all of the above comparisons an operating cash flow variable (labeled OPFLOW) was derived from the farm records data. Computer simulations of interest expense (see sections III.B.3a,3b,4.), debt repayment (see section III.B.5.), taxes (see section III.B.6.), and living expense were subtracted from OPFLOW to yield a residual measure of available cash flow from operations net of all normal, recurring claims on such cash flows.

Given the difficulties of determining where "profits" from farm operations are invested in considering dynamic linkages across time,

an operating cash flow approach was chosen. This allows the residual income to simply be compared directly between the two models, both in terms of average level and in terms of variability over time. OPFLOWV and OPFLOWF are the residual measures of "income" upon which the simulation comparisons will focus.

2. Calculation of Operating Cash Flow Variables (OPFLOWF, OPFLOWV, and OPFLOW)

The variability of the net operating cash flow for the variable versus fixed interest rate models is the focus of the simulation comparisons. Therefore the components of the residual variable are important. The net receipt and expense information from the farm management data form the foundation of the analysis. From this variable (OPFLOW) the interest expense, computed from the modelling assumptions (see section III.B.3a,3b,4.), is subtracted. Since living expenses are a use of cash which competes with debt servicing requirements, they are also netted out. (Living expenses are labeled LIVING3.) The repayment of principal (REPAYF or REPAYV, see section III.B.5.) is also an important use of funds and is subtracted from OPFLOW. Since interest is deductible on federal and state income tax returns, estimated taxes (NEWTAX4 for the fixed rate model and RTAXES for the variable rate model; see section III.B.6. for details) were also subtracted. Finally, the amount of increased short term borrowing is added back as a cash inflow to both models. This is done to account for the phenomenon of "permanent" borrowing, where operating funds are borrowed each year to cover expenses, including

the payment of the previous year's operating loan. Short term (operating) debt rises with total assets each year in the models. But each year the repayment of the previous year's short term loan is covered by the larger short term loan in the current year. Only the incremental portion is considered as a cash inflow in the models.

The operating cash flow variables are composed as follows.

OPFLOWF = OPFLOW - FNEWINT - REPAYF - LIVING3 - NEWTAX4 + STDEBTCH

where

OPFLOW = basic operating cash flow (see following pages)

FNEWINT = calculated fixed rate interest expense

REPAYF = fixed rate debt structure intermediate and real estate principal repayment

LIVING3 = living expenses; including personal food bought, clothing, recreation, phone, electricity, automobile, house repair

NEWTAX4 = federal and state income and social security taxes paid in current year for liabilities accrued in previous year

STDEBTCH = annual increase in short term debt outstanding

OPFLOWV = OPFLOW - VNEWINT - REPAYV - LIVING3 - RTAXES + STDEBTCH

where

OPFLOW = basic operating cash flow (see following pages)

VNEWINT = calculated variable rate loan interest expense

REPAYV = calculated variable rate intermediate and real estate loan principal repayment

LIVING3 = living expenses; including personal food bought, clothing, recreation, phone, electricity, auto, house repair

RTAXES = computed federal and state income and social security taxes paid in the current year for tax liabilities accrued in previous year

STDEBTCH = annual increase in short term debt outstanding

OPFLOW is calculated as follows:

OPFLOW = BEEFSALE + DAIRSALE + CHOGSALE + FHOGSALE + PIGSALE + FCATSALE + RESTSALE - (DAIRPURC + BEEFPURC + FCATPURC + CHOGPURC + PIGPURC + FHOGPURC + RESTPURC) + CROPINC - CROPEXP - STKEXP + BUTCHER + RESTINC - GASPURC - RESTEXP + NONFINC - NONFEXP

where

BEEFSALE = receipts from sales of beef breeding animals

DAIRSALE = receipts from sales of dairy animals plus milk sold

CHOGSALE = receipts from sales from complete farrow to finish hog enterprises

FHOGSALE = receipts from hog finishing enterprises

PIGSALE = receipts from sales of feeder pigs

FCATSALE = receipts from sales of finished feeder cattle

RESTSALE = receipts from sales of poultry, sheep, eggs, wool, horses, etc.

DAIRPURC = dairy cattle bought

BEEFPURC = beef breeding stock bought

FCATPURC = feeder cattle bought

CHOGPURC = swine purchased for complete hog operations

FHOGPURC = swine purchased for fattening in market feeder operations

PIGPURC = swine purchased for feeder pig production

RESTPURC = purchases of poultry, sheep, horses, etc.

CROPINC = income from sales of all crops

CROPEXP = seed, fertilizer, chemical, and drying expenses.

STKEXP = feed, bedding, veterinary expense

BUTCHER = value of stock butchered for domestic use, plus value of eggs and milk used

RESTINC = custom work, work off the farm, misc. farm income, coop patronage refund, gas tax refund

GASPURC = gasoline and oil bought

RESTEXP = custom work hired, repairs of equipment and buildings, wages of hired labor, real estate taxes, rents, general farm expense, farm share of telephone and electricity

NONFINC = investment income, income tax refunds, sale of investments

NONFEXP = investments purchased, life insurance payments

3. Interest Calculations

The interest calculations are divided into short, intermediate and long term portions. The short term component of the total farm debt has a maturity of one year, with both principal and interest payable in that time. The intermediate term segments are based on a

five year term, with one-fifth of the principal payable in each year, plus interest on the average outstanding balance. The long term components of the total were based on a fully amortized 25 year term with constant total payments.[1] (The proportions of interest and principal change from year to year but total payments remain the same.)

Each year's debt level was keyed to the level of total assets. This means that intermediate and long term debt levels rise incrementally with asset levels. New debt is added each year to cover the rise in asset level as well as old debt retired, in order to maintain a constant specified debt ratio. New debt incremented is carried at the interest rate currently charged by the lender for that year in the fixed rate model. (The overall effect is similar to a moving average, but given the low turnover of such debt in the early years of the amortization schedule the original amount outstanding at the start of the simulation period carries a much larger "weight" compared to subsequent annual increments.)

For the variable rate model, all debt is carried at the current interest rate applicable to each debt class, not just incremental portions.

3a. Interest Calculations: Variable Rate Model (VNEWINT)

The variable interest expense equations of the model are as

[1]The amortization schedule begins with year 1 in 1967. This minimizes the turnover of original debt of the fixed rate model.

follows:

VNEWINT = STINT + VITINT + VLTINT

STINT = TOTASSET * CLLTOA * STRATE

VITINT = TOTASSET * ILLTOA * ITRATE

VLTINT = TOTASSET * RELTOA * LTRATE

where

VNEWINT = total variable interest expense

STINT = interest expense on short term debt

VITINT = variable rate intermediate term interest expense

VLTINT = variable rate long term interest expense

TOTASSET = average total assets

CLLTOA, ILLTOA, RELTOA = short, intermediate, and long term liability to asset ratios (see discussion in section III.A.4. above)

STRATE, ITRATE, LTRATE = short, intermediate, and long term average annual effective interest rates

3b. Interest Calculations: Fixed Rate Model (FNEWINT)

The fixed interest expense equations of the model are as follows:

FNEWINT = STINT + FITINT + FLTINT

STINT[1] = TOTASSET * CLLTOA * STRATE

ITDEBT = TOTASSET * ILLTOA

LTDEBT = TOTASSET * RELTOA

[1]Same as in the variable interest expense model.

$$FITINT^{2} = ((ITDEBT_{t} - .8 * ITDEBT_{t-1}) * ITRATE_{t}) +$$
$$((.8 * ITDEBT_{t-1} - .6 * ITDEBT_{t-2}) * ITRATE_{t-1}) +$$
$$((.6 * ITDEBT_{t-2} - .4 * ITDEBT_{t-3}) * ITRATE_{t-2}) +$$
$$((.4 * ITDEBT_{t-3} - .2 * ITDEBT_{t-4}) * ITRATE_{t-3}) +$$
$$(.2 * ITDEBT_{t-4} - * ITRATE_{t-4})$$

$$TOTPMT^{3\ 4} = LTDEBT/((1 - (1/((1 + LTRATE) ** 25)))/LTRATE)$$

$$BALA = LTDEBT - (TOTPMT - LTDEBT * LTRATE)$$

$$BALB = BALA - (TOTPMT - BALA * LTRATE)$$

$$BALC = BALB - (TOTPMT - BALB * LTRATE)$$

$$BALD = BALC - (TOTPMT - BALC * LTRATE)$$

$$BALE = BALD - (TOTPMT - BALD * LTRATE)$$

$$BALF = BALE - (TOTPMT - BALE * LTRATE)$$

$$BALG = BALF - (TOTPMT - BALF * LTRATE)$$

$$BALH = BALG - (TOTPMT - BALG * LTRATE)$$

$$BALI = BALH - (TOTPMT - BALH * LTRATE)$$

$$BALJ = BALI - (TOTPMT - BALI * LTRATE)$$

$$BALK = BALJ - (TOTPMT - BALJ * LTRATE)$$

$$BALM = BALK - (TOTPMT - BALK * LTRATE)$$

$$BALN = BALM - (TOTPMT - BALM * LTRATE)$$

[2]The repayment schedule for intermediate term debt is similar to the interest calculation formula, but with .2 substituted for $ITRATE_{t-k}$. The net effect of the formula is that all t-4 aged debt is paid off in the fifth year, plus a decreasing proportion of $ITDEBT_{t-3}$, $ITDEBT_{t-2}$, and $ITDEBT_{t-1}$ respectively. The proportion paid off on the remainder of the debt is dependent on the asset growth rate.

[3]Derived from annuity formula, Handbook of Financial Mathematics, Formulas and Tables, Vichas, p.97.

[4] ** symbolizes exponentiation.

$$
\begin{aligned}
FLTINT^{5} = {} & ((LTDEBT_{t} - BALA_{t-1}) * LTRATE_{t}) + \\
& ((BALA_{t-1} - BALB_{t-2}) * LTRATE_{t-1}) + \\
& ((BALB_{t-2} - BALC_{t-3}) * LTRATE_{t-2}) + \\
& ((BALC_{t-3} - BALD_{t-4}) * LTRATE_{t-3}) + \\
& ((BALD_{t-4} - BALE_{t-5}) * LTRATE_{t-4}) + \\
& ((BALE_{t-5} - BALF_{t-6}) * LTRATE_{t-5}) + \\
& ((BALF_{t-6} - BALG_{t-7}) * LTRATE_{t-6}) + \\
& ((BALG_{t-7} - BALH_{t-8}) * LTRATE_{t-7}) + \\
& ((BALH_{t-8} - BALI_{t-9}) * LTRATE_{t-8}) + \\
& ((BALI_{t-9} - BALJ_{t-10}) * LTRATE_{t-9}) + \\
& ((BALJ_{t-10} - BALK_{t-11}) * LTRATE_{t-10}) + \\
& ((BALK_{t-11} - BALL_{t-12}) * LTRATE_{t-11}) + \\
& ((BALL_{t-12} - BALM_{t-13}) * LTRATE_{t-12}) + \\
& ((BALM_{t-13} - BALN_{t-14}) * LTRATE_{t-13}) + \\
& (BALN_{t-14} * LTRATE_{t-14})
\end{aligned}
$$

where

FNEWINT = total fixed interest expense.

STINT, FITINT, FLTINT = short, intermediate, and long term fixed interest expense.

[5]The BALX series of calculations computes the first 14 years of the amortization schedule of remaining principal for each farmer per year. This is repeated for each of the 14 years in the study period, resulting in 196 amortization calculations for each farmer. Only 14 of these are used in calculating FLTINT. The utilized calculations correspond to the first balance of a year ago, the second balance of two years ago, the third balance of three years ago, the fourth balance of four years ago, etc. This procedure reflects the changing balance size due to total asset growth.

STRATE, ITRATE, LTRATE = short, intermediate, and long term interest rates.

TOTASSET = average total assets

CLLTOA, ILLTOA, RELTOA = short, intermediate and long term (real estate) debt ratios.

ITDEBT, LTDEBT = intermediate and long term debt.

TOTPMT = amortized payment amount.

$BALX_{t-k}$ = balance of debt remaining after payment #X in year t-k.

4. Adjustments to Interest Expense for Detrended Simulations.

In order to examine the greatest potential differences between the fixed and variable rate models, five comparisons were made between the variable rate model and a fixed rate model for which the trend of rising interest rates was removed. Then the overall average interest expense levels were equalized so that proper comparisons of variance could be made.

The detrending adjustment was designed to synthetically produce a stable fixed rate series with a zero time trend from an actual time series that is characterized by neither stable fixed rates nor zero trend. Such an adjustment to the fixed rate series allows it to demonstrate the maximum potential stabilizing effect that can be produced by the use of fixed rate lending instruments. The detrending equations were as follows:

$$DEBTSUM_t = LTDEBT_t + ITDEBT_t + STDEBT_t$$

$$IBAR_t = FNEWINT_t / DEBTSUM_t$$

$$I2BAR = \left(\sum_{t=1}^{15} IBAR_t\right)/15$$

$$ADJUSTMENT\ FACTOR_t = (I2BAR/IBAR_t) * 1.232$$

where

$DEBTSUM_t$ = total debt in year t.

$STDEBT_t$, $ITDEBT_t$, $LTDEBT_t$ = short, intermediate, and long term debt in year t.

$IBAR_t$ = unadjusted average interest rate paid on debt in year t.

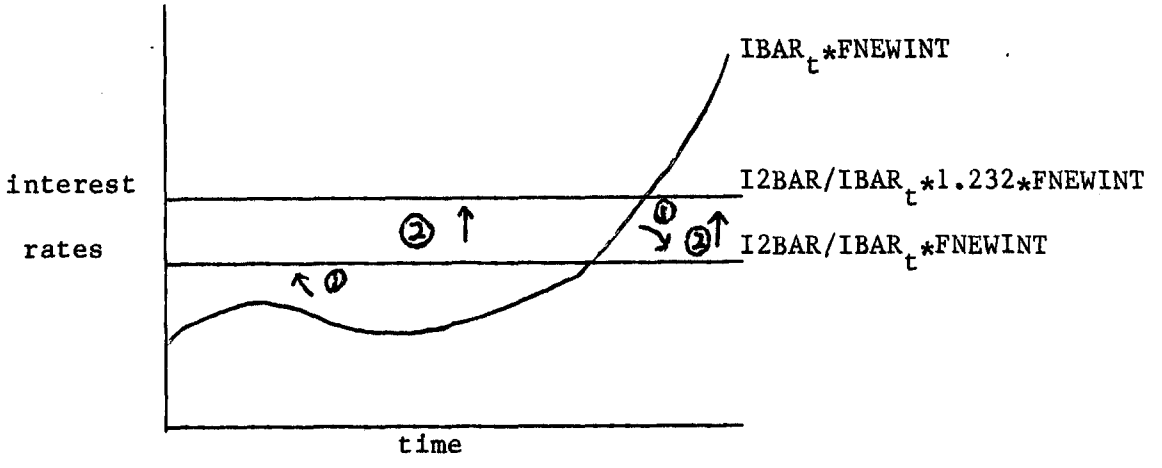
$FNEWINT_y$ = total fixed interest expenses (see section III.B.3a,3b for formulation in year t.

I2BAR = average interest rate over 15 years.

The grand mean adjustment factor (1.232 for mixed debt runs, 1.237 for real estate debt runs) was calculated by dividing the total interent expense under the variable rate model by the total interest expense of the indexed ($I2BAR/IBAR_t$) fixed rate model. This equalized the grand mean (over farm types and years) of the variable rate model and the "adjusted" fixed rate model. The adjustment factor was thus utilized to multiply the fixed interest expense variable (FNEWINT) and thereby equalize the average interest cost of the adjusted fixed rate model with that of the variable rate model.

The effect of the adjustment factor on the fixed interest expense was to raise the interest rate in years that are below the average for the time series (i.e. the early years of the time series) and lower it in the years when interest rates were high relative to the mean. (see figure 1)

Figure 1. ILLUSTRATION OF DETRENDING ADJUSTMENT



STEP 1: Series is detrended.
STEP 2: Series is equalized to average variable expense.

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5. Repayment Calculations (REPAYF, REPAYV)

The repayment of principal calculations follow the same asumptions as the interest rate formulations, and are as follows:

$$REPAYV = TOTPMT - VLTINT + .2 * ITDEBT$$

$$REPAYF^{1\ 2} = ((LTDEBT - BALA_{t-1}) * PORPMT_t) +$$

[1]The long term segment of REPAYF is calculated as if composed of a series of several different long term loans, of which one originates in year t, another in t-1, another in t-2, etc. and that $PORPMT_{t-k}$ is the percentage of the loan payment applicable to principal reduction for a 25 year loan that was originated K years ago and is being amortized with constant total payments.

[2]The repayment schedule for intermediate term debt is similar to the interest calculation formula, but with .2 substituted for $ITRATE_{t-k}$. The formula then simplifies to ITRATE * .2. The net result of the repayment formula is that all t-4 aged debt is paid off in the fifth year, plus a decreasing proportion of $ITDEBT_{t-3}$, $ITDEBT_{t-2}$, and $ITDEBT_{t-1}$ respectively. This proportion is dependent on the asset growth rate, with the higher the growth rate, the higher the proportion.

$$((BALA_{t-1} - BALB_{t-2}) * PORPMT_{t-1}) +$$
$$((BALB_{t-2} - BALC_{t-3}) * PORPMT_{t-2}) +$$
$$((BALC_{t-3} - BALD_{t-4}) * PORPMT_{t-3}) +$$
$$((BALD_{t-4} - BALE_{t-5}) * PORPMT_{t-4}) +$$
$$((BALE_{t-5} - BALF_{t-6}) * PORPMT_{t-5}) +$$
$$((BALF_{t-6} - BALG_{t-7}) * PORPMT_{t-6}) +$$
$$((BALG_{t-7} - BALH_{t-8}) * PORPMT_{t-7}) +$$
$$((BALH_{t-8} - BALI_{t-9}) * PORPMT_{t-8}) +$$
$$((BALI_{t-9} - BALJ_{t-10}) * PORPMT_{t-9}) +$$
$$((BALJ_{t-10} - BALK_{t-11}) * PORPMT_{t-10}) +$$
$$((BALK_{t-11} - BALL_{t-12}) * PORPMT_{t-11}) +$$
$$((BALL_{t-12} - BALM_{t-13}) * PORPMT_{t-12}) +$$
$$((BALM_{t-13} - BALN_{t-14}) * PORPMT_{t-13}) +$$
$$((BALN_{t-14} * PORPMT_{t-14}) -$$
$$FLTINT + (ITDEBT * .2)$$

$$PORPMT_{t-k} = 1/((1 - (1/((1 + LTRATE_{t-k}) ** 25)))/LTRATE_{t-k})$$

where

REPAYV, REPAYF = variable rate debt and fixed rate intermediate and long term debt principal repayment.

TOTPMT = amortized payment amount (see interest calculation for formulation) for long term debt.

VLTINT, FLTINT = interest expense for variable and fixed rate long term debt (see interest calculation for details)

ITDEBT = intermediate term debt.

BALX = balance of debt remaining after payment #X.

PORPMT = proportion of current year's payment applied to principal repayment.

LTRATE = long term interest rate.

6. Tax calculations (RTAXES, NEWTAX4)

Income tax data, when reported, was taken directly from the farm management records. When this information was not available, the data deficiencies were filled with approximations supplied by regression equations. The sample used to calculate these regressions was larger than that used for the remainder of this study, and comprised all cases for a particular type and year which contained nonzero tax information, regardless of whether they were "survivors" or not. The mix of actual and inferred tax figures became that used for the fixed rate model (NEWTAX4).

The tax figure for the variable rate model was NEWTAX4 modified by income changes due to the differences in interest expense levels between the two models. The change in taxes paid involved taking the difference in interest paid under the fixed and variable models and allowing that difference to be considered an increase or reduction in income for the variable interest rate model. A rise in interest expense when compared to the fixed rate model was considered a corresponding reduction in taxable income. A computer program was devised to take the fixed rate model tax liability (NEWTAX4) and adjust it higher or lower (across marginal tax brackets when necessary). Thus, the lower the taxable income became, the lower the

variable rate tax liability became.

The marginal rate structure compiled in the program took into account marginal federal and state income tax rates as well as marginal rates of social security contributions. Mutual deductibility of taxes on federal and state returns was also taken into account. The changed tax variable (RTAXES) become the tax figure for the variable rate model.

III. RESULTS

A. Introduction

The major focus of this study is the operating cash flow variable, which consists of sales minus purchases and expenses, as well as subtractions for calculated interest expense, family living expenses, income taxes payable, and repayment of principal. The results of this study are presented in ten tables; five cross-sectional tables comparing the means of operating cash flows for the fixed and variable rate models, and five time series tables presenting the standard deviations (and means) of operating cash flows for variability analysis.

The following remarks are broken down into three areas. First, a check of total cash flow (operating cash flow as well as cash flows due to financing; see next section for discussion) was conducted in order to verify the long term financial viability of the case farms. Second, the means of operating cash flows are compared in order to identify the major consequences associated with each type of financing for various types of farms. Also, effects of debt levels are analyzed to identify differences and to predict maximum debt ratios. Finally, the standard deviations of operating cash flows are examined in order to determine the additional variability due to variable rate loans at increasing levels of debt.

B. Cash Flow Viability Check

Operating cash flows are the focal variable in comparisons between the variable rate model and the fixed rate model due to the difficulty of determining of where earnings from farm enterprises are invested. (Nonfarm income and nonfarm investments are two of the sources of error). Cash flows reflect the basic financial liquidity and variability characteristics under study. However, the fourteen year averages of operating cash flows are negative for cash crop farms at debt to asset levels of .40. This is more financially threatening than an occasional negative cash flow year, since earnings in positive flow years can offset them. However, the fourteen year averages for cash crop farms implies liquidity problems of a more serious nature. This led to the concern that the assumptions postulated present too much of a financial burden for the sample farms to remain viable. In other words, the interest expense and principal repayment calculations used in this study may have been so much larger than those outlays actually experienced by the members of the record associations that they would not have been able to support them. The assumptions postulated in this study would be less useful if such were the case. In order to discover whether the assumed financial burdens were too large or not, a total cash flow check was run on the data. This consisted of adding a measure of financing cash flow to OPFLOWF and OPFLOWV (operating cash flows for fixed and variable rate models respectively) to determine the total cash flow. The financing cash flow measure consisted of machinery, equipment, building, and land

sales minus the purchases of these items, plus new borrowings in the current year. (New borrowings consist of the incremental increase in borrowing due to rising asset levels plus the amount of principal repaid in the previous year, thus maintaining a constant debt to asset relationship.) This was then added to the operating cash flow, resulting in the total cash flow measure used to check liquidity.

At higher debt to asset levels, the net financing cash flow became larger, offsetting the reduction in net of debt servicing operating cash flows resulting from increased interest and principal payments. As a result, the fourteen year averages (as well as most of the individual years) were positive for all of the farm types at a debt to asset ratio of .40. Therefore, the assumptions in interest, principal and debt calculations are financially feasible (assuming lenders allow maintenance of a constant debt to asset relationship at the specified level) and validate the assumptions made regarding debt load and repayment terms.

C. Means: Fixed versus Variable Rate Models

The results of the means of operating cash flow analysis are presented in Tables 1-5. An examination of the tables reveals observations in farm type differences and debt level differences.

In Tables 1-5, cash crops are consistently the farm type with the lowest operating cash flow, followed by the dairy only operations. Dairy-crop and Hog-crop operations vie for the highest levels of operating cash flow in all five comparisons. The low rate of return for the cash crop and dairy only farms suggest that these operations

have the least debt carrying capacity of the four farm types. This observation suggests that the synergistic and diversification effects inherent in crop-livestock farms is a significant factor, even more significant than government price support programs (since crop commodities and milk were supported, yet dairy-crops farms create a higher operating cash flow than either crops or dairy farms alone).

Table 1. OPERATING CASH FLOWS - MEANS BY TYPE AND YEAR FOR A 20% DEBT/ASSET RATIO WITH DEBT CONSISTING ENTIRELY OF REAL ESTATE DEBT

	Fixed (OPFLOWF)				Variable (OPFLOWV)			
Type	Cash crops	dairy + crops	hogs + crops	dairy only	cash crops	dairy + crops	hogs + crops	dairy only
N	6	10	21	10	6	10	21	10
Year								
1968	-2546	7341	9332	6346	-2643	7272	9262	6279
1969	1244	10416	9304	7934	932	10152	8996	7679
1970	3695	10714	11968	8118	3368	10444	11669	7834
1971	2251	9323	4916	10161	2106	9211	4806	10056
1972	3989**	12257	17941*	14001**	3919	12229	17916	13977
1973	6768*	21971	33540	21542	6591	21866	33444	21432
1974	32260	32512	37454	22003	31970	32238	37147	21682
1975	11030	10542	35442	10227	10756	10307	35138	9904
1976	15071	27373	30743	20431	14793	27083	30449	20110
1977	-2354	26330	24215	19671	-2506	26144	24029	19462
1978	22837	27722	41229	32825	22629	27563	41066	32624
1979	3460	35319	25612	44143	2774	34573	24633	43266
1980	4774	34042	12513	32688	3499	32836	10637	31248
1981	-2823	46685	14715	46909	-5698	44127	10957	44442
ave.	7118	22325	22066	21214	6007	21860	21439	20714

*differences between models not significant at 95% confidence level
**differences between models not significant at 90% confidence level

Table 2. OPERATING CASH FLOWS - MEANS BY TYPE AND YEAR FOR A 15% DEBT TO ASSET RATIO

	Fixed (OPFLOWF)				Variable (OPFLOWV)			
Type	Cash crops	dairy + crops	hogs + crops	dairy only	cash crops	dairy + crops	hogs + crops	dairy only
N	6	10	21	10	6	10	21	10
Year								
1968	-2825	6942	9214	5662	-2875	6905	9177	5624
1969	892	9975	9097	7188	747	9853	8958	7064
1970	3309	10206	11675	7338	3142	10062	11521	7177
1971	1827	8779	4627	9303	1749	8714	4564	9236
1972	3586••	11622	17694	12925•	3554	11606	17678	12910
1973	6443•	21350	33395	20256	6365	21302	33351	20203
1974	32427	31934	37314	20542	32287	31794	37163	20371
1975	10765	9605	35130	8592	10623	9471	34968	8403
1976	14960	26454	30399	18512	14820	26301	30246	18334
1977	-2531	24930	23575	17384	-2614	24825	23469	17260
1978	22799	26114	40431	30120	22694	26025	40338	30003
1979	2898	33620	24455	40429	2515	33153	23874	39843
1980	3231	30944	9712	27354	2355	29895	8297	25958
1981	-5092	42748	10535	40189	-6833	40831	8052	38080
ave.	6621	21087	21232	18985	6323	20767	20833	18605

•differences between models not significant at 95% confidence level
••differences between models not significant at 90% confidence level

Table 3. OPERATING CASH FLOWS - MEANS BY TYPE AND YEAR FOR A 20% DEBT TO ASSET RATIO

	Fixed (OPFLOWF)				Variable (OPFLOWV)			
Type	Cash crops	dairy + crops	hogs + crops	dairy only	cash crops	dairy + crops	hogs + crops	dairy only
N	6	10	21	10	6	10	21	10
Year								
1968	-3822	6083	8377	4667	-3889	6033	8328	4616
1969	-134	9031	8091	6094	-327	8868	7904	5928
1970	2207	9205	10559	6195	1984	9012	10354	5981
1971	731	7698	3553	8062	626	7611	3469	7973
1972	2374••	10383	16546	11367•	2330	10362	16526	11346
1973	5364•	19939	32004	18386	5259	19874	31945	18315
1974	31013	30028	35372	18317	30826	29841	35170	18088
1975	8767	7369	32630	6057	8578	7191	32414	5805
1976	12648	23811	27186	15358	12460	23606	26983	15120
1977	-5079	22205	19903	13550	-5189	22065	19762	13384
1978	19966	22914	36227	25773	19826	22796	36102	25617
1979	-437	29503	19367	34450	-950	28877	18590	33666
1980	-853	25688	3394	19763	-2030	24276	1486	17894
1981	-10129	36437	2772	32102	-12483	33837	-583	29224
ave.	4472	18592	18284	15724	4073	18161	17746	15211

•differences between models not significant at 95% confidence level
••differences between models not significant at 90% confidence level

Table 4. OPERATING CASH FLOWS - MEANS BY TYPE AND YEAR FOR A 25% DEBT TO ASSET RATIO

	Fixed (OPFLOWF)				Variable (OPFLOWV)			
Type	Cash crops	dairy + crops	hogs + crops	dairy only	cash crops	dairy + crops	hogs + crops	dairy only
N	6	10	21	10	6	10	21	10
Year								
1968	-4807	5233	7572	3678	-4891	5170	7511	3615
1969	-1158	8095	7103	5006	-1399	7891	6868	4797
1970	1115	8206	9454	5059	837	7964	9198	4791
1971	-364	6627	2486	6827	-494	6518	2381	6715
1972	1188••	9160	15422	9829•	1132	9133	15397	9803
1973	4316•	18566	30682	16537	4185	18485	30608	16448
1974	29740	28213	33534	16123	29507	27979	33281	15835
1975	6822	5159	30218	3550	6585	4936	29948	3235
1976	10425	21238	24095	12254	10191	20982	23841	11957
1977	-7572	19514	16313	9773	-7709	19338	16136	9566
1978	17222	19764	32112	21475	17046	19617	31955	21280
1979	-3731	25528	14406	28559	-4374	24741	13431	27577
1980	-4874	20500	-2828	12256	-6345	18716	-5236	9908
1981	-15037	30490	-4741	23402	-18034	27132	-9052	19793
ave.	2377	16164	15416	12452	1874	15614	14733	11809

•differences between models not significant at 95% confidence level
••differences between models not significant at 90% confidence level

Table 5. OPERATING CASH FLOWS - MEANS BY TYPE AND YEAR FOR A 40% DEBT TO ASSET RATIO

	Fixed (OPFLOWF)				Variable (OPFLOWV)			
Type	Cash crops	dairy + crops	hogs + crops	dairy only	cash crops	dairy + crops	hogs + crops	dairy only
N	6	10	21	10	6	10	21	10
Year								
1968	-7693	2742	5351	750	-7827	2642	5252	648
1969	-4213	5340	4252	1775	-4601	5005	3871	1438
1970	-2096	5224	6202	1690	-2544	4836	5791	1261
1971	-3634	3472	-666	3156	-3842	3300	-834	2977
1972	-2208••	5577	12194	5343•	-2299	5534	12153	5301
1973	1363•	14678	27125	11118	1153	14548	27007	10977
1974	26778	23319	28644	9721	26404	22944	28239	9259
1975	1302	-1317	23516	-3807	924	-1675	23081	-4316
1976	4295	13946	15560	3249	3920	13533	15152	2770
1977	-14719	11642	6035	-1214	-14938	11359	5751	-1547
1978	9526	10615	20294	8884	9241	10379	20043	8571
1979	-13365	14445	273	11408	-14411	13173	-1305	9824
1980	-16557	5341	-20936	-9756	-18945	2355	-24870	-13621
1981	-28989	13002	-26652	-1498	-33966	7149	-33920	-7558
ave.	-3586	9145	7229	2916	-4409	8220	6101	1856

•differences between models not significant at 95% confidence level
••differences between models not significant at 90% confidence level

As would be expected, for the mixed debt series of 15, 20, 25, and 40% debt ratios, the higher the level of debt, the lower the net of debt servicing operating cash flows. This occurs uniformly across all four farm types.

The only noteworthy observation occurs in the real estate series where real estate debt is 20% of assets (no short or intermediate liabilities). First note that the operating cash flows are higher in the long term debt simulation compared with the 20% mixed debt simulation (Tables 1 and 3). These higher cash flows are a result of two factors. The first is that there is a lower interest rate on the real estate debt on average, creating lower interest payments when compared to the mixed debt simulations. Second, because real estate debt is longer term debt, the total debt structure rolls over (is paid back) fewer times. Therefore the principal repayments are smaller in the long term debt simulations. Also note that the absolute differences between OPFLOWV and OPFLOWF are slightly greater in the real estate simulation. This reflects the fact that part of the mixed debt simulation includes short term debt, which does not contribute to differences between models, since short term debt is carried for only a one year term in both models, and is given the same mathematical formulation. In the real estate debt simulation, however, all 20% of the debt ratio contributes to divergence between the fixed and variable rate models.

1. Regression Analysis of Maximum Feasible Debt Ratios for Farm Types.

In order to determine whether there were significant differences

between the maximum debt capacities of the unadjusted fixed and variable rate models, regression equations were first constructed for each of the two model's four farm types. Confidence intervals of means of operating cash flows plus or minus two standard errors were then calculated on the regression equation where operating cash flows are zero (X-intercept).

Regressing the fourteen year averages for Tables 2-5 at 15, 20, 25, and 40% debt to asset ratios for each farm type yields the following regression equations for the fixed and variable rate models. Y is the debt ratio and X is the fourteen year mean.

FARM TYPE	REGRESSION	R SQUARE[1]
fixed cash crop	$Y = -.246 \times 10^{-4}X + .311$	.999
fixed dairy-crop	$Y = -.210 \times 10^{-4}X + .591$	.999
fixed hogs-crop	$Y = -.179 \times 10^{-4}X + .528$	.999
fixed dairy only	$Y = -.156 \times 10^{-4}X + .445$	.999
variable cash crop	$Y = -.234 \times 10^{-4}X + .296$	.999
variable dairy-crop	$Y = -.200 \times 10^{-4}X + .563$	.999
variable hog-crop	$Y = -.170 \times 10^{-4}X + .503$	.999
variable dairy only	$Y = -.149 \times 10^{-4}X + .427$	.999

Each regression was plotted from the four fourteen year means for a farm type at the four debt levels. This allows the prediction of the maximum feasible debt ratio for each farm type by inserting

[1] R square is a statistical measure of the regression equation's correlation to the plot of the actual data.

zero[2] for the value of X in the above regression equations. Thus the maximum feasible debt to asset ratio for cash crop farms is 29.6 - 31.1% while the maximum debt ratio for dairy only operations is 42.7 - 44.5%. For dairy-crops farms, the maximum debt ratio is 56.3 to 59.1% while for hogs-crops operations the maximum is 50.3 - 52.8%.[3] Since the confidence intervals of the regression constants for fixed and variable rate models do not overlap, the variable rate model's maximum debt ratio, though only 1.5 - 2.8% lower than the maximum debt ratio for the fixed model, is significantly different.

D. Variability and Risk Across Time

In addition to comparing the means of operating cash flows to determine which model has a greater adverse impact on financial feasibility, a comparison of standard deviations will reveal which model simulates the greatest variability (and therefore is the riskier loan pricing method). While it may seem self-evident that the variable rate pricing arrangement would be riskier, such is not necessarily the case. If pre-debt servicing cash flows move in tandem with (i.e. are positively correlated with) interest rates, the use of variable interest rate loans would actually reduce risk.

The standard deviations (and means) of operating cash flows for both the fixed and variable rate models are presented in Tables 6-10.

[2]This presumes some flexibility in rescheduling of loan repayments in below average years for the cash flows to be precisely zero.

[3]These results apply to the average farmer in each group. Also, these results presume that lenders add no risk premium to the interest rate as farms become more heavily leveraged.

These means and standard deviations are presented for each case farm over the fourteen year time span. The farms are classed by farm type for convenience. Selected F-tests[1] are also presented, comparing the variances of the fixed and variable rate models. The F-tests would need to be greater than approximately 2.08 to be significant at thirteen and thirteen degrees of freedom and the 90% confidence level. The adjusted fixed rate model is more stable than the variable model since it is detrended. This provides the maximum contrast to the variable rate model. Also, the equalized means make a more valid statistical comparison.

The principal observation is that while the largest F test of Table 7 (debt to asset ratio of 15%) is 1.32, the largest F test of Table 10 (40% debt to asset ratio) is 1.87. This suggests that the greater the debt to asset ratio, the greater the difference in variability and the greater the risk contributed by variable rate loans.[2] However, the increasing variance divergence between the fixed and variable rate models is not fully confirmed by means of F-tests for each farm type and debt level (see appendix E). (The selection of F tests in table 7-10 is intended to present the largest values of F generated and is not a random sample.) F tests of operating cash flows for the four farm types for each debt level were computed from

[1]The null hypothesis tested is that the variance of the variable rate model is equal to the variance of the fixed rate model. The alternative hypothesis is that the variances are not equal.

[2]Note, however, that none of the F tests are greater than 2.08 and therefore are not statistically significant at a 90% confidence level.

Table 6. OPERATING CASH FLOWS BY FARM FOR A 20% DEBT TO ASSET RATIO COMPOSED ENTIRELY OF REAL ESTATE DEBT

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)	
	means	S.D.	means	S.D.
cash crops				
1	-3972	14463	-3882	14885
2	-651	7389	-747	7463
3	8151	7738	8227	7964
4	17837	30091	17746	29852
5	10	11166	-121	11988
6	2480	5442	2473	5537
dairy + only				
1	-26	3029	-39	2971
2	17706	23889	17621	23091
3	19194	19970	19173	19403
4	24045	19427	24108	19026
5	25279	19702	25240	19259
6	10388	9404	10411	9202
7	6872	4792	6859	4679
8	12209	16003	12316	15694
9	26742	28524	26763	27987
10	13417	11982	13409	11902
hogs + crops				
1	3841	11489	3915	11915
2	28867	16202	28914	16550
3	45409	33567	45342	32839
4	3077	10141	2981	11149
5	15445	11139	15392	11215
6	3778	8682	3709	9510
7	10878	11173	10701	11436
8	17455	18714	17405	18449
9	28326	16941	28344	17176
10	323	81655	172	83159
11	-4532	44295	-4547	44173
12	36917	24724	36971	24643
13	23960	31173	23871	30794
14	5739	5808	5497	5910
15	7140	12301	7256	12179
16	16827	14874	16896	14708
17	8631	7676	8618	7554
18	1594	9532	1549	9638
19	19035	13084	19108	12952
20	6039	7851	6084	7935
21	12086	10779	12077	10542

Table 6. OPERATING CASH FLOWS BY FARM FOR A 20% DEBT TO ASSET RATIO COMPOSED ENTIRELY OF REAL ESTATE DEBT (continued)

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)	
	means	S.D.	means	S.D.
dairy only				
1	70190	64447	70234	63066
2	-92	2563	-50	2774
3	9108	8756	8127	8293
4	7394	5740	7378	5539
5	13838	14734	13794	14032
6	5218	6633	5217	6544
7	12717	15969	12740	15587
8	12425	11611	12439	11103
9	8262	16720	8347	16546
10	11931	10084	11887	10214

Table 7. OPERATING CASH FLOWS BY FARM FOR A 15% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
cash crops					
1	-5240	14962	-5256	15566	
2	-1026	7345	-1142	7557	
3	8679	7998	8665	8245	
4	17252	30040	17243	29827	
5	1116	11211	779	12139	1.17
6	2621	5418	2605	5530	
dairy + crops					
1	-161	2987	-174	2917	
2	15765	22462	15467	21205	1.12
3	17695	19083	17547	18345	
4	22132	18126	22001	17618	
5	22931	18058	22601	17494	
6	11037	9398	10921	9018	
7	7175	4943	7151	4806	
8	13130	16977	13128	16337	
9	26418	28274	26443	27688	
10	13342	11932	13335	11838	
hogs + crops					
1	2852	11795	2762	12462	
2	28418	16203	28372	16667	
3	44994	33016	44632	31854	
4	2687	10455	2488	11778	
5	14431	10801	14221	11011	
6	2404	9419	2088	10828	1.32
7	10233	11166	9849	11650	1.09
8	17567	18696	17532	18414	
9	29483	17388	29326	17586	
10	1349	81144	1050	83014	
11	-3755	44458	-3828	44373	
12	36377	24397	36236	24154	
13	23319	30635	23036	30042	
14	5244	5748	4804	6116	1.13
15	6896	12245	7037	12115	
16	16682	14731	16709	14603	
17	8353	7513	8301	7363	
18	1401	9542	1286	9698	
19	18739	12831	18635	12651	
20	5511	7855	5484	7979	
21	12005	10716	11869	10212	

Table 7. OPERATING CASH FLOWS BY FARM FOR A 15% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
dairy only					
1	65013	60133	64723	58147	
2	-327	2777	-349	3076	
3	7252	8008	7203	7435	
4	6788	5293	6734	5025	
5	11971	13291	11783	12350	1.16
6	4970	6459	4903	6409	
7	11465	14677	11330	14059	
8	10825	10188	10666	9470	
9	7953	16555	7953	16195	
10	10406	9734	10249	10065	1.07

Table 18. OPERATING CASH FLOWS BY FARM FOR A 20% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
cash crops					
1	-7287	15789	-7311	16616	
2	-2754	7612	-2935	8118	
3	7222	7808	7203	8268	
4	15897	30053	15879	29776	
5	-1932	11914	-2392	13663	1.36
6	2076	5425	2055	5602	
dairy + crops					
1	-349	2944	-366	2852	
2	12696	20163	12268	18471	1.19
3	15332	17886	15106	16888	
4	18470	15823	18282	15328	
5	18281	15119	17846	14950	
6	9629	8697	9470	8362	
7	5999	4460	5965	4407	
8	11662	16068	11655	15237	
9	24855	27651	24875	26831	
10	13022	11749	13012	11624	
hogs + crops					
1	-278	13005	-395	14068	
2	25722	15926	25651	16711	
3	40722	29154	40212	27742	
4	309	11677	23	13584	
5	11445	10223	11129	10973	
6	-410	11458	-810	13362	1.36
7	7414	11593	6900	12727	1.21
8	16980	18391	16931	18015	
9	26263	16201	26005	16935	
10	-1701	82136	-2111	84683	
11	-6313	45017	-6457	44954	
12	33499	22851	33311	22688	
13	20600	28920	20165	28235	
14	1923	6122	1328	7678	1.57
15	5547	12045	5732	11853	
16	15659	14415	15695	14262	
17	6887	6949	6817	6856	
18	120	9700	-35	10007	
19	15911	11249	15766	11294	
20	3576	8063	3537	8374	
21	11239	9828	11055	9176	

Table 8. OPERATING CASH FLOWS BY FARM FOR A 20% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
dairy only					
1	57058	53865	56647	51202	
2	-1171	3388	-1201	3814	1.27
3	4888	6381	4819	5720	
4	5864	4656	5792	4320	
5	9076	11209	8812	10034	1.24
6	3318	5838	3227	5990	
7	8988	12240	8805	11495	
8	7752	7815	7530	7109	
9	6600	15449	6598	14978	
10	7879	9439	7630	10148	1.16

Table 9. OPERATING CASH FLOWS BY FARM FOR A 25% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
cash crops					
1	-9325	16669	-9358	17728	
2	-4451	8084	-4699	8953	
3	5817	7895	5793	8607	
4	14554	30070	14528	29733	
5	-4864	13229	-5450	15817	1.42
6	1546	5458	1520	5710	
dairy + crops					
1	-536	2904	-558	2792	
2	9641	17927	9082	15852	1.27
3	12981	16847	12665	15627	
4	14838	13900	14586	13609	
5	13855	13156	13197	13781	
6	8293	8270	8087	8112	
7	4858	4165	4814	4289	
8	10324	15355	10308	14346	
9	23317	27020	23330	25963	
10	12706	11570	12694	11415	
hogs + crops					
1	-3364	14587	-3513	16063	
2	23072	15890	22973	17066	
3	36563	25731	35888	24262	
4	-2026	13129	-2399	15607	
5	8496	10183	8072	11670	
6	-3087	13523	-3684	16187	1.52
7	4651	12546	4005	14413	1.32
8	16406	18089	16344	17622	
9	23174	15548	22783	17114	
10	-4637	83076	-5158	86313	
11	-8782	45712	-9002	45719	
12	30747	21555	30496	21571	
13	17934	27372	17337	26718	
14	-1340	7694	-2093	10281	1.79
15	4227	11909	4455	11651	
16	14656	14123	14699	13956	
17	5442	6537	5352	6577	
18	-1139	9953	-1334	10448	
19	13148	10167	12954	10659	
20	1670	8530	1617	9071	
21	10497	8990	10265	8215	

Table 9. OPERATING CASH FLOWS BY FARM FOR A 25% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
dairy only					
1	49144	47813	48614	44558	
2	-2002	4050	-2042	4599	
3	2553	4987	2458	4441	
4	4944	4067	4854	3690	
5	6195	9327	5817	8007	1.36
6	1703	5612	1585	6087	
7	6539	9970	6307	9210	
8	4706	6119	4414	5915	
9	5292	14455	5286	13883	
10	4913	10127	4632	11408	1.26

Table 10. OPERATING CASH FLOWS BY FARM FOR A 40% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
cash crops					
1	-15384	19545	-15456	21323	1.19
2	-9366	10324	-9818	12420	1.45
3	1917	9507	1862	11020	1.34
4	10599	30143	10550	29655	
5	-12961	18979	-13933	23779	1.56
6	51	5679	5	6209	
dairy + crops					
1	-1093	2802	-1130	2635	
2	566	11865	-445	9462	1.57
3	6002	14948	5415	13716	
4	4124	11989	3629	13787	1.32
5	548	14244	-723	19498	1.87
6	4717	8595	4289	9710	1.27
7	1642	4515	1560	5473	1.46
8	7087	14311	6979	12777	
9	18913	25258	18888	23471	
10	11787	11064	11766	10816	
hogs + crops					
1	-12349	20503	-12636	23236	
2	15399	17106	15127	19867	
3	24758	19794	23341	20679	
4	-8774	18195	-9420	22296	
5	-136	12886	-893	16728	1.69
6	-11132	20990	-12162	25352	1.45
7	-3314	17288	-4367	21308	1.52
8	14767	17205	14665	16479	
9	14701	16528	13901	21278	1.65
10	-12770	85521	-13621	90865	
11	-15652	48490	-16111	49003	
12	22807	19446	22347	20749	
13	10246	23933	9161	24271	
14	-10778	14934	-12006	19787	1.76
15	447	11839	800	11369	
16	11765	13404	11825	13277	
17	1235	6417	1048	7306	
18	-4784	11167	-5101	12356	
19	5242	10742	4874	13272	1.52
20	-3880	10988	-3989	12293	
21	8417	6821	8039	5949	

Table 10. OPERATING CASH FLOWS BY FARM FOR A 40% DEBT TO ASSET RATIO

Farm Type and Number	Adjusted Fixed (OPFLOWF)		Variable (OPFLOWV)		Selected F Tests
	means	S.D.	means	S.D.	
crops only					
1	25655	31946	24584	27652	
2	-4418	6142	-4488	7053	
3	-4284	4567	-4467	6082	
4	2210	2874	2060	2767	
5	-2358	6597	-3090	7697	1.36
6	-2928	7158	-3139	8736	1.49
7	-643	5910	-1031	6895	
8	-4259	8787	-4796	11354	1.67
9	1637	12261	1616	11529	
10	-3139	14433	-3637	17172	1.41

the corresponding standard deviations. Again it should be noted that the values of the F tests are very small, and also that there is no consistent pattern of trend between the four farm types. Therefore, it is reasonable to assume that the variances of the variable interest rate model and the fixed interest rate model are not different from each other.

VI. CONCLUSION

The objective of this study was to determine whether variable interest rate or fixed interest rate loans had a greater negative impact on both the absolute level and variability of net of debt servicing operating cash flows.

Historical data covering the period from 1967 to 1981 was employed to model the two alternatives. Four farm types and five alternative debt level scenarios were simulated to observe inherent differences. As a result, the hypothesis that variable rate loans are more detrimental than fixed rate loans in regard to operating cash flows (when interest rates are rising) was proven correct. However, the small magnitude of these differences, even when debt levels were at 40% of asset levels, was surprising. This was at least partially due to a couple of reasons. First of all, the modelling assumptions resulted in adding small amounts of new debt at current rates to the debt load of the fixed rate model as asset levels rose. This made the average interest rate rise. This "moving average" effect negated some of the difference between the two models. Second, the effect of taxes in the simulation offset some of the larger interest expense of the variable rate model. Interest expense is a federal and state tax deduction. Higher interest expense was offset at the marginal tax rate through these deductions. This further lessened the impact of higher interest expense on operating cash flows. This implies that the higher the marginal tax bracket the farm operator is in, the less impact that higher interest rates have on the operator's net cash

flow.

A second major finding of the study was the differential maximum debt to asset levels for four farm types. Maximum debt to asset levels for cash crop, dairy-crop, hog-crop, and dairy only operations were found to be about 30, 58, 51, and 43 percent, respectively. The variable rate model is consistently lower than the debt ratio for the fixed rate model. These findings also suggest that there are significant synergistic and diversification effects from the combination of crops-livestock enterprises, and that over-specialization in one enterprise may not be the most advantageous means to maximizing net of debt servicing cash flows.

Thirdly, the results of the variability tests indicate that variable interest rate loans do not significangly increase the variability of operating cash flows when compared to fixed rate loans. This is apparently due to the fact that the marginal added variability of a variable rate loan over a fixed rate loan is miniscule compared to the other components of variability in operating cash flow.

APPENDIX E: F TESTS ON STANDARD DEVIATIONS OF THE SAMPLE OPERATING CASH FLOWS FOR EACH FARM TYPE

F Tests of Operating Cash Flows

Debt Ratio	Type of Farm			
	cash crop	dairy-crop	hog-crop	dairy only
.15	1.0224	1.0585	1.0149	1.0438
.20	1.0432	1.0752	1.0299	1.0625
.25	1.0679	1.0827	1.0507	1.0785
.40	1.1474	1.0281	1.1353	1.0385

Note: The null hypothesis tested is that the variance of the variable rate model is equal to the variance of the fixed rate model. The alternative hypothesis is that the variances are not equal.

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