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AN EVALUATION OF THE TRIPARTITE RED MEAT STABILIZATION PROGRAM FOR MANITOBA HOG PRODUCERS

BY

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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ABSTRACT

A number of provinces, including Manitoba, signed the National Tripartite Hog Stabilization Program (NTHSP) in 1986. However, the introduction of this program has raised several questions from both producers and governments. Producers are primarily concerned with impact of the program on their own operations while governments question the actuarial aspects of the NTHSP.

The objectives of this study are twofold,

1. to examine the effects of the NTHSP on individuals producers.
2. to assess the financial characteristics of the stabilization fund using the current premium rate as well as under several alternative rates.

In order to achieve the stated objectives a whole farm simulation model employing monte carlo techniques was utilized. The impact of the NTHSP on a case enterprise was evaluated with the aid of a series of probability distributions.

The results show an improvement in the financial position of producers participating in the NTHSP. Specifically, the case farm experienced higher levels of cash flow and net worth under the program. Furthermore, the results indicate no obvious differences in either enterprise cash flow or level of stabilization payment due to the alteration of premium rates. However, with respect to the fund balance the current

premium rate resulted in both higher probability and level of deficit than alternative higher premiums.

Therefore, in conclusion, the findings of this study suggest that while producers benefit from participation in the NTHSP, there is a high probability that sufficient revenues will not be generated under the current premium rate to offset stabilization payments.

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INTRODUCTION

The hog industry represents an important sector of the Manitoba economy. The attention focused on it is due to its contribution to both the agricultural sector and the supporting agri-business firms. Between 1970 and 1987 hog production was responsible for approximately 11 percent of total farm receipts and 25 percent of those from livestock sales within the province (Table 1.1). Despite the hog sector's relatively stable proportion of total provincial farm cash receipts, income from hog production rose from 58 million in 1970 to nearly 250 million in 1986, an increase of approximatly 350 percent. The revenue generated from hog production makes it the third largest contributor to farm cash receipts after wheat and cattle.

Further, the industry is responsible for additional jobs and investment, primarily in the feed milling, slaughter and processing industries. In 1984, the meat processing sector was the largest manufacturing industry in Manitoba, while the feed industry was ranked fourth.[1] Between them they employed over 2000 people, produced products the value of which totalled nearly 700 million, with a value added in production of over 100 million in 1984.[2] Gilson (1979) and Martin (1981) each commented on the large domestic multiplier effects of hog production on

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[1] In terms of value of shipments of goods of own manufacture.

[2] Statistics Canada, " Manufacturing Industries of Canada--National and Provincial Areas," Cat.No. 31-203 ,1984.

TABLE 1.1

Farm Cash Receipts from Farming Operations in Manitoba

1970-1987

Year	Total	Livestock	Hogs	Hogs % of Total	Hogs % of Livestock
	------million dollars-------			------------percent------------	
1970	341	201	58	17	29
1971	369	193	51	14	26
1972	492	238	66	13	28
1973	631	328	104	17	32
1974	830	335	95	11	28
1975	943	350	88	9	25
1976	892	356	80	9	22
1977	894	379	78	9	20
1978	1140	499	105	9	21
1979	1327	563	116	9	21
1980	1480	595	117	8	20
1981	1658	606	139	8	23
1982	1704	660	169	10	26
1983	1770	614	155	9	25
1984	1953	683	186	9	27
1985	2006	716	194	10	27
1986[1]	2078	760	243	12	32
1987	2006	748	253	13	34

Source: Manitoba Agriculture, 1985 Agriculture Yearbook
[1]Statistics Canada. Farm Cash Receipts, 21-001.

these industries.

Not to be overlooked in any discussion of the gains made in the hog industry is the contribution to exports. A surplus production region, Manitoba produced 212 percent more pork than it consumed in 1985. Thus, the province must rely heavily on exports. While trade occurs both interprovincially and internationally, the latter has increased dramatically since 1980. The export of both live hogs and pork have increased such that from 1980 to 1984 international exports as a proportion of production increased from 18 percent to 40 percent.

The past 15 years were not only ones of growth for the hog industry but also of structural change. Shifts in regional distribution patterns as a consequence of both federal and provincial programs prompted the decline in western Canada's and also Manitoba's proportion of production. From 1971 to 1986, while eastern production increased from 54 percent to 68 percent of Canadian production western levels fell from 46 percent to 32 percent. During the same period Manitoba levels were reduced from 13 percent of Canadian production in 1971, to a low of 9 percent in 1975 before rebounding to 11 percent in 1986.

1.1 STRUCTURE

The average size of hog operations has more than tripled since 1971 (Table 1.2); between 1971 and 1986 the average number of hogs per farm increased from 66 to 300. Meanwhile, there was also a trend towards fewer farms. As can be seen from Table 1.2 although the actual number of operations declined 75 percent, the percentage of farms with greater than 178 hogs grew by 40 percent between 1971 and 1986.

TABLE 1.2

Hog Farm Sizes, Manitoba, Census Years 1971-1986

Number of Head	1971	1976	1981[1]	1986
	------number of farms reporting-------			
0 - 32	8190	3858		
33 - 77	2719	738	3345	1807
78 - 177	1882	644		
178 - 272	589	306	971	820
273 - 527	567	313	436	478
528 - plus	245	209	346	458
Total	14201	6068	5098	3563
Average Number per farm	66	103	266	300
Percent with Greater than 273	6	9	15	26

Source: Statistics Canada Cat.#96-914, #96-807 and #96-109.
[1] Reporting method regarding number of farms was adjusted in 1986. Ranges for number of head were changed to read 0-77 and 78-272, the remaining ranges were unchanged.

1.2 PRICES

Agricultural, and especially livestock markets are subject to seasonal[3] variations in addition to longer term production and price cycles.[4] Seasonal variations are the product of normal variations in costs of

[3] Seasonality refers to the more or less normal within year variations which repeat themselves each year.

[4] Tomek and Robinson describe agricultural products as exhibiting cyclical behavior as opposed to being true cycles. True cycles are defined as recurring patterns which are self generated. Agricultural product cycles they argue are a result of a combination of systematic and random behavior. Further, the observed cycles tend to vary greatly in amplitude and length unlike true cycles.

production, in particular that of feed. Yap (1986) observed recurring seasonal patterns in hog prices and marketings over a 15 year period. Within year seasonal patterns in feed grain prices were reflected in similar irregularities in market prices for hogs, such that generally prices increase from winter through to summer, dropping in the fall.

The longer term cyclical behavior observed in production levels arise in part from the combination of a number of factors. Producer response to changing market conditions is constrained by a minimum 9 month production period.[5] Therefore, producer uncertainty in predicting price levels coupled with the biological conditions of production serve to create recurring and often irregular cycles. Hog production cycles are also influenced by the situation in the feed grain market. As the relatively most expensive input in the production process, the level of feed grain prices has a major influence upon the profitability of the industry. In the past hogs were viewed by prairie feed grain producers as a secondary market for their grain. Such was the situation from the late 60's through the early 70's, when buildups in barley stocks were reflected in similar increases in hog numbers. As was noted by Carter and Chadee (1986)

> In western Canada, a grain surplus region, the length and depth of the cycle has been affected by unsold stock, prices and the marketing prospects for feed grain. The 1969-1971 buildup in hog production in western Canada was in response to large carryovers of grain on the farms. Marketing it through hogs became the way to reduce the large barley glut.

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[5] This is an estimate in which only the time from conception to slaughter are considered. However, other factors are involved in the decision to alter production which may increase the response time. The most important of these is the holding over of gilts in the operation for breeding purposes. Should a producer not have suitable gilts available the response time can be increased by up to six months.

> In 1972 and 1973, grain surpluses were cleared rather suddenly by large Russian purchases and grain prices tripled. In response to high grain prices, western Canada farmers reduced their swine production by a precipitous 47 percent.[6]

In the 1970's hog numbers in Manitoba dropped from 1.35 million in 1971 to 903 thousand in 1976 as feed prices rose relative to hog prices. The situation is compounded by estimates that almost one third of the producers within the province purchase virtually all of their feed requirements.[7] These circumstances have permitted feed grain prices, specifically for barley, to affect hog numbers.

Theoretically, price cycles follow from the cobweb model of supply - demand relationships. One possible situation could have demand increasing faster than supply, thereby leading to higher prices and encouraging production.[8] Gradually, quantity supplied would approach that demanded until a surplus of the product would depress prices. As production declines in response to price reductions it drops below the quantity demanded, signalling the start of another cycle.

Instability in commodity markets is not a new phenomenon. Jobin (1984) noted the long history of of income instability in the prairie economy, while Petrie (1974) analyzed hog production and price cycles over a 24 year period. Attention was focused on instablity in the 1970's because of the magnitude of the fluctuations. The seventies were

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[6] Colin A. Carter and Dhurvanand Chadee, Structural Description of the Manitoba Hog Sector, Research Bulletin No.86-1., Dept.Agr.Econ. and Farm Mngt., University of Manitoba, July 1986. p.14.

[7] Manitoba Department of Agriculture.

[8] In the livestock industry the initial response of producers to retain animals for breeding purposes and the previously mentioned production delays also serve to further increase prices.

a period of expansion, specialization and a heightened awareness of the influence of international commodity markets on domestic agriculture. The variance of feed grain prices in response to export demand coupled with the financial structure of many hog producers served to increase their exposure to fluctuations in market prices. As noted by Martin (1981), producers' response to successive periods of low market returns is strongly influenced by the debt servicing commitments of the farm. Whalley (1980) identified market instability and the associated variation in incomes as the cause of the reduction in long term investment and development necessary for hog production on the prairies. This was confirmed by Paddock (1986) who stated that a stable environment is required to direct producer interest toward increasing efficiency through capital investment.

1.3 HOG STABILIZATION PROGRAMS

Governments have long recognized the need to stabilize agricultural markets. To overcome part of the uncertainty faced by producers the federal government established the Agricultural Stabilization Act (ASA) in 1958.[9] The objectives of the Act were twofold, firstly,

> to enact a measure for the purpose of stabilizing the prices of agricultural commodities in order to assist the industry of agriculture to realize fair returns for its labour and investment.[10]

Secondly,

[9] The Act provided for the stabilization of the prices of several "named" agricultural commodities, including cattle, hogs, lambs, wool and eggs, together with wheat, oats and barley produced outside the Wheat Board area. Later in 1975, the list of "named " commodities was altered. Eggs, butter and cheese were deleted, and corn, soybeans, industrial milk and industrial cream were added.

[10] Agricultural Stabilization Act. 1957-58, c.22, s.1. p.1 .

> to maintain a fair relationship between prices received by farmers and the costs of the goods and services that they buy.[11]

The rationale behind the ASA was to dampen producers' reactions to price changes, thereby maintaining production levels. An effective stabilization program must provide price and income support such that inherent cyclical changes do not seriously disrupt production. Initially, the ASA provided support to producers when the average market price in a year fell below the average market price of the previous ten years (prescribed price). The subsidy in the form of a deficiency payment was calculated as the difference between the market price and 80 percent of the prescribed price. Several flaws in the policy lead to amendments in 1975. The amendments which involved changes in the method of computation of the level of support altered the essential nature of the program. Formally a price stabilization scheme based on floor prices, as a result of the revisions it became more of an income stabilization program designed partially to protect producers from inflation and increases in input costs.[12] The base period was reduced from ten years to five and the coverage limit increased from 80 percent to not less than 90 percent. In addition, the determination of the prescribed price included adjustments for production costs. Therefore, under the revised ASA the prescribed price was calculated as 90 percent of the average price of the preceding five years and the difference between current cash costs and the five year average of these same costs. However, these amendments did little to rectify the fundamental problems. The annual

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[11] Ibid. p.1 .

[12] In theory the revised ASA could not be classified as strictly an income stabilization program. In fact, it is a program which as incorporated elements of both price an income stabilization. It could perhaps be more accurately described as a net return or margin stabilization program.

nature of the program failed to acknowledge the seasonal nature of hog production and protect operators from short term cash flow difficulties. Producers, therefore, continued to experience wide variations in prices before receiving a payment, if any. Also, producers marketing at the beginning of the year had to wait well over a year to receive a payment, if one was forthcoming.

For several years payments to hog producers were not authorized as shorter term periodic fluctuations were masked in the calculation of the yearly average market price. From 1975-76 through 1979-80[13] hog producers did not receive any disbursements from the ASA, this despite large quarterly price movements. In 1975, although the yearly average price was 63.99 per hundredweight (cwt) quarterly prices during the year ranged from 51.38 per cwt to 76.59 per cwt. It was not until 1980-81 that producers received their first payment under the revised ASA. Clements and Carter (1981) cite the use of the previous five years' market prices as the basis for calculations as one of the reasons for the lack of deficiency payments during this period. A similar argument was presented by Gilson and St.Louis (1986)

> Because of the high level of inflation which followed the 1975 amendment to the ASA, cattle and hog producers soon discovered that the price supports calculated under the amended act did not keep pace with the rapid increase in their own costs of production.[14]

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[13] Fiscal year ends March 31.

[14] J.C.Gilson and R. St.Louis, Policy Issues and Alternatives Facing the Canadian Hog Industry, Report prepared for Agriculture Canada and the Canadian Pork Council. 1986, p.74.

Another factor contributing to producer uncertainty concerned the the level of coverage, which could vary from 90 percent to 100 percent. Finally, because both payments and support levels were not announced until the end of each year the process did little to assist the decision making process of producers. It was this dissatisfaction with the ASA which resulted in the development of specialized stabilization programs in most provinces by 1981.[15] The situation was perhaps best described by Dawson (1976):

> The various short and long-term stabilization programs at the provincial level have originated because Federal stabilization plans have not been timely enough or generous enough. The gap left by Federal stabilization plans has pressured provinces into the development of programs ranging from the stop-loss to the guaranteed income approach. The level of stabilization offered by provinces has revolved largely around each provinces level of self-sufficiency, plus their own philosophies and long term production objectives. As a result Canada has perhaps the most fragmented approach to hog stabilization of any country in the world.[16]

The Manitoba government instituted the first of its two stabilization programs for hogs in 1981. A two year program, the stated objective of the Manitoba Hog Income Assurance Plan (MHIAP) was income stability. The plan provided for support quarterly based on a cost of production formula. Coverage under the program was limited to either 1250 hogs per quarter or 5000 hogs per year. In 1983 this program ended and the province introduced the Manitoba Hog Income Stabilization Plan (MHISP). A Management Committee was formed to administer the plan and was charged with conducting periodic reviews of the premium rate. As with the first

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[15] Only province not to implement a commodity stabilization program for hogs was Newfoundland.

[16] J.L.Dawson, "An Evaluation of Hog Stabilization Programs in Canada", in Proceedings of the 1976 Workshop of the Canadian Agricultural Economics Society. (March, 1976), p.185.

Manitoba plan the MHISP was a voluntary program financed in part by the contributions from participating producers.[17] The premium payable by producers was based on the product of a fixed percentage[18] of the index 100 price and the total weight of hogs sold. The provincial contribution was pegged to that of producers up to a maximum rate of 2 percent. As with the previous program, the MHISP support level was based on a cost of production formula. However, the terms differed; MHIAP payments were based on 93 percent of the total cost of production. Under the MHISP the percentage of the total cost covered in the formula was reduced to 87 percent. Although the MHISP was an ongoing program, it was recognized even at its inception that negotiations were proceeding regarding the formation of a national stabilization plan. When Manitoba eventually entered into the Tripartite Agreement for hogs in 1986 the MHIS program was discontinued. At that time the accumulated fund deficit, some 3.8 million dollars, was absorbed by the Manitoba government.

1.4 THE TRIPARTITE PROGRAM

At a national level the proliferation of provincial programs posed several problems, including resource allocation and producer equity across Canada. A National Tripartite Hog Stabilization Plan (NTHSP) funded by producers together with federal and provincial governments, was instituted in 1986,

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[17] The MHIAP was producer funded with the assistance of a five million dollar start up grant from the Manitoba government. In addition, the province provided for up to five million dollars in loan guarantees in the event of a deficit.

[18] The initial fixed rate of 4 percent was increased to 5 percent in July 1984, where it remained until the termination of the program in 1986.

> it will provide for a permanent role in program development and administration to producers and will require a firm legally binding commitment by both levels of government to the protection of the red meat sector against market instability.[19]

Of major concern to policy makers was the need to establish an equitable level of support to all producers. National market stability, it was felt, could not be achieved if the inter-provincial competition provided by the various provincial programs was continued. Proponents of uniform support argued provincial subsidies in altering the profitability of production among regions provided incentive in areas for overproduction. Eyvindson and Kerr (1976) attributed the shifts in production patterns which had previously been based on comparative advantage to differences between the federal and various provincial programs. In particular they pointed to support levels, eligibility limits and producer contributions (where applicable). Given the above information a five year period was established during which the individual provincial programs were to be phased out.[20]

Under the tripartite program premiums collected from participating producers, provinces and the federal government are placed into a stabilization fund from which payments are made. Premium levels are established by the Stabilization Committee at the beginning of each quarter.[21] The premium rate is adjusted (increased/decreased) whenever the

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[19] Government of Canada. Proposed Tripartite Red Meat Stabilization Program. Discussion Paper. 1984, p.2.

[20] This only applies to those programs in participating provinces. Therefore, provincial stabilization plans in several provinces, including Quebec, New Brunswick, Nova Scotia, and Prince Edward Island will continue to operate.

[21] The Committee is composed of nine members whose terms run for a maximum of three years. Three members each are appointed by the partici-

interest payable on the deficit/surplus is higher than a specified percentage of the premiums collected from producers in the preceding years.[22] The interest charged on deficits and paid on surpluses is fixed by the Minister of Finance for Canada in consultation with the Federal Minister of Agriculture. In this way over time the level of premiums collected should cover both the stabilization payments and interest adjustments.

Support prices are calculated from a combination of cash costs of production[23] and a percentage of the previous gross margin.[24] A stabilization payment is declared[25] in any quarter the support price exceeds the current market price.[26] Producers are eligible for payments on up to of 2000 hogs per quarter, for an annual maximum of 8000 hogs. Producers deciding to opt out of the plan must provide three years written notice, during which time they remain active members. Such operators cannot

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pating provincial and federal governments. The remaining members are selected by the Federal Minister of Agriculture from a list of producers submitted by the Canadian Pork Council.

[22] Percentage is determined by the Agricultural Stabilization Board on the advice of the Stabilization Committee.

[23] The national cash costs of production are estimated from production models of the cash costs of raising hogs in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Atlantic Region.

[24] Support price is equal to the estimated national current cash cost of production in the quarter plus a percentage (90-95%) of the difference between these cash costs and the national average market price of hogs in the same quarter over the preceding 5 years.

[25] The Stabilization Committee reserves the right to set a minimal level of support, payments falling below this level may be deferred until a later date.

[26] National average market price is the index 100 price of hogs in representative markets selected by the Stabilization Committee and weighted by the number of federally inspected hogs with an index of 80 or above.

rejoin the plan until five years after termination notice is given. Upon withdrawal[27] from the program the producer relinquishes the rights to premiums contributed to the fund.[28] Reviews of the operation of the program are conducted periodically by the Stabilization Committee until the termination of the program on December 31, 1995.[29]

In short, the design of the tripartite program has incorporated several important principals while proposing to ensure a reduction in income loss to producers from market risk.

1.5 AGGREGATE PROGRAM ANALYSIS

Since its emergence as one of the major issues of the boom and bust periods which characterized the 1970's several authors have examined the stabilizing effects of various programs.

1.5.1 Deficiency Payments

Research conducted by MacAulay (1977) documents the impact of the level and timing of a price deficiency program on the stability of net returns in an agricultural industry.[30] His results show that increasing

[27] Participating provinces may also resign from the plan by providing a similar written notice. Under the NTHSP agreement provinces are responsible for a share of any deficit remaining at that tome and agree to waive the rights to any surpluses.

[28] If a producer has received more support payments than he has paid in premiums none of the deficit has to be repaid.

[29] Program will cease to exist at that time unless renegotiated by the participating governments.

[30] MacAulay defines stability as a reduction in the amplitude of a cyclical variable so that it may converge to equilibrium in a shorter time period.

the amount and frequency of payments by using a moving average scheme is not in itself an automatic guarantee of improved stability. He further points out that a reduction of the base period on which the moving average is calculated does not alter this result, but only serves to increase the level of payment. Instead, he suggests that for those industries where prices are cyclical and trending upwards,

> what appears to be crucial is that the appropriate amount of payment be given at the right point in time to bring the system back as rapidly as possible towards equilibrium. Because of the importance of timing it seems reasonable to suggest that an optimal length of moving average might be determined so that maximum stability is obtained for the particular industry in question.[31]

Martin and MacLaren (1976) evaluated the effectiveness of alternative deficiency payment programs to achieve stabilization in the Canadian hog sector. Their study involved a comparison of the stabilizing effects of price[32] and margin[33] deficiency programs on several factors including gross revenue and gross margin.[34] From their analysis they concluded that for a commodity which exhibits variablity due to fluctuations in both input and product prices, deficiency programs resulted in both increased gross revenue and industry gross margin. However, a higher degree of stability was achieved using a margin deficiency program,

> In fact, the margin of instability in gross margin would have been reduced by a factor of over 30 percent in both Eastern and Western Canada, over this period, while the price deficiency program would

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[31] T. Gordon MacAulay, "The Timing of Deficiency Payments for Stabilization," Canadian J. Agricultural Economics, 23(1), (February , 1977), p.12.

[32] Price deficiency program based on a price support level of 95 percent of a five year moving average of market prices.

[33] Support level established at 95 percent of a five year moving average of market prices, net of feed costs.

[34] Gross margin is defined as gross revenue net of feed costs.

> have reduced the measure of instability by only 20 and 5 percent, respectively.[35]

In 1978 the federal government proposed a guaranteed margin (GM100) stabilization program for hog producers. The program was designed to cover cash costs of production in addition to 100 percent of the five year margin. A joint endeavor, its cost of operation was to have been shared between producers (1/3) and the federal government (2/3). Kennedy and Palacios (1980) conducted a study to estimate the costs and effects of the GM100 and the ASA for B.C. hog producers. While both programs resulted in increased levels and stability of producer income, the highest level of income and degree of stability was realized by the GM100.

1.5.1.1 The Western Grain Stabilization Program

The Western Grain Stabilization Act (WGSA)[36] represents an extension of the GM100 outlined by Kennedy and Palacios (1980). First established in 1976 the goals of the program are similar in nature to the NTHSP,

> the general objective of the WGSA is to protect grain producers in the Canadian Wheat Board designated area against unexpected declines in net returns due to short term price fluctuations, reduced marketings and increased production costs.[37]

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[35] Larry Martin and Donald MacLaren, "Market Stabilization by Deficiency Payment Programs: Theoretical Analysis and its Application to the Canadian Pork Sector", Canadian J. Agricultural Economics, 24(2), (July , 1976), p.48.

[36] Western Grain Stabilization Act is sometimes referred to as the Western Grain Stabilization Program (WGSP).

[37] Government of Canada. Proposed Amendments Western Grain Stabilization Act. Discussion Paper. April 1984. p.2.

When first introduced the WGSA was essentially an aggregate stabilization program where support was based solely on a measure of aggregate net cash flow over a five year period.[38] Although the original intentions of the program were set to account for variablity in both prices and production levels it was later found that these objectives were not met. The failure of the program to trigger stabilization payments in the early 1980's as increased volumes of marketings offset lower commodity prices raised producer concern and lead to amendments to the Act in 1984. One amendment required that a second support mechanism based on per unit (per tonne)[39] measurement be used in conjunction with the original.[40] Spriggs (1985) performed an analysis on the WGSA to determine the implications of the aforementioned revisions on among other things its stabilization potential of aggregate net cash flow, the size of the aggregate payout and the actuarial soundness of the stabilization fund. The analysis, conducted over a five year simulation period (1984/5 to 1988/9), found the revised WGSA to have a positive impact on the stabilization of aggregate net returns. His analysis also predicted the size of total disbursements would approximate $1.2 billion, with a standard deviation of 640 million dollars. On an annual basis the probability of no payout was estimated to be 50 percent. However, over the total time

[38] Net cash flow is measured as gross grain receipts from western grain sales, net of cash expenses and then adjusted for costs related to inventory and receipts not eligible for coverage under the program. A stabilization payment is triggered when prairie net cash flow in the current period is below the average value of net cash flow over the previous five years.

[39] To obtain per unit price support figures the net cash flow for each crop year is divided by the years' eligible marketings.

[40] The decision to use two methods was based on a desire to continue to protect producers against prolonged downturns caused by declining production levels while increasing the sensitivity of the program to upward shifts in grain volumes.

period the probability of that occurance was reduced to 1 percent. Finally, from the low probability, 12 percent, attached to the chance of deficit he concluded the revised program was actuarially sound.

In each case where utilized price and margin deficiency programs, were found to elicit a positive response on average aggregate net cash flow basis. However, while useful at the macro level this research does not address a fundamental question: do such programs stabilize the net returns of individual producers?

Recently Paddock (1986) recognized the need for dissagregated level analysis and outlined a scenario involving the WGSA. As previously mentioned, under the WGSA the net cash flow from seven major grains are stabilized jointly. As the major grain grown on the prairies, wheat production levels determine when payments are made. While successful in the aggregate, the program fails to provide support to producers in those areas where wheat is not the dominant crop, despite a definite need. A similar concern regarding the effectiveness of stabilization programs at the farm level was raised by Loyns and Martin (1985)

> Moreover, some stabilization programs (ASA & WGSA) may be more important for their macro effects than their direct on-farm significance. In the end, there is considerable need for careful analysis of the consequences of pork and beef stabilization programs.[41]

Buccola and Subaei (1985) and Harrison (1982) both illustrated how stabilization programs based on aggregative decision rules are less effective at the firm level. While acknowledging the need to maintain equity among producers, Gilmour and Cluff (1986) also recognize the possibility

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[41] R.M.A. Loyns and L.J. Martin, "Livestock Stabilization Programs-- The Canadian Experience" Paper presented to the Invited Papers Session at the Western Agricultural Economics Association Meeting in Saskatoon, July 9, 1985. pp.16-17.

that the design of the NTHSP may not be the most effective for producers.

1.6 STATEMENT OF THE PROBLEM

The situation experienced by hog producers during the past 15 years has been one of uncertainty. Producer concern was directed not only at the instability observed in the livestock markets, but also at the ability of government support policies to deal with market instability. Perceived inadequacies in the ASA led to amendments in 1975 and the introduction of the NTHSP in 1986. However, questions remain as to whether the NTHSP will fare any better at achieving the goal of stabilizing individual producer returns. Policymakers have acknowledged the existance of a disparity in costs and prices between regions across the country

> Red meats are produced across Canada. The absolute level of prices and costs are somewhat different in different regions, but because the markets for red meats and the major inputs used by producers of these commodities are closely interrelated, all producers of a particular red meat commodity suffer at the same time from the damaging impact of the periodic cost-price squeezes brought about by fluctuating input costs and low product prices.[42]

To address the question of regional differences, the calculations of both the support price and stabilization payments are based on national averages. Therefore, the performance of the program is dependant not only the producer's situation relative to the region, but also relative to the national average. However, an analysis of the ability of the NTHSP to stabilize returns at the individual producer level has yet to be completed.

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[42] Tripartite Red Meat Stabilization Program, p.1.

Of concern to governments in designing a national stabilization plan are the fiscal implications associated with instituting the program. From a federal prospective legislators are sensitive to the budgetary implications of such programs particularly in light of the provincial experience and the current economic situation. A number of provinces have had individual programs which have increased government expenditures above budgeted estimates. In Manitoba both the hog and cattle stabilization programs have experienced financial difficulty. In 1988 the Manitoba Beef Stabilization program had, over a six year period, accumulated a deficit of approximatly 21 million dollars. Upon termination in 1986 the MHIS plan had built up a deficit of 3.8 million dollars. This phenomenon is not confined to Manitoba; Loyns and Martin (1985) estimated a shortfall of at least 20 million dollars, at that time, for the Saskatchewan Hog Assured Returns program.

1.7 OBJECTIVES

The objectives of this study are twofold. In the past, the majority of research which has examined stabilization policies has concentrated on aggregate analyses. One purpose of this thesis is to study the effects of the NTHSP on an individual producer basis. To determine the relative changes attributable to the tripartite stabilization program requires that the effects of the program on hog producers' returns be examined for both participating and nonparticipating producers. The second objective relates to the concerns expressed by both levels of government regarding the financial characteristics, deficit or surplus, of the stabilization fund. These objectives will assessed after developing a model to measure the effectiveness of the alternative strategies, specifically alteration of the premium rate. The model design will incorporate the salient features of the NTHSP to ascertain levels of both producer returns and the fund balance over the simulation period.

1.8 SCOPE OF THE STUDY

The thesis consists of four chapters. Chapter I has discussed the importance and nature of the hog industry as well as outlining the various government initiatives to stabilize it. The problem to be addressed together with the objectives of the study are also contained in this chapter. Chapter II will present material related to the actual design of the model as well as a profile of the characteristics of the model. The model results are presented in Chapter III. Finally, Chapter IV presents conclusions and recommendations for further research.

Chapter II

THE SIMULATION MODEL

2.1 MODEL DEVELOPMENT

Simulation has long been recognized as an important analytical method in the evaluation of systems. Naylor (1971) noted that the complex nature of economic systems made them ideal candidates for evaluation using simulation techniques. In addition to making it possible to examine an existing system, simulation models allow for the manipulation of the system. In the area of agricultural economics, more specifically policy analysis, simulation models are often utilized as 'preservice tests' for new policies prior to their implementation. Without simulation, policy experimentation of this type would not be possible.

2.1.1 Stochastic Simulation

Mathematical simulation models can be differentiated from one another in a variety of ways. One of the more important distinctions made between models concerns their classification as either deterministic or stochastic. As described by Rubinstein (1981),

> In a deterministic model all mathematical and logical relationships between the elements are fixed. As a consequence these relationships completely determine the solutions. In a stochastic model at least one variable is random.[43]

[43] Reuven Y.Rubinstein, Simulation and the Monte Carlo Method. (New York: John Wiley and Sons, Inc., 1981), p.4.

Stochastic or more commonly Monte Carlo simulation[44] the method addresses the problems involved in modeling the uncertainty inherent in many variables. Variables in which a random component is a factor in their determination is overcome, in part, by their definition in terms of probability distributions. As was stated by Lusztig and Schwab (1977),

> A probability distribution is a much more precise way of presenting and interpreting beliefs regarding uncertainty, and its use can serve to reduce distortions and misunderstandings[45]

The next step in the stochastic process is to execute the simulation a predetermined number of times. With each iteration values for the stochastic variables are selected at random from the specified probability distributions. In light of the uncertainties associated with the variables involved, the results obtained at the conclusion of the simulation are also presented in the form of probability distributions. Monte Carlo simulation is, therefore, essentially a statistical sampling technique involving the use of random numbers and probability distributions. Monte Carlo simulation techniques have been applied in several areas including capital budgeting (Lusztig and Schwab), investment analysis (Hertz) and agricultural policy analysis (Baum and Richardson; Sharples; and Spriggs). While, the underlying theoretical basis has been known since 1949, potential uses for the Monte Carlo method as an analytical tool are still being discovered. Prior to the advent of the computer, the difficulties involved in the simulation of random numbers were prohibitive and made the application of the Monte Carlo method a formidable task. The current situation is perhaps best expressed by Rubinstein

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[44] For more detailed descriptions of the theory and application behind Monte Carlo simulation the reader is directed to Kleijnen (1974), Pindyck and Rubinfeld (1981) or Rubinstein (1981).

[45] Peter Lusztig and Bernhard Schwab, <u>Managerial Finance in a Canadian Setting</u>. (Toronto: Butterworth and Co.(Canada), 1977), pp.153.

(1981),

> The Monte Carlo method is now the most powerful and commonly used technique for analyzing complex problems. ... Recently, the range of applications has been broadening and the complexity and computational effort required has been increasing because realism is associated with more complex and extensive problem descriptions.[46]

2.1.2 Micromodels for Policy Analysis

The majority of simulation models developed to analyze policy initiatives have been aggregate sector models (Kennedy and Palacios; Martin and MacLaren; Sharples; and Spriggs). The critics of the use of macroeconomic models for policy analysis do not dispute their usefulness in estimating the aggregate behavior of economic variables,

> Typically, these models estimate the level and changes in macroeconomic variables such as net farm income, program benefits, crop and livestock prices and production patterns. However, the analysis of the dynamic impacts of agricultural policies at the individual farm level has not received the same level of research attention, even though actual production and resource decisions are made by individual producers. An implicit assumption often made by the users of these macro models is that an average farmers behavior and decision-making process can be sufficiently well estimated with aggregated data to answer microeconomic questions about the farm sector. This assumption may not be entirely correct.[47]

Baum and Harrington (1983) concur with the above statement and argue that in many instances aggregate analysis of the effects of agricultural policies have failed to recognize the diverse and heterogeneous nature of the firms which together form the farm production sector.[48] They fur-

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[46] Reuven Y.Rubinstein, Simulation and the Monte Carlo Method, p.12.

[47] Kenneth H. Baum and James W. Richardson, "FLIPCOM: Farm Level Continuous Optimization Models for Integrated Policy Analysis," in Modeling Farm Decisions for Policy Analysis, edited by Kenneth H. Baum and Lyle P. Schertz, (Boulder: Westview Press, Inc., 1983), pp.211-34.

[48] Kenneth H. Baum and David H. Harrington, Effects of Alternative Economic Scenarios and Commodity Policies on Regional Representative Farms. National Economics Division.,USDA. ERS Staff Report, Jan. 1983. pp.1-23.

ther state,

> it will be the position of the authors that an appreciation of the effects of economic policies affecting the farm sector entails probing behind national aggregate data for effects on individual farms.[49]

This is not to suggest that microeconomic models should replace aggregate models. However, it must be recognized that the policy making process could be enhanced by their increased use.

A renewed interest in the field of microeconomic models primarily for policy analysis in the 1980's led to the development of several farm level simulation models including FLIPSIM[50] and FLIPRIP[51] and prompted several research studies (Baum and Harrington; Baum and Richardson; Baum, Richardson and Schertz; Boehlje and Griffin; Eddleman, Musick and Hamill; Richardson and Smith).

The approach incorporated into the design of FLIPSIM and FLIPRIP most closely resembles the model utilized in the current study. The primary directive behind the development of each was to evaluate

> the impacts of agricultural policies and regulatory actions on income, cash receipts, expenses, resource acquisition, resource allocation and after tax cash flows.[52]

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[49] Ibid., p.2.

[50] James W. Richardson and C. Nixon. FLIPSIM: The Farm Level and Policy Simulator. Dept. of Agr. Econ. Technical Report 81-2 . Texas A&M Univ. 1980.

[51] Kenneth H. Baum, James W. Richardson and Lyle P. Schertz. "FLIPRIP: A Stochastic Recursive Interactive Programming Model of Farm Firm Growth" in Proceedings of the Third Symposium on Mathematical Programming with Data Perturbations, edited by Anthony V. Fiacco (Washington: George Washington Univ. 1982).

[52] Kenneth H. Baum and James W. Richardson and Lyle P. Schertz, "A Stochastic Recursive Interactive Programming Model," Comput. and Operations Research, 10(9), (Sept, 1984), p.2.

A complete outline of the data requirements for FLIPSIM and FLIPRIP[53] is provided in Richardson and Nixon (1980) and Baum, Richardson and Schertz (1982). Briefly, both models

> are capable of using data sets describing different sizes, tenure, equity, and types of crop and livestock farms in different production regions. Each data set also describes agricultural policies including commodity income and price support programs, the farms behavioral parameters and the macroeconomic environment.[54]

Both FLIPSIM and FLIPRIP may be described as hybrid models in which a set of optimizing[55] subroutines is linked with a series of accounting-decision subroutines. The optimizing techniques are employed to either select annual activity mixes (crop/livestock) or to determine the optimal growth strategy for the farm. Part of the logic behind the decision to use programming models to determine production activities and resource use was governed by the researchers' use of representative and not actual farms in the models. A programming model could replicate the behavior of producers in the allocation of available resources among the various activities with the goal of maximizing expected net revenue.

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[53] Both FLIPSIM and FLIPRIP are capable of analyzing crop or livestock operations either individually or as mixed farms. Both models have however been primarily been used to analyze strictly cropping enterprises. For example, the FLIPSIM model was used by Eddleman, Musick, and Hamill (1986) to analyze general crop farms (cotton, rice, soybeans, and wheat) in the Mississippi. The model developed for the current study is relatively commodity specific in that although mixed farming operations are considered the application is restricted to crops in which the production is solely utilized by livestock (hogs).

[54] Kenneth H. Baum and James W. Richardson, FLIPCOM: Farm Level Continuous Optimization Models for Integrated Analysis, p.212.

[55] Parvin (1983) noted that although conceptually identical FLIPSIM utilized a linear program while FLIPRIP used an interactive programming approach.

Having selected a production mix FLIPSIM and FLIPRIP proceed with the remaining simulation subroutines. The first step is to estimate net returns using available price and production data. The crop and livestock prices within the simulation routines are generated, as per the Monte Carlo method, from previously estimated probability distributions

> when a stochastic simulation is specified, random prices and yields are calculated from either multivariate or independant normal, triangular and beta distributions[56]

Other subroutines include procedures[57] to:

1. Calculate the net cash position of the farm after the payment of expenses (property taxes, existing debt, and family withdrawals).
2. Adjust enterprise cash flow for producer participation in government programs.
3. Calculate the value and depreciation of buildings and machinery.
4. Estimate the market value of land.

Finally, yearly cash flow is monitored and various options are available in the event refinancing becomes necessary.

Each of the models was designed to simulate the above activities over a ten year period, and, if requested each will perform a maximum of 300 iterations. At the end of the simulation the models produce a series of probability distributions for selected variables.

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[56] Kenneth H. Baum and James W. Richardson, FLIPCOM: Farm Level Continuous Optimization Models for Integrated Policy Analysis, p.223

[57] A complete list and description of the subroutines and their linkages can be found in Richardson and Nixon (1980) or Baum, Richardson and Schertz (1982).

Although the model used in this study is conceptually similar, several of the procedures adopted in FLIPSIM and FLIPRIP were not utilized in the development of the model for this study. One area in which the current model differs is in the use of mathematical programming techniques. Palacios (1978) questioned using optimizing models in policy analysis; he believed their use implied a higher degree of knowledge about the objective function than was usually available.[58] Use of the optimizing approach has also been criticized by House (1983) who cautioned against the use of single objective optimizing models

> "Many models have used the single objective of maximizing income.... A farm decision maker may in reality be concerned with maximizing income, leisure, crop yields, minimizing soil loss, equipment failure and so forth."[59]

All three models, FLIPSIM, FLIPRIP, and the model used here, acknowledge the nature of uncertainty evident in simulating values for several factors and model them as stochastic variables.

2.2 MODEL DESCRIPTION

The simulation model used in this study is constructed to approximate the dynamics of a farrow to finish operation over a large number of possible situations.[60] With the incorporation of the NTHSP, the model is

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[58] Alejandro Palacios, "A Simulation Analysis of Alternative Stabilization Schemes for the British Columbia Hog Industry". (Unpublished MSc. Thesis, University of British Columbia, 1978) p.13.

[59] Robert House, "A Comparison of Optimizing Modeling Methodologies," in Modeling Farm Decisions for Policy Analysis, edited by Kenneth H. Baum and Lyle P. Schertz, (Boulder: Westview Press, Inc.,1983) pp.351-52.

[60] The simulation model used in this study was first developed by Dzisiak (1987). Several modifications were necessary to incorporate the tripartite red meat stabilization program into the original model.

used to analyze the program's potential to stabilize the net cash flow of the enterprise.

A diagram of the risk simulation model is provided in Figure 2.1 . The model begins with the input of primarily financial data to establish initial values for the stochastic and non-stochastic variables. Future values of stochastic variables are determined in part with the aid of a random number generator. These variables include, U.S slaughter hog prices, U.S. grain prices, the Canadian/U.S. exchange rate and the Canadian interest rate. The values and the rate of change (quarterly or annual) of non-stochastic variables are supplied by the model user (operating expenses, non-farm revenue, personal and living expenses).

Historical data have revealed that the U.S. commodity prices determine to a large degree the price of their Canadian counterparts. Hence, the Canadian prices for both grain and hogs are derived from the conversion of U.S. prices. A more detailed description of the stochastic process as it relates to each of these variables is presented in section 2.6 .

Using the variables generated, the model proceeds to the computation of enterprise cash flow. Revenue from operations, input costs, support payments and producer levies will each affect cash flow. Enterprise cash flow together with nonfarm income and the cash balance at the start of the year are combined to form total cash resources.

Therefore, those sections of this chapter dealing with the basic model draw heavily on the description provided by Dzisiak (1987).

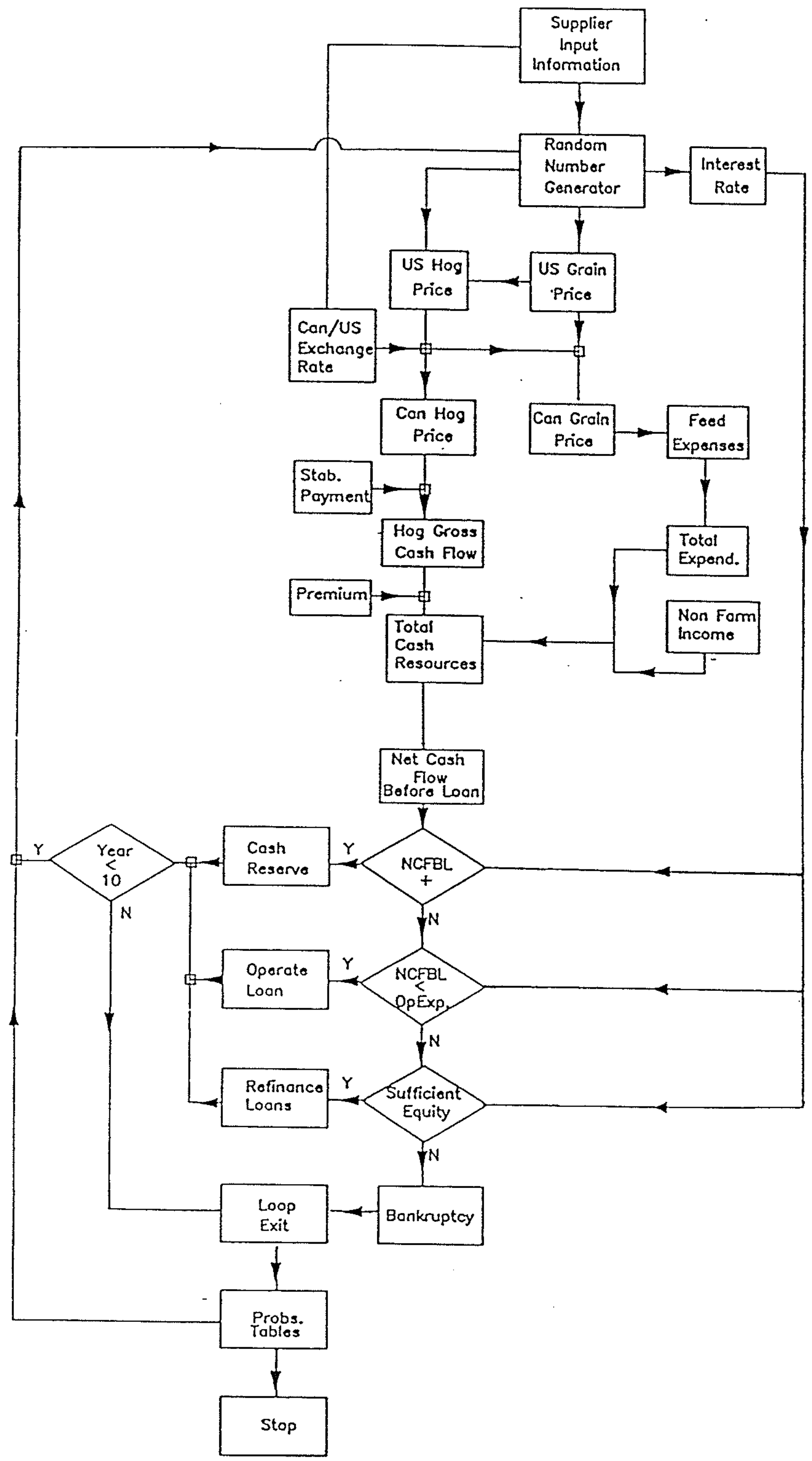

Figure 2.1 Flowchart of Simulation Logic

Net cash flow before loan (NCFBL) represents the cash available following the deduction of expenditures from total cash resources. As such, NCFBL is a reflection of the operation's annual ability to service debt. The NCFBL has two possible conditions, either positive or negative. If positive, NCFBL is forwarded to become a part of the succeeding period's cash pool. An operating loan is required in the event NCFBL is found to be negative. When NCFBL has been calculated to be in a deficit position, a second test determines the level of the necessary operating loan or alternatively if refinancing is needed. Should the value of the NCFBL be greater than that of total operating expenses, the model is prompted to consider the possibility of loan consolidation. The firm is judged to have insufficient equity to support this option if the debt/asset ratio is greater than one.[61] Should this situation occur the operation is declared insolvent and the simulation terminated.

This process continues as long as the firm remains solvent and the simulation year does not exceed ten. The ten year simulation is repeated 600 times, under different stochastic conditions.[62] Upon the conclusion of simulation the model provides information relating to probability of annual percent change in assets, liabilities, and equity. In addition to the above distributions for annual gross cash flow, stabilization payment and the ending fund balance are also given. Had insolvency been invoked during the simulation period the relevant year together with the probabilities listed above is presented. A more detailed description of each of the components of the model is presented

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[61] Barry, Hopkin and Baker (1979) indicate that many farm lenders use a maximum leverage ratio of one as a standard rule of thumb.

[62] Repetition of the simulation 600 times yielded stable probability distributions.

in the following sections.

2.3 INPUT INFORMATION

The program begins with the input of pertinent production, financial, and marketing information. These data are obtained from a series of questions which are presented in Tables 2.1 to 2.2. The questions were selected for several purposes:

1. To allow for the initialization of production and financial variables describing the enterprise to be analyzed.
2. To provide details regarding existing loan arrangements and the alternatives available for future financing (if necessary).
3. To give information related to current and future exchange and interest rates.

Each of the summaries was designed to be concise and yet still provide the maximum amount of information.

TABLE 2.1

Interactive Program Questions

Basic Financial, Marketing and Production Information

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1. The beginning year and quarter of the analysis(19__:__):
2. The current price of wheat ($/bu.):
3. The expected inflation rate for operating expenses:
4. The basic living and personal expenditures/year:
5. The expected inflation rate for living expenses:
6. The present non-farm income/year:
7. The expected annual increase in non-farm income:
8. The total value of cash and near cash, and operating supplies:
9. The market value of machinery:
10. The average replacement frequency of machinery (years):
11. The total amounts owing on accounts payable:
12. The current operating loan outstanding:
13. The interest rate on the current operating loan:
14. the total number of owned pasture land acres:
15. The present land taxes/acre:
16. The total number of owned hay, crop and fallow acres:
17. The present improved land taxes/acre:
18. The present average value/acre of improved farmland (no buildings):
19. The present value of all farm buildings (excluding livestock barns):
20. The average percent of actual cropped land/quarter section (%):
21. The number of productive sows in the enterprise:
22. The number of productive boars in the enterprise:
23. The average number of animals reaching weanling age/sow/litter:
24. The number of months between litters:
25. The death loss rate of finishing hogs/year (%):
26. The current price of feed supplement ($/tonne):
27. The total operating costs/year for veterinary services:
28. The total costs/year for utilities:
29. The total operating costs/year for other related expenses:
30. The total trucking charges/load shipped ($/load):
31. The total selling charges/head ($/head):
32. The number of months of hired labour/year:
33. The total wage expense/month (including room and board) ($):
34. The current market price of slaughter hogs ($/hog):
35. The average index received for slaughter hogs (#):
36. The present age of the existing hog barn (years):
37. The total size of the existing hog barn (sq./ft.):

Source: Adapted from Robert M.Dzisiak,
<u>An Evaluation of the Risk Associated with High Debt Farm Enterprises</u>

TABLE 2.2

Exchange And Loan Rate Summary

Exchange Rate Information

38. The Canadian/U.S. exchange rate:
39. The expected (Can./U.S.) exchange rate in 10 years:

Loan Information

A. Amortized, fixed interest rate
   1. The initial length of the loan (yr):
   2. The number of payments made:
   3. The present annual payment:
   4. The interest rate (%):

B. Equal principle,floating or locked interest rate
   1. The length of the loan (yr):
   2. The number of payments made:
   3. The annual principle payment:
   4. Enter the locked interest rate (%) or press return if the interest rate is floating:

C. Equal principle, renewable, fixed interest rate
   1. The length of the loan (yr):
   2. The number of payments made:
   3. The annual principle payment:
   4. The present locked interest rate (%)
   5. After how many years is the loan renewed (yr):

D. Renewable,amortized,fixed interest rate
   1. The number of years the loan is amortized over (yr):
   2. The total number of payments made:
   3. The present annual payment:
   4. The initial fixed interest rate (%):
   5. After how many years is the loan renewed (yr):

Source: Robert M.Dzisiak (1987),
<u>An Evaluation of the Risk Associated with High Debt Farm Enterprises</u>
p.21.

2.4 STOCHASTIC DETERMINATION OF EXCHANGE RATES

Historical evidence has revealed a high degree of correlation between U.S. commodity prices and their Canadian counterparts, expressed in common currency. In fact, the U.S. serves as the price discovery mechanism for several commodities including grains and hogs. To more accurately depict this situation the exchange rate is included in the simulation model. From a Canadian perspective U.S. prices need to be adjusted by the Canadian/U.S. exchange rate to account for the exchange rate differential. The adjustment procedure allows U.S. prices to be expressed in Canadian dollars, while recognizing the basis of price determination and the stochastic nature of exchange rates. Functional relationships among prices were derived from regressions on the historical data of each commodity.

Table 2.3 presents the Canadian/U.S. exchange rates and the annual percentage changes since 1970. The variability in the annual percentage change (-3.6 to 8.4 percent) in the exchange rate is represented using a triangular distribution.[63] Historical data from this series also provide information on the possible range of the distribution. Upper and lower bounds are established to ensure the variability of the forecasted variables not be greater than that observed in the past. The questions relating to the exchange rate on the input summary serve two purposes. In reality movement of exchange rates is a response to a complex set of economic conditions. Such conditions would be difficult, if not impossible, to simulate and then forecast into the future. Through Q38 and Q39 (Table 2.1) the model sets a pattern for the movement of exchange

[63] For a further discussion behind the choice of a triangular distribution see Dzisiak (1987).

TABLE 2.3

Canadian/U.S. Exchange Rates and Annual % Changes

Year	Rate	Yearly Percent Change
1970	1.0475	-----
1971	1.0103	-3.6
1972	0.9915	-1.9
1973	0.9960	0.5
1974	0.9906	-0.5
1975	1.0160	2.6
1976	0.9823	-3.3
1977	1.0940	8.4
1978	1.1858	8.4
1979	1.1666	-1.6
1980	1.1938	2.3
1981	1.1855	-0.7
1982	1.2288	3.7
1983	1.2444	1.3
1984	1.3217	6.2
1985	1.3983	5.5
1986	1.3805	-1.3

Source: Bank of Canada Review (1970-1986) rates based on the information supplied on the current exchange rate and the expected rate in ten years.[64] Although somewhat subjective, the pattern does ensure that changes in the exchange rates are each calculated in a consistent manner. The questions also fix the base value of the rate and establish its initial distribution. Using values obtained from the input summary the model calculates the annual incremental change (increase/decrease) in the exchange rate (equation 2.1 below). The value obtained is subsequently used in the calculation of the annual base value of the exchange rate.

As previously mentioned, the initialized value of the exchange rate and the range of changes historically have fallen within certain regions, which are maintained in the model. These overall restrictions together with the base value provided by the model user are combined to develop specific upper and lower bounds for the exchange rate in each year. At this time the random variable is introduced and a stochastic value which falls between the bounds is determined. In subsequent simulations the annual increment is added to the previous years base price and new bounds are calculated. Again a random number is generated and used in the calculation of the yearly average exchange rate. This simulation continues for a maximum of ten years, or until the operation becomes insolvent. The process may be described through the calculations below:

$$EYC = (EER - Po)/10 \quad 2.1$$

$$Pi = P(i-1) + EYC \quad 2.2$$

[64] It is expected that the maximum amount of information available relating to future events which may affect the exchange rate is taken into account in making the prediction of the ten year rate.

$$LBi = (0.95 * Pi) \qquad 2.3$$

$$UBi = (1.05 * Pi) \qquad 2.4$$

$$EXRi = [\, LBi + (UBi - LBi) * r \,] \qquad 2.5$$

where:

EYC = Annual increment in the exchange rate

EER = Expected exchange rate in ten years (as set by the model user in Q39, Table 2.2)

Po = Initial Canadian/U.S. exchange rate as set by the model user

P = Base value for calculating bounds of exchange rate equation in year i

LB = Lower bound for exchange rate

UB = Upper bound for exchange rate

EXR = Value of exchange rate to be used in simulation

r = Randomly generated number ($0 < r < 1$), generated using a triangular distribution

i = Time in years

2.5 STOCHASTIC DETERMINATION OF INTEREST RATES

One of the major contributors to the uncertainty of future cash flow is interest expense. The amount of interest expense is dependant on both the principle outstanding and the interest rate. Each year's cash flow must typically be sufficient for payments on term debts and an operating loan. Inability to meet one's obligations may lead to refinancing, a further demand on cash flow. The high and volatile interest rates of the late 1970's and early 1980's introduced additional sources of uncertainty. In an attempt to overcome the problems associated with inflation lenders reduced debt maturities and instituted loans with variable interest rates. Each of these options has increased the uncertainty of future incomes. A similar conclusion regarding the effect of interest rate variability was reached by Ashmead (1984) who stated,

> high and volatile levels of inflation have resulted in the creation of short term financial instruments which can vary with some firm exogenous variable such as the consumer price index (CPI), the prime interest rate, the LIBOR, currency exchange rates; or some firm endogenous variable such as farm net revenue or a commodity price index. This could add an additional measure of risk to the firm which does not exist with fixed debt obligations.[65]

Further,

> inflation has added a new element of risk to the financing of individual farm firms. The creation of variable debt instruments in this inflationary environment may have transferred interest rate risk to borrowers.[66]

The model uses a random number generator in a manner similar to that described for exchange rates to determine interest rates. Historical data, as presented in Table 2.4, with respect to percentage change in the interest rate (-21 to +41) point to the use of a rectangular distribution. The simulation of interest rates is complicated by the fact that their movement is governed through definition by two factors: the inflation rate and real interest rate. The model uses the percentage change in the consumer price index (CPI) as a proxy for the inflation rate. Since 1970 the inflationary ingredient has become the dominant factor responsible for the volatility in the nominal interest rate. The real rate as measured by the difference between the CPI and the nominal

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[65] Ralph W.Ashmead, "An Evaluation of the Impact of Interest Rate Variability on Farm Risk, Portfolio Choice and Diversification." (Unpublished PhD. Thesis, University of Manitoba, 1984) p.8.

[66] Ibid., p.10.

TABLE 2.4

Interest Rate and Inflation Rate

Year (yr)	Average Bank Prime Rate (%)	Change From Previous Year (%)	Change In CPI (%)	Deviation Between CPI and Interest Rate
1970	8.17			
1971	6.48	-21	2.9	3.6
1972	6.00	-7	4.8	1.2
1973	7.65	28	7.5	0.2
1974	10.75	41	10.9	-0.2
1975	9.33	-13	10.8	-1.5
1976	10.04	8	7.5	2.5
1977	8.50	-15	8.0	0.5
1978	9.69	14	9.0	0.7
1979	12.92	33	9.1	3.8
1980	14.25	10	10.1	4.2
1981	19.38	36	12.5	6.9
1982	16.94	13	11.6	5.3
1983	11.17	-34	5.8	5.4
1984	12.06	8	4.3	7.8
1985	10.58	-12	4.0	6.6
1986	10.52	-0.6	3.9	6.6

Source: Bank of Canada Review 1970 to 1986 interest rate has fluctuated between -2 and +7 percent. Therefore the model uses two sets of bounds to simulate the interest rate. The equations below illustrate the procedure used to forecast interest rates.

$$LBi = (1 - .25)\ IR(i-1) \qquad 2.6$$

$$UBi = (1 + .25)\ IR(i-1) \qquad 2.7$$

$$\text{IF} \quad LBi < (CPI - 2) \qquad 2.8$$

$$\text{THEN} \quad LBi = (CPI - 2) \ \ \& \ \ UBi = [(CPI - 2)/(.75)](1.25) \qquad 2.9$$

$$\text{IF} \quad UBi > (CPI + 7) \qquad 2.10$$

$$\text{THEN} \quad UBi = (CPI + 7) \ \ \& \ \ LBi = [(CPI + 7)/(1.25)](.75) \qquad 2.11$$

$$IRi = [\ LBi + (\ UBi - LBi\ ) * r\ ] \qquad 2.12$$

where:

LB = Lower bound in interest rate

UB = Upper bound in interest rate

IR = Interest rate (initial value of IR set by user, Q13)

CPI = Percent annual increase in cost of living (constant, set by user, Q5)

r = Random number ($0 < r < 1$), generated using rectangular distribution

i = Time in years

The procedure consists primarily of setting two sets of constraints on values of the distribution. Equations 2.6 and 2.7 restrict the overall movement of interest rates to +/- 25 percent of the initial, or previous years interest rate. The choice of this range is supported by the information regarding annual percentage change in the interest rates since 1970.

A second criterion using the inflation rate specified in the input summary further limits movement of the interest rate. The second set of constraints (equations 2.8 - 2.11) requires the interest rate to be within -2 or +7 of the assigned inflation rate. Again, the allowable region was derived from the observed maximum and minimum deviations in the real rate since 1970. Failure of either bound to meet this criterion results in the model resetting them according to either equation 2.9 or 2.11. Using these bounds and a randomly generated number the interest rate is forecasted as per equation 2.12.

2.6 STOCHASTIC ERROR TERM FOR GRAIN AND HOG PRICES

In the simulation of grain and hog prices a series of randomly generated numbers are used to form a normally distributed residual term.[67] The formation of the normal distribution follows from the central limit theorem.[68] Briefly, the model generates twelve random variables which are normally distributed and lie between the bounds of zero and one. Using the equation listed below the twelve variables are combined with their mean and standard deviation to result in an error term which is normally distributed.[69] The actual procedure which produces the following equation is presented in Appendix A.

[67] This is not to be confused with an error term which exhibits properties associated with a standard normal distribution for which the mean is zero and the variance one.

[68] The theorem states that as sample size (N) becomes large, the sum of N independant random variables will approach a normal distribution.

[69] Previous research conducted by Hartely (1976) has shown that N=12 not only provides a degree of computational ease but also provides relatively reliable results. However, the results are less conclusive for residual values outside ± three standard deviations.

$$a = \sigma \left(\sum_{i=1}^{12} r_i - 6 \right) + u$$

where:

a = normally distributed residual term

σ = 1 standard deviation of the normal distribution to be simulated

r = randomly generated number ($0 < r < 1$), generated from a normal distribution

u = mean of the normal distribution to be simulated

2.6.1 Randomly Generated Grain Prices

The model is designed to generate quarterly prices for wheat, corn and barley. Within the model wheat prices are assumed to govern the movement of prices in the feed grain market. Therefore, barley and corn prices are determined as functions of wheat prices. The interactions occuring among grain prices are illustrated in Figure 2.2 . Due to the dominant postion of the U.S. within the North American market with respect to grain prices, Canadian prices are directly connected to the quoted price in the U.S.. Therefore, Canadian wheat and barley prices are derived as functions of their U.S. counterparts and the Canadian/ U.S. exchange rate.

Among the various quantitative and forecasting models examined by Dzisiak (1987) cyclical patterns observed in historical U.S. wheat prices[70] were best captured using spectral analysis. As noted by Chow (1975) the technique is

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[70] The historical price series was comprised of the average quarterly price of No. 1 Dark Northern Spring Wheat, basis Minneapolis, from 1973 to 1985.

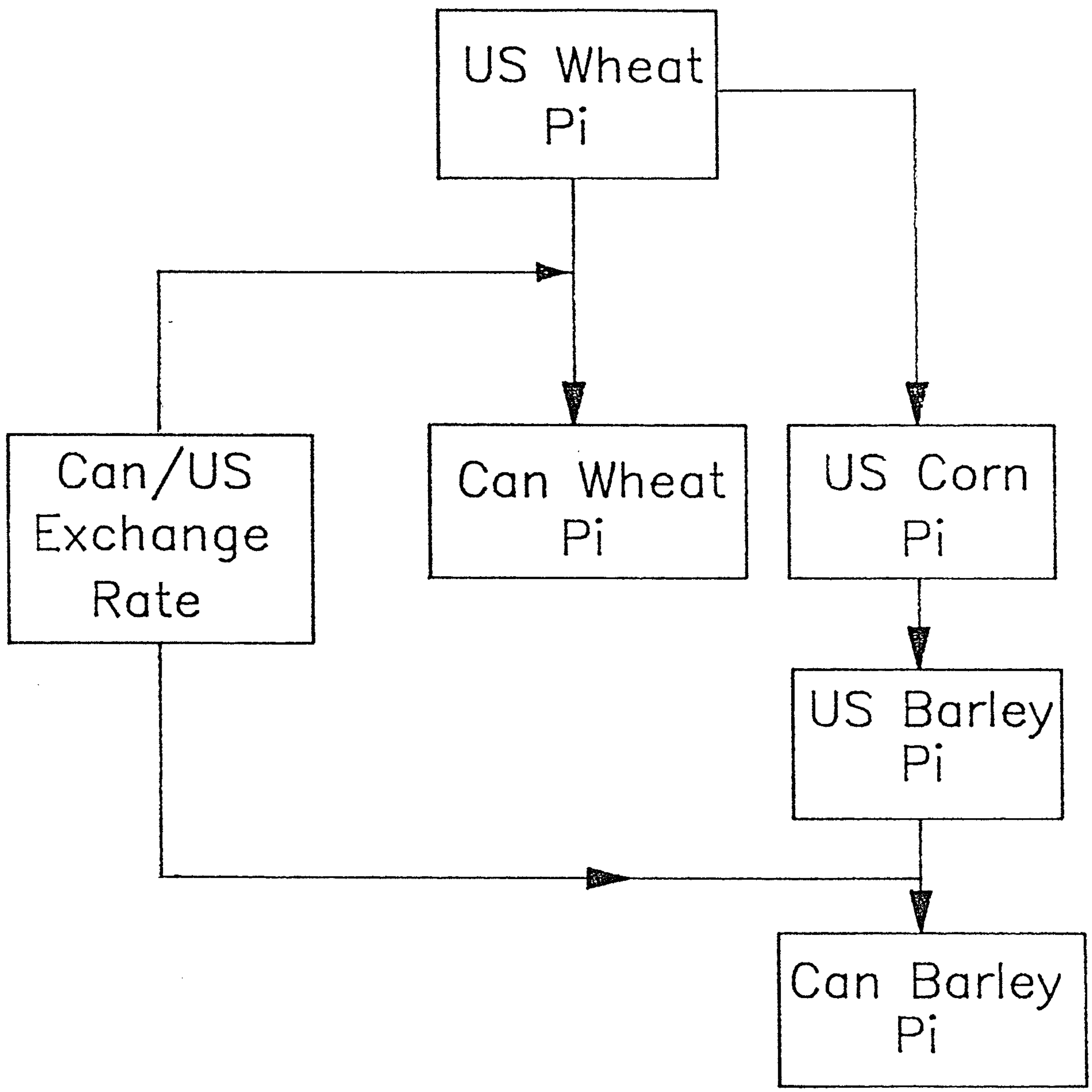

Figure 2.2 Grain Price Linkage

> useful for studying cyclical properties of econometric models. In addition and perhaps more prevalently, they are useful for extracting cyclical properties of observed economic time series without the intervention of an econometric model.[71]

A brief investigation of the literature has unveiled the use of spectral analysis in several fields including physics, engineering, and psychology.[72] In books by both Granger and Hatanaka (1964) and Fishman (1969) the spectral approach has been applied to the analysis economic time series. In agricultural economics Yeh and Black (1964) used the technique for the specification of weather cycles to assist in the prediction of crop yields. Finally, Granger and Hughes (1971) analyzed cyclical movement in wheat prices by examining the Beveridge Wheat Price series.[73] Their research found clear evidence of a cycle of approximately 13 years.

Essentially, spectral analysis is concerned with the estimation of a spectral density function (spectrum) of a time series. The spectral procedure, a modification of Fourier Analysis, regards a time series as a function comprised of a weighted sum of sine and cosine terms with different periodicities. The spectral density function therefore describes how variability in a time series may be accounted for by cyclic components at different frequencies.

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[71] R.Chow, "Analysis and Control of Dynamic Economic Systems", (New York:John Wiley and Sons, 1975), p.90.

[72] A more complete list is available in Brillinger (1981).

[73] The series consists of a time series index of wheat prices in Western and Central Europe for the period 1500 to 1869. There is some controversy as to whether these observed cycles are in fact true cycles.

As with other techniques used to analyze time series it is necessary for the series to be stationary; that is, it must not exhibit systematic changes in either mean or variance. Conversion of a series, referred to as prewhitening, generally requires some transformation of data. Economic time series are often made non-stationary through adjustment for both trend and seasonal variation. Variablity due to either factor must be removed prior to analysis as they each obscure other effects which may not be apparent in a spectrum of the raw data. Prewhitening of raw data is especially important when estimating a spectrum of a relatively short time series. It is recommended that a minimum of 100 to 200 observations are required to obtain unbiased estimates without prewhitening. However, research conducted by Granger and Hughes (1968) using series with as few as 30 observations found reasonable estimates could be obtained providing data had been prewhitened, producing a series with a flatter spectrum. They concluded that without prewhitening of shorter series only very large peaks would be found. Several references including Granger and Hatanaka (1964), Jenkins and Watts (1969), Chow (1975), Chatfield (1980), and Brillinger (1981) provide more detailed explanation of the theory, assumptions and applications of spectral analysis.

Application of the spectral procedure to the historical quarterly wheat price series confirmed the existance of a cyclical pattern. Periodogram analysis yielded a large peak at twenty-four observations, indicating a six year cycle. This cycle together with the historical wheat price series is presented in Figure 2.3 . Each of the individual cycle values presented in Table 2.5 was calculated according to an equation, the coefficients of which were obtained from the spectral pro-

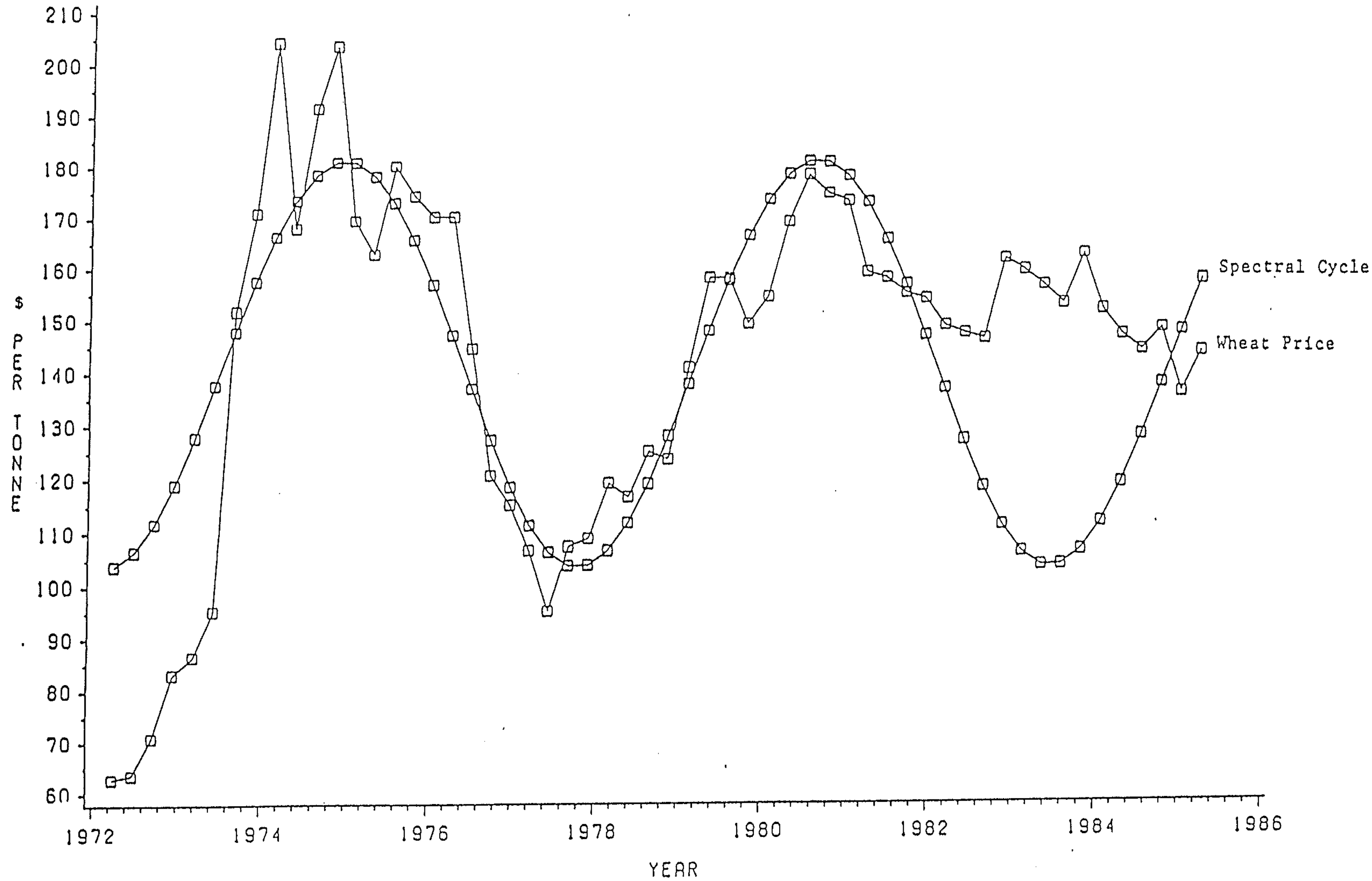

Figure 2.3: Historical Wheat Cycles and Spectral Cycle Values

Source: Dzisiak(1987)

TABLE 2.5

Spectral Wheat Cycle Values

Cycle Length (k)	Cycle Value (Ck)	Year (quarter) (t)
1	-5.481	1985 (3)
2	-15.250	1985 (4)
3	-23.979	1986 (1)
4	-31.074	
5	-36.052	
6	-38.572	
7	-38.464	
8	-35.735	
9	-30.570	
10	-23.322	
11	-14.485	
12	-4.660	
13	5.482	
14	15.250	
15	23.979	
16	31.074	
17	36.052	
18	38.572	
19	38.464	
20	35.734	
21	30.570	
22	23.322	
23	14.484	
24	4.660	

Source: Robert M. Dzisiak (1987)
<u>An Evaluation of the Risk Associated with High Debt Farm Enterprises</u>
p.37.

cedure.[74]

Having established individual values for each point along the cycle, the model is ready to commence its simulation of wheat prices. The model is flexible with regard to the spectral cycle value at which the simulation begins.[75] A starting point is determined which matches information gathered from the input summary (regarding the year and quarter in which the analysis starts) with similar values in Table 2.5. Once an initial starting point for the simulation is established, the corresponding cycle value must be adjusted to match the upward movement present in the historical series, which was removed during the spectral analysis. This is accomplished by adding the mean value for the historic U.S. wheat price, corrected for inflation, to cycle values.[76] Subsequent quarterly values of the mean are each increased by an inflationary factor. Variablity in cycle values is introduced through a normally distributed random error term, the characteristics of which were discussed in section 2.6 .

As with several other commodities the U.S. government has established a minimum, or floor price for wheat prices, referred to as the loan rate.[77] Should the market clearing price drop below the minimum, the

[74] Further explanation of the procedure involved in the specification of the cycle is presented in Dzisiak (1987).

[75] Providing the background information required is provided by the model user.

[76] The model automatically resets the cycle back to its initial value upon reaching the twenty-fourth value in the spectral cycle.

[77] Administered by the Commodity Credit Corporation (CCC) the loan rate is the basic price support mechanism used in the U.S. to support farm incomes by guaranteeing a minimum price for certain commodities to producers. The 1986 loan rate established for wheat under the 1985 Food Securities Act is \$88.1/tonne (\$2.28/bushel).

floor price is maintained until either surplus stocks are removed or the price increases above the loan rate. To reflect the effects of U.S. commodity support programs each price simulated by the model must be checked to ascertain if it is below a predetermined support price.[78] If it is, the price of wheat is set equal to the support price and the spectral cycle count remains unchanged in determining the simulated price for the next quarter.

The final step in the simulation is to convert U.S. prices to Canadian prices using the previously established Canadian/U.S. exchange rate. A description of the equations of the wheat price model is as follows:[79]

Canadian Wheat Prices

$$WCPt = (INF * M(t-1) + Ck) \quad 2.13$$

$$Wt = WCPt + at \quad 2.14$$

$$\text{IF } W(t) - W(t-1) > 35 \quad 2.15$$

$$\text{THEN } W(t) = W(t) - DIFF + 35 \quad 2.16$$

$$\text{IF } W(t) - W(t-1) < -35 \quad 2.17$$

$$\text{THEN } W(t) = W(t) - DIFF - 35 \quad 2.18$$

$$\text{IF } W(t) - W(t-2) > 15 \quad 2.19$$

$$\text{THEN } W(t) = W(t) - DIFF + 15 \quad 2.20$$

$$\text{IF } W(t) - W(t-2) < -15 \quad 2.21$$

$$\text{THEN } W(t) = W(t) - DIFF - 15 \quad 2.22$$

---

[78] The type of wheat used in the spectral analysis was of higher quality (14% protein) than the average produced in the U.S. for which the loan rate is set. Therefore, a premium ($27.55/tonne) representing the average price differential between wheat of average quality and that used in this study was added to the basic loan rate.

[79] Support for the mathematical form of the wheat price model is presented in Dzisiak (1987). The model form was accepted based on comparisons between historical and simulated price distributions.

$$IF\ W(t) - W(t-3) > 9 \qquad 2.23$$

$$THEN\ W(t) = W(t) - DIFF + 9 \qquad 2.24$$

$$IF\ W(t) - W(t-3) < -9 \qquad 2.25$$

$$THEN\ W(t) = W(t) - DIFF - 9 \qquad 2.26$$

$$IF\ W(t) - W(t-4) > 8 \qquad 2.27$$

$$THEN\ W(t) = W(t) - DIFF + 8 \qquad 2.28$$

$$IF\ W(t) - W(t-4) < -8 \qquad 2.29$$

$$THEN\ W(t) = W(t) - DIFF - 8 \qquad 2.30$$

$$IF\ (Wt < LOANt) \qquad 2.31$$

$$THEN\ (Wt = LOANt) \qquad 2.32$$

$$IF\ (Wt > LOANt) \qquad 2.33$$

$$THEN\ (k = k + 1) \qquad 2.34$$

$$CANWHTt = (Wt * EXRt) \qquad 2.35$$

where:

WCP = Wheat cycle price adjusted for the inflation rate, and the mean value

C = Spectral cycle value of the quarter being simulated

k = Quarter in the spectral cycle ($1 < k < 24$)

INF = Quarterly inflation rate

M = Mean price of the wheat series (Mo = 143.69)

t = Time in quarters ($1 < t < 40$)

W = Average quarterly price of U.S. wheat (\$/tonne)

a = Normally distributed random error term (see section 2.6)

DIFF = Difference between the current quarterly wheat price (Wt) as simulated by the model and the wheat price in several previous quarters [ie. W(t-1), ... W(t-4)]

LOAN = U.S. loan rate + \$27.55/tonne

CANWHT = Average quarterly price of Canadian wheat (\$/tonne)

EXR = Canadian / U.S. quarterly exchange rate (see eq. 2.5)

2.6.1.1 Feed Grains

In addition to the simulation of wheat prices the model generates feed grain prices for U.S. corn, U.S. barley and Canadian barley. On the surface it would appear that as the major feed grain utilized in western Canada, only barley prices need be generated by the model. However, movement in barley prices is not governed solely by the previous period's price. Within the U.S., corn is the primary feed grain utilized in swine production. Therefore, as prices in the model are initially developed in the U.S. market, a relationship must first be modelled between wheat and corn. As barley is a secondary feed grain in the U.S., the price of barley is first determined as a function of the U.S. corn price. The value of Canadian barley is subsequently modelled to follow the price developed in the U.S. The nature of the relationships existing between feed grains may be illustrated using the equations below:

1. $\text{Ln USCRNt} = \alpha_1 + \beta_1 (\text{Ln USWHTt}) + u$

2. $\text{Ln USBLYt} = \alpha_2 + \beta_2 (\text{Ln USCRNt}) + u$

3. $\text{Ln CANBLYt} = \alpha_3 + \beta_3 (\text{USEXBLYt}) + u$

where:

Ln USWHT = U.S. wheat price in natural log form

Ln USCRN = U.S. corn price in natural log form

Ln USBLY = U.S. barley price in natural log form

USEXBLY = Price of U.S. barley in Canadian dollars

α = is a constant term

β = represents the slope of the function

t = Time in quarters ($1 < t < 40$), over the period 1973 to 1985

u = Stochastic error term, mean = 0

As outlined above U.S. corn prices are determined as a log linear function of U.S. wheat prices. Regression coefficients together with the standard error of the estimate, obtained from the ordinary least squares solution of this equation (see Dzisiak), are combined to define two initial bounds for corn prices. Following transformation of the bounds from natural logarithms, a value for U.S. corn price is calculated. The forecasted price for corn must meet two final criteria before being employed by the model. Governmental policy in the U.S. has set a floor price for corn; therefore the value of corn forecasted by the model must never be lower than the U.S. loan rate.[80] The second criterion restricts the maximum value of the U.S. corn price to eighty-five percent of the price of wheat to reflect historic patterns. A description of the equation used in this process is as follows:

U.S. Corn Prices

$$LnLBt = [\ \alpha_1 + \beta_1 \ (\ Ln\ USWHTt\ ) - \gamma_1\ ] \qquad 2.36$$

$$LBt = Antilog\ (\ LnLbt\ ) \qquad 2.37$$

$$LnUBt = [\ \alpha_1 + \beta_1 \ (\ Ln\ USWHTt\ ) + \gamma_1\ ] \qquad 2.38$$

$$UBt = Antilog\ (\ LnUBt\ ) \qquad 2.39$$

---

[80] Loan rate for corn is set internally by the model and fixed for the duration of the simulation. The 1986-87 loan rate established for corn under the 1985 Food Security Act is $75.42/tonne ($1.83/bushel).

USCRNt = LBt + (UBt - LBt) * r 2.40

Overall Bounds

IF [USCRNt > (0.85 * USWHTt)] 2.41

THEN USRNt = (0.85 * USWHTt) 2.42

IF (USCRNt < CRNLOANt) 2.43

THEN (USCRNt = CRNLOANt) 2.44

CRNLOANt = CRNLOANo 2.45

where:

LnLB = Lower bound in natural log form

LB = Lower bound

Ln USWHT = U.S. wheat price in natural log form

LnUB = Upper bound in natural log form

UB = Upper bound

USCRN = Price of U.S. corn

CRNLOAN = U.S. loan rate for corn

α_1 = 0.956775

β_1 = 0.735813

γ_1 = 0.106644 (standard error as estimated from the log linear regression equation between corn and wheat)

t = Time in quarters

r = random number generator (0 < r < 1), generated from a normal distribution

Using the U.S. corn price established from equations 2.36 to 2.45 the model proceeds to the calculation of U.S. barley prices. The model adopts new parameter values reflecting the relationship between U.S.

corn prices and U.S. barley prices to assign upper and lower bounds of the distribution. Further, the model limits the U.S. barley price to 0.75 and 1.25 times the price of corn.[81] Should the forecasted price not fall within these limits the model repeats the steps outlined in equations 2.46 to 2.55 until a satisfactory price is achieved.

Once determined the U.S. barley price is converted by the Canadian / U.S. exchange rate and expressed in Canadian dollars. The method by which Canadian barley prices are forecast differs from that described for their U.S. counterparts only in the regression coefficients used to determine initial bounds as seen below:

U.S. Barley Prices

$$LnLBt = [\alpha_2 + \beta_2 (LnUSCRNi) - \gamma_2] \qquad 2.46$$

$$LBt = Antilog (LnLBt) \qquad 2.47$$

$$LnUBt = [\alpha_2 + \beta_2 (LnUSCRNt) + \gamma_2] \qquad 2.48$$

$$UBt = Antilog (LnUBt) \qquad 2.49$$

$$USBLYt = [LBt + (UBt - LBt)] * r \qquad 2.50$$

Overall Bounds

```
IF [ USBLYt > ( 1.25 * USCRNt ) ]                2.51
  DO SIMUL UNTIL
    [ USBLYt < ( 1.25 * USCRNt ) ]               2.52
IF [ USBLYt < ( 0.75 * USCRNt )                  2.53
  DO SIMUL UNTIL
    [ USBLYt > ( 0.75 * USCRNt ) ]               2.54
USEXBLYt = [ USBLt * EXRi ]                      2.55
```

[81] Upper and lower bound limits were based on an historical examination of the data conducted by Dzisiak (1987).

where:

LnUSCRN = U.S. corn prices in natural log form

USBLY = Price of U.S. barley

USEXBLY = Price of U.S. barley in Canadian dollars

α_2 = 0.566466

β_2 = 0.871689

γ_2 = 0.118634 (standard error as estimated from the log linear regression equation between barley and corn)

EXR = Canadian / U.S. exchange rate (see eq. 2.5)

SIMUL = Generate price from simulation model

i = Time in years

<u>Canadian Barley Prices</u>

$$LnLBt = [\alpha_3 + \beta_3 (Ln\ USEXBLYt) - \gamma_3] \tag{2.56}$$

$$LBt = Antilog (LnLBt) \tag{2.57}$$

$$LnUBt = [\alpha_3 + \beta_3 (Ln\ USEXBLYt) + \gamma_3] \tag{2.58}$$

$$UBt = Antilog (LnUBt) \tag{2.59}$$

$$CANBLYt = [LBt + (UBt - LBt)] * r \tag{2.60}$$

<u>Overall Bounds</u>

IF [CANBLYt > (1.25 * EXUSBLYt)] 2.61

DO SIMUL UNTIL

[CANBLYt < (1.25 * EXUSBLYt)] 2.62

IF [CANBLYt < (0.75 * EXUSBLYt)] 2.63

DO SIMUL UNTIL

[CANBLYt > (0.75 * EXUSBLYt)] 2.64

where:

CANBLY = Price of Canadian barley

α_3 = 1.487937

$\beta_3 = 0.691272$

$\gamma_3 = 0.0925208$ (standard error as estimated from the log linear regression between Canadian and US barley)

2.6.2 Randomly Generated Hog Prices

The generation of hog prices is necessary for two reasons. Firstly, prices are required to calculate the yearly receipts generated by the hog enterprise. Secondly, market value is one of the elements involved in the determination of quarterly support prices under the TRMSP.

The conceptual development of the hog model involved a number of the factors which affect the price of hogs. A North American market similar to that observed for grains also exists for hogs such that Canadian market prices follow those cited in the U.S.[82] Therefore, the model is first specified in terms of U.S. prices and subsequently converted to Canadian dollars using the Canadian / U.S. exchange rate. As previously mentioned in section 1.2, hog prices are greatly influenced by feed grain prices. Thus, the model has incorporated the price of feed into the simulation model for hogs. In addition, feed grain prices are one of the factors instrumental in defining the cyclical nature of hog prices. For forecasted prices to conform to this pattern, a cyclical component is included in the price simulation model.

Studies conducted by Brandt and Bessler (1983) and Leuthold et al.(1970) recommend the use of an Autoregressive Integrated Moving Average (ARIMA) model to forecast hog prices. This conclusion was based on evaluations of the forecasting abilities of several techniques including

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[82] Prices between the two countries differ slightly due to several factors including, the exchange rate, transportation costs and the imposition of countervailing duties and tariffs.

evaluations of the forecasting abilities of several techniques including time series and econometric models.[83] Techniques to analyze time series data ARIMA models are based entirely on the past history of a series (or related series).[84] As described by Nelson (1973) ARIMA models

> attempt to infer from the data what mechanism it is that generated the data. Thus, the past history of the time series is called upon to do double duty: First, it must inform us about the particular mechanism which describes its evolution through time, and, second it allows us to put that mechanism to use in forecasting the future.[85]

While two general groups (univariate and multivariate) of ARIMA models exist, the bivariate approach was utilized in this study primarily for two reasons. Univariate models are built based upon the characteristics of a single time series. Bivariate and multivariate models utilize information provided by other data to assist in the estimation process and are used when

> one or more independant variable time series (inputs) may be used to explain the stochastic behavior of a dependant variable time series (output).[86]

A simulation model developed using the multivariate approach would therefore take into consideration the perceived relationship between feed grain and hog prices. Secondly, as pointed out by Brandt and Bes-

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[83] Although the research conducted by Leuthold et al. (1970) concluded slightly superior results were obtained using econometric approach they suggest that the additional costs involved in setting up such a model do not necessarily warrant its use. This statement is echoed by Granger and Newbold (1977) who agree that a balance must be struck between the cost of making particular forecasting errors and the cost of producing the forecast.

[84] This is not to be confused with econometric procedures which are based on prior research and economic theory.

[85] Charles R.Nelson, Applied Time Series Analysis for Managerial Forecasting (San Francisco: Holden-Day, Inc., 1973), p.19.

[86] Richard McCleary and Richard A. Hay, Applied Time Series Analysis for the Social Sciences (Beverly Hills: Sage Publications, Inc., 1980), p.26.

sler (1983):

> The intended use of forecasts, in large degree, influences or dictates the type of model selected to generate the forecasts.[87]

The dependability of forecasts obtained from univariate models is usually restricted to one or two periods (McCleary and Hay, 1980). Alternatively, multivariate models provide reliable long range forecasts, a necessary feature in a model required to simulate quarterly prices for a ten year period.

The bivariate hog forecasting model specified by Dzisiak (1987) was developed using the Box-Jenkins approach to time series analysis. The model building strategy discussed in McCleary and Hay (1980) can be described as a three step procedure: identification, estimation and diagnosis. Identification of the class of ARIMA model involves a thorough examination of the autocorrelation (ACF) and partial autocorrelation (PACF) functions. The parameters of the tentative ARIMA model are then estimated and investigated to determine if they are statistically significant and lie within the bounds of stationarity and invertibility.[88]

As previously mentioned in section 2.6.1 stationarity implies that a time series not exhibit systematic changes in either mean or variance.[89]

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[87] Jon A. Brandt and David A. Bessler, "Price Forecasting and Evaluation: An Application in Agriculture," <u>Journal of Forecasting</u>, 2(3), (July - September, 1983), p.237.

[88] More in depth explanations for both stationarity and invertibility are available in McCleary and Hay (1980); Nelson (1973); Pankratz (1983) and Pindyck and Rubinfeld (1981).

[89] The alternative to this assumption would be a process for which the mean was different for each period. Obtaining an estimate for the mean, given the aforementioned situation, would require the availability of several observations for one variable for each period. Given current data sources this is not an option normally available

Without this requirement parameter estimates could not be determined with any degree of confidence thus rendering them and the estimation technique virtually useless. Stationarity, in itself, is not a concept unique to the process of ARIMA models. As noted by Pindyck and Rubinfeld (1981),

> "... if the stochastic process is fixed in time, i.e., if it is stationary, then as we will see, it is possible to model the process via an equation with fixed coefficients that can be estimated from past data. This is analogous to the single equation regression model in which one economic variable is related to other economic variables, with coefficients that are estimated under the assumption that the structural relationships described by the equation is invariant overtime (i.e., it is stationary). ...Time series do not use economic relationships. However, our task of describing a stochastic process will be much easier if the characteristics of that process do not change overtime.[90]

The stationarity condition, as it pertains to ARIMA models, is applicable only to the autoregressive (AR) portion of the ARIMA model. In practical terms this involves an examination of both the ACF and the estimated AR coefficients to determine if they satisfy the stationarity requirements.

Having established the stationarity of the AR parameters the moving average (MA) process is checked for invertibility. Algebraically invertibility is equivalent to stationarity, but as applied to to MA coefficients. To be invertible estimates of the MA parameters must form a convergent series. More specifically, the weights attached to past disturbances must decline as the lag length increases. This condition is not unreasonable in that one would normally expect recent disturbances to have a greater effect on the process than those in the more distant

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to most researchers.

[90] Robert S.Pindyck and Daniel L.Rubinfeld, Econometric Models and Economic Forecasts. (New York: McGraw-Hill Inc.,1981), p.497.

past.[91]

Finally, the behavior of the residuals is checked to determine if it resembles white noise.

When applied to U.S. hog and corn prices these procedures resulted in the bivariate ARIMA model in equation 2.65.[92] from which Canadian prices are determined as described in the expressions below:[93]

<u>Bivariate ARIMA Slaughter Hog Price Forecasting Model</u>

$$\widehat{PH}(t) = PH(t-6) + \omega_0 [X(t-3) - X(t-4)] + \theta_0 - [\theta_0] - \theta_1 a(t-1) - \delta_6 a(t-6) + \theta_1 \delta_6 a(t-7) \quad 2.65$$

$$PH(t) = \widehat{PH}(t) + a(t) \quad 2.66$$

IF [a(t) > +10.95] or [a(t) < -10.95] 2.67

THEN RERUN

IF PH(t) - PH(t-1) > 15.6 2.68

THEN PH(t) = PH(t-1) + DIFF - 15.6 2.69

IF PH(t) - PH(t-1) < -15.6 2.70

THEN PH(t) = PH(t-1) + DIFF + 15.6 2.71

IF PH(t) - PH(t-2) > 18.36 2.72

THEN PH(t) = PH(t-2) + DIFF - 18.36 2.73

IF PH(t) - PH(t-2) < -18.36 2.74

THEN PH(t) = PH(t-2) + DIFF + 18.36 2.75

---

[91] In addition, the imposition of the condition of invertibility has a secondary effect. Invertibility in conjuction with stationarity ensures that the ACF can be matched to one specific ARIMA mechanism.

[92] Further discussion of the process to develop the bivariate hog model is presented in Dzisiak (1987).

[93] Historical validation of the hog forecasting model is presented in Dzisiak (1987).

IF PH(t) - PH(t-3) > 21.12 2.76

THEN PH(t) = PH(t-3) + DIFF - 21.12 2.77

IF PH(t) - PH(t-3) < -21.12 2.78

THEN PH(t) = PH(t-3) + DIFF + 21.12 2.79

IF PH(t) - PH(t-4) > 23.88 2.80

THEN PH(t) = PH(t-4) + DIFF - 23.88 2.81

IF PH(t) - PH(t-4) < -23.88 2.82

THEN PH(t) = PH(t-4) + DIFF + 23.88 2.83

IF PH(t) - PH(t-5) > 26.65 2.84

THEN PH(t) = PH(t-5) + DIFF - 26.65 2.85

IF PH(t) - PH(t-5) < -26.65 2.86

THEN PH(t) = PH(t-5) + DIFF + 26.65 2.87

CANP(t) = PH(t) * EXR(t) 2.88

SOW(t) = [8.4957 + (0.5326 * CANP(t))] 2.89

BOAR(t) = [0.75 * SOW(t)] 2.90

where the estimated coefficients are :

$\theta_0 = 48.4536$

$\theta_1 = -0.953097$

$\omega_0 = -0.201947$

$\delta_6 = 0.706031$

and

PH = Actual U.S. slaughter hog price

X = U.S. Corn price

a = residual term, generated as per section 2.6

$\widehat{PH}$ = Predicted U.S. slaughter price

EXR = Canadian / U.S. exchange rate

CANP = Canadian price of slaughter hogs

SOW = culled sow price

SOW = culled sow price

BOAR = culled boar price

DIFF = Difference between the current price of hogs [PH(t)] as simulated by the model and the price in several previous periods [ie. P(t-1), PH(t-2), ... PH(t-5)]

r = random number ($0 < r < 1$) , generated from a normal distribution

t = time in quarters ($-7 < t < 40$)

The bivariate model outlined in equation 2.65 forecasts predicted values for U.S. hog prices as a function of its own past price, that of U.S. corn in addition to several lagged residual terms.[94] The variability in prices simulated by the model undergoes a series of checks to ensure the range conforms to the variability in the historical series. Firstly, residual values are monitored and constrained to occur within (+/-) two standard deviations of the mean of the historical price series. Secondly, deviations between the current quarters price and those of several lagged periods are restricted to the maximum values observed in the past.

In addition to forecasting values for slaughter hogs the model calculates prices for culled sows and boars. As illustrated in Figure 2.4 sow values are first determined as a function of slaughter hogs; boars are valued at seventy five percent of sows.

[94] Lagged values for each variable are stored within the model for later reference.

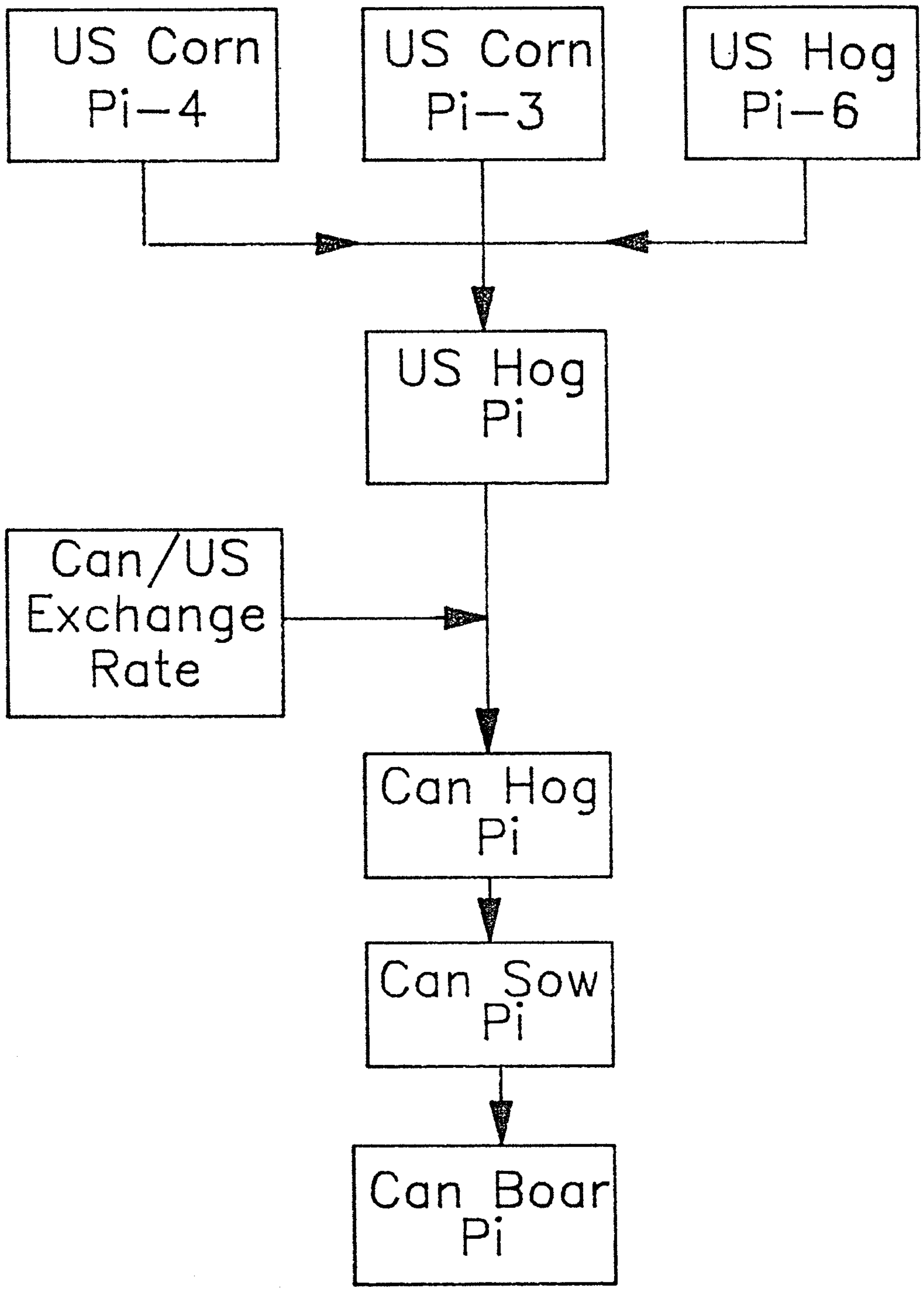

Figure 2.4 Hog Price Linkage

2.7 REVENUE

The major sources of revenue linked to hog production are included in the simulation model. Using information gathered from the input summary (Table 2.1), the model is able to calculate the level of returns produced from the enterprise. Additional revenue generated off the farm together with the cash surplus from previous years is also included in the calculation of total revenue.

2.7.1 Operating Revenue

Total enterprise revenue is calculated as a product of total hog sales and their value as determined by the model in section 2.6.2. The production information supplied in Table 2.1 is used to initialize variables related to the size of enterprise including number of slaughter hogs, sows,and boars sold per year. Total production is reported as a function of the number farrowings per year (Q24), the birth rate (Q23), and the mortality rate (Q25).

Market hogs are sold when they reach an average weight of 220 pounds (99.7 kilograms) at the price determined by the model.[95] A premium over market price is received by operators whose average index exceeds 100.[96] Therefore, in Q35 (Table 2.1) an index variable is included in the model.

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[95] Slaughter prices are based on a carcass weight of 170 pounds (77.1 kilo grams).

[96] Carcass quality of slaughter hogs is indicated by an index. This index based on warm carcass weight and backfat thickness is used to calculate the monetary value. Market price is based on an index of 100; thus, animals achieving higher indicies receive a premium.

Revenue from hog operations also results from the sale of breeding stock. The size of the breeding herd initialized in Q21 and Q22 (Table 2.1) is based on a 25 percent replacement rate for sows and a 33 percent replacement rate for boars. Returns are determined by the value and number of sows and boars culled.[97]

2.7.2 Nonfarm Income and Cash Resources

Nonfarm income often serves as an important component of an operation's total revenue. Therefore, the present value of off-farm income (Q6) and its expected rate of increase (Q7) are included in the model. Cash resources accumulated from previous years cash surpluses are initialized using Q9.[98] In later years income not immediatly required is retained by the operation and added to an interest earning cash surplus pool.[99]

2.8 EXPENDITURES

The cash flow of an operation is dependant on both the level of inflow (revenue), and outflow (expenditure). Successful management of each is required to avoid refinancing due to cash shortages. Several sources of expenditures are examined by the model included are:

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[97] Average live weight of culled breeding stock 500 pounds (226.7 kilograms).

[98] Near cash refers to those assets which can quickly be converted to cash if necessary.

[99] Interest rate set at prime.

1. Operating expenses
2. Expenses associated with current and potential financing arrangements
3. Building replacement
4. Capital input replacement
5. Living and personal withdrawals
6. Income Tax

2.8.1 <u>Total Operating Expenses</u>

Operating expenses are a reflection of those costs directly attributable to the farm's operations. As illustrated in Table 2.6 operating expenses may be divided into two groups, production related expenses and marketing related expenses.

TABLE 2.6

Total Operating Expenses

Production Related Expenses	Marketing Related Expenses
Feed	Trucking Charges
Breeding Stock Replacement	Selling Charges
Utilities	
Veterinary Services	
Hired Labour	
Miscellaneous	

The cost of feed represents the largest relative production expense in a farrow-to-finish enterprise. Separate rations are formulated for each group of animals within the operation. The cost of the supplement[100] portion of the ration is supplied by Q26. The price of barley is determined as outlined in section 2.6.1.1.

Maintenance of a healthy and productive breeding herd is essential to the viability of a farrow-to-finish operation and requires the periodic culling of animals. The cost of replacing culled breeding stock therefore represents an additional expense. No cost is associated with replacement of sows which are taken directly as gilts from the enterprise. Replacement boars are purchased as determined by the culling rate at twice the price quoted for slaughter hogs.[101]

Costs resulting from utilities and veterinary services are specified in Q27 and Q28. Hired labour expenses are calculated as the product of wages per month (Q33) and (Q32), the number of months of hired labour.

Expenses associated with the marketing of animals include trucking and selling charges (Q30 and Q31). Trucking costs are assigned on a per load basis where an average load is assumed to be 40,000 pounds. The number of loads are calculated by the model using the number of animals shipped and their average weight. The value determined for the total selling expense is also based on production levels.

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[100] Supplements are composed of a mixture of protein, minerals, vitamins, and antibiotics.

[101] Average weight of replacement boars 300 pounds (136 kilograms).

Finally each of the variables is increased throughout the simulation by an inflation established in Q3.

2.8.2 Annual Loan Payments

The size of an operation's loan payments is a function of the debt level and the terms of financing. Several financing options are available within the model.

1. Amortized, fixed interest rate loan.
2. Equal principle, floating/fixed interest rate loan.
3. Equal principle, renewable, fixed interest rate loan.
4. Renewable, amortized , fixed interest rate loan.

The specifics of loans outstanding at the start of each simulation are entered into the model according to Table 2.2. As the simulation continues the purchase of land, replacement of buildings or capital equipment, or the refinancing of existing loans may necessitate the negotiation of additional loans. Financing of loans for building replacement are assumed to be 100 percent debt, 25 year amortized, three year variable interest rate loan. Terms for refinanced loans reflect those of the original loan but at the prevailing interest rate.

2.8.3 Building Replacement

Expenditures corresponding to the replacement of buildings, specifically hog barns, not only affect a firm's debt structure, but also its cash flow situation. Additional buildings may be required for either of two reasons. First, the current structure is of insufficient size for the number of animals produced. Second, the present age of the building, coupled with a ten year simulation period, exceed the assumed 25 year life span of livestock barns. Using the information from Table 2.1 (Q36 and Q37) the model evaluates the possibility of replacement based on the two scenarios.

By monitoring the size of livestock barns the model ensures that each is capable of accommodating the number of animals associated with the operation. In those situations in which the area is inadequate, the building space is automatically increased by the model until the correct size is achieved. Financing of this expansion will occur as described in section 2.8.2 . Buildings whose useful lives expire during the simulation are also replaced. If, after computation of the structures' remaining life indicates this to be a possibility, additional calculations determine the replacement year, size, and investment necessary. As indicated in the equations below an inflationary component allows for increases in construction costs.

Remaining Life of Current Livestock Barn

LIFE = (25 - AGE) 2.91

IF (LIFE < 10) 2.92

THEN (Replace in year = LIFE) 2.93

where:

LIFE = Remaining estimated life of current barn

AGE = Age of current livestock barn

Replacement Cost of Hog Barn

REPHOG = (1589.65 * SOWHRD) * (1 + INF) 2.94

where:

1589.65 = [(136.33 sq.ft. /sow) ($11.66 /sq.ft.)], based on 1987 Manitoba Department of Agriculture budget

SOWHRD = Total number of productive sows in the operation

REPHOG = Replacement cost of farrow-to-finish barn

INF = Percent annual inflation rate (Q5)

i = Time in years

2.8.4 Capital Input Replacement

For the majority of farrow-to-finish enterprises capital input requirements are minimal. However, for mixed crop and livestock operations, expenditures related to capital replacement can have a significant effect on debt levels and cash flow.[102] In certain instances capital investment may be deferred until favourable financial conditions within the operation prevail.

The model uses data from Table 2.1, market value of farm machinery (Q9) and the average replacement frequency (Q10) to determine if and when replacement of capital occurs. Possibility of replacement occurs when the total machinery requirement (target level) does not equal the market value of the existing machinery. The process begins with the establishment of a target level of machinery investment which is either specific to a particular enterprise or based on a default set within the model.[103] In the first year of simulation the model compares the target level to the initial market value (Q9). However, the market value of

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[102] The NTHSP assumes that feed, is purchased from the cropping operation at market prices. Although the model developed for the current study is capable of simulating dual enterprises, a strictly livestock operation was assumed for the purposes of this study.

[103] Currently the value is set to approximate the average machinery investment within Manitoba in 1985, $182.86 per acre.

subsequent simulations is measured as a function of a coefficient[104] (0.86) expressing the average relationship between current and past years' market value, the prior years' market value of equipment, the value of equipment traded in and inflation. The procedure outlined above determines the amount by which market value differs from the required level of machinery investment. The discovery of a shortage of capital inputs does not always necessitate the purchase of new equipment. A firm's cash flow and/or debt situation may negate the purchase option until a later date. Postponement of capital purchases cannot continue indefinitly. A minimum amount of equipment must be available for the firm to operate efficiently. Should the market value drop below the minimum value indicated by the model, equipment must be purchased to reestablish the lower bound. Representation of this process is outlined below.

<u>Replacement of Capital Equipment</u>

$$TVEt = [\ TKEt * ACRE * CRPPCT * (\ 1 + INF\ )^{t}] \qquad 2.95$$

$$APEt = (\ TVEt - MVEt\ ) \qquad 2.96$$

$$TIEt = [\ APEt * (\ 0.86\ )^{TF}] \qquad 2.97$$

$$MVEt = [(\ 0.86 * (\ MVE(t-1) + APE(t-1) - TIE(t-1)) * (\ 1 + INF\ )] \qquad 2.98$$

$$IF\ (\ APEt < 0\ )\ \ OR\ (\ TGMt - DEBTt - HHt\ ) < 0 \qquad 2.99$$

$$THEN\ (\ APEt = 0\ )\ AND\ (\ TIEt = 0\ ) \qquad 2.100$$

$$IF\ [\ (\ TGMt - DEBTt - HHt\ ) - APEt\ ] < 0 \qquad 2.101$$

$$THEN\ [\ APEt = (\ TGMt - DEBTt - HHt\ )\ ] \qquad 2.102$$

<u>Overall Bounds</u>

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[104] Value for the coefficient obtained from Dzisiak (1987).

$$IF\ [\ (\ MVE_t - (\ 0.65 * TVE_t\ )\ ] < 0 \qquad 2.103$$

$$THEN\ [\ APE_t = (\ (\ 0.65 * TVE_t\ ) - MVE_t\ )\ ] \qquad 2.104$$

where:

TVE = Target value (required level) of machinery investment

MVE = Market value of machinery

TF = Trade or replacement frequency of machinery (years)

INF = Percent annual inflation rate (Q5)

TIE = Value of equipment traded in

APE = Annual purchase of equipment

TKE = Machinery investment per acre (1985 = 182.86)

ACRE = Total improved cropped acres

CRPPCT = The average percent of actual cropped land per quarter section , Q20

HH = Household living expenses (see section 2.8.5)

TGM = Total gross cash flow

DEBT = Annual debt payments

2.8.5 Living and Personal Withdrawals

Withdrawals from cash flow for living and personal use are initialized through Q3. Through the course of the simulation the value of this variable is adjusted by the relevant inflation rate (Q5).

2.8.6 Income Tax

Income taxes become an expense item in years of taxable income. Taxable income as illustrated in the following equations is calculated as a residual after deductions for interest expenses, operating expenses and capital cost allowance (CCA).

Income Tax Calculation

$$TAXINC_i = (GROSS_i - TOTINC_i - CCA_i) \quad 2.105$$

$$CCA_i = (MACHDEP_i + BLDGCCA_i) \quad 2.106$$

$$GROSS_i = (GRSHOG_i + NONFRM_i) \quad 2.107$$

where:

TAXINC = Taxable Income

GROSS = Total of all gross cash flow and nonfarm income

TOTINC = Total interest expense

CCA = Total capital cost allowance

GRSHOG = Gross cash flow for a farrow-to-finish enterprise

NONFRM = Non-farm income

Interest expense is based on the total interest portion of payments on existing loans. Operating expenses are determined as outlined in section 2.8.1 . The original cost of buildings and equipment of an enterprise cannot be charged as an operating cost. Instead the cost is allocated over several years. This deduction for income tax purposes is referred to as capital cost allowance (CCA). The rate at which assets are depreciated for CCA is governed by the Canadian Income Tax Act and varies depending on the asset in question. In 1986 the depreciation rate was set at five percent for buildings and fifteen percent for machinery.[105] The calculation of yearly CCA for each is presented below:

CCA Deduction for Buildings

$$BLDGCCA_i = (BLDGDED_i + HOGDED_i) \quad 2.108$$

[105] The Department of National Revenue, Farmers Income Tax Guide, Ottawa: Revenue Canada Taxation, 1986 , p.24.

$$BLDGDEDi = (BLDG * 0.05) \quad 2.109$$

$$HOGDEDi = [(1589.65 * SOWHRD) * 0.05] \quad 2.110$$

where:

1589.65 = [(136.33 sq.ft. /sow) ($11.66 /sq.ft.)], from 1987 Manitoba Department of Agriculture budget

BLDGCCA = Total yearly CCA deduction for all farm buildings

BLDGDED = The yearly CCA deduction for all buildings excluding livestock barns

HOGDED = The yearly CCA deduction for a farrow-to-finish barn

<u>CCA Deduction for Machinery</u>

$$MACHCCAi = [MACHDEPi * 0.15] \quad 2.111$$

$$MACHDEPi = [(MVEo * (1 - 0.15)) + MACHREPi] \quad 2.112$$

$$MACHREPi = [(MACHREP(i-1) * (1 - 0.15)) + APEi] \quad 2.113$$

where:

MACHCCA = The yearly CCA for capital machinery

MACHDEP = Total undepreciated cost of machinery

MVEo = Initial market value of equipment

MACHREP = Total machinery replacement

APE = Annual purchase of equipment

The income tax payable by an operation varies according to the level of taxable income and the corresponding marginal tax rate. The marginal tax rate schedule used in this study is based on three levels of taxable income. No assessment is made for operations whose taxable income is under 5000 dollars.[106] A maximum marginal tax rate of 28 percent is levied against taxable incomes greater than 50,000 dollars.[107] The marginal

[106] It is assumed that personal exemptions will reduce the tax liability to zero.

tax rate for taxable incomes between 5000 and 50,000 dollars is calculated using equation 2.114.

$$MTRi = 6.222 * 10^{-6} (TAXINCi) - 0.0311 \qquad 2.114$$

$$TAXPAY(i+1) = MTRi * TAXINCi \qquad 2.115$$

where:

MTR = Marginal tax rate

TAXINC = Taxable Income

TAXPAY = Income tax payable

2.9 FINANCING

At the end of each simulation the model performs a check on the financial situation of the operation by examining the net cash flow before loan (NCFBL). Positive balances are added to the cash surplus pool initialized in Q8 . Two alternatives are available should expenditures exceed revenues. The deficit is covered by an operating loan if it is less than the level of operating expenses. Firms with higher losses must apply for refinancing through loan consolidation[108] provided the operation has sufficient equity. To determine the viability of this option the model compares the consolidated debt/asset ratio with a predetermined debt/asset ratio. Values greater than one are rejected and the operation is declared insolvent.

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[107] Maximum tax rate for an incorporated farm.

[108] Consolidation of all existing mortgage, current operating and building/machinery replacement loans.

2.10 SIMULATION LOOP TERMINATION

The model is designed to perform a series of 600 iterations of the simulation processes outlined in the preceding sections for a ten year period unless the operation becomes insolvent due to an inability to refinance consolidated loans (see section 2.9).

2.11 ANNUAL EQUITY CALCULATION

The equity position of the enterprise is presented at two points during the simulation. Initial equity values are based on information provided in Table 2.1 . The ending net worth, whether in year ten or in a previous year due to bankruptcy, is also calculated.

Included in the determination of asset levels are the value of the breeding herd, slaughter hog inventory, real estate (including buildings), and machinery. The value of farm buildings (excluding livestock barns) is initialized using Q19. An approximate value for the hog barn is determined by depreciating[109] the cost of a new barn by the age of the existing barn (Q37) as illustrated below:

Valuation of Livestock Barns

$$HOGBRN_i = [1589.65 * SOWHRD) (1 - (0.04 * HOGAGE))] \qquad 2.116$$

where:

1589.65 = [(136.33 sq.ft. / sow) ($11.66 / sq.ft.)]

HOGBRN = Total value of hog barn

SOWHRD = Total number of productive sows in the operation

HOGAGE = The present age of the farrow-to-finish barn

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[109] Twenty five year straight line depreciation.

Thus, the total value of all farm buildings may be calculated as:

<u>Total Value of All Farm Buildings</u>

$$VB_i = (BLDG_i + HOGBRN_i) \quad 2.117$$

where:

VB = Total value of all farm buildings

BLDG = Value of all farm buildings excluding livestock barns

HOGBRN = Value of farrow-to-finish barn

i = Time in years

The value of real estate is determined from a series of questions (Q14, Q15, Q16, Q17, Q18) in Table 2.1 . An estimated price for pasture land is calculated based on the relative difference between taxes for improved (Q17) and pasture land.

<u>Total Value of All Real Estate</u>

$$TR_i = (TP_i / TI_i) \quad 2.118$$

$$PP_i = (TR_i * TP_i) \quad 2.119$$

$$TVR_i = [(PI_i * AI_i) + (PP_i * AP_i) + VB_i] \quad 2.120$$

where:

TVR = Total value of all real estate

TR = Tax ratio

TP = Taxes on pasture land ($ / acre)

TI = Taxes on improved farmland ($/ acre)

PI = Value of improved farmland ($ / acre) (no buildings)

AI = Total owned acres of improved farmland

PP = Estimated price of pasture land ($ / acre)

AP = Total owned acres of pasture land

VB = Total value of all farm buildings

i = Time in years

Machinery values are defined as in section 2.8.4 .

Both current (accounts payable, operating loan) and long term liabilities are deducted from assets in the computation of net worth.

Equity Calculation

$$EQi = [\ CAi + (\ PHi * HHRD\ ) + PHi * HINV\ ) + MVEi + TVRi\ ] - LIAi \qquad 2.121$$

where:

EQ = Equity (initial, year ten or year of insolvency)

CA = Cash , near cash and operating supplies

PH = Market price of the breeding stock

HHRD = The number of sows, gilts, and boars in the herd

HINV = The outstanding slaughter hog inventory

MVE = Market value of machinery

TVR = Total value of all real estate

LIA = Outstanding liablities

i = Time in years

2.12 STABILIZATION PROGRAM

The various attributes of the national tripartite stabilization program are incorporated into the design of the model. Briefly, the NTHSP is designed to provide producers with deficiency payments during periods of reduced margins. Payments are made from stabilization fund consisting of levies collected from participating producers, provincial governments and the federal government.[110]

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[110] Recall that the balance in the stabilization fund at any time also

2.12.1 Support Price

Under the conditions of the NTHSP, and therefore the model, a support price is established at the end of each quarter. The level of support is based upon a combination of the cash costs of production for the current quarter and a percentage[111] of the average difference between cash costs and market prices for the same quarter in the preceding five years.[112] As a proxy for the national average market price the model uses prices simulated by the bivariate hog model described in section 2.6.2. Cost of production figures are calculated from the cash costs of operating an enterprise in each quarter. These include the cost of feed, herd health management, utilities, hired labour, marketing fees, trucking charges and other miscellaneous cash expenses. Quarterly expenditures related to items other than feed are calculated directly from annual values determined as per section 2.8.1. Feed costs represent the largest cash expense in a farrow to finish operation. An equal division of annual enterprise feed costs was rejected due to the variability of barley prices outlined in section 2.6.1.1. In addition, separate equations for the cost of barley and supplement were developed for each group of animals within the enterprise due to their differing consumption levels. The calculations used to determine enterprise costs of

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includes interest revenue as earned on positive balances and the interest expense associated with deficits.

[111] Although the percentage of the guaranteed margin in the current study is fixed at 90 percent with the NTHSP this percentage is to decline at the rate of 1 percent annually from 95 percent in 1986 to 90 percent in 1991.

[112] Annual values for the first five years' market prices and cash costs of production are entered by the user. Slaughter prices were taken from the 1986 Manitoba Agriculture Yearbook. Values for the previous five years cash costs were estimated using information from the data input summary and the relevant farm input price indicies.

production are presented below:

Barley Expense

$$COPBGMt = [(BCGM / HM) * CANBLYt] / DWHC \qquad 2.122$$

$$COPBGt = [(BCG * NSOW/HM) * CANBLYt] / DWHC \qquad 2.123$$

$$COPBSt = [(BCS * NSOW/HM) * CANBLYt] / DWHC \qquad 2.124$$

$$COPBBt = [(BCB * NBOAR/NSOW * NSOW/HM) * CANBLYt] / DWHC \qquad 2.125$$

Supplement Expense

$$COPSGt = [(SCG * NSOW/HM) * PSUPt] / DWHC \qquad 2.126$$

$$COPSSt = [(SCS * NSOW/HM) * PSUPt] / DWHC \qquad 2.127$$

$$COPSBt = [(SCB * NBOAR/NSOW * NSOW/HM) * PSUPt] / DWHC \qquad 2.128$$

Veterinary, Utilities, Labour, Other Related Cash Expenses

$$COPVt = [VEt / HM] / DWHC \qquad 2.129$$

$$COPUt = [UEt / HM] / DWHC \qquad 2.130$$

$$COPLt = [HLEt / HM] / DWHC \qquad 2.131$$

$$COPOt = [OREt / HM] / DWHC \qquad 2.132$$

Marketing Charges

$$COPMCt = [MC / DWHC] \qquad 2.133$$

Trucking Fees

$$COPTt = [(TRF * LOADS) / HM] / DWHC \qquad 2.134$$

Cash Cost of Production

$$COPt = COPBGMt + COPBGt + COPBSt + COPBBt + COPSGMt + COPSGt + COPSSt + COPSBt + COPVt + COPUt + COPLt + COPOt + COPMCt + COPTt \qquad 2.136$$

Support Price

$$SPt = COPt + 90\% (GM) \qquad 2.137$$

where:

COPBGM = Barley ration cost for grower ($/cwt)

BCGM = Barley consumption grower to market (tonne/hog)

COPBG = Barley ration cost for gilt ($/ cwt)

BCG = Barley feed consumption for gilt (tonne/gilt)

NSOW = Number of sows in the operation (Q21)

HM = Number of hogs marketed per quarter

CANBLY = Price Canadian barley (see section 2.4.1)

DWHC = Dressed weight of hog carcass (1.7 cwt/hog)

COPBS = Barley ration cost for sow ($/cwt)

BCS = Barley feed consumption for sow (tonne/sow)

COPBB = Barley ration cost for boar ($/cwt)

NBOAR = number of boars in the operation (Q22)

COPSGM = Supplement ration cost for grower ($/cwt)

SCGM = Supplement consumption for grower to market (tonne/hog)

PSUP = Price of supplement (Q26)

COPSG = Supplement ration cost for gilt ($/cwt)

SCG = Supplement consumption for gilt (tonne/gilt)

COPSS = Supplement ration cost for sow ($/cwt)

SCS = Supplement consumption for sow (tonne/sow)

COPSB = Supplement ration cost for boar ($/cwt)

SCB = Supplement consumption for boar (tonne/boar)

COPV = Cost of production for veterinary expenses ($/cwt)

VE = Veterinary expenses (Q27)

COPU = Cost of production for utilities ($/cwt)

UE = Utility expenses (Q28)

COPL = Cost of production for hired labour ($/cwt)

HLE = Hired labour expense (Q32,Q33)

COPO = Cost of production for other related cash expenses ($/cwt)

ORE = Miscellaneous cash expenses (Q29)

COPMC = Cost of production for marketing charges ($/cwt)

MC = Marketing Charges (Q31)

COPT = Cost of production for trucking ($/cwt)

TRF = Trucking fees (Q30)

LOADS = Number of loads

COP = Cost of production ($/cwt)

SP = Support Price ($/cwt)

GM = Guaranteed margin (determined within the model)

t = Time in quarters

2.12.2 Stabilization Payment

A stabilization payment is declared in any quarter in which the average market price is below the support price established by the model. The level of payment is calculated as shown below:

Stabilization Payment

$$STABt = SPt - CANPt \qquad 2.138$$

$$SPPHt = STABt * DWHC \qquad 2.139$$

where:

STAB = Stabilization payment ($/cwt)

SP = Support Price ($/cwt)

CANP = Market price of hogs (see section 2.6.2)

SPPH = Stabilization payment per hog

DWHC = Dressed weight of hog carcass (1.7 cwt/hog)

t = Time in quarters

Payments received by producers are placed by the model into the operations gross cash flow.

2.12.3 Producer Premiums

As previously mentioned the operation of the NTHSP is supported through a stabilization fund from levies collected from producers (1/3), the provincial government (1/3), and the federal government (1/3).[113] In order to ensure the maintenance of an actuarially sound stabilization fund the premium rate established by the Stabilization Committee must be adjustable. Ideally, the levies collected should be able to cover not only stabilization payments but also the interest charged on deficits. A minimum requirement of the premium rate is that it be of a level that over time does not cause the fund to fall into a prolonged deficit situation. Therefore, in keeping with the aforementioned goals, the premium rate to be utilized throughout the simulation period can be determined by the model user. Announced and payabie at the beginning of each quarter, premium rates are calculated as a percentage[114] of the previous quarters' market price. Premiums from all sources are then held in an interest bearing account, with fund balances reported quarterly by the model.

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[113] Under the NTHSP a maximum limit has been established on the premiums to be contributed by the federal and provincial governments. Program funding provided by either government cannot exceed three percent of the estimated average aggregate market value of hogs sold by by producers during any given year ant the two previous years.

[114] Current rate established by the Stabilization Committee is 7.5 percent.

2.13 PRESENTATION OF RESULTS: PROBABILITY DISTRIBUTIONS

The effect of the stabilization program on individual operations is assessed with the aid of a series of probability distribution tables. As formulated within the model the distributions express the change between the initial and final years of the simulation and are obtained after a specified number of iterations have been completed. Several probability distributions are calculated by the model including:

1. Annual change in Net Worth
2. Annual change in Current Assets
3. Annual change in Intermediate and Long Term Assets
4. Annual change in Liabilities
5. Level of Gross Cash Flow (annual and aggregate)
6. Level of Stabilization Payment (annual and aggregate)
7. Level of the Fund Balance (annual and aggregate)

Probability distributions may be reported in either of two forms, cumulative and non-cumulative. The distributions to be be presented in the text of this study are cumulative probability distributions.[115] While the data utilized in the formation of each distribution are identical the information to be derived is not. Cumulative probability distributions allow one to determine the percent chance, as measured on the vertical axis, of being below the corresponding value of a variable on the horizontal axis. This is in contrast to non-cumulative probability distributions which report the percent chance of a variable being between two specified values.

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[115] Non-cumulative probability distributions are presented in Appendix B.

Chapter III

DATA REQUIREMENTS AND EMPIRICAL RESULTS

The purpose of this chapter is to evaluate the performance of the NTHSP through the application of the simulation model developed in the previous chapter. The assessment of the stabilization program was conducted by an analysis of the results produced from two scenarios. The first scenario investigates the economic consequences of implementing the current NTHSP on both the balance sheet accounts and the potential to stabilize net cash flow of a 100 sow farrow to finish operation in Manitoba. In the second experiment the effects of altering the premium rate of the current program are examined. The second scenario is analyzed with respect to three criteria, stabilization potential, the size of stabilization payments and that of the fund balance. Finally, as a means of achieving the aforementioned objectives an outline of the initial data requirements and a discussion of the output produced by the simulation are also presented.

3.1 ENTERPRISE DATA REQUIREMENTS

Table 3.1 outlines initial data requirements for the utilization of the simulation model. The information entered by the model user into Table 3.1 establishes values for several financial, marketing and production variables. Briefly, the case study operation utilized in the simulation model outlined in Chapter Two was a 100 sow farrow to finish enterprise, with an annual production of approximately 1800 hogs. This particular size of operation was chosen because of its similarity to the operation employed in the national cost of production (NCOP) model used to estimate production costs for the NTHSP. While the NTHSP breeding herd (130 sows, 8 boars) and therefore production (2251 hogs/year) are slightly higher than those in this study several other important production variables were found to be comparable. For example, the NCOP model assumes each sow has 2.1 litters per year, 8.5 piglets weaned per farrowing and a death loss rate of 3 percent at the grower finisher stage. As noted in Table 3.1 slightly higher values were assumed for the number of farrowings per year, 2.4 (calculated from Q24), and the death loss rate for finisher hogs (Q25), 5 percent. Also, fewer hogs, 8, were weaned per sow per litter, according to Q23 (Table 3.1). The similarities observed between of the two operations are important and ensure, at least to some degree, that the costs of production generated from this study approximate those estimated in the NCOP and utilized by the NTHSP.

TABLE 3.1

Interactive Program Data

Basic Financial, Marketing and Production Data

1. The beginning year and quarter of the analysis(19__:__):1986:01
2. The current price of wheat ($/bus.): 4.40
3. The expected inflation rate for operating expenses: 4.00
4. The basic living and personal expenditures/year: 20000
5. The expected inflation rate for living expenses: 4.00
6. The present non-farm income/year: 0.00
7. The expected annual increase in non-farm income: 0.00
8. The total value of cash, near cash, and operating supplies: 113360
9. The market value of machinery: 59000
10. The average replacement frequency of machinery (years): 15
11. The total amounts owing on accounts payable: 4500
12. The current operating loan outstanding: 0.00
13. The interest rate on the current operating loan: 11.0
14. The total number of owned pasture land acres: 10
15. The present pasture land taxes/acre: 0
16. The total number of owned hay, crop and fallow acres: 10
17. The present improved land taxes/acre: 13.65
18. The average value/acre of improved farmland (no buildings):500
19. The present value of all farm buildings (excluding livestock barns):
20. The average percent of actual cropped land/quarter section (%):
21. The number of productive sows in the enterprise: 100
22. The number of productive boars in the enterprise: 6
23. The average number of animals reaching weanling age/sow/litter: 8
24. The number of months between litters: 5
25. The death loss rate of finishing hogs/year (%): 5
26. The current price feed supplement ($/tonne): 290
27. The total operating costs/year for veterinary: 2090
28. The total costs/year for utilities: 20000
29. the total operating costs/year for other related expenses: 16602
30. The total trucking charges/load shipped ($/load): 315.30
31. The total selling charges/head ($/head): 1.5
32. The number of months of hired labour/year: 12
33. The total wage expense/month (including room and board): 1145
34. The current market price of slaughter hogs ($/hog): 66.60
35. The average index received for slaughter hogs (#): 100.0
36. The present age of the existing hog barn (years): 0
37. The total size of the existing hog barn (sq./ft.): 10500

TABLE 3.2

Loan Information

Amortized, Fixed Interest Rate Loan

1. The initial length of the loan (yr): 20
2. The number of payments made: 0
3. The present annual payment ($): 21,730
4. The interest rate (%): 11

Using information gathered from Tables 3.1 and 3.2 an initial balance sheet is formulated and presented as Table 3.3 . This initial financial statement is later compared with results generated from the probability distributions outlined in section 2.13.

TABLE 3.3

Initial Enterprise Balance Sheet

Assets	
Current Assets[1]	156,383
Intermediate and Term Assets[2]	300,214
Total Assets	456,598
Liabilities[3]	174,847
Owner Equity	279,055

[1]Included in the calculation of current assets are the values of cash, near cash and operating supplies, as given by the model user, and the market value of the hog inventory.
[2]Intermediate and term assets includes values for machinery investment, real estate and buildings, as supplied by the user. Also includes an estimated value for the breeding herd.
[3]Included in the calculation of the enterprise liabilities are values for outstanding accounts payable, operating loan, and the remaining principle on the long term debt all of which are supplied by the user.

3.2 DESCRIPTION OF MODEL OUTPUT

At the conclusion of each iteration annual values for key marketing, production, and financial variables are tabulated by the model. The information reported includes: enterprise revenue and expenses, a summary of annual net cash flow, and finally a stabilization report outlining a selection of the data used in calculations connected with the NTHSP.

3.2.1 Enterprise Output

At the conclusion of each iteration the model tabulates enterprise revenues and expenditures generated during the ten year period. An example of the variables involved in the calculation of enterprise cash flow are shown in Tables 3.4 and 3.5. Included in the firm revenue data, presented in Table 3.4, are quarterly values for both number of hogs sold and their average selling price. Also listed are the annual average market price of hogs and total enterprise revenue.

Values for both expenditures and gross cash flow are presented in Table 3.5 . As feed costs represent the largest component of a livestock operation's expenditures, enterprise expenses have been divided into feed and operating expenses. As noted in section 1.2 the variability observed in feed costs is due primarily to price fluctuations in the feed grain market. Therefore, both quarterly feed expenses and barley prices ($/bushel) are given. The other variables in Table 3.5 include annual values for the remaining operating expenses, total cash costs of production and gross cash flow. For those scenarios utilizing the NTHSP enterprise returns are adjusted to reflect the net effect of the stabilization program.

Table 3.4
Farrow to Finish Enterprise Revenues (1st Iteration)

Year	# Hogs Sold (Qtr.)	Average Selling Price ($/cwt) Qtr.1	Qtr.2	Qtr.3	Qtr.4	Year	Total Revenue
1	449	70.48	77.92	75.14	70.48	73.51	224,822
2	449	69.29	65.43	65.27	73.13	68.28	208,838
3	449	77.00	64.90	63.52	67.31	68.18	208,534
4	449	64.33	68.99	57.59	54.63	61.38	187,743
5	449	60.96	68.47	59.21	60.42	62.27	190,440
6	449	74.30	71.62	64.37	74.08	71.09	217,435
7	449	55.50	72.98	63.93	63.46	63.97	195,642
8	449	54.38	74.46	71.85	76.77	69.36	212,152
9	449	67.93	74.63	63.41	63.19	67.29	205,812
10	449	70.23	65.22	52.27	52.55	60.07	183,716

Table 3.5

Farrow to Finish Enterprise Expenses (1 Iteration)

Year	Price of Barley ($/bus.) Qtr.1	Qtr.2	Qtr.3	Qtr.4	Feed Expense Qtr.1	Qtr.2	Qtr.3	Qtr.4	Total Feed Expense	Other Operate Expense	Total Operate Expense	Gross Cash Flow
1	1.99	1.93	1.90	2.51	22289	21804	21584	26333	92011	58605	150617	71773
2	2.35	2.40	2.30	2.09	25087	25471	24695	23055	98310	58543	156853	58994
3	2.43	2.17	1.77	2.35	25735	23672	20607	25068	95083	58541	153625	59108
4	2.90	2.20	1.53	2.78	29361	23896	18748	28415	100421	58460	158881	56903
5	2.88	2.47	2.36	3.37	29195	25975	25136	32967	113274	58470	171745	52333
6	3.62	2.69	3.25	3.93	34910	27743	32035	37319	132009	58576	190586	35983
7	3.29	4.03	2.18	2.59	32345	38104	23737	26917	121105	58491	179596	31602
8	2.16	2.52	4.31	3.12	23622	26426	40276	31015	121340	58556	179896	36786
9	3.41	2.26	2.62	2.78	33262	24386	27210	28430	113289	58531	171821	28586
10	2.68	3.13	2.73	2.19	27654	31101	27997	23828	110581	58444	169025	27326

3.2.2 Summary of Enterprise Annual Net Cash Flow

Variables relating to annual net cash flow are summarized and presented in Table 3.6. In addition, at the conclusion of each iteration the model produces a balance sheet which presents initial and ending figures for assets, liabilities, and net worth. Also included with the simulation summary balance sheet is the value for the balance which has accumulated in the hog stabilization fund.

The calculation of an operation's net cash flow begins with the determination of yearly gross cash flow. Total enterprise gross cash flow (column 3) is computed by combining the farrow-finish cash flow (column 1) obtained from Table 3.5 with non-farm income (column 2) where the initial value for the latter is supplied in Q6 and increased annually by an inflationary factor specified in Q7 from Table 3.1.

Beginning cash assets (column 5) represent the firm's value of near cash assets,[116] operating supplies and cash on hand. The initial value for beginning cash assets, $113,360, is provided from Q8 in Table 3.1 . The value for this variable in succeeding years is estimated from the product of the previous years net cash flow before loan (NCFBL), column 12, and the prevailing interest rate (column 4).

The annual cash reserve (column 6) is calculated by adding total gross cash flow (column 3) to beginning cash assets (column 5).

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[116] Defined as assets which can quickly be converted to cash. Normally refered to as liquid assets they may include accounts receivable, prepaid expenses and in some instances inventory.

Table 3.6
Summary of Annual Enterprise Cash Flows (1 Iteration)

Year	(1) Farrow-Finish Income ($)	(2) Non-Farm Income ($)	(3) Total Gross Cash ($)	(4) Interest Rate (%)	(5) Begin Cash Asset ($)	(6) Cash Reserve ($)	(7) Debt Payment ($)	(8) Total Expense ($)	(9) Replace Capital Input ($)	(10) Living and Person ($)	(11) Income Tax ($)	(12) Net Cash (NCFBL) ($)
1	71773	0	71773	19.0	113360	185133	21730	150617	0	20000	0	143403
2	58994	0	58994	10.0	156674	215668	21730	156853	0	20799	3335	169802
3	59108	0	59108	10.0	188464	247572	21730	153625	0	21631	882	203328
4	56903	0	56903	12.0	225513	282417	21730	158881	0	22497	1141	237048
5	52333	0	52333	12.0	266929	319262	21730	171745	0	23397	1002	273133
6	35983	0	35983	15.0	307015	342999	21730	190586	0	24333	537	296398
7	31602	0	31602	11.0	342159	373761	21730	179596	0	25306	0	326725
8	36786	0	36786	13.0	362852	399639	21730	179896	0	26318	0	351590
9	28586	0	28586	10.0	398966	427552	21730	171821	0	27371	0	378451
10	27326	0	27326	8.0	417652	444979	21730	169025	0	28466	0	394783

NOTE: An * beside the debt payment means the outstanding debt has been refinanced

Simulated Summary Balance Sheet

Year	Current Assets	Term Assets	Total Assets	Liabilities	Equity	Hog Stabilization Fund
0	156,383	300,214	456,598	174,847	279,055	0
10	539,938	150,680	690,618	128,040	562,578	-3,406

The level of remittances, illustrated in column 7, represent the total amount of annual payments on all outstanding liabilities with the exception of payments on operating loans.

Annual deductions from cash flow for the purpose of maintaining the the required level of capital investment as determined within the model are presented in column 9. Typically, the level of capital replacement in this study is insignificant as the amount of machinery investment for a livestock operation without a cropping enterprise is minimal.

As previously mentioned, values for several variables are initialized by the model user. Such is the case with the level of living and personal withdrawals (column 10). The procedure used to calculate yearly values closely adheres to that described for non-farm income, where both the initial value (Q4) and the inflationary component (Q5) are supplied in Table 3.1 .

Income taxes payable are calculated as outlined in section 2.8.6 . Within the model gross cash flow (column 3) serves as the measure of taxable income. Income taxes (column 11) levied against the operation are deducted from NCFBL in the year following that in which they were incurred to give a more accurate picture of NCFBL.

The final value to appear in Table 3.6, NCFBL (column 12), is computed by subtracting various expenses, debt payments, capital input replacements, living and personal expenditures and income taxes payable (columns 7,9,10, and 11) from cash reserves. As such, NCFBL represents the firm's opening financial position in the following year and is therefore a prerequisite to determining the need for an operating loan.

An operating loan is deemed necessary in the event NCFBL is not only negative, but also has an absolute value less than the level of operating expenses outlined in column 8.[117] The value of the resulting loan, principal and interest payments, is calculated and presented as a negative value in column 5 in the succeeding year. However, should the value be greater, a loan consolidation is initiated whereby the level of annual debt payments (column 7) are increased to accommodate the additional financial responsibilities. Years during which this procedure occurs are marked within the table by the placement of an asterisk adjacent to the revised value in column 7.

3.2.3 Stabilization Report

Information on data directly pertaining to the operation of the NTHSP are recorded in Tables 3.7 and 3.8. These include quarterly values for cash costs of production, guaranteed margins and stabilization payments. Moreover, per annum figures are calculated for the operations proportion of premiums, stabilization payments and the accumulated fund balance.

The cost of production calculations follow the framework outlined in section 2.12.1 whereby the cash costs of operating the enterprise are estimated for each quarter.

The values for guaranteed margin (GM) are computed as the difference, in the same quarter for the preceding five years, between the aforementioned cash costs of production and market prices (Table 3.4). For

[117] It must be recalled that the values presented in column 8, total operating expenses, have already been subtracted from revenue in Table 3.4. Thus, their presence in Table 3.6 is strictly for comparative purposes to determine either the level of annual operating loan or the need for a loan consolidation.

Table 3.7
Stabilization Report (1 Iteration)

Year	Average Selling Price ($/cwt) Qtr.1	Qtr.2	Qtr.3	Qtr.4	Cash Costs of Production Qtr.1	Qtr.2	Qtr.3	Qtr.4	Five Year Average Margins Qtr.1	Qtr.2	Qtr.3	Qtr.4	Stabilization Payment/Cwt. Qtr.1	Qtr.2	Qtr.3	Qtr.4
1	70.48	77.92	75.14	70.48	48.32	47.68	47.39	53.61	23.70	23.70	23.70	23.70	0.00	0.00	0.00	4.45
2	69.29	65.43	65.27	73.13	51.95	52.46	51.44	49.30	21.34	22.96	22.46	20.29	1.86	7.69	6.38	0.00
3	77.00	64.90	63.52	67.31	52.80	50.10	46.09	51.93	21.78	22.52	22.20	22.02	0.00	5.47	2.55	4.44
4	64.33	68.99	57.59	54.63	57.52	50.37	43.64	56.28	23.37	22.23	22.43	21.84	14.22	1.38	6.23	21.31
5	60.96	68.47	59.21	60.42	57.30	53.09	52.00	62.24	21.08	22.30	21.57	17.86	15.31	4.69	12.19	17.89
6	74.30	71.62	64.37	74.08	64.81	55.44	61.05	67.96	14.84	18.41	16.04	10.53	3.87	0.38	11.12	3.35
7	55.50	72.98	63.93	63.46	61.43	68.96	50.17	54.33	12.30	15.59	11.15	8.38	16.99	10.01	0.00	0.00
8	54.38	74.46	71.85	76.77	50.04	53.71	71.83	59.71	7.65	13.80	11.14	5.44	2.54	0.00	9.99	0.00
9	67.93	74.63	63.41	63.19	62.64	51.03	54.73	56.32	3.68	14.99	7.66	5.77	0.00	0.00	0.00	0.00
10	70.23	65.22	52.57	52.55	55.28	59.79	55.73	50.28	3.37	15.99	6.60	7.48	0.00	8.95	9.40	4.45

example, in the first quarter of the sixth year a GM of $14.84/cwt is estimated by subtracting from the five year average of a quarters market prices, [($70.48/cwt + $69.29/cwt + $77.00/cwt + $64.33/cwt + $60.96/cwt)/5] = $68.41/cwt, the cost of production, [($48.32/cwt + $51.95/cwt + $52.80/cwt + $57.52/cwt + $57.30/cwt)/5] = $53.58/cwt .

In accordance with the guaranteed margin formula (eq. 2.138), noted in section 2.12.2, disbursements from the stabilization fund are paid in those quarters where the support price (eq. 2.137) is greater than the market price (Table 3.4). Again, in the first quarter of year six a support price was estimated at $78.16/cwt. Recalling the market price for this period of $74.30/cwt this resulted in a stabilization payment of $3.87/cwt in accordance with equation 2.138 .

As previously indicated, Table 3.8 presents both the annual charges levied against and payments to producers. Remittances are calculated as per section 2.12.3, where the value obtained is a product of the total number of hogs sold[118] (Table 3.4), the average dressed carcass weight[119] and a fixed percentage[120] of the market price (Table 3.4) in each of the previous four quarters. For example, in year six total premium charges owed by producers amounted to $4493, or [.025($64.37/cwt) + .025($71.62/cwt) + .025($74.30/cwt) + .025($60.42/cwt)] * 1.7 * 449. Recorded in Table 3.8 are the annual level of disbursements to producers. Values presented in the payments column are computed as the prod-

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[118] For the case study operation the number of hogs sold by the enterprise per quarter was equal to 449.

[119] Average dressed weight of a hog carcass is 1.7cwt/hog.

[120] Current producer proportion of total premium rate is set at one third of 7.5 percent or 2.5 percent.

Table 3.8

Stabilization Fund Balance (1 Iteration)

Year	Producer Premium ($)	Total Stabilization Payments ($)	Ending Fund Balance ($)
1	5831	3400	15398
2	5170	12179	20789
3	5325	9524	30210
4	4936	32978	13558
5	4650	38288	-12116
6	5175	14309	-12584
7	5094	20651	-19937
8	5049	9580	-16305
9	5405	0	-99
10	4796	17432	-3406

uct of payments per hundredweight, mentioned earlier in this section, the annual number of animals produced (Table 3.4) and the average dressed carcass weight. In year six the model estimated a payout of $14,309 to producers, or [$3.87/cwt + $0.38/cwt + $11.12/cwt + $3.35/cwt] * 449 * 1.7 . Finally, premiums collected from producers and both levels of government are deposited into an interest bearing account from which stabilization payments are then made. Presented in Table 3.8 is the accumulated balance including interest charged on deficits and earned on any surplus. As indicated, in year six the stabilization fund had an ending balance of -$12,584.

3.3 SIMULATION SCENARIOS

Presented in this section are descriptions of the scenarios designed to address the objectives outlined in section 1.7. Each scenario is analyzed with respect to a series of probability distributions. Statistically stable probability distributions were obtained through the replication of each scenario 600 times over the ten year period. Firms in each experiment were furnished with identical debt structures. The debt level was based on a fixed amount, 38 percent, of the operations assets.[121] Each loan was amortized over a twenty year period at 11 percent, which is the interest rate specified in Q13 of Table 3.1 .

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[121] Percentage was established based on information on the financial structure of Manitoba hog farms reported in the 1984 Farm Survey conducted by the Farm Credit Corporation (FCC).

3.3.1 Baseline

The baseline scenario, an examination of the case study operation in the absence of the NTHSP, was constructed for two reasons. First, to outline the situation which would prevail without the presence of tripartite stabilization and the second to serve as a base point for later comparisons. The baseline scenario is outlined below.

3.3.2 Scenario 1

As noted earlier, one objective of stabilization policy is to protect producers during periods of low market returns. The first scenario was designed to assess the effect of the NTHSP through a comparison of the data generated from selected distributions. This data includes; assets, liabilities, equity and net income with and without the program. In this way, the net effect of the policy on cash flow can be evaluated.

3.3.3 Scenario 2

The second scenario studies the consequences of adjusting the premium percentage of the current program. These modifications involved changing the current percentage of 7.5 percent to 9.0, 10.5 and 12.0 percent. For the purposes of this study it was assumed that premium payments, during the ten year simulation period, were shared equally among participants. Therefore, pursuant to the information regarding premium rates, outlined in section 2.12.3, the two latter levy rates, 10.5 and 12.0 percent, examined in this study represent hypothetical situations.[122]

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[122] It is important to remember that under the NTHSP contributions by the two levels of governments are capped at 6 percent. Therefore, in reality if the total premium required is 12 percent, each government wou;d pay a maximum of 3 percent and the producer would make up

The scenario is analyzed with respect to three criteria. In addition to examining potential cash flow differences, size of payment and the status of the stabilization fund under each premium rate are assessed.

3.4 EMPIRICAL RESULTS

The evaluation of the NTHSP was conducted by an examination of the empirical results obtained from a series of probability distributions summarized in section 2.13. With regard to cash flow, stabilization payments, and the accumulated fund balance cumulative probability distributions[123] from years three, seven and ten were selected to provide an overview of the effect of the policy on these variables through time.

3.4.1 Baseline

Without the NTHSP, the simulation results (Figure 3.1) indicate that there is a high probability, 69 percent, of the ten year aggregate enterprise cash flow being between 0 and 50,000 dollars, with approximately half below $30,000. With the exception of year three an examination of the annual figures show that this is a relatively consistent trend throughout the simulation period. In looking at the balance sheet variables the baseline results show a 40 percent probability of a decline in current assets. Reductions detected in the level of intermediate and term assets were found to be due to the normal depreciation process. Of the declines recorded in liabilities the majority, 87 percent, were in the 0 to 2 percent range. At the same time there was also

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the difference, 6 percent.

[123] Non-cumulative probability distributions for each of the figures presented in this section are given in Appendix B.

a 10 percent probability of upward movement in liabilities in the 2 to 10 percent range. Further, there were seven insolvencies registered when the NTHSP was not in place. The overall impact of all the above was a relatively high probability (64 percent) of reductions in net worth.

3.4.2 Scenario 1

3.4.2.1 Cash Flow

The imposition of a stabilization policy resulted in an decrease in the overall probability of negative cash flow from 13 to 1 percent (Figure 3.1). This was further confirmed by results obtained from annual figures for selected years. With the exception of the 1 percent negative cash flows observed in year three (Figure 3.2), the probability of negative enterprise cash flow was approximately 20 percent (Figure 3.3, Figure 3.4). This contrasts sharply with the cash flow pattern established under the current program, where, in each of the selected years the probability of negative returns were consistently below 1 percent. Not only was the probability of a positive level of cash flow higher but, the cash flow itself was also enhanced. As previously mentioned (section 3.4.1) without the program returns were generally concentrated between 0 and 50,000 dollars. Using the same evaluation criteria with the introduction of the NTHSP the range of average enterprise net income was found to increase $15,000, with a high percentage (40 percent) between 40,000 and 70,000 dollars.

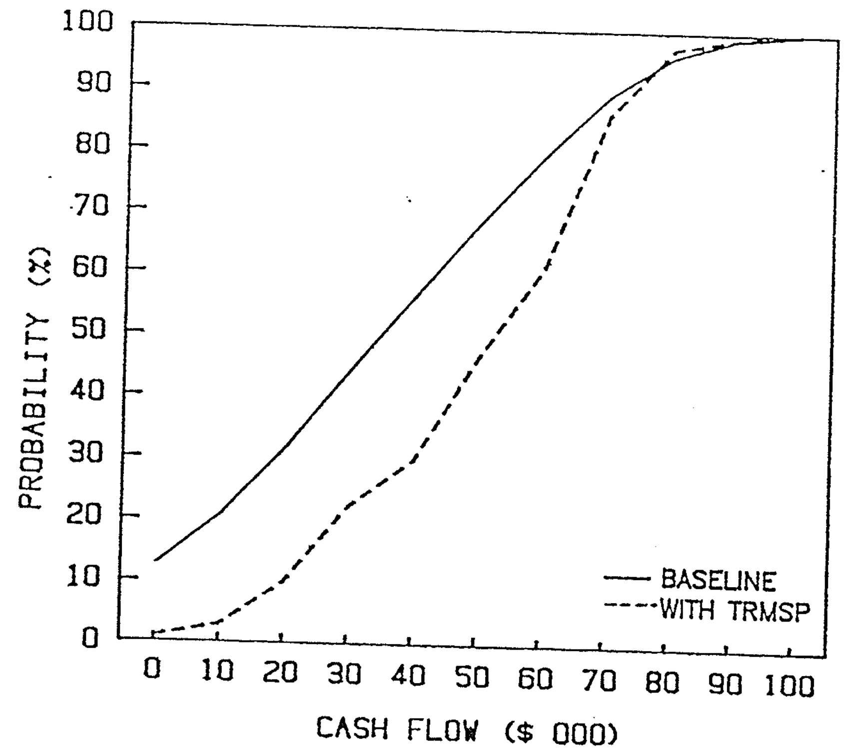

Figure 3.1 10 Year Aggregate Cash Flow

Baseline and TRMSP

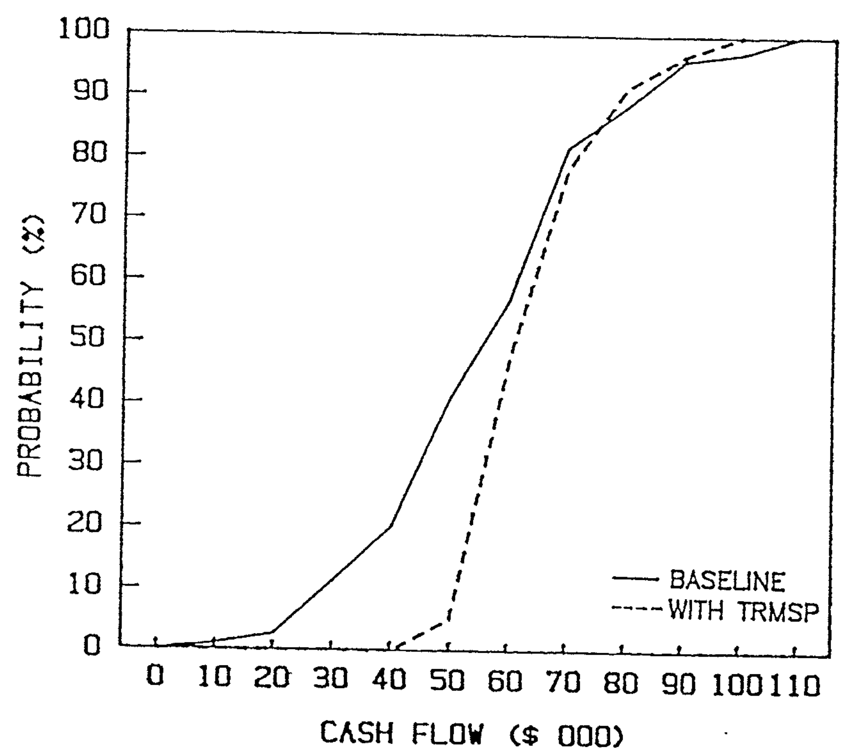

Figure 3.2 Cash Flow Year 3

Baseline and TRMSP

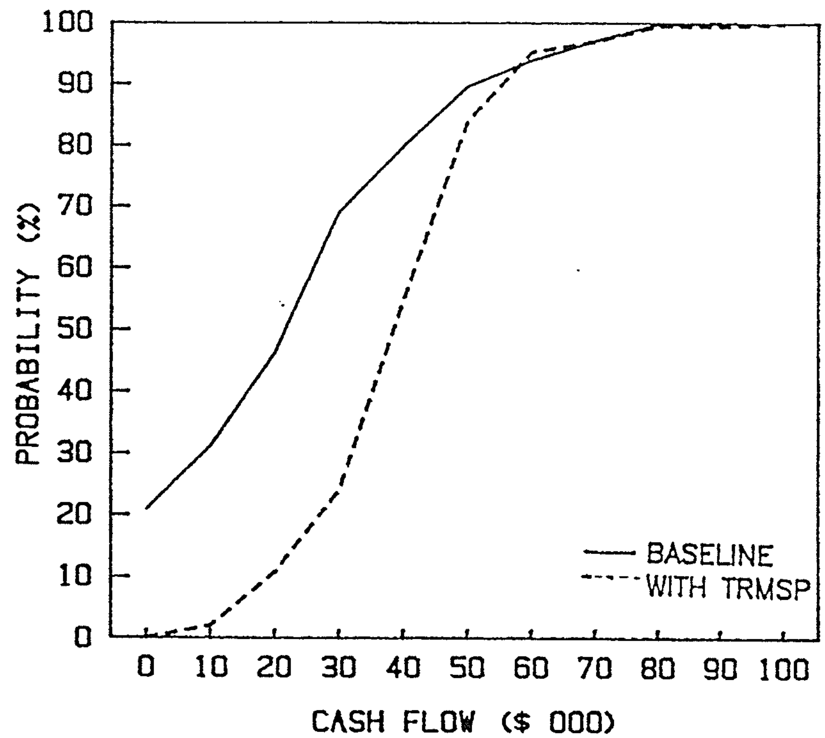

Figure 3.3 Cash Flow Year 7
Baseline and TRMSP

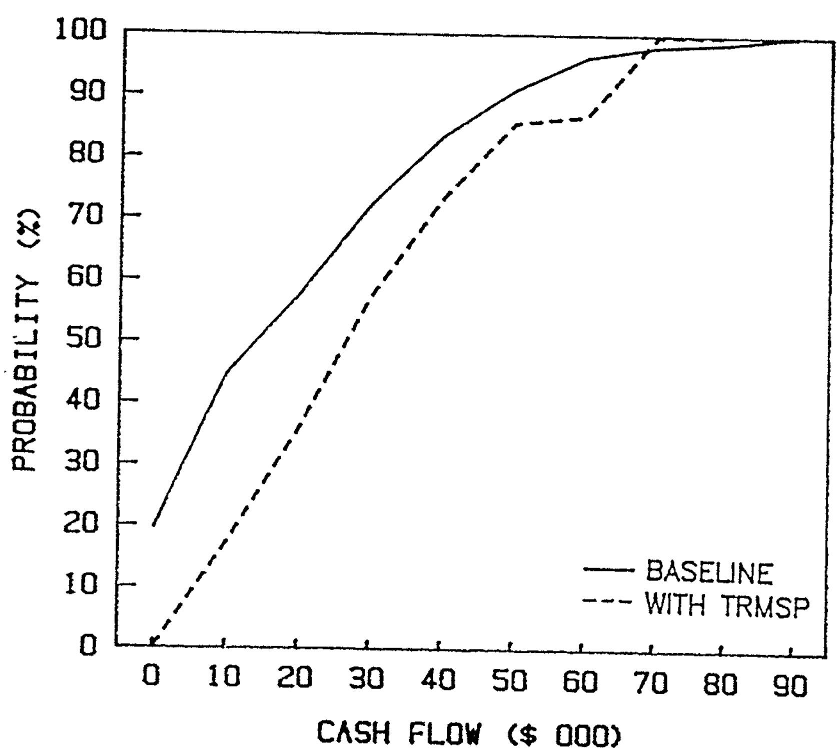

Figure 3.4 Cash Flow Year 10
Baseline and TRMSP

3.4.2.2 Asset Values

A second, but related effect noted after the implementation of a stabilization policy was an increase in assets owned by the farm. The implementation of the NTHSP resulted in substantial increases to cash flow. The resulting increases to retained earnings were eventually translated to the firms balance sheet in the form of current assets. As observed from Table 3.7, a direct result of the Tripartite program was the decline in the probability of a reduction to current assets. The percent chance of having no change in current assets dropped from 37.5 precent to 5.1 percent during the ten year period. The majority of the increases observed in current assets due to the program were in the 10 to 14 percent range.

Changes in the level of term assets were identical in both cases. As was noted earlier, observed reductions were postulated to be a result of the normal depreciation of these assets during the course of the simulation.

3.4.2.3 Liabilities

Associated with the decline in current assets, specifically cash, in the absence of the program were increases in the levels of liabilities and the number of insolvencies. No new debts were incurred by the firm during the ten year period when the NTHSP was in place. However, when the NTHSP was not present the probability of an increase in debt rose to 16 percent. Further, while no insolvencies occured with a program seven insolvencies were reported in its absence.[124]

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[124] However, given that 600 iterations of the simulation were performed

Table 3.9

Probability of Percentage Change in Balance Sheet Accounts

Probability of Percentage Change to Current Assets

	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
Baseline	10.1	10.5	1.3	1.3	1.3	2.8	3.1	7.0	4.3	8.3	9.9	8.9	7.8	9.4	7.8	3.1	3.0
NTHSP	4.1	0	0	0	0	0.1	0	0.6	0.8	4.4	4.8	8.9	15.8	19.6	20.3	11.9	8.4

Probability of Percentage Change to Intermediate and Term Assets

	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
Baseline	0	0	0	0	100												
NTHSP	0	0	0	0	100												

Probability of Percentage Change to Liabilities

	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
Baseline	1.1	0	0	0	0	0	82.3	5.4	3.1	3.4	1.8	1.9	1.0				
NTHSP	0	0	0	0	0	0	100										

Probability of Percentage Change to Net Worth

	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
aseline	36	0	0	0	5	6	8	11	8	9	8	5	3	3			
NTHSP	6	0	0	0	1	2	5	5	12	17	22	17	10	3			

3.4.2.4 Net Worth

The overall effect of the aforementioned differences can be summarized by an examination of net worth, also reported in Table 3.7. With the advent of the NTHSP the probability of an operation experiencing a decline in net worth was reduced by 45 percent.

3.4.3 Scenario 2

Presented in this section are the empirical results generated from the second scenario. As previously mentioned this scenario is to be analyzed with respect to three criteria. Therefore, the following discussion was also subdivided to reflect those criteria.

3.4.3.1 Cash Flow

Among the four premium rates examined none resulted in obvious differences to either overall (Figure 3.5), or annual enterprise cash flow levels (Figure 3.6, Figure 3.7 and Figure 3.8). The pattern established under the current program and discussed earlier in section 3.2.1 was generally repeated in each case. A number of factors could be considered responsible for this result. Recall from section 2.12.3 that in each instance the amount paid by the producer represented only one third of the total premium. Thus, while in actual terms total premium rates were increased from 7.5 to 12 percent, the producer portion was raised from 2.5 to 4.0 percent, or an increase of 1.5 percent.

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this represents less than 2 percent.

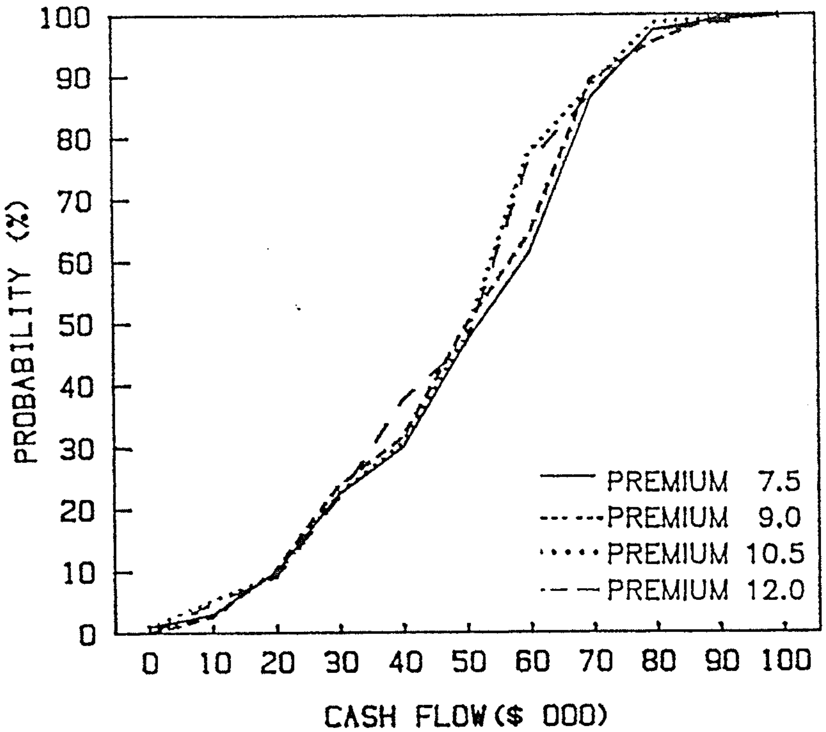

Figure 3.5 10 Year Aggregate Cash Flow with Premium Adjustment

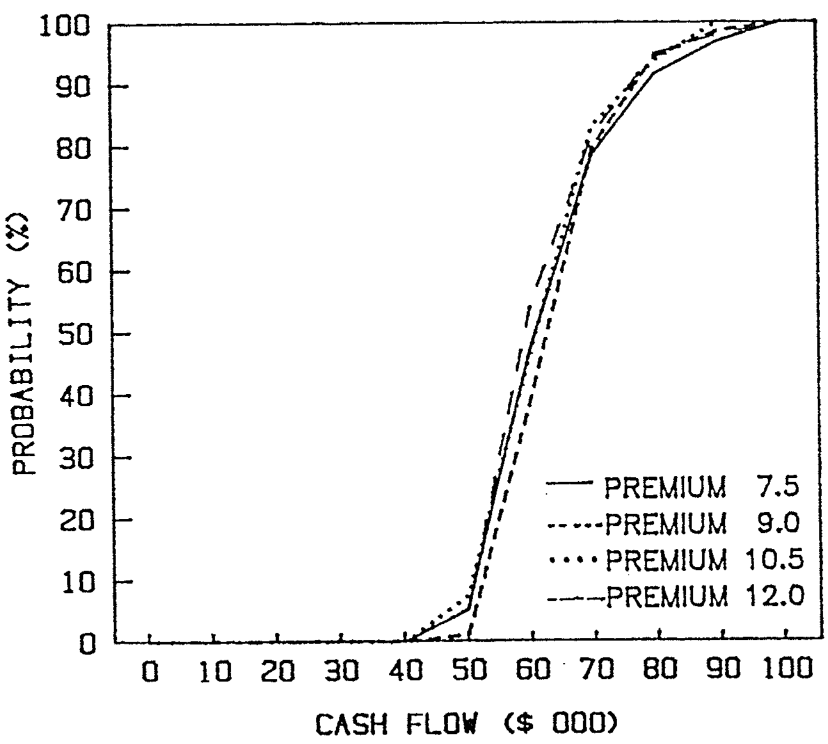

Figure 3.6 Cash Flow with Premium Adjustment Year 3

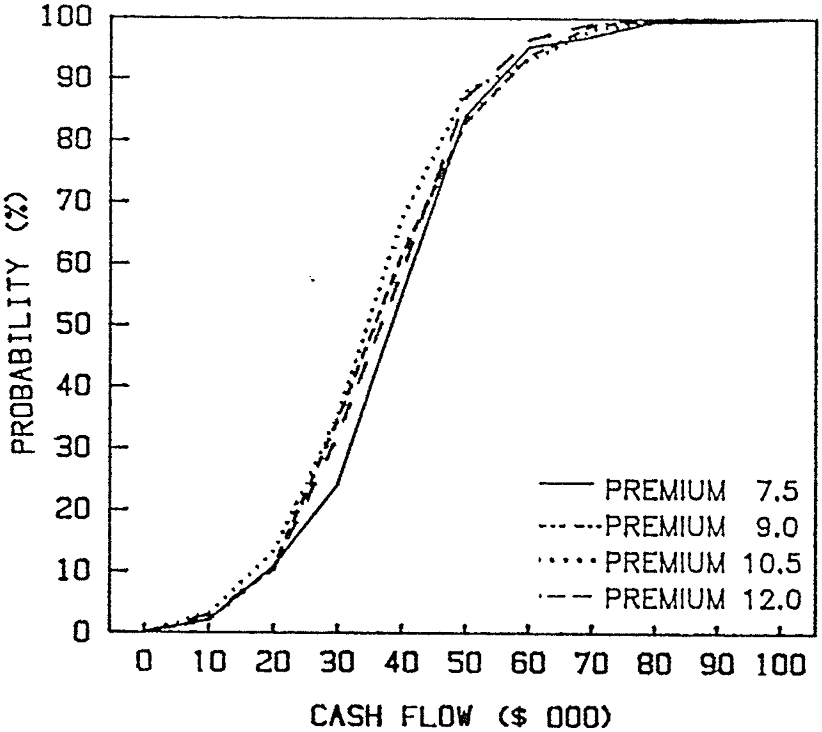

Figure 3.7 Cash FLow with Premium Adjustment
Year 7

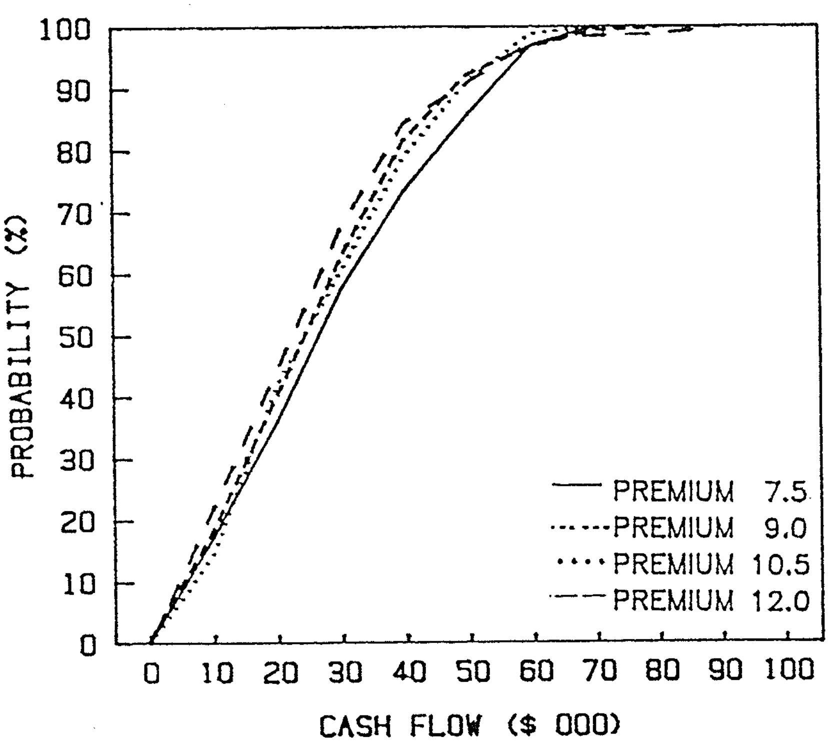

Figure 3.8 Cash Flow with Premium Adjustment
Year 10

Moreover, adjusting the premium rate has no effect on the other determinants of cash flow. As noted in section 3.2.1 these include the price and number of hogs sold, the operating expenses incurred during their production and the level of stabilization payments received. Therefore, the overall effect of changing the rate from 7.5 to 12 percent on cash flow was minimal given the relatively low level of increase in the producer portion of the premium payment.

3.4.3.2 Stabilization Payment

As was the case with cash flow no discernable differences were observed between premium rates as to the frequency or size of stabilization payment. Overall, size of payment ranged from 0 with a probability of 4.6 percent to 80,000 dollars where the probability was less than 1 percent (Figure 3.9). However, within the aforementioned ranges disbursements were generally skewed toward the lower end of the field (Figure 3.10, Figure 3.11 and Figure 3.12).

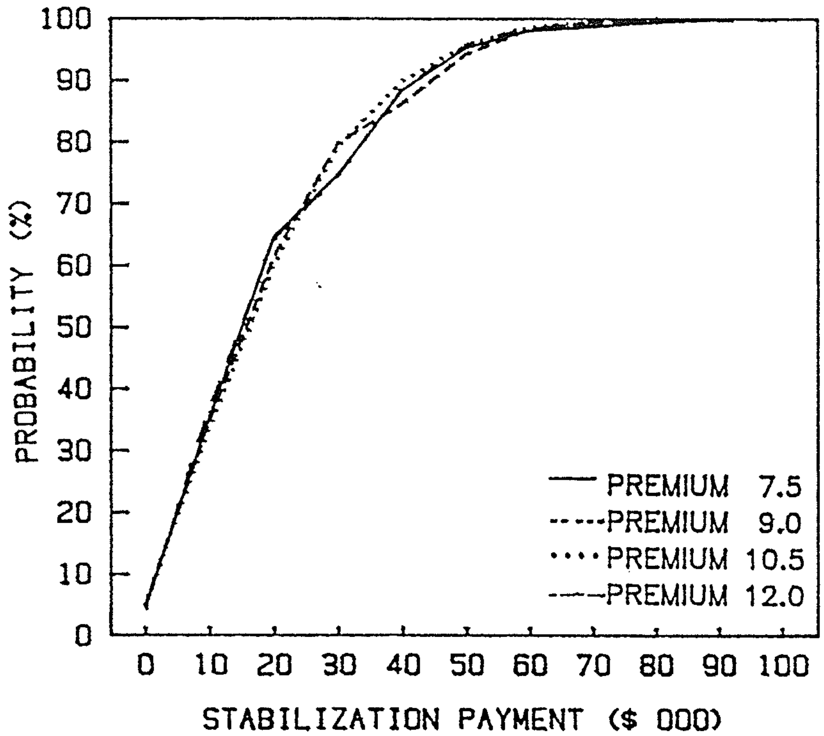

Figure 3.9 10 Year Aggregate Stabilization Payments with Premium Adjustment

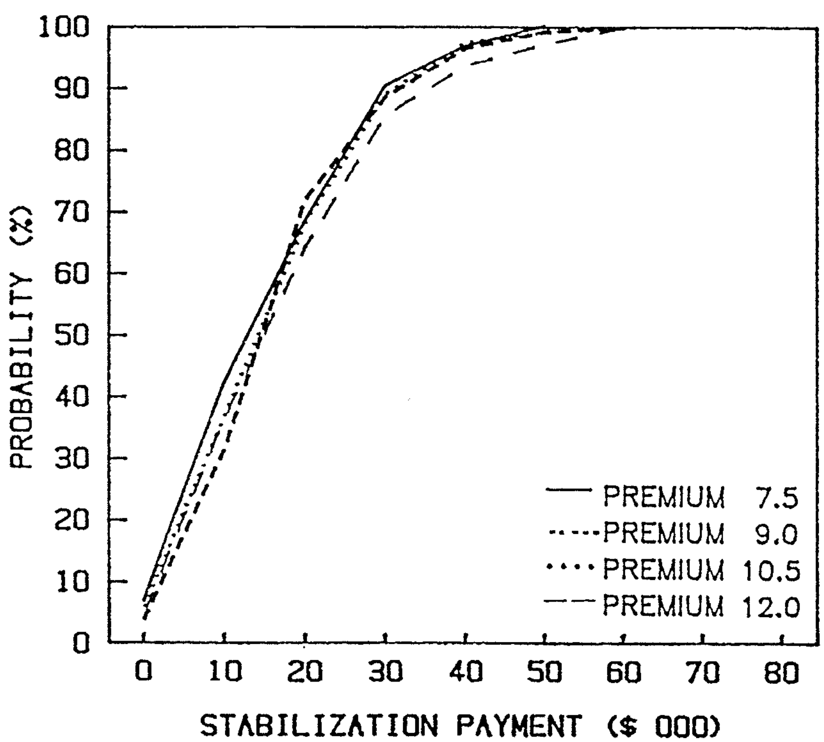

Figure 3.10 Stabilization Payments with Premium Adjustments Year 3

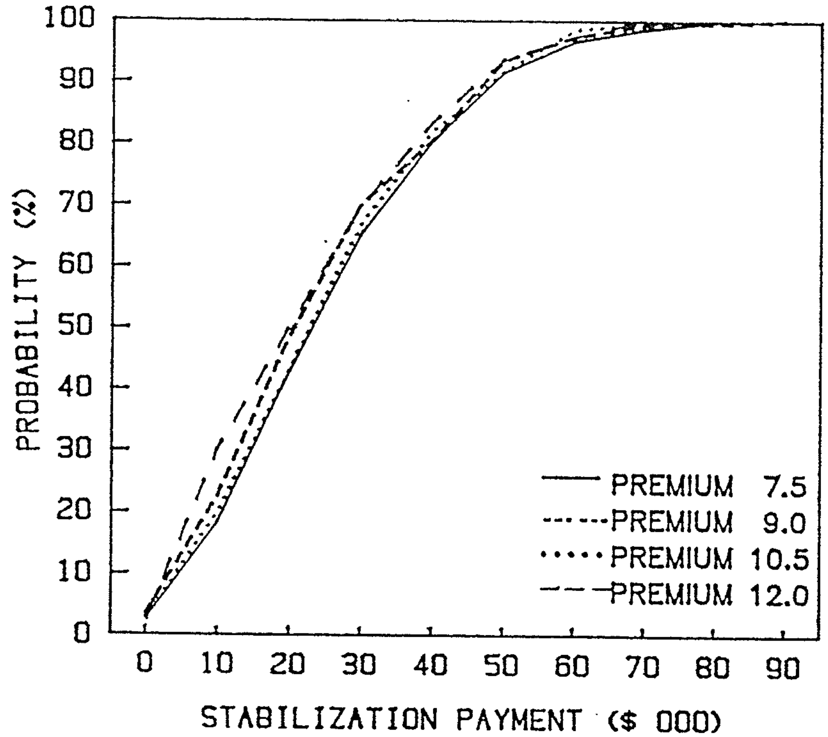

Figure 3.11 Stabilization Payments with Premium Adjustments
Year 7

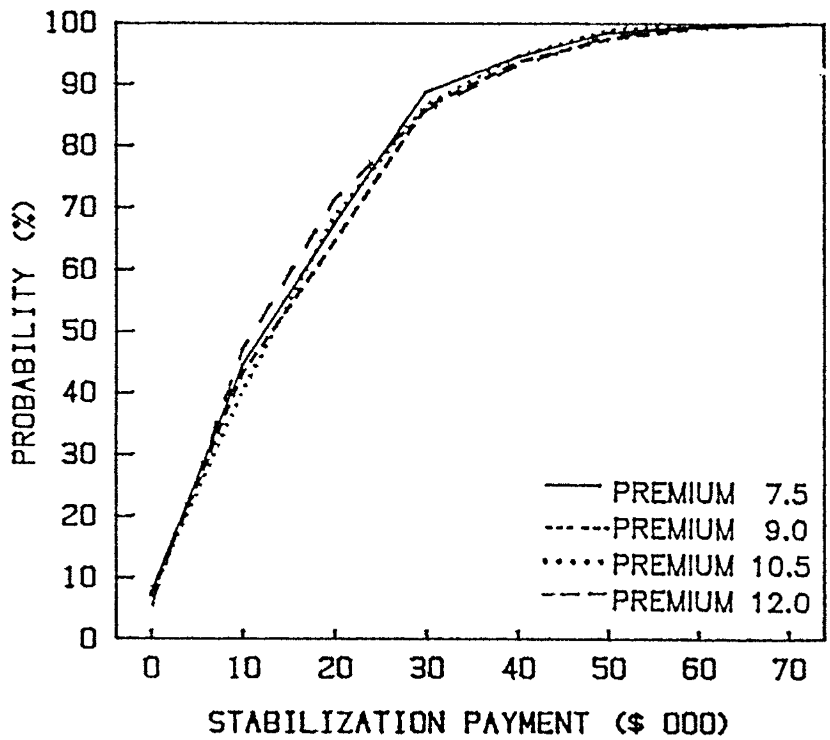

Figure 3.12 Stabilization Payments with Premium Adjustments
Year 10

The majority, 90 percent, consisted of payments of less than 40,000 dollars of which 60 percent were lower than 20,000 dollars. The pattern established from the aggregate values was generally repeated in each of the selected years (Figure 3.10, Figure 3.11, Figure 3.12). As shown in the diagrams little variability in either probability or size of stabilization payment was expressed between rates.

Both the overall and annual results confirmed expectations with respect to probability and size of stabilization payment. According to the formula utilized in the calculation of payments, equation 2.138, disbursements are not affected by the alteration of the premium percentage.

3.4.3.3 Fund Balance

One concern expressed by policymakers when designing the NTHSP was a desire to to have the premiums collected approximate stabilization payments made. That is, it is anticipated that at the conclusion of the program the expected value of the fund should be zero. Therefore, two conditions of importance in analyzing of the status of the stabilization fund are the probabilities and relative sizes of both deficits and surpluses.

In looking at the performance of the fund over the ten year period, Figure 3.13, the highest probability of the fund being in a deficit situation, 60 percent, was accorded to the current program. Other premium rates, specifically 9.0 and 10.5 percent had overall probabilities of negative balances of 34 and 26 percent respectively. It was not until the rate was increased to 12 percent that this probability dropped to a figure below 10 percent.

A direct relationship emerged between levy rates and the overall size of the fund deficit. Using a premium rate of 12 percent the size of the negative balance fluctuated between 0 and -200,000 dollars, where the majority, 93 percent, occured in the 0 to -50,000 dollar range. Under each of the remaining rates, 7.5, 9.0 and 10.5 percent, not only did the size of the negativity increase but also the trend toward the lower ends of the distributions. In the case of a 10.5 percent levy rate the increase over the deficit established under a 12.0 percent rate was 50,000 dollars. This was subsequently raised by an additional 50,000 dollars when the rate dropped to 9.0 percent. Again, results as to the size of negative balance were skewed downward, below -$50,000, with frequencies of 26 and 20 percent for premium rates 9.0 and 10.5 percent respectively. percent. The drop in premium rates to the current level resulted in the range of the negative balance increasing to -$300,000. With the rate set at 7.5 percent of the total deficit, approximatly 33 percent was less than -$50,000.

Two distinctive patterns emerged from the data for selected years regarding the percent chance of a negative balance (Figure 3.14, Figure 3.15 and Figure 3.16).

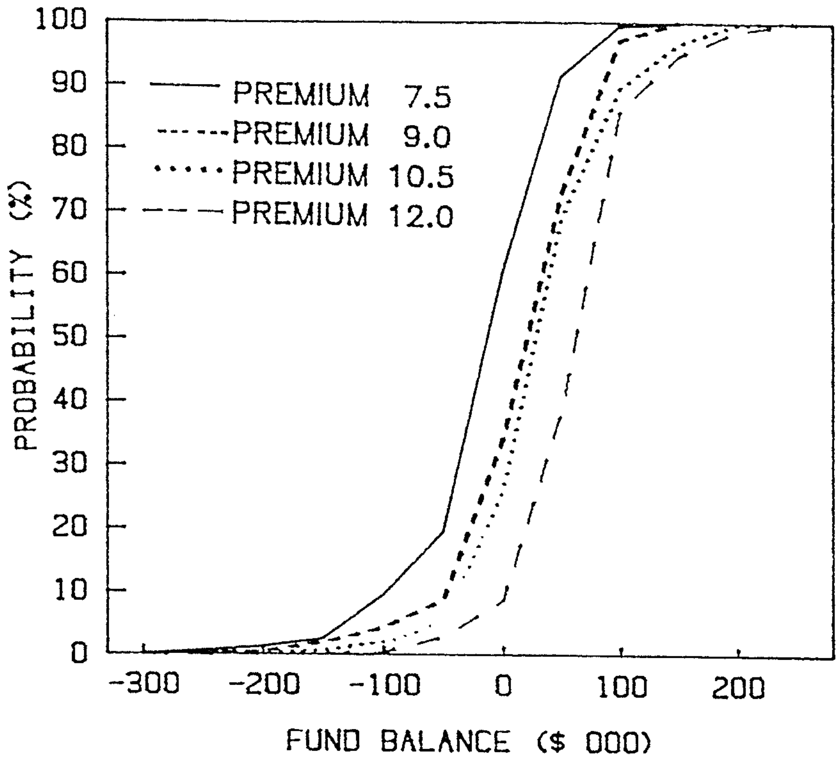

Figure 3.13: 10 Year Aggregate Fund Balance w/ Premium Adjustments

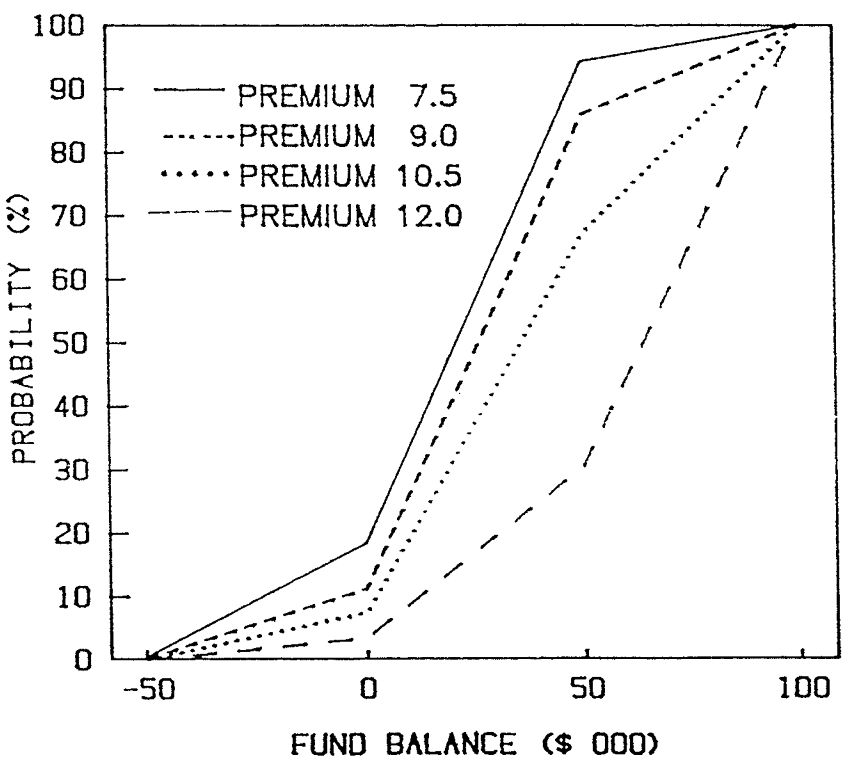

Figure 3.14: Fund Balance with Premium Adjustments, Year 3

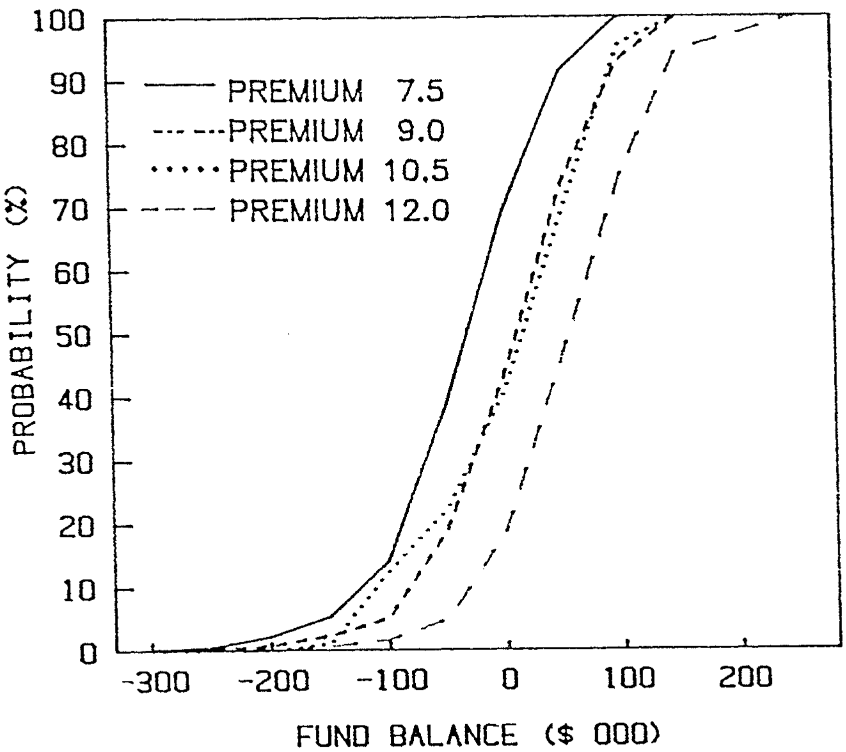

Figure 3.15: Fund Balance with Premium Adjustments, Year 7

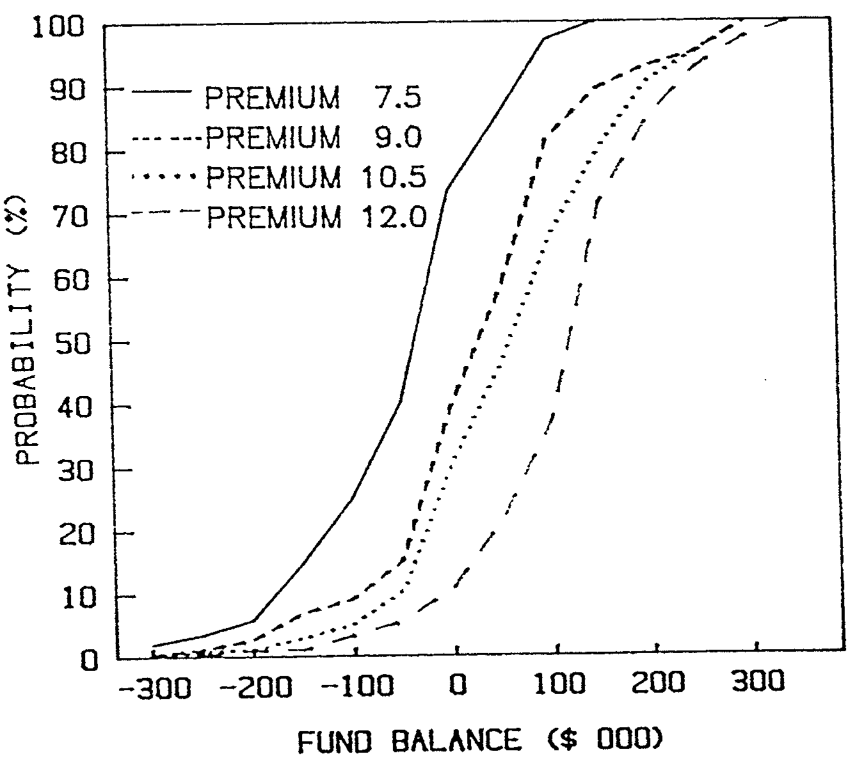

Figure 3.16: Fund Balance with Premium Adjustments, Year 10

Cross-sectional analysis of balances generated as a result of each rate revealed a steady decline in the probability of a deficit in each year as the premium level was increased. As illustrated in Figure 3.16 the most dramatic decrease was reported year ten where the level dropped from 74 to 10 percent when the premium rates were raised from 7.5 to 12.0 percent.

Secondly, during the ten years, the condition of the fund went through periods where it first worsened and then improved. As shown in Figures 3.14, 3.15 and 3.16, and considering a premium rate of 10.5 percent, the probability of a negative balance increased from 8 percent in year three to 41 percent in year seven before dropping to 30 percent by the end of the simulation. This is in contrast to the situation experienced when the current premium rate was utilized. In that instance the probability of a deficit rose from 20 percent in year three to over 70 percent in years seven and ten.

Although the size of the deficit in selected years varied between premium rates, the largest percentage tended to settle in the 0 to -50,000 dollar range. The first signs of variability with respect to size were observed in year seven. As indicated in Figure 3.15 the highest level of deficit during this period -300,000 dollars was accorded to a premium rate of 7.5 percent. During the same time period a premium rate of 9.0 percent resulted in a maximum size of -$250,000 and -$150,000 was reported under each of the remaining rates. of the remaining rates reported maximum sizes of -150,000 dollars. Maximum levels in year ten were the same between rates, -$300,000. However, among the rates examined the probability of reaching this maximum varied from 2 percent for a 7.5 percent premium to less than 0.5 percent for each of the other rates.

Any analysis regarding the status of the stabilization fund would be incomplete without some discussion as to the probability and size of surplus. As indicated in Figure 3.13 the overall percent chance of surplus increased with the premium rate. The lowest probability, 40 percent, was generated using the current premium rate, 7.5 percent. With the remaining rates, 9.0, 10.5, and 12.0 percent, the percent chance of surplus rose substantially, to reach levels of 66, 74 and 91 percent respectively. The majority of these balances were concentrated in the 0 to 50,000 dollar range. As noted in Figure 3.13, for the most part the surplus range was dependant on the premium utilized. Using either the current premium rate or a premium of 9.0 percent resulted in the generation of surpluses which fluctuated between 0 and 150,000 dollars. The top of this range was increased by 250,000 dollars for premium rates of 10.5 and 12.0 percent. It must be noted that although their maximum values were the same, the probability associated with each surplus was different. The percent chance of attaining a level of 250,000 dollars was greater using a rate of 12.0 percent as opposed to 10.5 percent.

Two patterns emerged regarding the performance of each premium rate when analyzed throughout the simulation period. Over time, and utilizing the current rate, the probability of surplus declined from 80 percent in year three to 26 percent in year ten. For each of the remaining rates initial reductions in probability between years three and seven were overcome by the end of the simulation. According to results, illustrated in Figures 3.14 - 3.16, and considering a premium rate of

12.0 percent, by year seven the probability of surplus had deteriorated from 96 to 81 percent. Yet, by the end of the simulation the probability had rebounded to 90 percent.

Chapter IV

CONCLUSIONS AND RECOMMENDATIONS

The overall purpose of this study was to address some of the concerns expressed by producers and governments regarding the effectiveness of a national stabilization program. To achieve these objectives a simulation model was developed and later applied to a representative Manitoba hog producer. This chapter presents the conclusions emanating from the results given in Chapter 3. In addition, a number of recommendations are made regarding the need for further research.

4.1 SUMMARY AND CONCLUSIONS

The decision by a producer to participate in a voluntary stabilization program is likely to based, to a large degree, on the overall impact of said program on their own operation. Results generated from the first scenario, institution of the NTHSP as currently structured, point to a definite improvement in the financial position of participating producers. Data from both cumulative and selected years indicated that as a result of the NTHSP producers experienced declines in the probability of negative returns and increased levels of cash flow. As a consequence of the combination of these two events the case study operation, in any of the 600 iterations, did not require any additional financing, in the form of loan a consolidation, during the ten year simulation period. Further, no insolvencies were reported with the NTHSP in place. Overall the effect of enhanced levels of cash flow and reductions to liabilities was an increase in owner's equity. Thus, from a producer perspective, participation in the program yielded beneficial results. To fully appreciate this statement it must be recalled that producer interest was directed primarily at the issue of stability. The achievement of stability must be judged not strictly on the receipt of a payment, but on the timing of said payment. As indicated from the results, implementation of the NTHSP successfully addressed these concerns.

Fiscal considerations played a large role in determining the participation of governments in the NTHSP. In addition, legislators were concerned with the impact of the initiatives on hog producers. The second scenario therefore examined not only the effect of altering the premium rate on the fund balance but also on producer cash flow.

No perceptible changes to either producer returns or stabilization payments were observed following adjustments to the premium rate from its current level of 7.5 percent to 9.0, 10.5 and 12.0 percent. However, definite differences were observed with respect to the fund balance as a result of altering the premium rate. Briefly, the fund experienced the highest probability (60 percent) under the currently established levy rate. Probability of deficit, as shown in the aggregate figures, was reduced considerably for each of the remaining rates. Annual figures pointed to the third year as the point at which the fund most often began to experience difficulties.

The highest overall percent chance of surplus was achieved utilizing the highest premium rate, 12.0 percent. Of the other rates analyzed only the current rate was not in a surplus position for the majority of the time. As was previously mentioned, policymakers in designing the NTHSP intended for the program to be self sustaining entity. According to the results summarized above the currently established premium rate will not generate sufficient revenues to offset predicted stabilization payments, given the conditions outlined in the simulation. This situation, was partially overcome when the rate was increased to 10.5 percent. However, prior to contemplating this option two factors must be examined. The first relates to the effect of an increase in levy rate on producer cash flow. The results indicate that no significant burden was placed on producer returns as a consequence of increasing the rate. The second factor to be considered relates directly back to the objective, espoused by policymakers, of a zero expected value upon termination of the plan. In utilizing a 10.5 percent rate, the probability and size of surplus are increased to levels of 75 percent and 25z0,000 dollars respectively. While the probability of the fund not being in a deficit situation is good, the possibility of the higher premium rate generating large surpluses represents an undesirable condition. The solution to this problem would seem to be one which the simulation model, in its current form, can infer but not definitely determine; that is, the implementation of a variable premium rate. Information gathered from the annual figures suggest an improvement to the situation under the economic conditions simulated here would be forthcoming provided the rate were adjusted at some time between years three and seven. One possibility, supported by the evidence gathered from annual figures, intimates that a rate increase, to 10.5 percent, could assist in alleviating the deficit condition. Given the current status of the model no definite conclusion could be reached as to whether this would be a temporary or permanent cure. That decision would largely depend on the deficit accumulated at that time.

4.2 MODEL LIMITATIONS

The analysis of the results and ensuing conclusions, as presented, must be tempered with a discussion of the models' various shortcomings. The first of these , the inflexibility of the premium rate, has already been noted in the previous section. Briefly, the scope of the analysis, notably the second scenario, was constrained by the inability to alter the rate between years. More conclusive results could be obtained from the model in the event this fixed process were abandoned. It must also be stated that adjustments to the methods of price determination for any of the commodities utilized within the model could produce results different form those presented in this study. This is particularly important for the mechanism used in the hog model. It must be remembered that stabilization payments are calculated as a function of not only costs of production but also market prices.

4.3 RECOMMENDATIONS FOR FURTHER RESEARCH

Many questions remain with respect to the effect of the NTHSP on individual producers. The avenues yet to be explored include that of enterprise diversification, particularly into feed grains. The current study has investigated the performance of the NTHSP from the perspective of a strictly livestock operation. However, within the province there are also a number of mixed (crop/livestock) enterprises. Participation in the program by producers is not limited to strictly livestock operations. Thus, an examination of the impact of the NTHSP on mixed enterprises would be beneficial. In addition, the model could be utilized to determine relative differences between diversification and the NTHSP as alternative methods of stabilization. Finally, it would be of interest to examine the implications of the program on enterprises of various sizes and with different debt structures. Currently, the NTHSP uses as its basis the NCOP, which assumes a breeding herd of 130 sows. In attempting to approximate the NCOP the current study modelled an operation with 100 sows. Statistics for Manitoba indicate that sizes of breeding herds vary from 1 to 528 sows per farm. Further, approximately 80 percent of the farms reported herds with less than 100 sows. As a result, further research is needed to assess the impact of the NTHSP on producers with different sized operations.

As was noted in the first chapter debt servicing commitments have had a strong influence on producers' response during periods of low market returns. Therefore varying the debt structure from that utilized in the current study would provide a more complete picture of the impact of the NTHSP on producers, particularly in the area of cash flow.

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Appendix A

NORMALLY DISTRIBUTED RESIDUAL TERM

This appendix describes the subroutine used to formulate a normally distributed error term using a series of randomly generated numbers which vary between zero and one.[113] A series of random numbers could be represented by Xi, where i= 1,2,3...N. It is assumed that each Xi has a mean, u

$$E(X1 + X2 + \ldots XN) = E(X1) + E(X2) + \ldots E(XN) = Nu$$

and a variance, σ

$$V(X1 + X2 + \ldots XN) = V(X1) + V(X2) + \ldots V(XN) = N\sigma$$

Having defined the interval for the random number to be between zero and one the mean and the variance can be defined as

$$E(X) = \int_0^1 x\,dx = x^2/2\Big|_0^1 = 1/2 - 0 = 1/2$$

$$V(X) = E(X^2) - [E(X)]^2$$

$$= \int_0^1 x^2\,dx - 1/4 = x^3/3\Big|_0^1 - 1/4 = 1/3 - 1/4 = 1/12$$

Therefore, given that this process occurs for all N of the random numbers generated, the mean becomes

$$E(\sum_{i=1}^{N} ri) = N/2$$

and the variance

$$V(\sum_{i=1}^{N} ri) = N/12$$

and consequently the standard deviation

$$\sigma = (N/12)^{1/2}.$$

A standard normal curve may be fitted to this data using the equation

[113] This subroutine was taken from one specified in Hartley (1976).

$$z = \frac{x-u}{\sigma} = \frac{ri - N/2}{(N/12)}$$

Therefore,

$$x = \sigma (12/N)^{1/2} \left[\sum_{i=1}^{N} ri - N/2 \right] + u$$

where:

σ = standard deviation of the normal distribution to be simulated

u = mean of the normal distribution to be simulated

Appendix B

NONCUMULATIVE PROBABILITY DISTRIBUTIONS

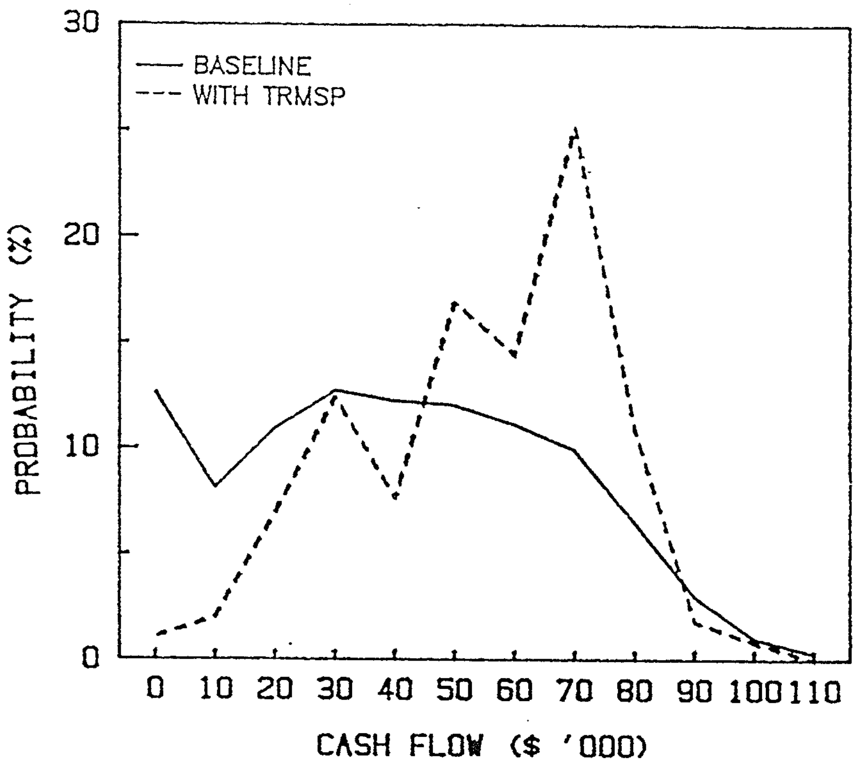

Figure B.1 10 Year Aggregate Cash Flow
Baseline and TRMSP

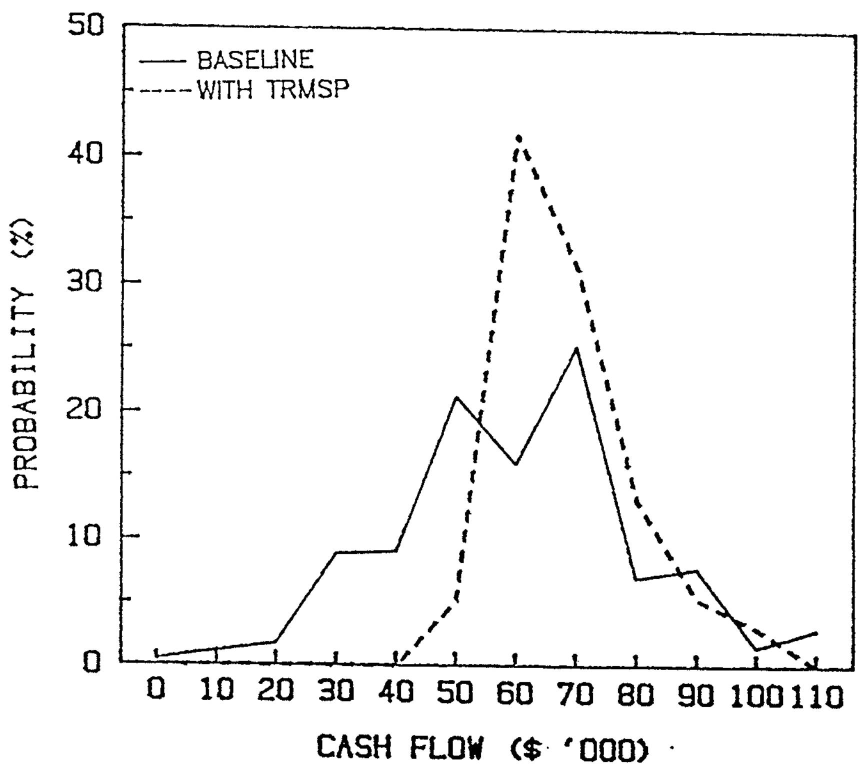

Figure B.2 Cash Flow Year 3
Baseline and TRMSP

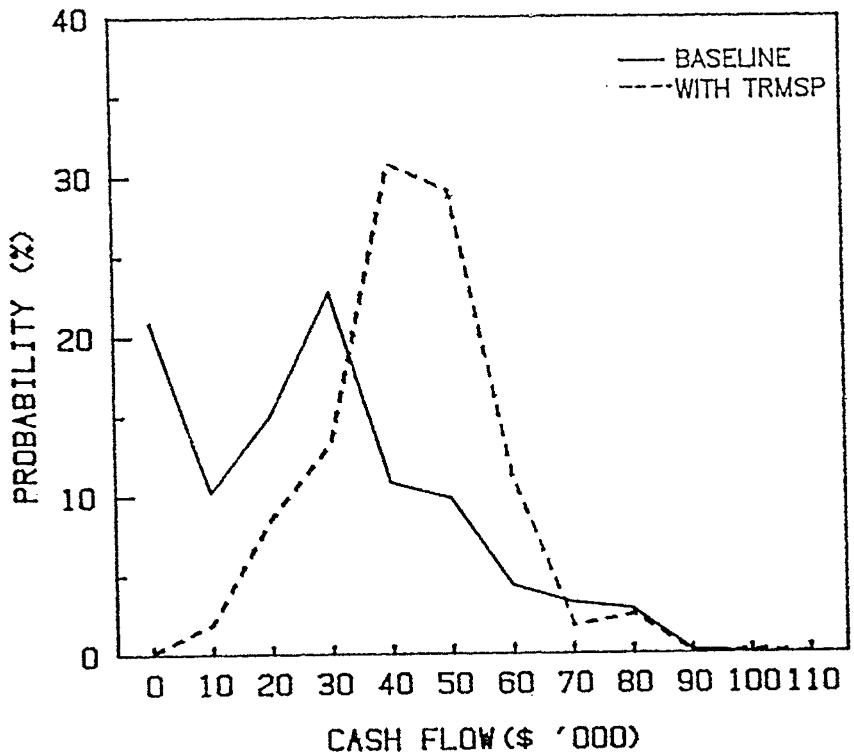

Figure B.3 Cash Flow Year 7 , Baseline and TRMSP

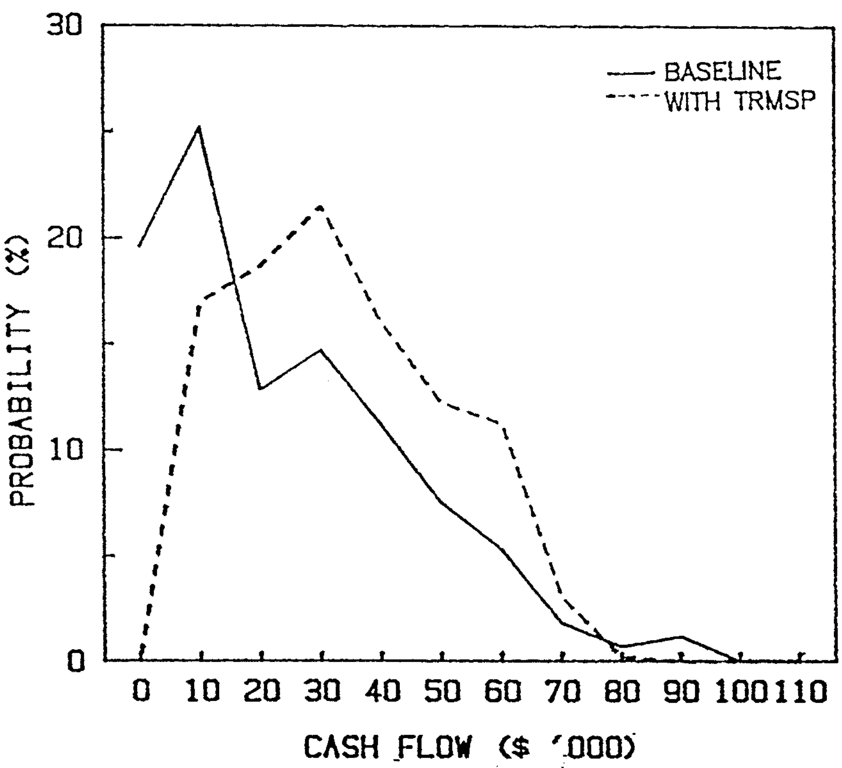

Figure B.4 Cash Flow Year 10 , Baseline and TRMSP

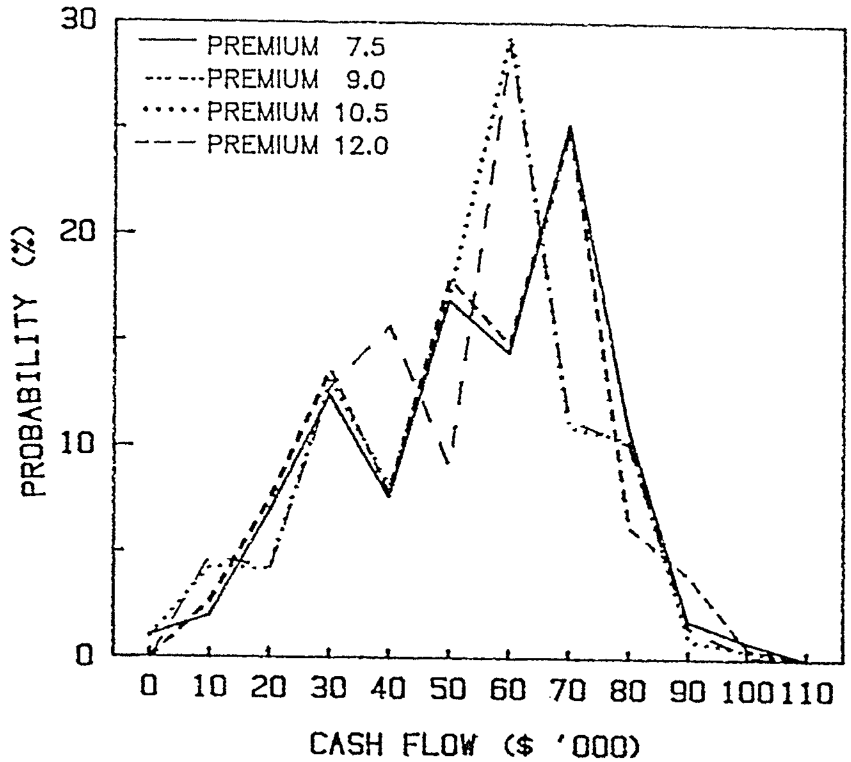

Figure B.5 10 Year Aggregate Cash Flow with Premium Adjustment

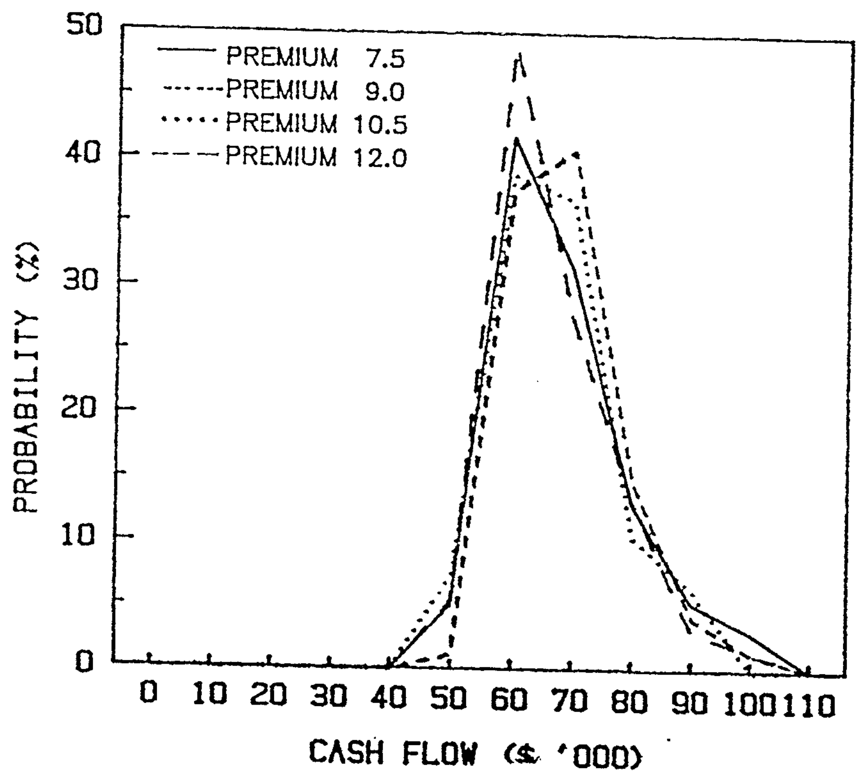

Figure B.6 Cash Flow with Premium Adjustment , Year 3

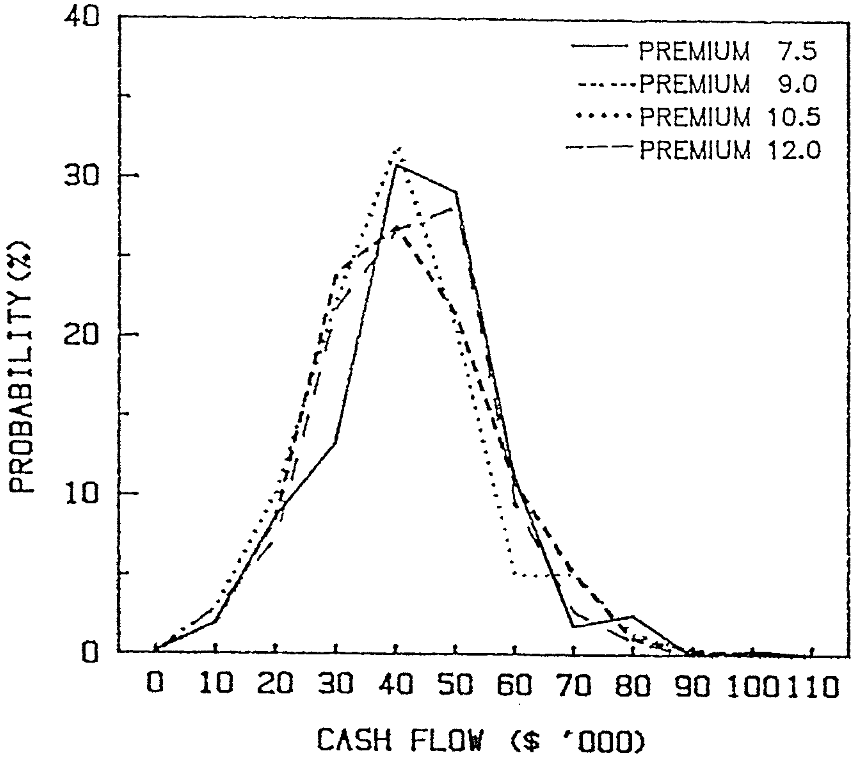

Figure B.7 Cash FLow with Premium Adjustment , Year 7

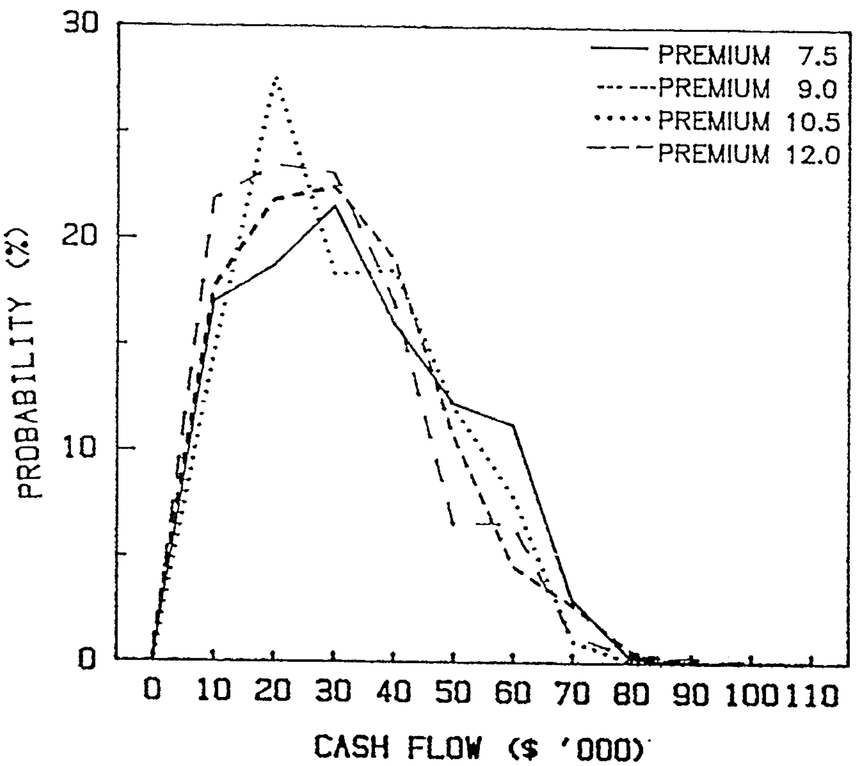

Figure B.8 Cash Flow with Premium Adjustment , Year 10

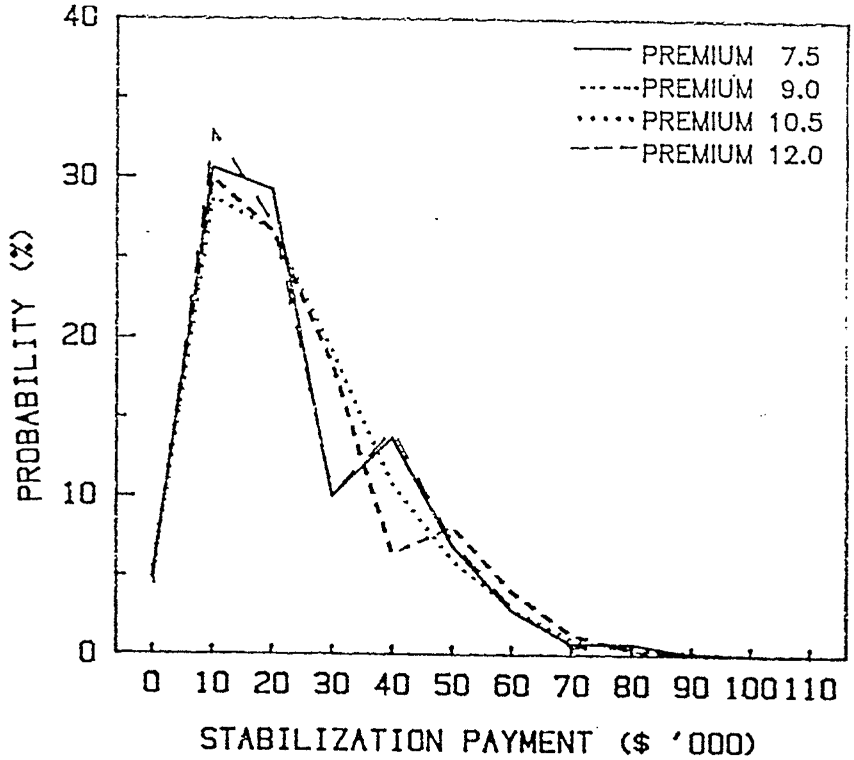

Figure B.9 10 Year Aggregate Stabilization Payments with Premium Adjustment

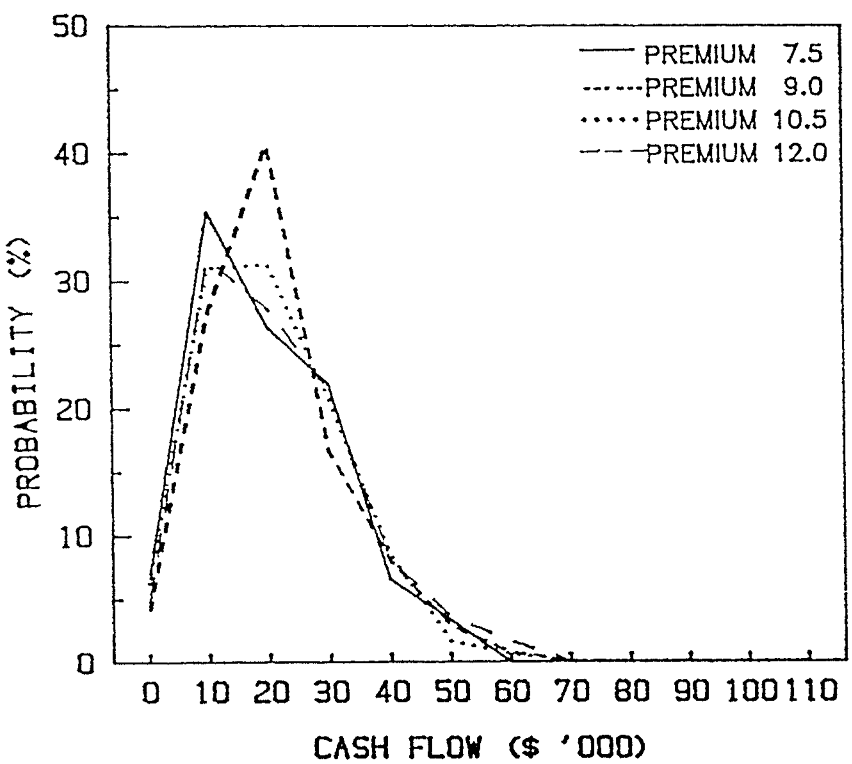

Figure B.10 Stabilization Payments with Premium Adjustments Year 3

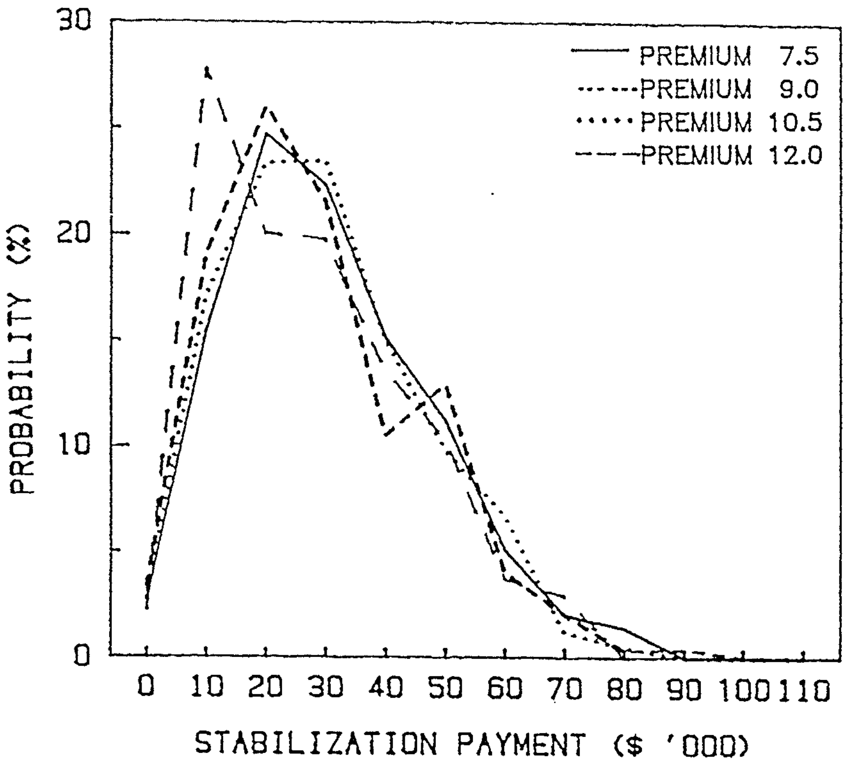

Figure B.11 Stabilization Payments with Premium Adjustments
Year 7

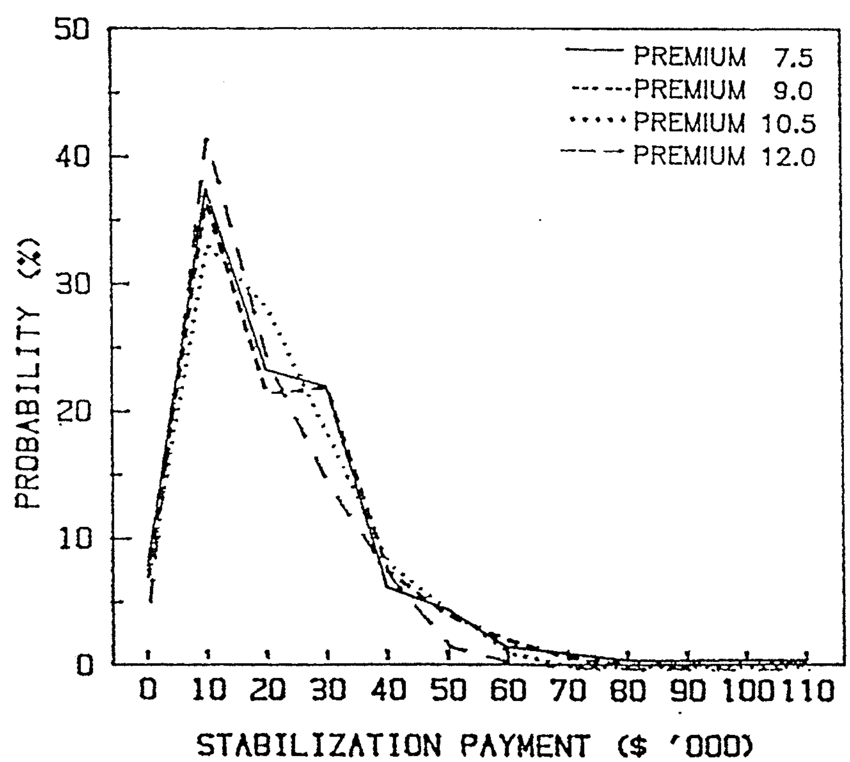

Figure B.12 Stabilization Payments with Premium Adjustments
Year 10

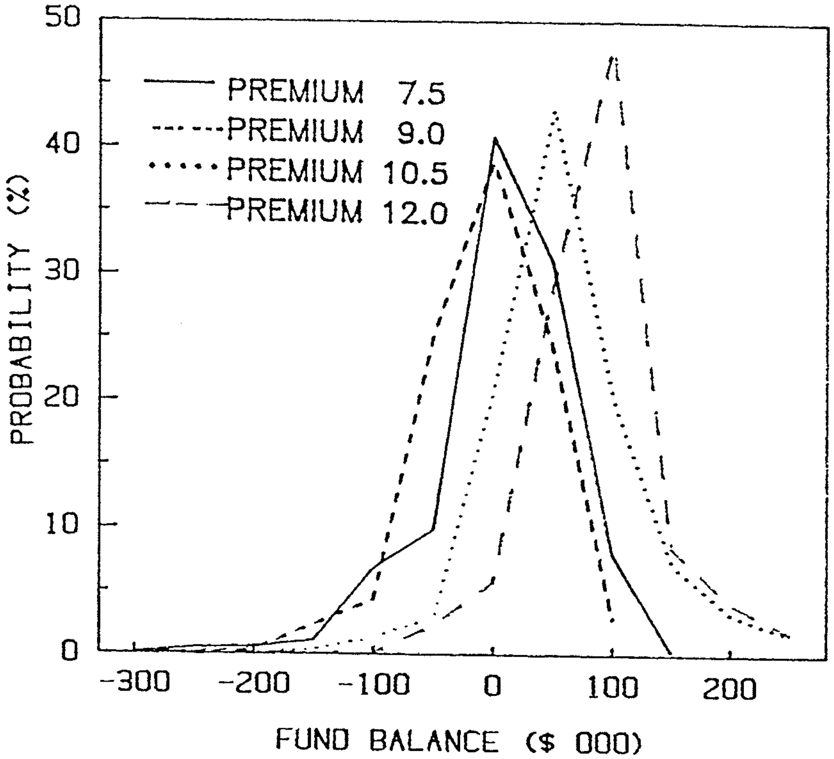

Figure B.13 10 Year Aggregate Fund Balance with Premium Adjustments

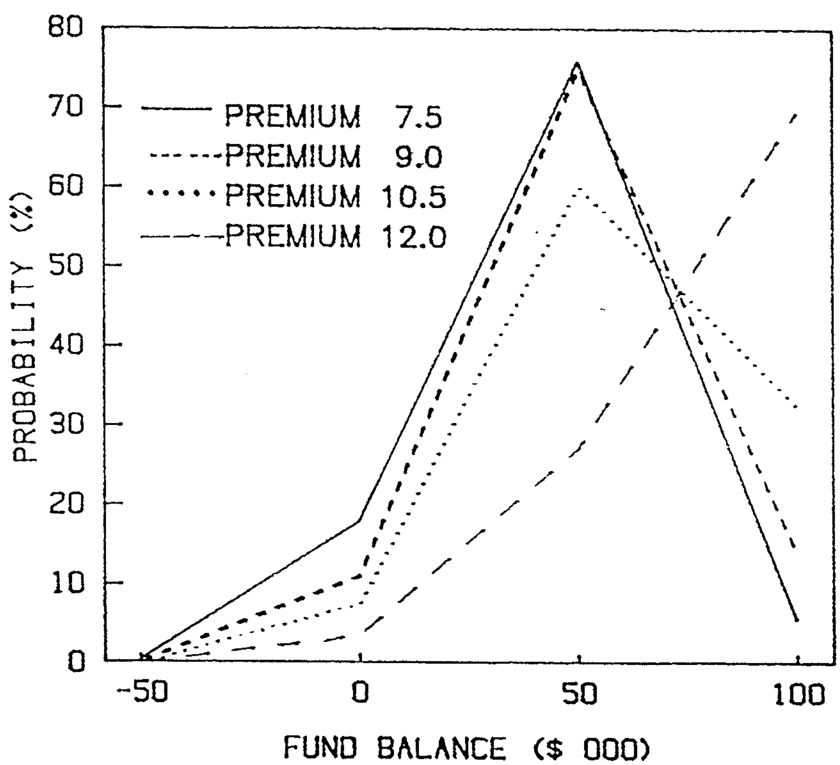

Figure B.14 Fund Balance with Premium Adjustments Year 3

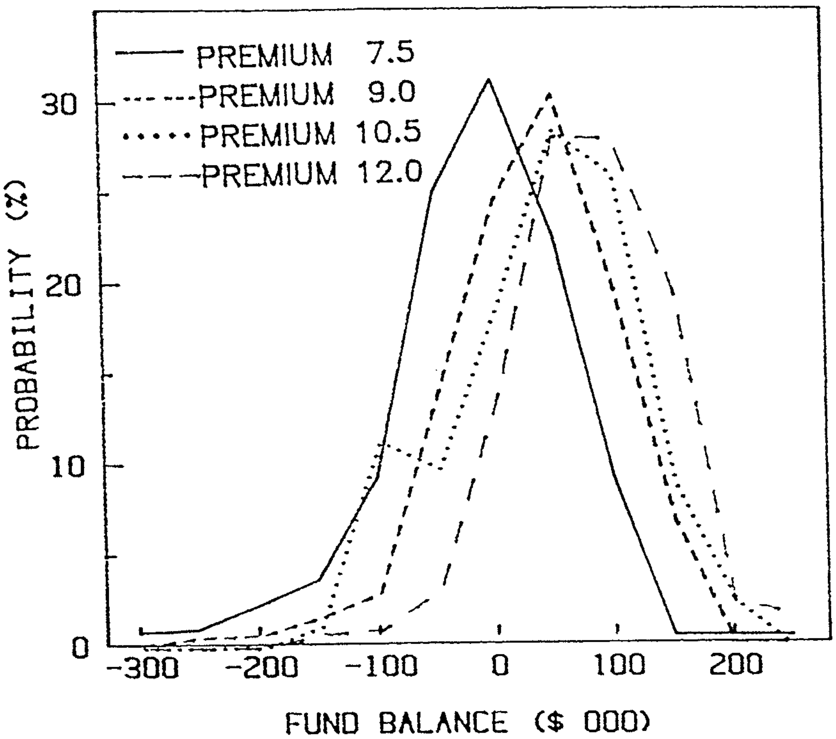

Figure B.15 Fund Balance with Premium Adjustments Year 7

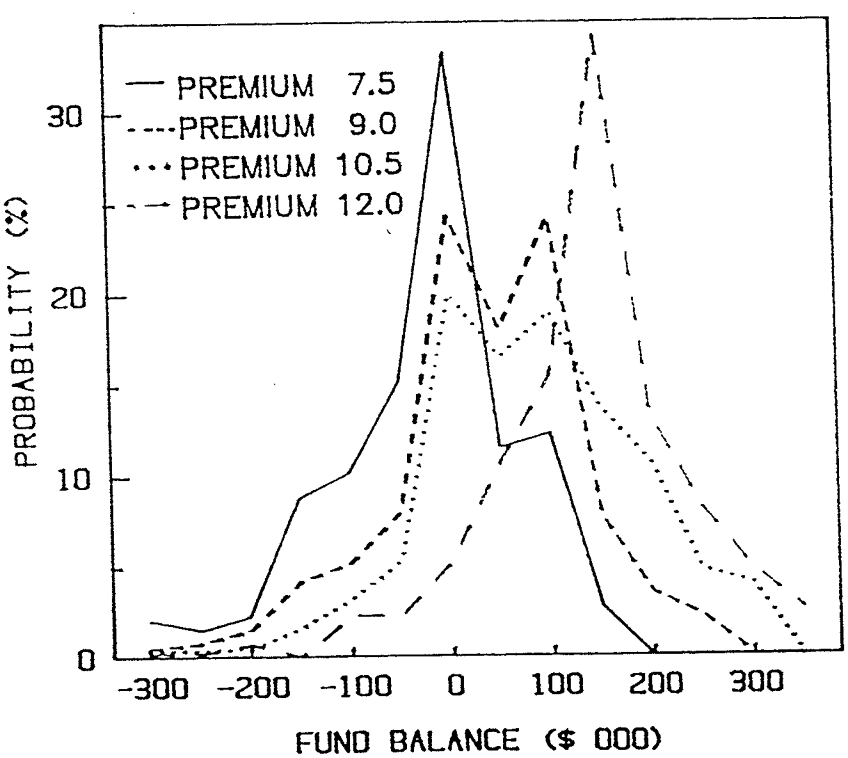

Figure B.16 Fund Balance with Premium Adjustments Year 10