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DISCUSSION PAPER NO. 360

A Review of the Economies of Farm Enterprise Size and Implications for Farm Diversification

by

William J. Brown

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RÉSUMÉ

La présente étude poursuit trois objectifs :

- résumer les résultats déjà publiés sur les économies de taille des exploitations agricoles;
- calculer le rendement net des exploitations céréalières et des entreprises d'élevage, ainsi que le rendement des actions et obligations; et
- estimer les gains ou pertes pouvant être réalisés par la diversification des exploitations agricoles spécialisées.

Plusieurs enquêtes ont révélé que la courbe de coût à long terme de la plupart des types d'entreprises agricoles affiche une configuration en L plutôt qu'en U. En conséquence, il n'y a ni augmentation ni diminution notable, à partir d'un certain "seuil" de taille, du coût unitaire de production. Voilà pourquoi les exploitations agricoles familiales dont la taille dépasse ce seuil peuvent envisager l'avenir avec confiance.

L'examen des ouvrages déjà publiés sur le sujet démontre que la taille "seuil" de l'entreprise de céréales et de l'entreprise de céréales et d'oléagineux varie en moyenne de 550 à 700 acres dans les régions de terre noire des Prairies, et de 830 à 1100 acres dans les régions de terre brune. Quant aux parcs d'engraissement de bovins, il faut songer à des troupeaux d'environ 1500 têtes; néanmoins, des études américaines ont démontré que les seuils devraient être beaucoup plus élevés et atteindre même 10 000 têtes. Cette dernière estimation paraît d'ailleurs plus réaliste. Pour un troupeau de vaches de boucherie, le seuil semble se situer entre 40 et 100 têtes. Bien qu'en ce cas les estimations soient plutôt confuses, les économies de taille deviennent plus évidentes avec des troupeaux de 200 à 500 têtes. Pour les entreprises d'élevage de porcs, dans la mesure où les données américaines sont applicables aux Prairies, le seuil est atteint avec une exploitation de 200 truies assurant un volume de ventes d'environ 3 000 têtes par année.

Il importe que les agriculteurs des Prairies qui veulent diversifier leur exploitation dépassent le seuil à partir duquel le coût unitaire se stabilise. Ce seuil peut certes varier d'une exploitation à l'autre, mais il semble que les investissements nécessaires pour y parvenir excèdent largement les sommes que les agriculteurs des Prairies peuvent ou souhaitent engager. Toutefois, en rassemblant leurs ressources, des groupes d'exploitants et d'autres investisseurs pourraient bénéficier d'économies de taille.

Pour la plupart des fermes, il sera peut-être impossible de parvenir à la taille et au degré de diversification optimaux. La création et le maintien de telles exploitations exigent des techniques de gestion et des capitaux que la plupart des agriculteurs n'ont pas à leur disposition. Il serait sans doute

préférable que les agriculteurs spécialisés envisagent des moyens de diversification à l'extérieur de leur exploitation. Cette diversification pourrait prendre la forme d'investissements en capital-actions, dans des titres de sociétés ouvertes, dans des obligations du gouvernement, dans divers types d'entreprises conjointes du secteur agricole, comme les parcs d'engraissement à façon pour grands troupeaux de bovins ou de porcins; il pourrait aussi être avantageux, dans d'autres cas, de simplement prendre un emploi à l'extérieur du secteur agricole durant les périodes creuses de l'année.

ABSTRACT

The objectives of this paper are threefold:

- to review the literature on the economies of the size of farm enterprises;
- to measure the net returns from typical crop and livestock enterprises, as well as from stocks and bonds; and
- to measure the gains or losses that could be realized from diversifying specialized farm operations.

Several investigators have found that the long-run cost curves of most farm types are L-shaped rather than U-shaped. This implies that unit costs of output neither decrease nor increase significantly beyond a certain "threshold" size. It is for this reason that family farms, larger than the threshold size, can be expected to persist well into the future.

A review of existing studies shows that the "threshold" enterprise size for grain and grain-oilseed enterprises ranged from roughly 550 to 700 acres on the black Prairie soil to 830 to 1,100 acres on the brown Prairie soil. The threshold-size of beef feed-lot operations appears to be in the neighbourhood of 1,500 steers although U.S. studies have shown significantly larger threshold sizes in the neighbourhood of 10,000 head of cattle. The latter estimate appears to be more credible. The threshold size for a beef-cow herd appears to be in the 40- to 100-cow range although the data are rather erratic in this instance and further economies are evident in the 200- to 500-cow range. To the extent that U.S. data can be applied to Prairie farms the threshold size for hog enterprises was around a 200-sow enterprise selling some 3,000 heads per year.

It is concluded that Prairie farmers need to go beyond the threshold size when they diversify. Although that size may vary from farm to farm it is recognized that it may well require a larger investment than most Prairie farmers are willing or able to raise. Groups of farmers and other investors, however, could take advantage of the economies of size if they pooled their resources.

Economically sized and diversified enterprises may not be feasible on the average farm. The management skills and capital required to successfully establish and maintain such a business would be substantial and beyond the ability of most farmers. It may well be better for specialized farmers to look for diversification off the farm. Such diversification may be in the form of investments in stocks, in public companies, government bonds, various forms of joint ventures related to agriculture, such as custom feeding in large cattle or hog operations, or simply off-farm employment during slack times of the year.

CONTENTS

FOREWORD

This is one of several studies on diversification of the agricultural sector in the Prairies -- one of the themes in the Economic Council's project on the Future of Prairie Agriculture. The Council published its recommendations based on the research for this project in 1988 in Handling the Risks: A Report on the Prairie Grain Economy.

Farms on the Canadian Prairie must be large enough to capture the cost economies so that Prairie farm families can make a reasonable living. At the same time there is a need to stabilize farm income. This study addresses the cost economies of enterprise size as well as the question whether diversification of Prairie crop farms into livestock or other investments, can improve the farmer's net returns and reduce the risk associated with instability of market prices and other factors.

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A Review of the Economies of Farm Enterprise Size and Implications For Farm Diversification

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I. INTRODUCTION

1.1 Economies of Size and Diversification

The economies of farm size and the question of farm specialization versus diversification are related and important issues facing farmers on the Canadian prairies. The size of individual farm enterprises must be large enough to capture economies specific to that type of enterprise, that is to say it must be large enough to lower the average total costs per unit so that a reasonable profit can be realized. In the past 20 years, in general, farms on the Canadian prairies have grown to take advantage of these economies of size and in the process have also specialized, mainly into grain production. The current downturn in grain prices has demonstrated that farms on the Canadian prairies are too specialized and are suffering a great deal.

Diversification in the context of this paper is defined as investing in at least two different assets or enterprises. If all the capital of a farm business manager is invested in one risky enterprise the rate of return realized is solely dependent on the net return generated by that enterprise. If the farm business manager invests in two non-identical enterprises, in order to get a low or negative return, both enterprises must have low or negative returns at the same time. Taken individually, both enterprises may be equally risky. However, depending on the correlation between the net returns, investment into both enterprises may reduce the risk over investing in either enterprise alone. The result is diversification can reduce risk. The diversification of prairie crop farms into livestock or other investments may help to improve net returns and reduce risk.

Diversification in the form of the mixed farm of 30 and 40 years ago, with several enterprises all of which would be too small by today's standards to realize any economies of size, will lower net returns as well as stabilize them. The mixed enterprise farm of 30 to 40 years ago has not survived today because the cost structure has changed in that capital has been substituted for the more expensive and scarce labor. The substitution of capital for labor has resulted in the cost structure of agricultural enterprises shifting from an emphasis on variable costs (labor) to an emphasis on fixed costs (capital). Farm business managers have had to spread the fixed costs over a larger number of units in order to maintain profits. This substitution has in many instances freed up some labour so that it could be invested profitably off the farm. Miller (1979) points out however that for the most part it is not decreasing costs that encourage farm size growth but rather larger incomes, which, as long as costs don't increase, translates into increased profits[1].

Economically sized and diversified enterprises may not be realizable on the average farm. The management skills and capital required to successfully establish and maintain such a business would be substantial and beyond the ability of most farmers. It may be better for specialized farms to look for diversification off the farm. Off-farm diversification may come in the form of investments in stocks in public companies, government bonds, various forms of joint ventures related to agriculture, such as custom feeding in large cattle feedlots or hog operations, or simply off-farm employment during slack times in specialized operations. The livestock investments should be large enough to take advantage of the economies of size but divisible into units that can be financed by the average farm business. Therefore these operations will most likely not take place on current crop farms but rather in other locations.

The policy implications of facilitating diversification of prairie crop farms are manifold. Governments need to encourage research into the economies of size of the various agricultural enterprises on the Canadian prairies in order to make certain uneconomically sized enterprises are not encouraged. Research along the lines of the current paper should also be encouraged to make sure that diversification reduces the risk faced by prairie farms without reducing income significantly. The management skills and education of farmers will have to be improved in order for them to handle investments into a range of enterprises, including bonds and securities. Finally, some form of capital will have to be made available to farmers that wish to diversify their investment portfolios, whether it be on or off the farm.

1.2 Objectives

The first objective of this study is to measure the cost and returns for various sized grain-oilseed, cow-calf, beef feedlot, hog farrowing and hog finishing operations. The approximate 'threshold' size at which the average total costs of production stop decreasing dramatically for each farm enterprise type is designated. This result indicates that investments into a particular farm enterprise smaller than the 'threshold' size may prove to be uneconomic or at the very least too small to realize economies of size.

The second objective is to measure the net returns from

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[1]The dynamics of farm growth also have a great deal to do with the eventual success or failure of a farm business. The year chosen to start or substantially expand a farm enterprise can dictate its degree of success.

investments in the above mentioned farm enterprises as well as off-farm investments in stocks and bonds and returns from off-farm employment over the period 1971 to 1987. These net returns are measured as a percentage net return on investment in both nominal and real terms. Net cash returns on investments are also measured in nominal terms. The correlation coefficients between the percentage net returns from the farm enterprises and the off farm investments are calculated.

The third objective is to measure the gains or losses, as indicated by increases in net returns and/or reduced variability of net income that could be realized from diversifying specialized farm operations. The diversification options include combinations or portfolios of grains, oilseeds, pulses and summerfallow in different fixed rotations over the time period in question. To these are added the net returns from cattle and hog enterprises as well as those from such off-farm investments as stocks in public companies, and government bonds. Note that the diversification into the various crops can occur on most typical specialized grain farms on the Canadian prairies. In fact, investment into public stocks and government bonds is currently an option open to those grain farmers with the financial means to do so. The investment into the cattle and hog operations however, requires that the size of these operations be large enough to take advantage of the economies of size. Therefore these investments may take the form of joint ventures, such as feeder associations with custom feeding in large cattle feedlots or cooperatively organized hog operations.

1.3 Off-farm Income and Part-time Farming

Off-farm income has become a more common form of income for farmers on the Canadian prairies. In 1971, 26 percent, 31 percent, and 34 percent of Saskatchewan, Manitoba and Alberta farmers respectively reported off-farm work (Statistics Canada). These percentages have grown to 32 percent, 35 percent, and 43 percent, respectively by 1986 (Statistics Canada). In addition, prairie farmers have devoted more time to off-farm work. In 1976, the average prairie farmer spent between 35 to 50 days working off the farm (Statistics Canada). By 1981, this figure had grown to between 48 and 70 days (Statistics Canada).

Off-farm income can be used to counteract any decrease in net farm income and is thereby an excellent form of diversification for crop farmers on the Canadian prairies. In the past off-farm income has contributed substantially to total farm family income, especially in times of low net farm income. In 1971, the only year for which such data is available and a low net farm income year, prairie farmers earned only 39 percent of their total income from net farm income, while 40 percent was earned from wages and salaries, and the rest from non-farm self employment, investment income, government transfers or other income (Davey et al.). If data were available for the rest of the 1970's, which were relatively high net farm income years, it would most likely have shown an increase in the contribution of net farm income to total income. However, if data from the 1986 census were available, it would probably show off-farm income's contribution to total income even higher.

The prevalence of off-farm work as a significant source of income for so many farm families on the Canadian prairies, and its excellent ability to diversify total family income make it a legitimate topic for any discussion of farm diversification. The ideal off-farm job should be within the local community to reduce time away from the farm business and family; would coincide with slack periods on the farm; would be consistent and reliable from one year to the next; and would pay a decent wage. Ideally the off-farm work should be based in an industry that is stable or at the very least counter cyclical to the agriculture industry. Thereby off-farm work will be available when needed the most, that is, in low net farm income years.

Consistent and substantial off-farm income and the continued substitution of capital for labor have changed the nature of many farm businesses. In many cases the owner, operator, and manager is no longer a full-time farmer, but rather a permanent part-time farmer. This phenomena may have serious repercussions for economies of farm enterprise size and diversification. Part-time farmers may wish to substitute their more expensive labor (opportunity cost) for even more capital (machinery) per acre than the average farmer. On the other hand 'threshold' enterprise size may not be as important if off-farm income can compensate net farm income. Part-time farmers may also not want to diversify because of increased time requirements and due to the fact they are already extremely well diversified (off-farm income). Clearly, many of the concepts discussed in this paper apply primarily to full-time farmers. However, as part-time farming becomes more prevalent, studies on economies of size, farm diversification, and the policy implications arising will have to include this important group.

II. ECONOMIES OF SIZE

2.1 The Relationship Between Long-run and Short-run Costs

In the short run, the farm manager has a fixed number of acres, buildings and equipment with which to work. The only way output can be expanded is by changing the amount of the variable inputs used. In the long-run all inputs are variable and the farm manager is able to change the size of the business.

Profits are maximized in the short-run at production levels where the marginal cost of producing the last unit of production is equal to the marginal revenue generated by that unit. If the price of the output rises or the costs of the inputs decline, the profit maximizing output level will increase. The desire to expand output in the short-run is usually a response to potential profit making situations or to take advantage of lower costs. The short-run output expansion may cause average total costs to increase. If cost efficiencies do occur, a larger farm will be in a better position to take advantage of them, and eventually lower costs and increase profits. Therefore, the size of the farm will increase in the long-run.

The long-run average total cost (LRAC) curve, also called the planning curve, resembles an envelope formed from all the short-run average total cost (SRATC) curves (Figure 1). It shows the different sizes of operation that could be implemented in the long-run when all resources are variable. The shape of this LRAC curve is of particular interest in this study. Figure 1 presents the classic U-shaped LRAC; Figure 2 presents the different types of LRAC curves that are possible. The LRAC curves depicted in Figure 2-C and D are most likely the shape of those facing the more common agricultural enterprises on the Canadian prairies. Figure 2-C depicts decreasing average costs (economies of size) at all output levels. Figure 2-D illustrates; significant cost economies (decreases in average costs) when the farm is very small; constant average costs over a rather wide range of output levels; and diseconomies (increases in average costs) only at very large output levels.

2.2 Economies of Size Studies

2.2.1 General Farm Types

Stanton (1978) endeavors to put the theory into perspective with regards to the structure of American agriculture. He concludes that there is definitely economies with respect to size when dealing with the American family farm. However these economies soon give way to diseconomies and that perhaps a more important determinant of farm size, rather than cost structure, is the control of risk and uncertainty with respect to production and financing. Other issues relating to farm size such as diversification and farmer socioeconomic characteristics are analyzed in Pope and Prescott (1980). Among other

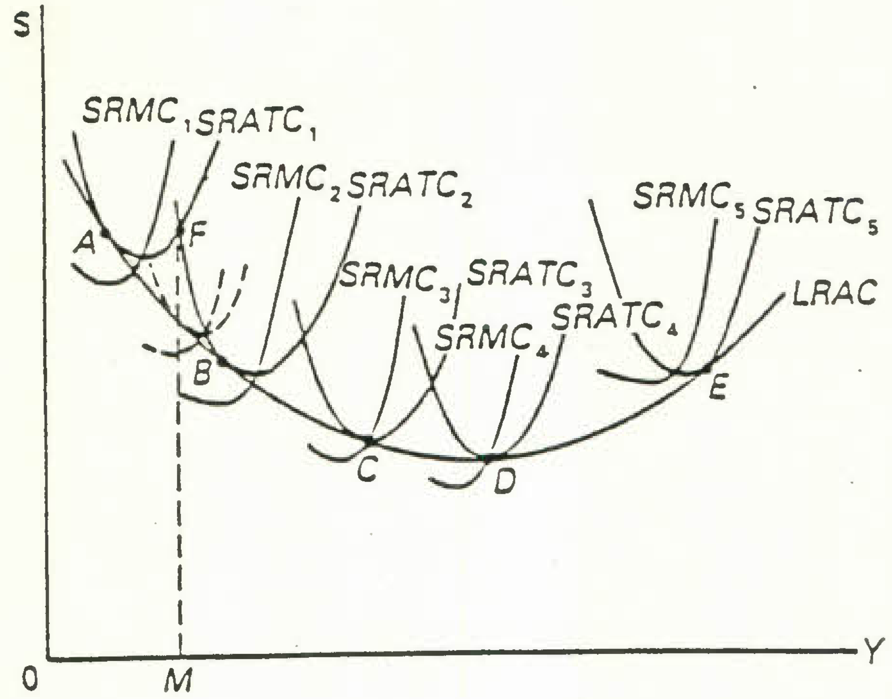

Figure 1: Long-run Average Cost for Several Farm Sizes.

Source: Doll, J.P. and F. Orazem. 1984. Production Economics: Theory with Applications. 2ed. Toronto, Ontario:John Wiley and Sons.

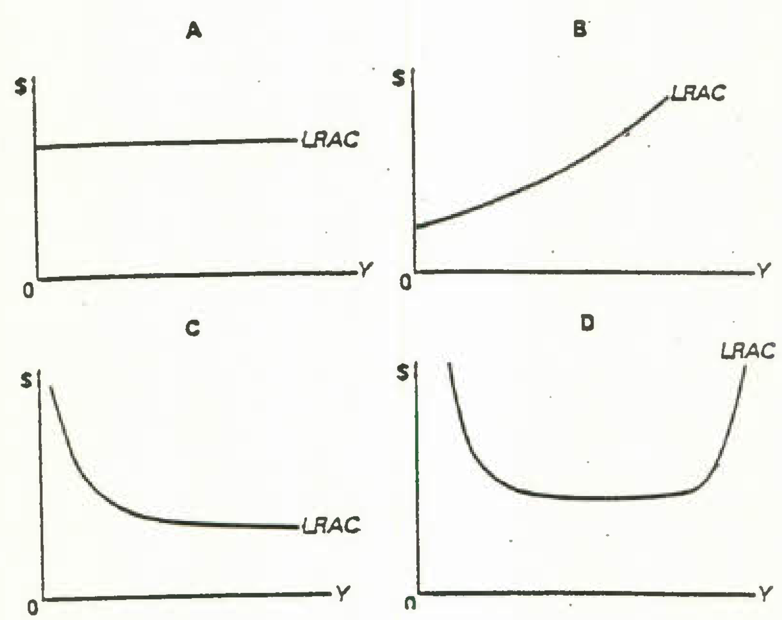

Figure 2: Different Types of Long-run Average Cost Curves.

Source: Doll, J.P. and F. Orazem. 1984. Production Economics: Theory with Applications. 2ed. Toronto, Ontario:John Wiley and Sons.

things they found a sample of California crop farms to be more diversified the larger they became and smaller poorly financed farms were more specialized. Both results are contrary to what theory would predict and what other studies have found (White and Irwin) and (Raup).

Anderson and Powell (1973), in a synopsis of U.S.A. work indicate that most LRAC curves are L-shaped rather than U-shaped. Relatively small farms can exploit most of the technological cost economies available to larger farms, meaning that LRAC curves tend to be horizontal over a wide range of output. The change in the U.S. is in the direction of larger farms while the number of smaller farms decline. With both output and costs of inputs measured in constant prices, this suggests that technological change has increased efficiency. Other factors such as differences in sample of farms between surveys and varying seasonal conditions could be very important. Overall, Anderson and Powell found that economies of size exist for small to medium-sized farms and that AC curves are nearly horizontal.

Hall and Le Veen (1978) discuss issues relating to the structure of agriculture and the survival of the family farm. They discuss the relationship between economic efficiency and farm size. Smaller farms may be able to survive, but they require more resources to do so; hence, there could be an efficiency cost. However, large farms generally have lower production costs. A relationship exists between farm size and economic efficiency either because there are economies of scale in the physical production function of the farm or because relative prices are such that cost savings result from increasing size. Hall and Le Veen found that the LRAC curve is L-shaped, meaning that production costs decline rapidly with initial increases in size and then decline slowly. Little evidence is found of increasing production costs for very large firms. In spite of higher production costs, small farms are still found to be economically viable. A wide range of farm sizes are found to produce at least enough income to cover all costs and the opportunity costs of capital.

Economies of size, whereby large farms reduce their costs by spreading fixed machinery and labour costs over more output and land, are evident. Economies of size in volume discounts for purchased inputs are thought to be significant for large farms. However, it cannot be determined if the cost savings is derived from lower input prices or from more efficient uses of the inputs. In either case, the cost advantages associated with purchased inputs did not contribute in any substantial way to the overall advantage of large farms. It is found that sales per acre for various kinds of crop production are higher and may be due to three reasons.

1. Large farms probably have greater access to high-quality resources. For example, large farms have relatively more irrigated land.

2. Large farms may produce more per acre because they are better managed.

3. Large farms may be able to sell more of their output because of greater market access and availability of premium prices for large volume producers.

However, improved marketing arrangements may help to offset the disadvantages experienced by the small farms but to a limited extent only.

Overall, Hall and Le Veen conclude that, while there is a significant technical basis for economies of size, other factors such as management, resource quality and the overall institutional structure are more important.

Stanton (1978) discusses three incentives for increased size.

1. More volume means greater income unless unit costs rise very rapidly.

2. Farm real estate has been a high return investment for the past forty years (the majority of this has been in capital gains).

3. Larger businesses mean labour saving equipment and a greater capacity to get things done on time.

He feels that no single system or distribution of size is best or optimal in all situations. Heady (1952) states that optimum size will differ between farms depending on the stock of labour and management possessed in the household of each. The continuance of the family farm as the main structure of agriculture suggests that if economies of size exists they soon give away to diseconomies. In addition, Miller et al. (1981) demonstrate that much of the gains from economies of size occur at relatively small sizes. Using 1978 data for the Northern Plains area of the U.S. they found that farms averaging 232 acres of cropland had 90 percent of the resource return rates of the most efficient farms that averaged 1,476 acres of cropland.

Ehrensaft (1983) concludes that an increase in the scale and degree of concentration in Canadian agriculture is associated with a trend towards new forms of farm enterprises. In 1971, a farm had to have $89,440 or more in sales to rank in the top one percent of Canadian farms. In 1981, the percentile limit for the top one percent had risen to $400,000. He feels that family farms still constitute the model form of farm enterprise for Canadian agriculture as a whole. However, the tendency is towards nontraditional forms at the upper end of the size distribution of structure.

Ehrensaft and Bollman (1986) forecast the future of the "traditional" family farm in the year 2000. They state that grain production will be dominated by family farms but a significant minority of production will come from very large, nonclassic specialized grain enterprises. They define nonclassical enterprise organization as being farms with two or more man-years of salaried labour, and/or farms organized as non-family corporations. However, some of the largest grain producers will be top animal production farms which are providing their own grain. Many mid-sized farms are likely to judge that the somewhat lower returns they receive still make it quite worthwhile to stay in farming.

They are confident that the family farm will still be an important part of the rural landscape by the year 2000. Very large agricultural enterprises, however, are here to stay. Given the high value placed on farming as a way of life, some family farms will struggle quite tenaciously to survive in agriculture, even if it means lower returns and higher risks compared to the larger farms.

An article by Trant (1986) discusses farm producers in the past and present. He states that between 1941 and 1981 average farm size continued to increase from 237 acres in 1941 to 463 acres in 1971. Small farms, hobby farms and farms used for recreation still exist even though farm size is continually increasing over the years. Small farms are a pervasive and persistent group and will probably always be with us (Buttel, 1980). With large farms getting larger, farm numbers decreasing and small farms continuing to persist despite high average total costs (ATC), it would seem that change would come at the expense of the middle-sized farms. Brinkman and Warley (1983) indicate that this is not the case, middle-sized farms appear to be a healthy persistent group of farms.

Since 1966, moderate to large-sized farms are responsible for a growing proportion of national production. The production gap between small and larger farms appears to be widening. It is apparent that small farms represent an ever increasing proportion of farms and a decreasing proportion of agricultural production. Large farms on the other hand, are increasing in size but decreasing in numbers with the decline particularly rapid among the very large members of the group. The moderate sized farms appear to be well established.

Trant concludes that large farms are becoming larger and producing an increasing proportion of agricultural products. He feels agricultural production is being concentrated among fewer, larger, more specialized operations. They are dependent upon purchased inputs, borrowed capital and are more integrated with the food, processing and distribution sectors.

2.2.2 The Beef Industry

Marshall (1969) discusses the size and structure of the livestock industry in Canada. Reconciliation of supply changes with demand shifts forces changes in marginal costs (MC) of production, as well as changes in Canada's competitive relationship with other countries. With respect to feedlot services, technological and organizational developments promote growth to a capacity subject only to the limit of economic restraints. In feeder cattle production; expansion creates increasing MC with respect to extending land areas to be used for cow-calf operations. It is noted that any increase in beef herd expansion is encountered by high land values.

Statistics Canada data is summarized by Ehrensaft (1987). He finds that average operating costs follow a curvilinear pattern as farm size increased for most major sectors. Costs are found to exceed gross farm sales for smaller farms and then decrease for mid-sized farms and then rise slowly for the largest farms. According to this view, most economies of size are achieved after a relatively modest threshold and then AC remain basically constant over a wide size range.

Between 1966 and 1981, average size of beef beeflots went from 312 to 725. The 33 farms with 1000+ steers in 1966 had six percent of the national herd while 93 farms with 1000+ steers had 14 percent of the herd and average gross farm sales of $3 million in 1981. Low levels of concentration in the beef cow herd (cow-calf enterprises) show no changes over the 1966 to 1981 period. The top one percent of farms with beef cows account for only 12 percent of the national herd, while mid-sized farms account for the majority, 58 percent, of the national beef cow herd. This proportion has been steady since 1966. In 1966, one needed 23 to 58 cows in an Upper Middle beef cow farm. In 1981, one needed 37 to 99 cows to remain in the same class. Even if relative shares of size classes remain steady, each farm will have to increase its real resources in order to retain the same relative ranking. Previous studies suggest that AC curves would either be L-shaped until one reached the largest size class, with some decline in AC for the 500+ cow herds; or one would observe a modest decline in costs as herd size increases.

Ehrensaft and Bollman (1986) also forecast the beef sector for the year 2000. They expect the final stages of feeding animals for meat production to be dominated by the previously defined nonclassic forms of enterprise organization. They also feel that family farms will not disappear from the sector. Some family farms will maintain a position in the sector, but technical conditions, transaction costs and tax structure tend to favour larger enterprises. Most of these larger enterprises are family farm units that expand to become semi-managerial or independent managerial farms. The minority are agribusiness firms that integrate agricultural production into their enterprise.

Finally, Doll and Orazem conclude the trend is toward fewer and bigger livestock enterprises. Also, a trend toward fewer and larger units in grass-fed cattle and calf operations is apparent, but the degree of change is not as extensive as for grain-fed cattle. Cow herd operations are more difficult to mechanize and automate than feedlots. One of the major problems facing feeders seems to be insufficient volume to effectively use livestock equipment and buildings.

2.2.3 The Hog Industry

Economies of size in the hog production industry in the U.S.A. are analyzed rather thoroughly by Van Arsdall and Nelson (1985). They find that large hog operations achieve economies of size over small hog operations. This is done through more intensive use of facilities, somewhat better feed conversion, lower feed costs and lower unit labour use. The economies of size are large enough that in a year of low returns, some small enterprises may fail to cover cash costs, whereas large enterprises cover all costs, including capital replacement. The large producers' advantage is less when only short run cash costs are considered. As the planning period lengthens, so does the large producers' advantage.

Performance varies among producers of all sizes. It is found that large producers fair significantly better on pigs farrowed and weaned per litter, litters farrowed and pigs weaned per female per year, death losses and feed conversion rates. They also perform better on four of the five price performance measures - prices received for hogs, prices paid for feeds, ration and labour costs. Performance varies significantly for all producers on total returns. It is noted that performance varies widely among hog producers of similar size but variability is greatest among small producers. Overall, however, large size of enterprise alone is no assurance of success.

According to Van Arsdall and Nelson, hog production is likely to continue to shift toward a smaller number of large, industrialized, and highly specialized operations, increasingly separate from crop production resulting in:

1. businesses associated with hogs will be affected during the shift toward larger hog enterprises in terms of the mix of labour, goods and services required by large rather than small producers.

2. closed, more concentrated operations should retard the introduction and spread of hog diseases.

3. alternative uses for manure will become important as hog production becomes increasingly separate from crops.

4. meat quality and consistency is likely to improve, while cost to consumers should decline.

5. larger firms will have less flexibility in output

contributing to sticky supply response.

Producers marketing more than 1000 hogs a year continue to gain shares in the major hog-producing regions. Large volume producers may gain economic advantage over small ones through two basic avenues. First, they may have the knowledge and ability to get more output from their physical resources. Secondly, prices may not be the same for everyone. That is, larger producers may use less costly inputs or get discounts because they buy large quantities.

As the operations increase from small to large, unit investments change in steps, decrease for a time, then increase before continuing to decline as size of enterprise grows. The unit investments drop as the size of hog operations increase because of a number of factors, mostly pertaining to size. The investment components are more important to large operations. Evidence also suggests that large producers likely produce higher quality slaughter hogs than do small ones. For example, packers know high quality from reputation and past receipts, so hogs are not graded on a regular basis.

Farrow-to-finish producers with large enterprises achieved sizeable economic advantages over small enterprises in 1980, 1982 and 1983. Large operations' advantage increases over small in terms of cost vs. income when a charge or return is allocated to unpaid labour.

Despite considerable variations among farms, average performance consistently improves as size of hog operations increase. Overall, evidence from this study indicates a continued restructuring of the hog industry to fewer, larger and more specialized operations.

Trant (1986) shows a drop of 65 percent in the number of farms reporting pigs. The number of farms declined 154,528 in 1966 to 55,765 in 1981. The amount of pig numbers almost doubled from 5.4 million in 1966 to 9.9 million in 1981. Also, the concentration of production is increasing in the hog sector. In 1966, 90 percent of pigs were produced by 29 percent of the farms reporting pigs, but by 1981 this production was concentrated among 18 percent of the farm operations reporting pigs. Thus, Trant concludes that medium to large enterprises will continue to evolve as the dominant size in hog operations.

Wilson and Eidman (1985) discuss dominant enterprise size of the swine production industry in the U.S. They feel that the size of hog operations are determined by the geographic location of the production unit and the risk attitudes of the producer. The principal structural determinants of the hog production industry are technological change, favorable price ratios (both product and input), labour availability and urban encroachment.

Their research indicates that the pattern of dominance across enterprise size is consistent within several geographic locations. The risk-averse individual prefers smaller swine operations while risk-loving agents select larger enterprises. Generally, the larger operations expose the risk-averse individual to high levels of variability which he is not willing to accept. Large enterprises are more dominant for risk-loving individuals but lose their dominance as agents become more risk averse. A more risk-averse decision maker prefers the distribution with less variance and a small probability of obtaining high or low income levels.

Wilson and Eidman conclude that as swine production becomes more effective at risk management, medium to large enterprises will continue to evolve as the dominant enterprise size in the hog industry. The medium-sized operations are quite competitive with the larger operations and in little danger of being forced out of business.

2.3 Conceptual Issues in Economies of Size Studies

There are three major conceptual issues that have to be raised when dealing with economies of size studies (Miller, 1983). These issues are relevant because the traditional assumptions used in each case; 1) predetermine the results of the analysis, and 2) cover up the need for research on the true underlying issues. The three issues are: a) How does the cost of operator labor affect economies of size? b) Should the cost of land and of differential land rents, be calculated or left as a residual? and c) How are the benefits of improved technology, and thereby economies of size, shared in society?

2.3.1 Operator Labor and Economies of Size

The two most common procedures for evaluating operator labor is to either assume the same total annual labor and management reward for all sizes of farms, or that the opportunity cost per hour for labor is the same for all farms. There is nothing wrong with these assumptions when considered on an individual basis. It is evident that the use of larger machinery will lower per unit labor costs if the farm operator is charging the same annual or hourly rate for his labor. However, if the economies of size study is to be used in policy analysis where these efficiencies are translated to industry efficiencies with respect to farm size, caution should be exercised. Opportunity labor costs change between types of farms, farm operators and machinery used. Leisure or hobby farmers, that is those farmers not in farming to generate a profit, may have no opportunity labor costs. Many part-time farmers, the most rapidly growing sector of the agricultural industry, may be facing very large opportunity costs for their time. The larger more sophisticated machinery may require more technically proficient operators thereby raising labor costs. Miller concludes that it is better to omit operator labor costs from aggregate empirical estimates of economies of size used in policy making because it is better to assume that the physical labor efficiency gained by increased size is offset by increased labor costs per unit of measurement. Therefore studies that include a single opportunity cost for operator labor may actually have less severe economies of size, that is LRAC curves are less negatively sloped at small sizes, than they depict. The 'threshold' size may then be more of a range of sizes than a particular size.

2.3.2 Land Costs and Economies of Size

The cost associated with land is very difficult to measure accurately, and whether or not it is included in economies of size studies affects the level and slope of the LRAC curve and thereby the 'threshold' size. Miller argues that if land is unlimited, or can be bid away by other uses, its opportunity cost should be included in the analysis. Industry studies such as the wheat industry or the cattle industry fall into this category. Land could conceivably be taken out of grain production and used to produce beef, therefore the opportunity cost associated with beef production should be used in the grain study. Studies that deal with a limited supply of land, such as the supply of irrigable land in a district or the assumption that the long-run supply of land is fixed should treat its costs as the residual claimant. Finally, differential land rents may negate other technical cost efficiencies in that small farms may have lower rents because of intangible returns to farming.

2.3.3 Technological Benefits and Economies of Size

The policy implications of economies of size research in agriculture include the measure of who benefits and losses from technological improvements that lower the LRAC, or environmental restrictions that reduce production efficiency (Miller). The degree to which landowners, farm operators, and the rest of society share in the benefits of new technology depends on whether or not the supply of land in the study was assumed to be fixed. A study in which the supply of land is not fixed and its opportunity cost can be computed, assumes the benefits of lower LRAC will be passed onto the rest of society and landowners and farm operators will be no worse off. Studies that calculate a residual to land assume the benefits of a lower LRAC will be captured entirely by landowners through higher land values. The underlying assumptions of the study need to be known before policy implications can be made from the results.

2.4 The Threshold Enterprise Size on the Canadian Prairies

The current study is not interested in the long-run least cost size of the various agricultural enterprises being investigated. Rather, it is the approximate size at which the LRAC curve ceases to decline as rapidly as it does at smaller sizes. The approximate enterprise size at this point is labelled the 'threshold' size. Enterprises smaller than this size experience severe diseconomies and are most likely unprofitable. Enterprises larger than this size may experience lower costs but most of the economies of size are captured in the 'threshold' size. The 'threshold' size is by no means fixed from farm to farm and can vary a great deal depending on a number of factors, not the least of which is management ability.

Ehrensaft (1987) has analyzed the National Farm Survey data from 1983. The costs used in this study did not include an estimate for farm labor, nor an opportunity cost for land. Figure 3 demonstrates that the 'threshold' farm size for all types of farms in the Canadian Wheat Board (CWB) region is around the 75th percentile or $56,000 of gross sales. Since all types of farms are included it is difficult to translate the gross sales to number of acres or head of livestock. However, this could be interpreted that a full 75 percent of farms in the CWB region are smaller than the 'threshold' size but not necessarily experiencing negative net incomes. Upon close examination of Figure 3 and the other Figures up to and including Figure 8, it can be seen that as much as 25 to 30 percent of some farm types have total costs/sales ratios of greater than one thereby indicating negative net incomes. How do these farms survive with negative incomes? Undoubtedly many don't. Others farms don't cover depreciation costs and thereby don't replace machinery, but continue to produce with old machinery. Still others may have off-farm income. Finally, some farms may have had negative incomes in the year the data was gathered but had positive incomes in other years and are thereby surviving on savings.

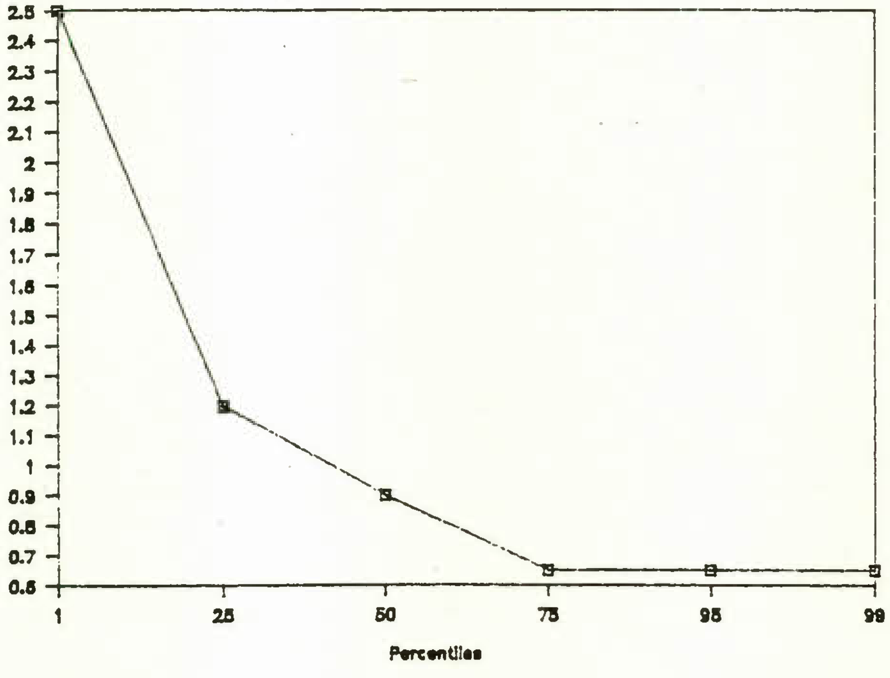

Figure 3: Total Costs/Sales Ratio: All Farm Types, CWB Region, 1983

2.4.1 The Grain-Oilseed Industry

Ehrensaft calculates the 'threshold' size for wheat, coarse grains and oilseed farms in the CWB region to be around the 75 percentile or $56,000 of gross farm sales in 1983 (Figures 4, 5 and 6). A grain farm in the black soil zone of the Canadian prairies following a 1/3 fallow 2/3 canola-wheat rotation with a canola on fallow yield of .476 tonnes/acre and price of $384.00 per tonne and a wheat on stubble yield of .68 tonnes per acre and price of $173.10 per tonne in 1983 would generate the 'threshold' total revenue with 559.1 cultivated acres.[2] Similarly, a grain farm in the brown soil zone of the Canadian prairies following a 1/2 fallow 1/2 wheat rotation with a fallow wheat yield of .68 tonnes per acre would generate the 'threshold' total revenue with 951.5 cultivated acres.

Statistics Canada and Canfarm data have also been summarized for grain farms in Saskatchewan (Jensen) and (Fleming and Uhm). The Jensen study included a charge of $4.00 per hour for operator labor and calculated the residual as a return to land. Therefore, the LRAC curve calculated will be steeper and the diseconomies associated with sizes smaller than the 'threshold' size more severe. The 'threshold' farm size in the Jensen study appears to be around a total revenue figure of $50,000 in 1977. A grain farm in the black soil zone of the Canadian prairies following a 1/3 fallow 2/3 canola-wheat rotation with a canola on fallow yield of .635 tonnes/acre and price of $285.73

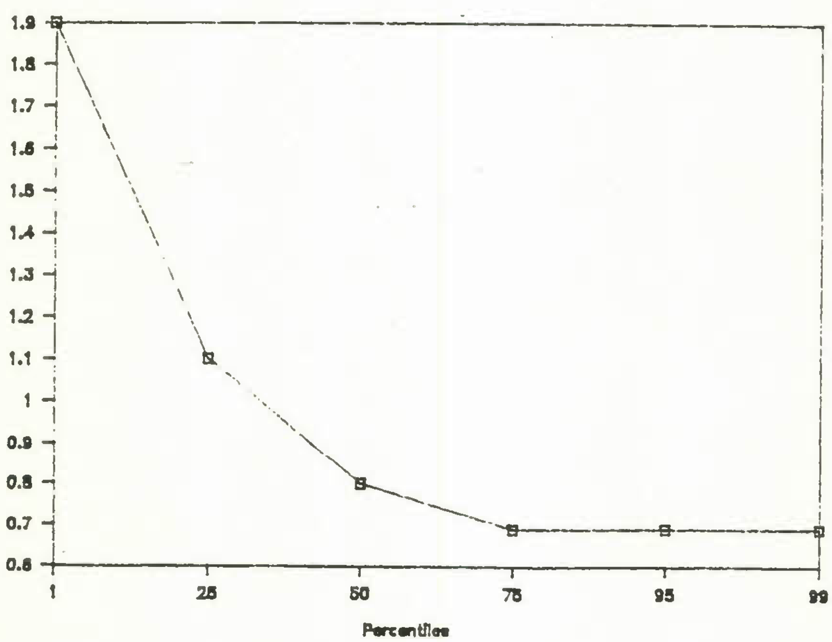

Figure 4: Total Costs/Sales Ratio: Wheat Farms, CWB Region, 1983

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[2] Yields and prices from Brown and Forsberg.

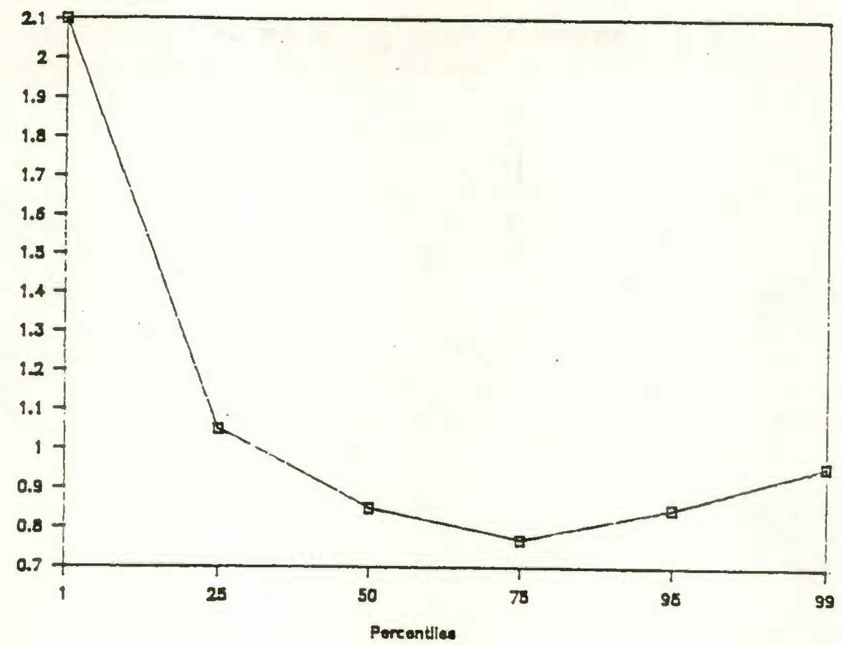

Figure 5: Total Costs/Sales Ratio: Coarse Grain Farms, CWB Region, 1983

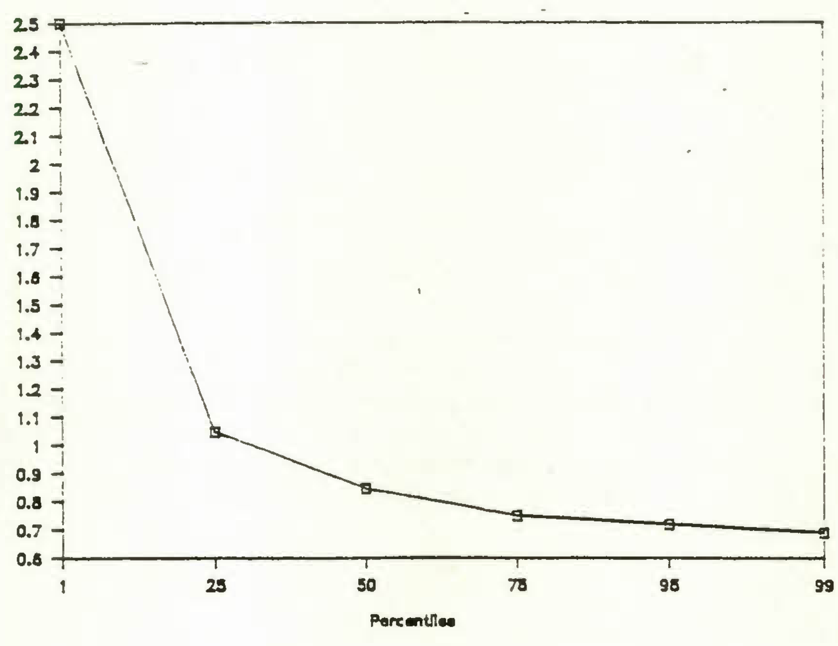

Figure 6: Total Costs/Sales Ratio: Oilseed Farms, CWB Region, 1983

per tonne and a wheat on stubble yield of .871 tonnes per acre and price of $106.57 per tonne in 1977 would generate the 'threshold' total revenue with 546.9 cultivated acres. Similarly, a grain farm in the brown soil zone of the Canadian prairies following a 1/2 fallow 1/2 wheat rotation with a fallow wheat yield of .844 tonnes per acre would generate the 'threshold' total revenue with 1,111.8 cultivated acres. Applying a similar argument to the 1977 Canfarm data used by Fleming and Uhm whose 'threshold' total production level is around 350 tonnes produced would result in a 697.2 cultivated acre farm in the black soil zone and a 829.4 cultivated acre farm in the brown soil zone. Fleming and Uhm did not include an allowance for operator labor nor a residual cost for land. Therefore the LRAC curve should be lower and less sloped and the diseconomies associated with sizes smaller than the 'threshold' size less severe.

Miller et al. (1981) studied the economies of size in field crop farming for several regions of the U.S. The study analyzed the data from all three perspectives outlined above, that is:

1. The exclusion of both opportunity operator labor costs and land rent.

2. The exclusion of only land rent as a cost.

3. The inclusion of both opportunity operator labor costs and land rent.

The 'threshold' size for the Northern Plains region did not change significantly by method of calculation and was as small a 232 acres of cropland, which is significantly smaller than that described in the Canadian studies. Miller et al. (1981) show very little additional gains, (as stated earlier, only 10 percent), from increasing the size to 1,476 acres of cropland.

The resulting 'threshold' size from the above Canadian studies range between 546 to 697 cultivated acres in the black soil zone and between 829 and 1,111 cultivated acres for the brown soil zone. The studies consistently designate larger farms in the brown soil zone than those in the black soil zone. Unfortunately they do not predict the evident trend to larger farms, but perhaps this trend is slowing somewhat. The 'threshold' sizes may also seem rather small, but it must be remembered that these are not the least cost size of farms. In fact the literature would indicate that there are still economies, or at least higher volumes of income to be gained by larger sizes. What is important to remember here is that investments into grain and oilseed farms significantly smaller than these 'threshold' sizes may well be uneconomic.

2.4.2 The Beef Industry

The National Farm Survey done by Statistics Canada in 1986 has been summarized by Ehrensaft (1987). The 'threshold' size of beef feedlot in the CWB region appears to be in the neighborhood of 1500+ steers (Figure 7). The average cost curve is almost horizontal but economies are evident at the larger sized feedlots. U.S. studies with respect to beef feeding have also been summarized (Carter and Schmitz) and have found significantly larger 'threshold' sizes in the neighborhood of 10,000 head. It would appear the U.S. data with respect to cattle feeding are more credible because Statistics Canada does not breakdown herd sizes larger than 1,500 head. The 'threshold' size for the beef cow herd in Canada as a whole appears to be in the 37-99 cow range however the data is rather erratic and further economies are evident in the 200-499 cow range (Figure 8).

2.4.3 The Hog Industry

To the extent that U.S. data and conditions can be translated to Western Canada, a 'threshold' size in 1983 for a hog farrowing operation and a hog finishing operation was around 3,000 head sold per year in each enterprise. Given a weaning rate of 15 pigs/sow/year the hog farrowing operation would equal a 200 sow enterprise. Costs continued to decline as size increased up to the maximum measured 10,000 head sold per year in 1983 (Van Arsdall and Nelson).

2.5 Linkages Between Economies of Size and Diversification

Pope and Prescott (1980) state that the relationship between farm size and diversification is an indicator of tradeoffs between risk reduction and possible economies of size in a particular activity. That is, if there are substantial economies of size in a particular activity, one clearly gives up a large expected return in order to insure against risk through diversification. A basic theorem is that if returns in activities are independently and identically distributed, then diversification is optimal with equal proportions in each activity. Thus, diversification is likely to be optimal for a risk averter. However, large disparities in average returns or resource constraints may provide incentives for specialization. Other variables that may affect diversification choices are: net worth, experience of the farm operator, form of ownership (i.e. family farm, corporation) and variables which delineate geographical location and the extent of irrigation, etc.

There is a strong indicator of a positive relationship between diversification and size. Also, there is a negative relationship between diversification and measures of financial "well-being". A farm diversifies to spread risk and wealthier farmers have fewer incentives to spread risk. Finally, farmer experience or age tends to exhibit a positive effect on diversification. That is, younger or less experienced farmers are less diversified. Pope and Prescott go on to speculate that younger farmers may be less risk averse, or they may start small and specialize and diversify later, or this may be

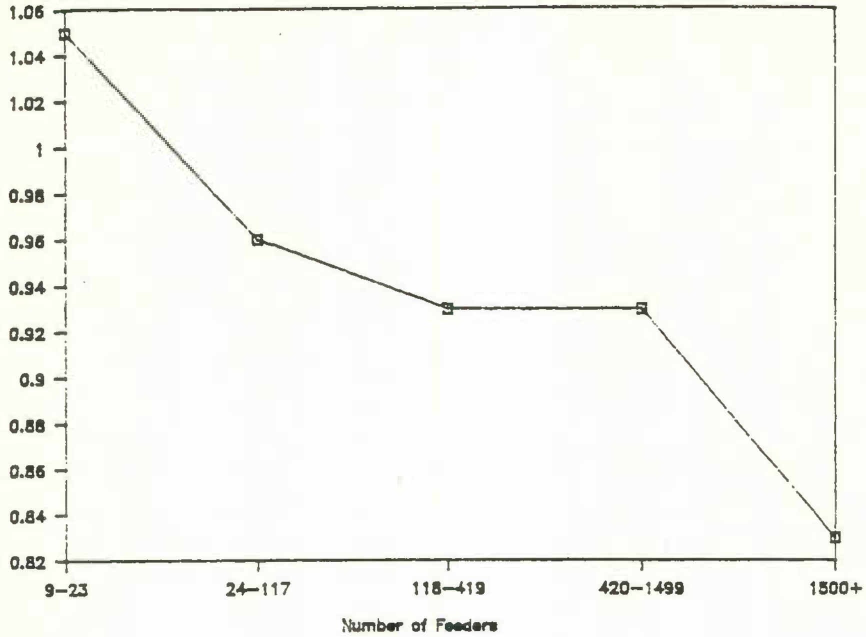

Figure 7: Total Costs/Sales Ratio: All Beef Types, Canada, 1986

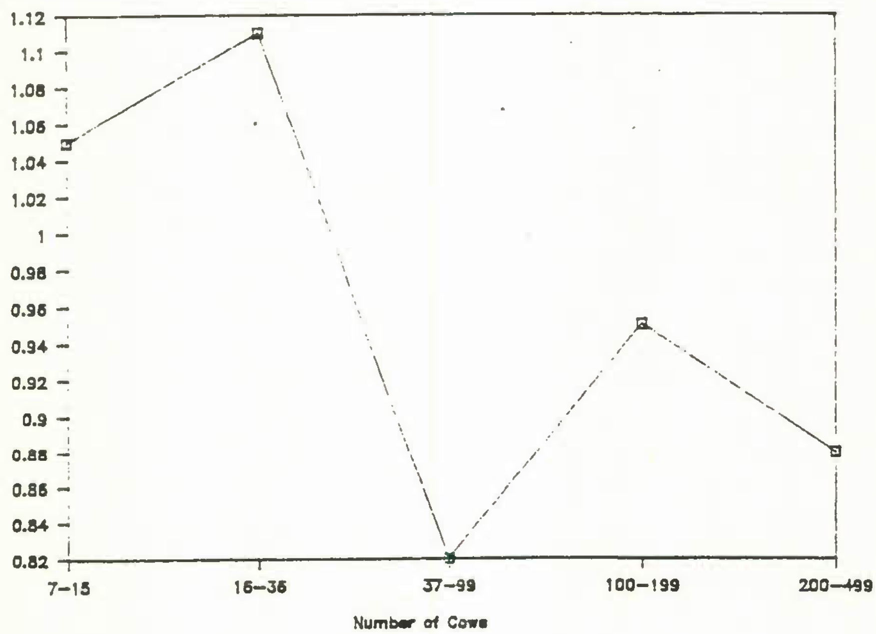

Figure 8: Total Costs/Sales Ratio: Cow-Calf Enterprises, Canada, 1986

indicative of capital shortages for younger farmers, or finally, it may be difficult for less experienced farmers to manage diverse activities. Pope and Prescott's discussion would seem to indicate that policies promoting diversification may have less impact among younger less experienced farmers.

III. GAINS AND LOSSES FROM DIVERSIFICATION

3.1 Theoretical Background

3.1.1 Mean-Standard Deviation Trade-off

The analysis of farm level decisions under risk has been prominent in the agricultural economics literature of the last 20 years. Within this category decision theory has dominated. It suggests that the maximization of satisfaction or utility is the appropriate criterion upon which to make decisions under risk. The expected utility model (EUM) became the basis for much decision analysis under risk despite operational problems with its practical application (Barry, p. 68).

Several decision criteria have been developed to overcome some of the shortcomings of the single valued utility function (Boehlje and Eidman). First there are criteria that do not require probability estimates: maximin, maximax and principle of insufficient reason criteria. Second, there are criteria that require probability estimates: maximizing expected monetary value and safety-first. Finally, there are efficiency criteria that consider the trade-off between the expected net return and the dispersion of the net return. These criteria provide an ordering of alternatives given specified restrictions on the decisions maker's preferences and the probability distributions of the net returns. As such, these efficiency criteria can be used to eliminate some alternatives without requiring detailed information about the decision maker's utility function.

The most commonly used efficiency criterion is the mean-variance or mean-standard deviation trade-off. When dealing with net income, those alternatives exhibiting the lowest standard deviation of net income for given levels of expected net income, or conversely the maximum level of expected net income for given levels of standard deviation of net income, are said to be on the risk efficiency frontier of risk neutral and risk averse decision makers. The mean-standard deviation trade-off has both strengths and weaknesses. It is an effective means of summarizing data and identifying alternatives having the greatest expected value for a variable for a given level of standard deviation of that same variable. However, in order for it to be technically correct the net income must be normally distributed or the decision maker's utility must only be a function of mean (expected net income) and standard deviation (variation of expected income). Distributions of alternative net income exhibiting skewness and higher moments are common in agricultural situations (Barry, p. 73). The risk averse decision maker may choose an alternative that is not on the risk efficiency frontier when these additional characteristics of the distribution of outcomes are considered. Therefore, efficiency criteria that consider the total distribution of outcomes rather than one or two summary statistics may be preferred. Stochastic efficiency is such a criteria, but is beyond the scope of this paper. A more in depth discussion of stochastic efficiency can be seen in Brown (1987), Barry, Anderson et al., and Zentner et al.

3.1.2 Portfolio Risk and Diversification

Diversification means investing in at least two enterprises or activities that differ. The rate of return for the resulting portfolio is the weighted average of the returns from the individual enterprises included in it. The total risk of the portfolio depends on the standard deviations and correlations of the individual enterprises included in it. The standard deviation measures the uncertainty as to returns on an individual enterprise or portfolio of enterprises. The correlation coefficient measures the degree to which the returns of one enterprise vary with the returns of another. Diversification reduces risk if the returns from the various enterprises within a portfolio are not highly correlated.

The following example illustrates how diversification affects risk. Take two enterprises, A and C, both have average returns of 20 percent and standard deviations of returns of 22 percent. If the variation of the returns for the two enterprises was perfectly positively correlated, that is, a correlation coefficient of +1.0, any combination or portfolio of the two enterprises would also have an average return of 20 percent and a standard deviation of returns of 22 percent. However, if the variation of returns for the two enterprises was perfectly negatively correlated, that is, a correlation coefficient of -1.0, any combination or portfolio of the two enterprises would also have an average return of 20 percent and a standard deviation of returns of 0 percent. The standard deviation of the portfolio of A and C for all possible values of the correlation coefficient is shown in Figure 9.

There is a limit to the amount of risk reduction that can take place in any portfolio. Only the nonsystematic risk can be diversified away. Systematic risk, that is the risk associated with the market portfolio cannot be diversified away by investing in enterprises from within the market. In addition, it is difficult to find enterprises with negative correlations, especially within the same industry. However, Schall et al. point out that portfolio risk is reduced, even when the enterprises are positively correlated (+.5) by increasing the number of enterprises (Figure 10). In addition, it does not take a great deal of diversification to receive most of the benefits. Investing in more than 10 enterprises reduces risk only slightly (Figure 11). The only risk remaining in a well diversified portfolio is the market or systematic risk. Therefore, the returns from a well diversified portfolio are highly correlated (close to 1.0) with the entire market.

Turvey and Driver conclude that the opportunities for diversification within agriculture are limited. In order for farmers to reduce the amount of systematic risk in their market portfolio, that is the agriculture portfolio, they must make off-farm investments such

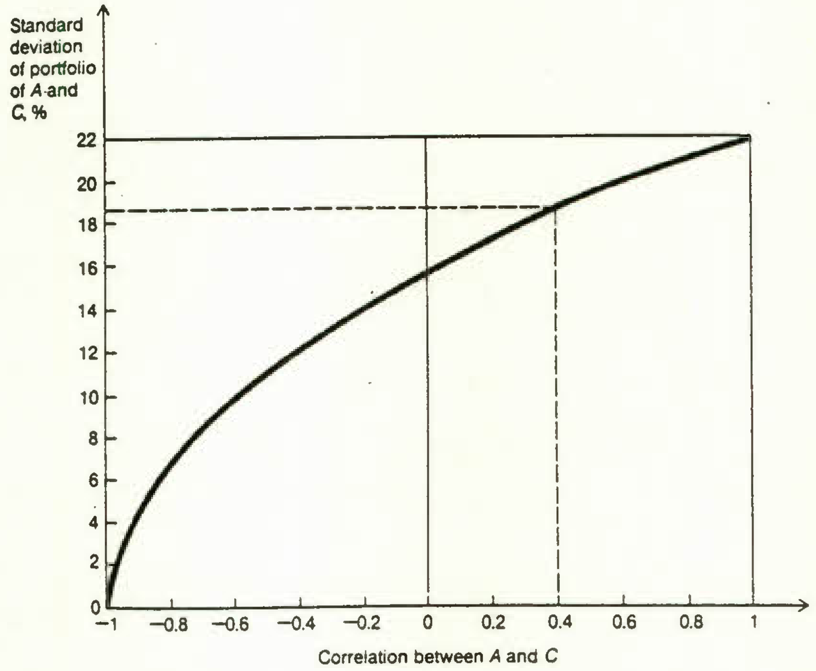

Figure 9: Portfolio Standard Deviation For Different Correlation Coefficients Between Enterprises.

Source: Schall et al., Introduction to Financial Management, 1987.

as securities. By moving outside the agriculture portfolio to a general market portfolio the systematic risk within agriculture becomes nonsystematic risk in the general market portfolio. The advantages of off-farm investments is that they have low correlations with the farm sector and can be used to reduce the now nonsystematic risk to zero through diversification. In addition, the liquidity of the capital markets allows for greater flexibility in transferring capital between farm and off-farm uses.

3.1.3 The Capital Asset Pricing Model (CAPM)

The underlying assumptions of CAPM as outlined in Schall et al. (1987) are as follows:

1. The investor is concerned only with the return over a single period.
2. The investor has a specific amount of money to invest.
3. The investor likes high expected portfolio return and low standard deviation of portfolio return.
4. The investor has estimates of the expected rates of return and

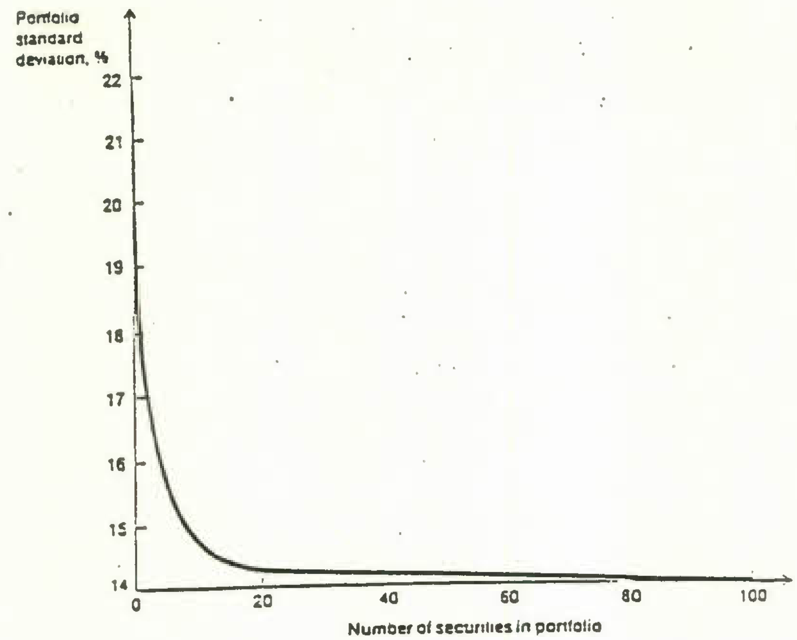

FIGURE 10: Impact on Portfolio Standard Deviation of Diversification Among Positively Correlated Securities (Correlation Coefficient = +.5)
Source: Schall et al., Introduction to Financial Management, 1987

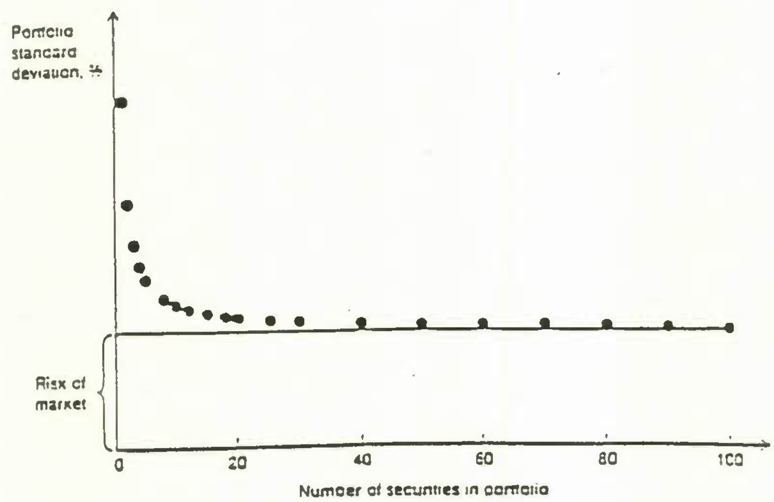

FIGURE 11: Impact on Portfolio Standard Deviation of Random Diversification
Source: Schall et al., Introduction to Financial Management, 1987

the standard deviations from all portfolios of risky assets.

5. The investor is able to borrow or lend at the same (risk-free) rate of interest.

6. Securities are bought and sold in a highly competitive market with no transaction costs (such as brokerage fees).

7. All investors have the same expectations regarding the future returns from owning securities (same expected rates of return and standard deviations for all portfolios).

8. Taxes do not bias investors in favour of one investment over another.

The underlying assumptions of CAPM hold for the current study. Assumption number 1 holds in that the current study can only estimate what investors should do now based on the data used, as time goes on the data will change. Assumption number 2 holds in that the current study assumes investments will be made into agricultural enterprises of 'threshold' size. Due to the magnitude of these 'threshold' sizes these will most likely have to be joint ventures or cooperatives where entrances shares can be standardized between enterprises. Assumptions number 3 and 4 hold in that number 3 is a basic assumption underlying the current study and the means and standard deviations mentioned in number 4 has been calculated. Assumption number 5 holds for the current study because it is assumed that investors can enter any enterprise analyzed without any kind of capital constraints. In reality this may not be true especially with regards to the magnitude of 'threshold' enterprise sizes. However, as stated above, joint ventures or cooperatives will most likely have to be formed to overcome capital constraints. Assumption number 6 with regards to a competitive market and no transaction costs is somewhat tenuous when dealing with agricultural land but is probably no worse than market securities when dealing with the livestock enterprises, especially if they are part of joint ventures or cooperatives. Assumptions number 7 and 8 with regards to future expectations and taxes also hold for the current study.

Schall et al. point out that the CAPM assumes that properly priced securities or enterprises should provide an expected rate of return equal to the rate of interest on riskless securities (government treasury bills) plus a premium for bearing risk. The risk is measured by the enterprise's beta. The enterprise's beta is equal to the security's correlation coefficient with the market portfolio (eg. Toronto Stock Exchange (TSE) Index 300) times it's standard deviation all divided by the market portfolio's standard deviation. The beta for the market itself is 1.0, as implied by the definition of beta. Therefore a beta of 1.0 indicates that the expected rate of return on the enterprise is the expected rate of return on the market. Enterprises with low or negative correlations of returns to the market will have low or negative betas and visa versa. The 'security market line' represents the linear relationship between an enterprise's beta and the expected rate of return on that enterprise, that is, the current risk-return trade-off in the market (Figure 12). If an enterprise's beta is high, it indicates that the enterprise is

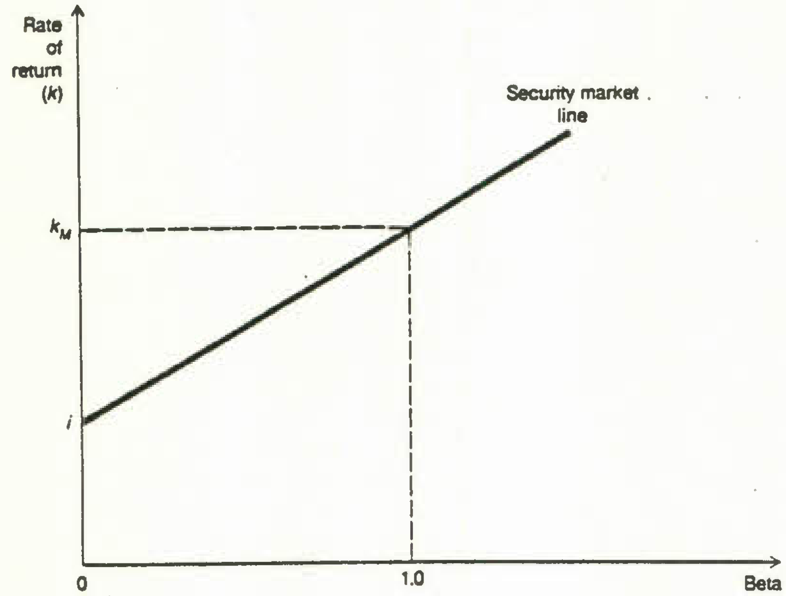

Figure 12: The Security Market Line

associated with high risk. The security market line indicates what rate of return is needed to compensate the investor for this increased risk. If the rate of return does not meet this rate, investors won't invest until the risk is reduced or the rate is increased. If an enterprise's beta is 0 or less than 0 it indicates that the enterprise is associated with low risk. However, if the rate of return is consistently below the risk free rate of return (ie. the rate of return when beta is 0) investors will not invest (they can do better with government treasury bills and have no risk) until the investment cost in the enterprise is reduced and the rate of return increased.

Turvey and Driver used a similar approach to analyze various agricultural enterprises in Ontario. However, they use cash rent for land as their risk free asset and create a 'farm sector portfolio' rather than using the TSE 300 as the market portfolio. Therefore their betas measure the relative risks of various enterprises within Ontario agriculture, whereas the betas calculated here measure the relative risk of various enterprises as compared to investing in the stock market.

IV. THE DATA

4.1 Crop Rotation Net Returns

4.1.1 Crop Gross Margins

Gross margins from 1971 to 1987 were calculated for the fallow enterprise (that is, the cost of fallowing) and for the following crops, on both fallow and stubble, for the dark brown soil zone; spring wheat, barley, oats, fall rye, flax, canola, peas and lentils. (See Brown and Forsberg 1987 for more detail on data construction).

The first component in a crop gross margin is output price. Farm price was used for all crops other than spring wheat. The spring wheat price is calculated as follows: the initial payment received each year from the Canadian Wheat Board (CWB) for #1, 2, 3, and Feed grades of red spring wheat were reduced by charges for transportation to the terminal point, country elevation, and removal of dockage for each year. The final payment received from the CWB for each grade each year was added to the adjusted initial price for the following year to account for the time lag in final payments. This adjusted price received by farmers for each spring wheat grade was further adjusted to reflect the percentage of each grade marketed. The percentage of grade marketings are taken from crop district No. 6 in Saskatchewan, which is in the dark brown soil zone (Ulrich and Furtan). The final result is a weighted farm price received for spring wheat.

The second component in calculating a crop gross margin is yield. Yield data for the crops on both fallow and stubble were based on Saskatchewan Crop Insurance Corporation (SCIC) risk area No. 12, which is in the dark brown soil zone. Note that the dark brown soil zone occurs in both central Saskatchewan and central Alberta. Separate fallow and stubble yield data for 1971 and 1972 were not available, so the average yield for those years was adjusted by the relationship between fallow and stubble yields established through 1973 to 1987. Lentil and pea yields were supplemented by information from the Saskatchewan Agriculture Specialty Crop Reports (Saskatchewan Agriculture 1980-1984).

The final component needed in the calculation of crop gross margins are the direct cash costs which are subtracted from gross income. Direct cash costs were assumed to be the direct operating costs of machinery power and repair and crop materials. These were obtained from Schoney (1985, 1986, 1987), based on the detailed costs from some 60 to 120 farmers from Saskatchewan. Although this is not a random sample it is the best estimate of actual production costs presently available in published form. Note also that the data used is all from the dark brown soil zone of Saskatchewan, however, cost comparisons with Alberta show larger variation within provinces but across soil zones than across provinces but within soil zones (Alberta

Agriculture).[3]

Fallow and stubble cash costs were not available for all crops. Procedures used to estimate these costs are outlined in Brown and Forsberg (1987). The 1985 cash costs were deflated for the period 1971 to 1984 using an index based on the amount expended each year in Saskatchewan on: petroleum, diesel oil and lubricants (machinery power and repair), and fertilizer and other crop expenses (crop materials) (Saskatchewan Agriculture 1986). This index represents inflationary price trends and the shift in agricultural technology between 1971 and 1985 and allows for increased use of fertilizer and chemicals on all crops. Its weakness is that it includes the shift away from fallow and thereby over adjusts the cash costs, particularly of stubble crops. A second indexing procedure based on the Western Canada farm input price index for: machinery and motor vehicle operation and petroleum products (machinery power and repair), and crop production expenses (crop materials) was also used (Saskatchewan Agriculture 1986). The results based on this second index were similar and are reported in Brown and Forsberg (1987).

The above method of calculating crop gross margins over time is not ideal. A random sample of producers keeping detailed enterprise records is preferable but is not available. Since costs were deflated by two methods based on rather different assumptions with the results not changing significantly the approach adopted appears satisfactory. However, no direct relationship between increased expenditures on inputs (fertilizers and chemicals) and increased yields is accounted for. However, the relationship between increased input use and increased yield should be accounted for in the cost and yield data since these data are based on actual producer behaviour. The relationship built into the data is really one of yield response to

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[3]Crop production costs vary more from soil zone to soil zone than they do from province to province. The 1984 dark brown soil zone variable cash costs used in the paper for wheat on fallow, wheat on stubble, and summerfallow totalled $93.87 per acre. Similar costs taken from Costs and Returns for Crop Production in Alberta (Alberta Agriculture) totalled $109.14 per acre for Stettler-Coronation which is in the dark brown soil zone and $74.24 per acre for Oyen-Hanna which is in the brown soil zone. There is an approximate 16 percent different between the two dark brown soil zone costs even though they are in different provinces. There is an approximate 26 percent difference between the Oyen-Hanna costs and those used in the paper and an approximate 47 percent difference between the two Alberta numbers. In addition, the same costs for Barrhead, which is in the black soil zone, exceed those of Oyen-Hanna, by approximately 52 percent (Alberta Agriculture). This magnitude of within province discrepancy is prevalent in all the provinces because there is more similarity within soil zones than within provinces. The dark brown soil zone was chosen for the study because its costs structure is between that of the brown and black soils.

input use and weather conditions.

4.1.2 Correlation Coefficients of Crop Gross Margins

Given the above, gross margins for a number of hypothetical rotations for the period 1971-1987 are calculated. Portfolio theory specifies that individual components within a portfolio exhibiting high positive correlation add to the risk or variance of the portfolio. Gross margins for all crops, both fallow and stubble were compared with that of wheat on fallow. The correlation coefficients for each crop are shown in Table 1.

For simplicity the objective was to have the hypothetical rotations include only one representative from the grain, oilseed and specialty crop categories. Wheat on fallow and stubble was chosen as the grain because of its dominant area on the prairies. Barley, oats, fall rye and durum wheat, on both fallow and stubble, were eliminated from all rotations because of their high correlation coefficients. Canola was chosen over flax as the oilseed representative in the rotations because of its lower correlation coefficient and its greater acceptance by farmers in the past. Lentils was chosen over peas as the specialty crop representative in the rotations because of their lower correlation coefficient.

4.1.3 Hypothetical Fixed Crop Rotations

Hypothetical rotations as selected stay constant for the period 1971 to 1987 and are shown in Table 2. These rotations were assumed to contain either wheat or canola and no more than 33.3 percent lentils. Note that rotation 11 represents the approximate average crop rotation (or cropland use pattern) for Saskatchewan. The effect on the level and standard deviation of gross margin of reducing fallow intensity and diversifying into canola (oilseeds) and/or lentils (specialty crops) may be calculated by comparing these variables for the 24 hypothetical fixed crop rotations.

In the calculation of the rotation gross margins two points should be noted. First, the weightings of the crops in each rotation have been kept constant over time because the objective was to compare the distributions of gross margins from fixed rotations. One or several other rotations in which individual crop weightings change from year to year may well dominate the rotations outlined in Table 2. Second, the wheat and canola yields in rotations which include lentils have not been adjusted to compensate for the nitrogen fixing ability of lentils. This benefit to following crops has not been documented in the literature and may be off set by the increased chances of weed problems in lentils and crops following lentils (Slinkard and Drew).

Table 1: Correlations of Wheat on Fallow Gross Margins with Alternate Crops 1971-85

Wheat on Fallow	DARK BROWN SOIL ZONE
Fallow	-0.47
Wheat on Stubble	0.89
Barley on Fallow	0.75
Barley on Stubble	0.53
Oats on Fallow	0.56
Oats on Stubble	0.31
Durum on Fallow	0.82
Durum on Stubble	0.77
Canola on Fallow	0.46
Canola on Stubble	0.48
Fall Rye on Fallow	0.70
Fall Rye on Stubble	0.25
Flax on Fallow	0.79
Flax on Stubble	0.47
Lentils on Fallow	0.32
Lentils on Stubble	0.13
Peas on Fallow	0.40
Peas on Stubble	0.49

4.1.4 Saskatchewan Crop Insurance Corporation (SCIC), Western Grain Stabilization Program (WGSP), and Special Canadian Grains Program (SCGP)

The monetary effect on a per acre basis of participation in the SCIC, WGSP, and SCGP have been calculated into the net returns of each rotation. Average annual SCIC payments to farmers less premiums for risk area 12 have been calculated on a per acre basis for 1971 to 1987. These calculated annual acreage benefits or costs have been added to or subtracted from the rotation gross margin for the year in question. The method of calculation used is not rotation specific but does reflect the monetary effect of crop insurance on a per acre basis for the dark brown soil zone.

WGSP payments to Saskatchewan farmers less producer levies paid were divided by the total marketings of the seven crops included in the program each year to derive an annual per tonne impact of the program (Saskatchewan Agriculture). The per tonne impact was then added to the price of wheat and canola in the appropriate year and calculated into the returns of each rotation. No WGSP impact was calculated for lentils as they are not included in the program.

Table 2: Twenty-four Hypothetical Crop Rotations Showing Percentage of Each Crop In Each Rotation, 1971-87

Rotation	Fallow	Wheat/f	Wheat/st	Canola/f	Canola/st	Lentils/f	Lentils/st
1	50	50					
2	40	40	20				
3	30	30	40				
4	20	20	60				
5	10	10	80				
6			100				
7	50			50			
8	40			40	20		
9	30			30	40		
10			33.3		33.3		33.3
11	32	28	29	4	4		3
12	50	25		25			
13	40	20	10	20	10		
14	30	15	20	15	20		
15	20	10	30	10	30		
16	10	5	40	5	40		
17			50		50		
18	50	25				25	
19	40	20	10			20	10
20	50	16.7		16.7		16.7	
21	40	13.3	6.7	13.3	6.7	13.3	6.7
22	30	10	13.3	10	13.3	10	13.3
23	20	6.7	20	6.7	20	6.7	20
24	10	3.3	26.7	3.3	26.7	3.3	26.7

The SCGP payments on a per tonne basis were added to the price of wheat and canola in the appropriate years. No SCGP adjustment was calculated for lentils as they were not included in the program in 1986 and 1987.

4.1.5 Canadian Wheat Board (CWB) Quotas

The effect of CWB quotas on the rotation gross margins were calculated. The CWB quotas for wheat and canola were gathered from CWB annual reports for the 1971-1987 time period. Quotas were adjusted to account for the level of delivery allowed for all grades of wheat and canola. That is, if one grade of wheat had an open quota and another only 10 bushels per quota acre, the wheat quota that crop year was calculated as 10 bushels per quota acre. A quota acre was considered to be the same as a rotation acre, that is, it included that portion of the rotation acre either seeded to the crops considered (including lentils) or fallowed; perennial forage was not included. The CWB 'Bonus Acres' program was included in the calculation from 1982 to 1987.

For years when the production of one crop from a particular rotation was above its quota level and the production of another crop in the same rotation was less than its quota level; quota allocations were adjusted accordingly to allow for the maximum delivery of all crops. Production above the quota level was stored at no cash cost and sold when the quota level permitted. This adversely affected rotation gross margins in low quota years and greatly increased them in subsequent years when quotas eventually increased or became open. This method of calculation is a valid measure of the variability of cash flows (gross margins) resulting from following the 24 fixed rotations during the time period.

4.1.6 Net Return on Investment for the Crop Rotations

The annual net return on investment associated with following each of the hypothetical crop rotations is calculated by the procedure outlined in equation 1. The operator labor charge and the capital recovery charge for machinery and buildings was taken from various cost of production studies over the time period and indexed in those years that data were missing (Brown, 1988). Missing labor data were indexed by the hired farm labor price index. Missing machinery and building data were indexed by an 80 percent-20 percent weighting of the machinery and building replacement price indices. Appendix A presents the nominal net returns on investment. Appendix B presents real net returns on investment by multiplying the nominal net returns by the Consumer Price Index (CPI) for the appropriate year. Appendix C presents net cash returns on investment by excluding noncash costs such as interest on operating capital, operator labor, machinery and buildings capital recovery charges (CRC), and noncash income such as capital appreciation.

$$ROIC_{ij} = \frac{GM_{ij} - INT_{ij} - LAB_{ij} - FC_{ij} + CAPP_{ij}}{BI_{ij}} \qquad \text{Eq. 1}$$

Where:

$ROIC_{ij}$ = Residual return per acre of cropland investment in year i by following crop rotation j.

GMi_j = Gross margin in year i of crop rotation j. (See Brown and Forsberg)

INT_{ij} = An interest charge on direct costs per acre for 1/2 year at prime plus 2 percent in year i for crop rotation j.

LAB_{ij} = A per acre charge for operator labor in year i for crop rotation j.

FC_{ij} = A per acre charge for the fixed cost in year i associated with rotation j. It includes property taxes, general farm overhead (5 percent of direct costs), and a capital recovery charge for machinery and buildings that assumes a 15 percent rate of depreciation and an interest charge of prime.

$CAPP_{ij}$ = The capital appreciation of the land investment per acre in year i as measured by the land value at the end of the year less the land value at the beginning of the year.

BI_{ij} = The value of the land investment at the beginning of year i as measured by average cropland values for Saskatchewan.

4.2 Cattle and Hog Net Returns

Annual return on investment for each year during the period 1971 to 1987 is calculated for the cow-calf, beef feedlot, hog weanling and hog finishing enterprises. They are presented on a nominal basis in Appendix A, real basis in Appendix B, and cash basis in Appendix C.

4.2.1 Net Return on Investment for the Cow-calf Enterprise

The return on investment associated with the cow-calf enterprise is calculated by the procedure outlined in equation 2.

$$ROICC_i = \frac{INC_i - PC_i + CAPP_i}{BI_i} \qquad \text{Eq. 2}$$

Where:

$ROICC_i$ = Residual return on investment per cow in year i.

INC_i = Income per cow in year i assuming a calf crop of 90 percent, and the sale of a 500 lb calf.

PC_i = Total costs of production in year i excluding a charge for investment per cow.

$CAPP_i$ = The capital appreciation of the investment per cow in year i as measured by the investment value at the end of the year less the investment value at the beginning of the year.

BI_i = The value of the investment per cow at the beginning of year i.

The total costs of production and investment per cow figures for 1987 are from the Saskatchewan Agriculture Farm Business Management Data Manual (1988). The total cost of production figures include grazing, winter feed, bedding, veterinary and medicine, breeding, machinery, buildings and handling facilities, cow death loss, interest on operating capital, cow replacement, trucking and marketing, and a labor allowance. The 1987 cost of production figures are then indexed back over the time period using the animal production cost index for Western Canada. The calculation of investment per cow includes an allowance for owned pasture, buildings and facilities, and the price of the cow. The 1987 cow price is indexed back over the time period using an index constructed by lagging calf prices by 1 year. The remainder of the investment per cow consisted mostly of pasture and was indexed back using the change in farmland values in Saskatchewan as the index.

4.2.2 Net Return on Investment for the Beef Feedlot Enterprise

The return on investment associated with the beef feedlot enterprise is calculated by the procedure outlined in equation 3.

$$ROIBF_i = \frac{INC_i - PC_i}{BI_i} \qquad \text{Eq. 3}$$

Where:

$ROIBF_i$ = Residual return on investment per head in year i.

INC_i = Income per head in year i assuming purchase of a 500 lb. calf and the sale of an 1100 lb finished animal.

PC_i = Total costs of production in year i excluding a charge for feeder investment.

BI_i = The value of the feeder investment at the beginning of year i.

The income figures reflect the annual net payouts after producer levies resulting from participation in the Saskatchewan Beef Stabilization Plan (Saskatchewan Beef Stabilization Plan). The total costs of production figures for 1987 are from the Saskatchewan Agriculture Farm Business Management Data Manual (1988). They include feed, bedding, veterinary and medicine, breeding, machinery, buildings and handling facilities, death loss, interest on operating capital, trucking and marketing, and a labor allowance. The 1987 cost of production figures are then indexed back over the time period using the animal production cost index for Western Canada.

4.2.3 Net Return on Investment for the Hog Weanling Enterprise

The return on investment associated with the hog weanling enterprise is calculated by the procedure outlined in equation 4.

$$ROIHFW_i = \frac{INC_i - PC_i + CAPP_i}{BI_i} \qquad \text{Eq. 4}$$

Where:

$ROIHFW_i$ = Residual return on investment per sow in year i.

INC_i = Income per sow in year i assuming 13 pigs weaned per sow in 1971 steadily increasing to 17.7 in 1987 and selling a 45 lb weanling pig.

PC_i = Total costs of production in year i excluding a charge for investment in buildings, equipment and breeding stock per sow.

$CAPP_i$ = The capital appreciation of the investment per sow in year i as measured by the investment value at the end of the year less the investment value at the beginning of the year.

BI_i = The value of the investment per sow at the beginning of year i.

The total costs of production and investment per sow figures for 1987 are from the Saskatchewan Agriculture Farm Business Management Data Manual (1988). The total cost of production figures include feed, sow and boar replacement, hired labor, buildings and equipment repairs and maintenance, utilities and insurance, veterinary and medicine, marketing and transportation, interest on operating capital, an operator labor and management allowance, and depreciation. The 1987 cost of production figures are then indexed back over the time period using the animal production cost index for Western Canada. The 1987 investment per sow is also indexed back over the time period. The index used in this case is the building replacement cost index for Western Canada.

4.2.4 Net Return on Investment for the Hog Finishing Enterprise

The return on investment associated with the hog finishing enterprise is calculated by the procedure outlined in equation 5.

$$ROIHF_i = \frac{INC_i - PC_i + CAPP_i}{BI_i} \qquad \text{Eq. 5}$$

Where:

$ROIHF_i$ = Residual return on investment per head in year i.

INC_i = Income per head in year i assuming the purchase of a 45 lb. weanling pig and the sale of a 170 lb dressed weight index 100 finished hog.

PC_i = Total costs of production in year i excluding a charge for investment in buildings, equipment and weanling pig per head.

$CAPP_i$ = The capital appreciation of the investment per head in year i as measured by the investment value at the end of the year less the investment value at the beginning of the year.

BI_i = The value of the investment per head at the beginning of year i.

The income figures reflect the annual net payouts after producer levies resulting from participation in the Saskatchewan Hog Assistance and Rehabilitation Plan (SHARP) (Saskatchewan Hog Assistance and Rehabilitation Plan). The total costs of production and investment per head figures for 1987 are from the Saskatchewan Agriculture Farm Business Management Data Manual (1988). The total cost of production figures include feed, purchase of weanling pig, hired labor, buildings and equipment repairs and maintenance, utilities and insurance, veterinary and medicine, marketing and transportation, interest on operating capital, an operator labor and management allowance, and depreciation. The 1987 cost of production figures are then indexed back over the time period using the animal production cost index for Western Canada. The 1987 investment per head is also indexed back over the time period. The index used in this case is the Western Canada building replacement cost index for the building and equipment and the price for weanling pigs.

4.3 Stocks and Bonds

The return on investment associated with the stocks and bond enterprises can be seen in Appendix A (Nominal), Appendix B (Real). The stocks are represented by the percentage change in the TSE Index

300 plus the average annual dividend rate on the stocks in question. The bonds are Government of Canada bonds with maturity dates greater than 10 years.

V. THE RESULTS

5.1 Enterprise Mean-Standard Deviation Trade-off

5.1.1 Nominal and Real Net Returns on Investment

The mean nominal and real net return on investment and standard deviation of these returns for each of the 30 enterprises investigated are plotted in Figure 13 (Nominal) and Figure 14 (Real). Figures 13 and 14 demonstrate that if the 30 enterprises investigated were the only ones available, a visual estimate of the risk efficiency frontier would run between bonds (Bonds), hog finishing (HogFin) and rotation 10, which consists of 33.3 percent each of wheat, canola, and lentils; 0 percent fallow (WhtCanLen/0%Fal). There is little difference between Figures 13 and 14 other than the real means and standard deviations in Figure 14 are smaller.

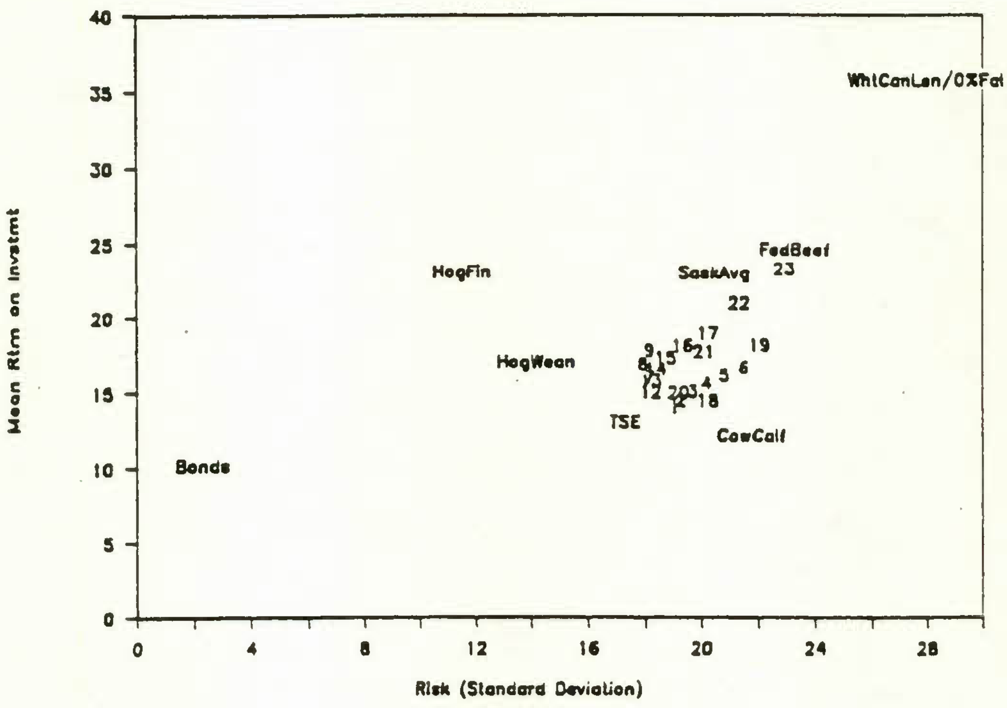

Figure 13: Mean-Standard Deviation Trade-Off (Nominal Returns on Investment)

Legend:
Numbers 1 through 24 are the hypothetical fixed crop rotations presented in Table 2;
SaskAvg = Rotation 11;
WhtCanLen/0%Fal = Rotation 10;
HogWean = Hog Weanling;
HogFin = Hog Finishing;
CowCalf = Cow Calf;
FedBeef = Beef Feedlot;
Bonds = Government Bonds with maturity greater than 10 years;
TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

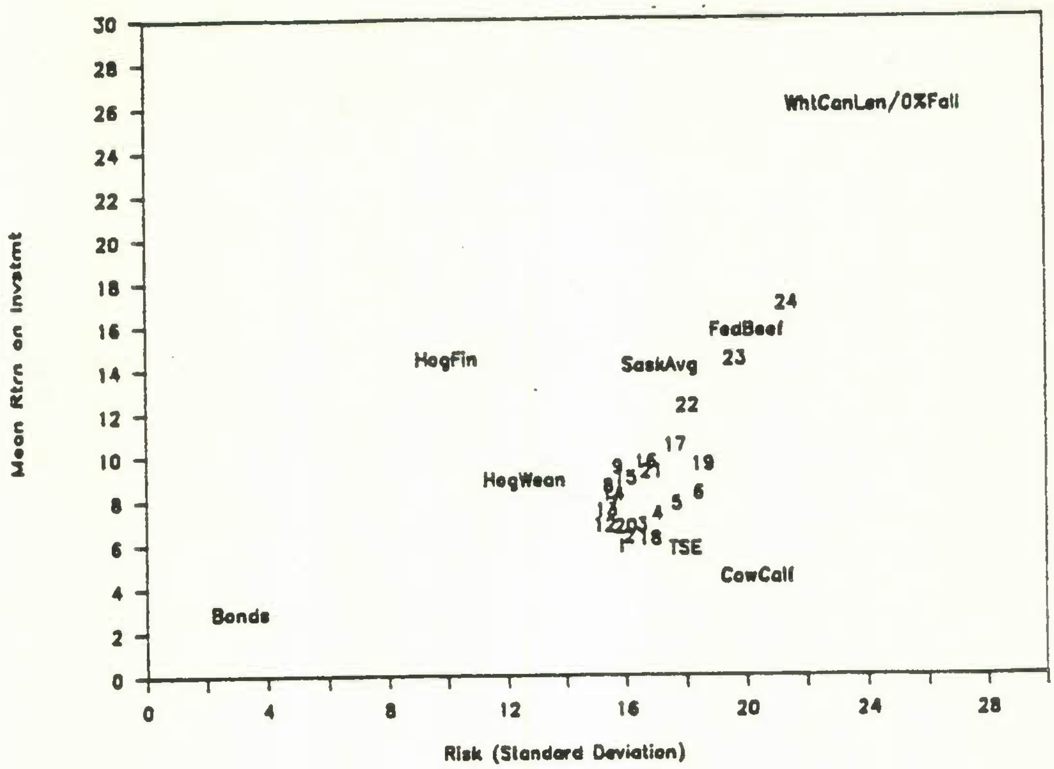

Figure 14: Mean-Standard Deviation Trade-Off (Real Returns on Investment)

Legend:
Numbers 1 through 24 are the hypothetical fixed crop rotations presented in Table 2;
SaskAvg = Rotation 11;
WhtCanLen/0%Fal = Rotation 10;
HogWean = Hog Weanling;
HogFin = Hog Finishing;
CowCalf = Cow Calf;
FedBeef = Beef Feedlot;
Bonds = Government Bonds with maturity greater than 10 years;
TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

The three enterprises on the risk efficiency frontier represent the highest average return on investment for a given amount of risk (standard deviation). All other enterprises either have lower returns, higher risk, or both. The most risk efficient enterprise depends on the risk preferences of the decision maker. Highly risk averse decision makers would choose bonds. Those with less risk aversion would choose hog finishing. Those decision makers much more willing to take risk, but still risk averse would choose crop rotation 10.

Crop rotation 11 (approximate average Saskatchewan land use; 32 percent fallow, 28 percent wheat on fallow, 29 percent wheat on stubble, 4 percent canola on fallow, 4 percent canola on stubble, and 3 percent lentils on stubble) (SaskAvg) is very close to the frontier and is one of the more risk efficient crop rotations. It has higher investment returns than most of the other crop rotations and less risk than the crop rotations with large amounts of lentils (23, 24, and 10). It would appear the risk management ability of Saskatchewan farmers is significant. Note also that other than the addition of lentils to crop rotations not much gains from diversification by crop rotation are apparent noted by the clustering of most crop rotations around similar levels of mean return and standard deviation.

The location of the other enterprises in the mean-standard deviation trade-off space is also of interest. The TSE does not seem to perform well compared to the other enterprises. However it may have some advantage in diversification if it has low or negative correlation with the agricultural enterprises. The cow-calf and hog weanling enterprises don't perform as well as their respective finishing enterprises. Part of this is due to the government assistance program payments (Beef Stabilization and SHARP) being allocated to the finishing enterprise. The beef feedlot enterprise (Fedbeef) exhibits high returns but also high risk.

5.1.2 Net Cash Returns on Investment

Nominal net cash returns on investment and the standard deviation of these returns have been measured for each of the 30 enterprises and plotted in Figure 15. The calculation of net cash returns eliminated noncash costs from the cost side and capital appreciation from the return side. The calculation of returns for Bonds and the TSE were not affected by this adjustment. As can be seen from Figure 15 this adjustment causes a realignment of the enterprises in the mean-standard deviation trade-off space. The risk efficiency frontier is more apparent than in Figures 13 and 14. Bonds and hog finishing (HF) still appear to be on the frontier. The beef feedlot (Fedbeef) is also on the frontier, albeit at a higher risk level. However, several of the crop rotations, the cow-calf enterprise (CC) and the hog weanling enterprise (HW) are also very close to the risk efficiency frontier. The TSE does not seem to be competitive with most agricultural enterprises based on nominal net cash returns.

The adjustment to net cash returns is informative because it presents the picture seen by most farmers. Farmers seldom include non-cash costs such as interest on operating capital, operator labor, and machinery and building capital recovery charges, nor noncash income such as capital appreciation in their calculations. Figure 15 demonstrates that, if one is only looking at net cash returns, one sees crop farming is a relatively low income, low risk enterprise. In order to increase income, one also must take on considerably more risk either through lentil, hog or beef production. The remainder of the paper will investigate which combinations of the 30 enterprises have a chance on increasing income without substantially increasing risk.

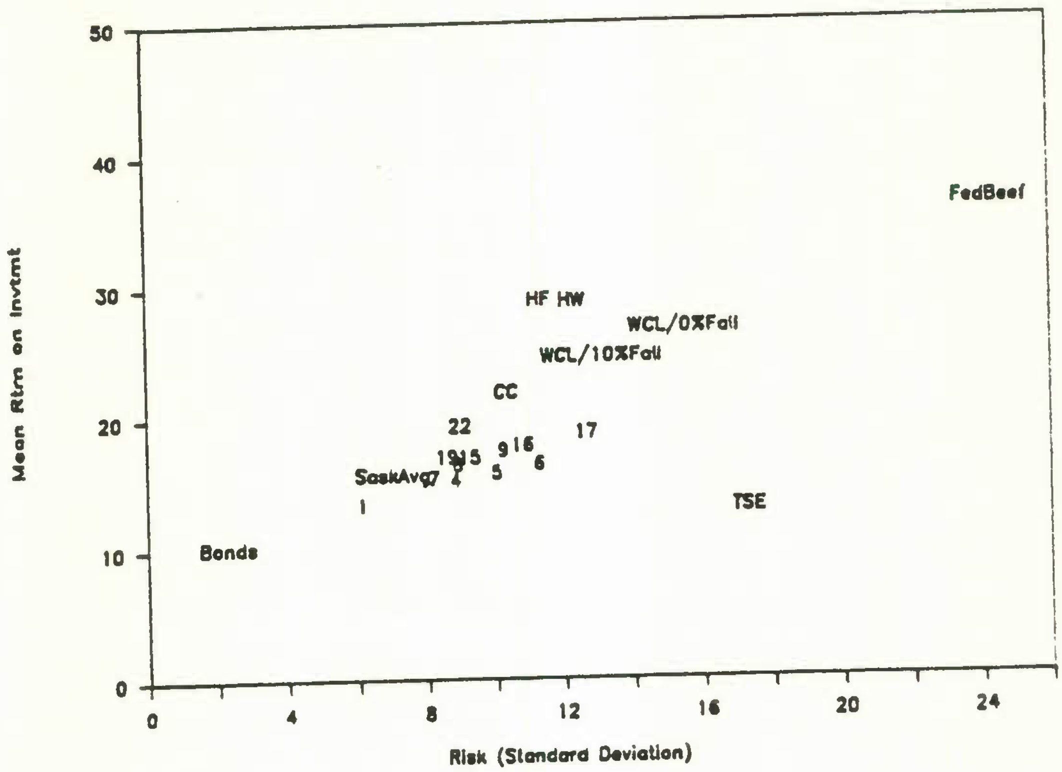

Figure 15: Mean-Standard Deviation (Nominal Cash Returns on Investment)

Legend:
Numbers 1 through 24 are the hypothetical fixed crop rotations presented in Table 2;
SaskAvg = Rotation 11;
WCL/0%Fall = Rotation 10;
WCL/10%Fall = Rotation 24;
HW = Hog Weanling;
HF = Hog Finishing;
CC = Cow Calf;
FedBeef = Beef Feedlot;
Bonds = Government Bonds with maturity greater than 10 years;
TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

5.2 Enterprise Correlations

The correlation coefficient is a measure of the mutual relationship between two variables. It ranges between -1.0 and +1.0, with -1.0 meaning perfect negative correlation (the variables move in opposite directions), 0 meaning no correlation between the variables, and +1.0 meaning perfect positive correlation (the variables move in the same direction). The most gains from diversification are realized when enterprises with negative or low positive correlations are combined. The correlations of nominal net returns for the various farm and off-farm enterprises with rotation 11 (SaskAvg) are presented in Table 3. Tables 4 and 5 present the enterprise correlation based on real net returns on investment and nominal net cash returns on investment respectively. Notice that none of the crop rotations have correlation coefficients of less than +.52 and most are over +.90. Therefore little gains can be made by crop farmers from diversifying into other crops. The correlation coefficients with the livestock enterprises are lower, all below +.5. Therefore there are potential gains from crop farms diversifying into livestock enterprises provided their size is large enough. The correlation coefficients for the cow-calf and hog weanling enterprises are very low based on nominal and real net returns but increase when based on nominal net cash returns. The beef feedlot and hog finishing enterprises exhibit the exact opposite trend. The correlation coefficients for the TSE and government bonds are all negative with the highest being -.06. Gains from crop farms diversifying into the TSE and/or government bonds may be possible, especially when government bonds exhibit a -.87 correlation coefficient based on real net returns on investment. Unfortunately, Bonds and the TSE for the most part exhibit lower mean net returns than most of the agricultural enterprises measured.

5.3 Capital Asset Pricing Model (CAPM) Betas

Beta values were calculated for each of the 30 enterprises and are presented in Table 6. The market portfolio was assumed to be the TSE 300 plus an average annual dividend. Beta values for all the agricultural enterprises are extremely low, even for the cow-calf

Table 3: Enterprise Correlations Based on Nominal Net Returns on Investment

	Correlation Coeff.		Correlation Coeff.		Correlation Coeff.
Crop Rotation #1	.99	Crop Rotation #11	1.00	Crop Rotation #21	.94
2	.99	12	.98	22	.93
3	.98	13	.99	23	.90
4	.97	14	.98	24	.87
5	.96	15	.97	Cow-Calf	.13
6	.94	16	.95	Beef Feedlot	.38
7	.93	17	.91	Hog Weanling	.40
8	.93	18	.93	Hog Finishing	.40
9	.91	19	.91	TSE 300	-.06
10	.85	20	.94	Bonds	-.33

Table 4: Enterprise Correlations Based on Real Net Returns on Investment

	Correlation Coeff.				Correlation Coeff.
Crop Rotation #1	.98	Crop Rotation #11	1.00	Crop Rotation #21	.93
2	.99	12	.98	22	.91
3	.98	13	.98	23	.88
4	.97	14	.98	24	.85
5	.95	15	.96	Cow-Calf	.09
6	.93	16	.93	Beef Feedlot	.28
7	.91	17	.89	Hog Weanling	.28
8	.91	18	.91	Hog Finishing	.22
9	.89	19	.89	TSE 300	-.13
10	.83	20	.93	Bonds	-.87

Table 5: Enterprise Correlations Based on Nominal Net Cash Returns on Investment

	Correlation Coeff.				Correlation Coeff.
Crop Rotation #1	.93	Crop Rotation #11	1.00	Crop Rotation #21	.69
2	.94	12	.90	22	.66
3	.93	13	.91	23	.63
4	.90	14	.90	24	.61
5	.87	15	.87	Cow-Calf	.37
6	.83	16	.83	Beef Feedlot	.15
7	.67	17	.79	Hog Weanling	.50
8	.69	18	.54	Hog Finishing	.06
9	.70	19	.52	TSE 300	-.18
10	.59	20	.68	Bonds	-.73

enterprise when one considers beta values for many major companies traded on the TSE usually range between .5 and 1.3 (Schall et al.). High beta values for agricultural enterprises mean they add risk to a well diversified portfolio and thereby the investor will need a higher rate of return to justify his investment into it. If the rate of return is not there then one can argue that investors in agricultural enterprises are either not being compensated for the risks they are taking or agricultural asset values are over priced. A low beta value for an agricultural enterprise means it's addition to a well diversified portfolio lowers the risk and investors are either willing

Table 6: Beta Values for Nominal, Real, and Nominal Cash Returns on Investment Enterprise

Number	Nominal Betas	Real Betas	Nominal Cash Betas
1	-0.005	-0.073	-0.048
2	-0.024	-0.087	-0.059
3	-0.010	-0.076	-0.044
4	0.010	-0.059	-0.024
5	0.036	-0.037	0.002
6	0.058	-0.018	0.023
7	-0.053	-0.082	-0.088
8	-0.078	-0.097	-0.103
9	-0.089	-0.101	-0.103
10	0.125	0.022	0.103
SaskAvg	-0.065	-0.123	-0.071
12	-0.056	-0.100	-0.091
13	-0.067	-0.107	-0.096
14	-0.072	-0.108	-0.094
15	-0.072	-0.105	-0.088
16	-0.068	-0.099	-0.078
17	-0.060	-0.090	-0.064
18	-0.051	-0.129	-0.090
19	0.019	-0.075	0.029
20	-0.052	-0.114	-0.089
21	-0.015	-0.083	-0.055
22	0.021	-0.054	-0.021
23	0.061	-0.021	0.016
24	0.103	0.014	0.055
Cowcalf	0.451	0.449	0.214
Fedbeef	-0.178	-0.182	-0.157
Hogwean	-0.006	0.001	-0.030
HogFin	-0.022	-0.018	-0.028
TSE	1.000	1.000	1.000
Bonds	-0.011	0.033	-0.014

to accept a lower rate of return on these enterprises or will bid the asset price up. The results presented in Table 6 point toward gains from diversification between agricultural enterprises and the TSE. However, Figures 13, 14, and 15 indicate the gainer may well be the TSE investor rather than the farmer.

5.4 Portfolio Mean-Standard Deviation Trade-off

The mean-standard deviation trade-off of a number of combinations (portfolios) of the 30 enterprises are plotted in Figures 16 (Nominal), 17 (Real), and 18 (Nominal Cash). The objective was to see what combinations of rotation 11 which represents the average land use in Saskatchewan (SaskAvg) and the other enterprises would both increase net returns and reduce risk for the 'typical' crop farm on the Canadian prairies. The size of the agricultural enterprises in the chosen portfolios are assumed to be those that reflect the economies of size investigated earlier. For example, the base portfolio may be a 1 1/2 section crop farm following rotation 11 (SaskAvg); portfolio 2 may be the same 1 1/2 section crop farm with 20 percent of the investment in a beef feedlot or hog finishing enterprise. The livestock operations may or may not be located on the same farm but should be as large or larger than their respective 'threshold' size. Other portfolios include the base plus an investment in government bonds and/or the TSE 300.

The risk efficiency frontier would appear to be similar in Figures 16 and 17 and consist of bonds, hog finishing (HogFin or HF),and the wheat, canola, lentils, and 0 percent fallow rotation (WhtCanLen/0%Fal or rotation 10). The risk efficiency frontier also would appear to include a portfolio labelled SAWCLHF which is a 33.3 percent equal combination of the SaskAvg or rotation 11, the wheat, canola, lentils, and 0 percent fallow rotation (WhtCanLen/0%Fal or rotation 10), and hog finishing (HF).

The only portfolios that both increased net returns and reduced risk compared to the SaskAvg rotation were the above described SAWCLHF portfolio, a portfolio consisting of a 50-50 split between SaskAvg and Fedbeef labelled SABF, a portfolio consisting of a 50-50 split between SaskAvg and HogFin labelled SAHF, and the HogFin enterprise. Undoubtedly there are numerous other portfolios that increase net returns and reduce risk compared to SaskAvg but they will most likely consist of combinations of HogFin and/or WhtCanLen/0%Fal and/or FebBeef and/or SaskAvg. Portfolios with larger than 50 percent SaskAvg also increase net returns and decrease risk compared to SaskAvg but are too close to SaskAvg for plotting purposes.

There are several other portfolios in Figures 16 and 17 that reduce the risk associated with the SaskAvg but also reduce the net returns. The portfolios shown in the figures consist of 50-50 combinations of SaskAvg and the TSE (SAT), bonds (SAB), cow-calf (SACC), and hog weanling (not plotted because very close to SAT). Undoubtedly there are numerous other portfolios that reduce risk but also reduce net return compared to SaskAvg. However, they will most likely consist of combinations of bonds, and/or the TSE, and/or cow-calf and/or hog weanling, and/or SaskAvg. Portfolios with larger than 50 percent SaskAvg also reduce risk but also reduce net return compared to SaskAvg are too close to SaskAvg for plotting purposes.

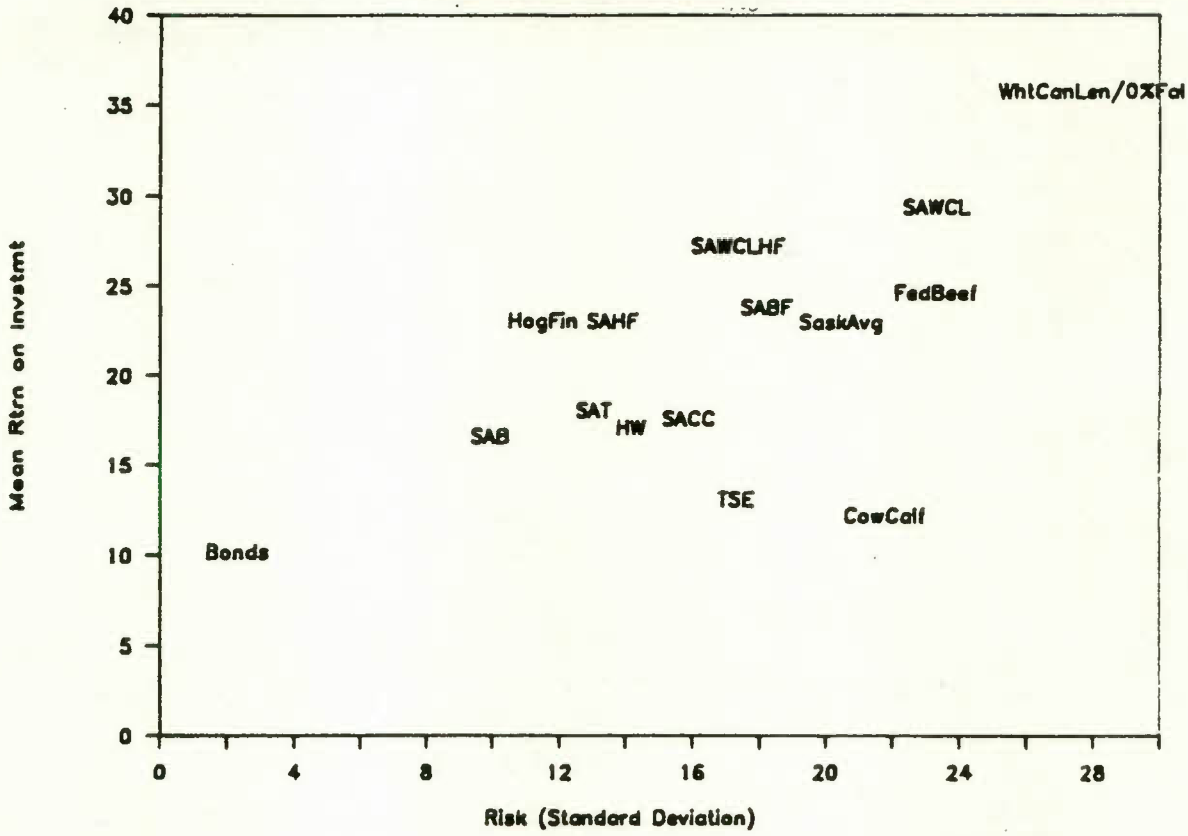

Figure 16: Mean-Standard Deviation Trade-Off (Nominal Returns on Investment)

Legend:

SaskAvg = Rotation 11;
WhtCanLen/0%Fal = Rotation 10;
SAWCL = 50% Rotation 11 and 50% Rotation 10;
SAWCLHF = 33.3% Rotation 11, 33.3% Rotation 10, and 33.3% Hog Finishing;
SAHF = 50% Rotation 11 and 50% Hog Finishing;
SABF = 50% Rotation 11 and 50% Beef Feedlot;
SACC = 50% Rotation 11 and 50% Cow Calf;
SAT = 50% Rotation 11 and 50% TSE;
SAB = 50% Rotation 11 and 50% Bonds;
HW = Hog Weanling;
HogFin = Hog Finishing;
CowCalf = Cow Calf;
FedBeef = Beef Feedlot;
Bonds = Government Bonds with maturity greater than 10 years;
TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

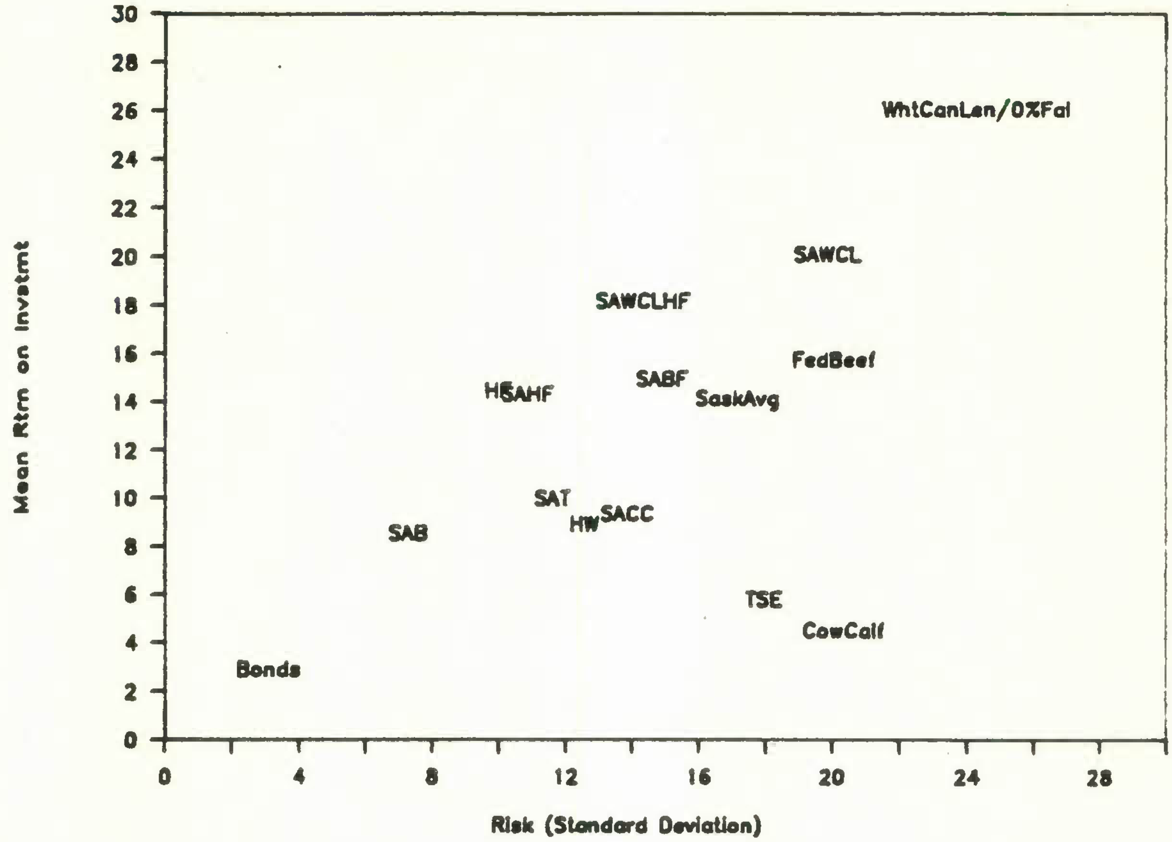

Figure 17: Mean-Standard Deviation Trade-Off (Real Returns on Investment)

Legend:

SaskAvg = Rotation 11;
WhtCanLen/0%Fal = Rotation 10;
SAWCL = 50% Rotation 11 and 50% Rotation 10;
SAWCLHF = 33.3% Rotation 11, 33.3% Rotation 10, and 33.3% Hog Finishing;
SAHF = 50% Rotation 11 and 50% Hog Finishing;
SABF = 50% Rotation 11 and 50% Beef Feedlot;
SACC = 50% Rotation 11 and 50% Cow Calf;
SAT = 50% Rotation 11 and 50% TSE;
SAB = 50% Rotation 11 and 50% Bonds;
HW = Hog Weanling;
HF = Hog Finishing;
CowCalf = Cow Calf;
FedBeef = Beef Feedlot;
Bonds = Government Bonds with maturity greater than 10 years;
TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

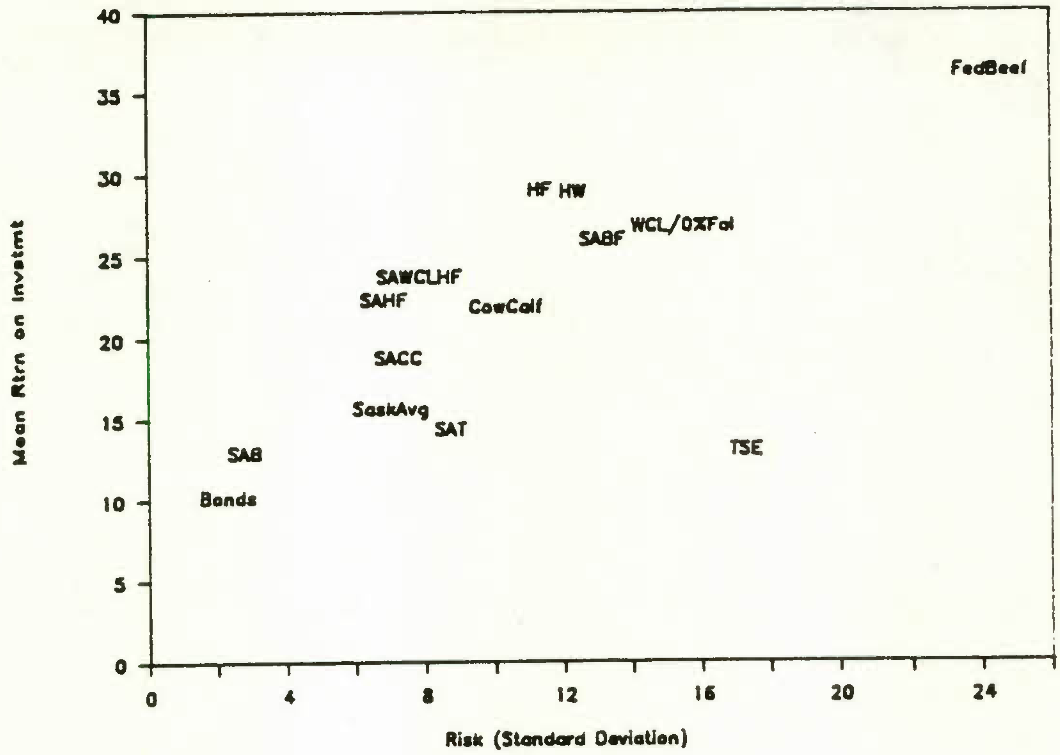

Figure 18: Mean-Standard Deviation (Nominal Cash Returns on Investment)

Legend:
- SaskAvg = Rotation 11;
- WCL/0%Fal = Rotation 10;
- SAWCLHF = 33.3% Rotation 11, 33.3% Rotation 10, and 33.3% Hog Finishing;
- SAHF = 50% Rotation 11 and 50% Hog Finishing;
- SABF = 50% Rotation 11 and 50% Beef Feedlot;
- SACC = 50% Rotation 11 and 50% Cow Calf;
- SAT = 50% Rotation 11 and 50% TSE;
- SAB = 50% Rotation 11 and 50% Bonds;
- HW = Hog Weanling;
- HF = Hog Finishing;
- CowCalf = Cow Calf;
- FedBeef = Beef Feedlot;
- Bonds = Government Bonds with maturity greater than 10 years;
- TSE = Toronto Stock Exchange 300 plus an average annual dividend rate.

Figure 18 plots the same portfolios as outlined in Figures 16 and 17 only the net returns are measured as nominal net cash returns on investment. The risk efficiency frontier would appear to consist of a number of portfolios, all defined above and listed here; bonds, SAB, SAHF, SAWCLHF, HF, HW (hog weanling), and Fedbeef. No combinations of SaskAvg and the other enterprises both increase net cash returns and reduce risk compared to SaskAvg. The only combinations of SaskAvg and the other enterprises to reduce risk but also reduce net cash returns include portfolios consisting of bonds and SaskAvg.

At least one other important point arises from the examination of Figures 16, 17, and 18. Crop farmers can reduce risk (not when calculated on a net cash return basis), but also reduce net return, when they include the TSE in their investment portfolios. However, current investors in the TSE can both increase net returns and reduce risk when investing in most agricultural enterprises. This may have major implications for future investment in agriculture.

VI. SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

6.1 Objectives

The objectives of this paper were threefold. First, review the economies of farm enterprise size literature to approximate the 'threshold' size needed in various enterprises to take advantage of any initial sharp decrease in average total costs. Second, measure the net returns realized from typical crop and livestock enterprises as well as those from stocks and bonds for the period 1971 to 1987. Finally, measure the gains or losses, as indicated by increases in net income and/or reduced variability of net returns that could be realized from diversifying specialized farm operations.

6.2 Economies of Size

Several investigators (Anderson and Powell (1973), Hall and La Veen (1978), and Miller et al. (1981)) have found that the LRAC curve for most farm types is L-shaped rather than U-shaped. This finding implies that there may not be any one enterprise size that is the least cost and it may be more worthwhile to concentrate on the approximate size where LRAC ceases to decrease as rapidly. The area around the heel of the L-shaped LRAC curve has been labelled the 'threshold' size.

The L-shaped LRAC implies that unit costs neither decrease or increase significantly past the 'threshold' size. It is for this reason those family farms larger than the 'threshold' size will persist well into the future. However, a number of investigators (Ehrensaft (1983), Ehrensaft and Bollman (1986), Trant (1986), Doll and Orazem (1984), Van Arsdall and Nelson (1985), and Wilson and Eidman (1985)) predict that both grain and livestock farms will become more specialized and larger over time. Farms size will continue to grow in the future because of the following incentives to increase beyond the 'threshold' size:

- More volume means greater income unless unit costs rise very rapidly.
- Farm real estate has been a high return investment for the past forty years (the majority of this has been in capital gains).
- Larger businesses mean labor saving equipment and a greater capacity to get things done on time.

Miller (1983) points out three conceptual issues that have to be raised when dealing with economies of size studies. The first issue deals with whether or not a calculation of a single opportunity cost for operator labor has been included as a cost. If it has been included, the LRAC curves may actually be less negatively sloped at smaller sizes than they depict, thereby making the actual 'threshold' size a range of sizes rather than a particular size. The second conceptual issue deals with an opportunity cost for land. Miller argues that if land is unlimited, or can be bid away from other uses, its opportunity cost should be included in the analysis. The final conceptual issue deals with the benefits from technological change. A study in which the supply of land is not fixed and its opportunity cost can be computed, assumes the benefits of lower LRAC will be passed onto the rest of society and landowners and farm operators will be no worse off. Studies that calculate a residual to land assume the benefits of a lower LRAC will be captured entirely by landowners through higher land values. The underlying assumptions of the study need to be known before policy implications can be made from the results.

The 'threshold' enterprise size for grain and grain-oilseed, beef and hog enterprises on the Canadian prairies were calculated from a number of studies. The resulting 'threshold' size for the grain and grain-oilseed enterprise ranged between 546 and 697 cultivated acres in the black soil zone and between 829 and 1,111 cultivated acres in the brown soil zone. The 'threshold' size of beef feedlots in the CWB region according the Statistics Canada data appears to be in the neighborhood of 1500+ steers. U.S. studies have found significantly larger 'threshold' sizes in the neighborhood of 10,000 head. It would appear the U.S. data with respect to cattle feeding are more credible because Statistics Canada does not breakdown herd sizes larger than 1,500 head. The 'threshold' size for the beef cow herd in Canada as a whole appears to be in the 37-99 cow range however the data is rather erratic and further economies are evident in the 200-499 cow range. To the extent that U.S. data and conditions can be translated to Western Canada, a 'threshold' size in 1983 for a hog farrowing operation and a hog finishing operation was around 3,000 head sold per year in each enterprise. Given a weaning rate of 15 pigs/sow/year the hog farrowing operation would equal a 200 sow enterprise.

6.3 Gains and Losses from Diversification

Three theoretic concepts were used as a basis for measuring the gains and losses from diversification, that is to say, the risk efficiency of diversification. First, the mean-standard deviation trade-off is used to measure the risk efficiency of various investment alternatives consisting of combinations of agricultural and nonagricultural enterprises. When dealing with net income, those alternatives exhibiting the lowest standard deviation of net income for given levels of expected net income, or conversely the maximum level of expected net income for given levels of standard deviation of net income, are said to be on the risk efficiency frontier of risk neutral and risk averse decision makers.

The second concept used to measure the gains and losses from diversification dealt with portfolio risk. The total risk of a portfolio depends on the standard deviations and correlations of the individual enterprises included in it. Diversification reduces risk if the returns from the various enterprises within a portfolio are not highly correlated. There is, however, a limit to the amount of risk reduction that can take place in any portfolio. The only risk remaining in a well diversified portfolio is the market or systematic risk. Therefore, the returns from a well diversified portfolio are highly correlated (close to 1.0) with the entire market. In order for farmers to reduce the amount of systematic risk in their market portfolio, that is the agriculture portfolio, they must make off-farm investments such as securities. By moving outside the agriculture portfolio to a general market portfolio, the systematic risk within agriculture becomes nonsystematic risk in the general market portfolio. The advantage of off-farm investments is that they have low correlations with the farm sector and can be used to reduce the new systematic risk to zero through diversification. In addition, the liquidity of the capital markets allows for greater flexibility in transferring capital between farm and off-farm uses.

The third and final concept used to measure the gains and losses from diversification dealt with the Capital Asset Pricing Model (CAPM). The CAPM assumes that properly priced securities or enterprises should provide an expected rate of return equal to the rate of interest on riskless securities (government treasury bills) plus a premium for bearing risk. The risk is measured by the enterprise's beta. The enterprise's beta is equal to the security's correlation coefficient with the market portfolio (eg. Toronto Stock Exchange (TSE) Index 300) times it's standard deviation all divided by the market portfolio's standard deviation. The beta for the market itself is 1.0, as implied by the definition of beta. Therefore a beta of 1.0 indicates that the expected rate of return on the enterprise is the expected rate of return on the market. Enterprises with low or negative correlations of returns to the market will have low or negative betas and visa versa. The 'security market line' represents the linear relationship between an enterprise's beta and the expected rate of return on that enterprise, that is, the current risk-return trade-off in the market. If an enterprise's beta is high, it indicates that the enterprise is associated with high risk. The security market line indicates what rate of return is needed to compensate the investor for this increased risk. If the rate of return does not meet this rate, investors won't invest until the risk is reduced or the rate is increased. If an enterprise's beta is 0 or less than 0 it indicates that the enterprise is associated with low risk. However, if the rate of return is consistently below the risk free rate of return (ie. the rate of return when beta is 0) investors will not invest (they can do better with government treasury bills and have no risk) until the investment cost in the enterprise is reduced and the rate of return increased.

6.4 The Data

Net returns on investment from 1971 to 1987 were calculated for 24 hypothetical fixed crop rotations, the cow-calf, beef feedlot, hog weanling, and hog finishing enterprises as well as, the TSE 300, and government bonds. The net return on investment for the agricultural enterprises was calculated by subtracting total production costs from gross returns plus or minus any change in the value of the capital invested that occurred in the year, all divided by the beginning year value of the investment. The net return on investment associated with the stocks were represented by the percentage change in the TSE Index 300 plus the average annual dividend rate on the stocks in question. The net return on investment associated with bonds were represented by Government of Canada bonds with maturity dates greater than 10 years.

6.5 The Results

The mean and standard deviations of net returns on investment for the 24 hypothetical crop rotations, 4 livestock enterprises, the TSE 300, and government bonds were plotted in both nominal and real terms and the risk efficiency frontier visually estimated. Figures 13 and 14 show that the risk efficiency frontier, if it were plotted, would run between bonds, hog finishing and rotation 10 (33.3 percent each of wheat, canola, and lentils; 0 percent fallow). Note that the TSE does not seem to perform well compared to the other enterprises.

Nominal net cash returns on investment and the standard deviation of these returns for each of the 30 enterprises were measured and plotted. As can be seen from Figure 15 this adjustment causes a realignment of the enterprises in the mean-standard deviation trade-off space. The risk efficiency frontier, if plotted, would be much more apparent than in Figures 13 and 14. Bonds and hog finishing still appear to be on the frontier. Fedbeef is also on the frontier, albeit at a higher risk level. However, several of the crop rotations, the cow-calf enterprise and the hog weanling enterprise are also very close to the risk efficiency frontier. The TSE does not seem to be competitive with most agricultural enterprises based on net cash returns.

None of the crop rotations have correlation coefficients with respect to crop rotation 11 (SaskAvg) of less than +.52 and most are over +.90. Therefore little gains can be made by crop farmers from diversifying into other crops. The correlation coefficients with the livestock enterprises are lower, all below +.5. Therefore there are potential gains from crop farms diversifying into livestock enterprises provided their size is large enough. The correlation coefficients for the cow-calf and hog weanling enterprises are very low based on nominal and real net returns but increase when based on net cash returns. The beef feedlot and hog finishing enterprises exhibit the exact opposite trend. The correlation coefficients for the TSE and government bonds are all negative with the highest being -.06. Gains from crop farms diversifying into the TSE and/or government bonds may be possible, especially when government bonds exhibit a -.87 correlation coefficient based on real net returns on investment.

Beta values were calculated for each of the 30 enterprises assuming the market portfolio to be the TSE 300. Beta values for all the agricultural enterprises are extremely low. A low beta value for an agricultural enterprise means it's addition to a well diversified portfolio lowers the risk and investors are either willing to accept a lower rate of return on these enterprises or will bid the asset price up. The results presented in Table 6 point toward gains from diversification between agricultural enterprises and the TSE. However, Figures 13, 14, and 15 indicate the gainer may well be the TSE investor rather than the farmer.

The mean-standard deviation trade-off of a number of combinations (portfolios) of the 30 enterprises are plotted in Figures 16 (Nominal), 17 (Real), and 18 (Nominal Cash). The objective was to see what combinations of the Saskatchewan average land use (rotation 11, SaskAvg) and the other enterprises would both increase net returns and reduce risk for the 'typical' crop farm on the Canadian prairies. The size of the agricultural enterprises in the chosen portfolios are assumed to be those that reflect the economies of size investigated earlier. The livestock operations may or may not be located on the same farm. Other portfolios include the base plus an investment in government bonds and/or the TSE 300.

In Figures 16 and 17 the only portfolios that both increased net returns and reduced risk compared to the SaskAvg rotation were a 33.3 percent equal combination of the SaskAvg crop rotation, the wheat, canola, lentils, and 0 percent fallow crop rotation, and the hog finishing enterprise labelled SAWCLHF, a portfolio consisting of a 50-50 split between SaskAvg and Fedbeef labelled SABF, a portfolio consisting of a 50-50 split between SaskAvg and HogFin labelled SAHF, and the HogFin enterprise.

Figure 18 plots the same portfolios as outlined in Figures 16 and 17 only the net returns are measured as nominal net cash returns on investment. No combinations of SaskAvg and the other enterprises both increase net cash returns and reduce risk compared to SaskAvg.

6.6 Conclusions

6.6.1 Economies of Size

It is important that 'threshold' enterprise size be met when crop farmers on the Canadian prairies are thinking about diversification. The 'threshold' size undoubtedly will vary from farm to farm due to varying amounts of management ability. The 'threshold' sizes outlined may well require a larger investment than most farmers are willing or able to raise. Therefore, groups of crop farmers and other investors will have to pool their resources to form joint ventures or cooperatives that can take advantage of the economies of size and provide real diversification for crop farmers on the Canadian prairies.

6.6.2 Gains and Losses from Diversification

It is clear from the data presented that there is not much to be gained from diversifying within crops on the Canadian prairies. All of the rotations other than those with large amounts of lentils offered very similar amounts of net returns and risk. Significant addition of lentils, or other specialty crops, raises net returns but also raises risk higher than most prairie farmers are willing to take. It is significant that the SaskAvg rotation is one of the most risk efficient rotations tested. It would seem the risk management ability of crop farmers on the Canadian prairies is substantial.

Diversification into hog finishing and cattle feeding not only increase the net returns of crop farmers but also reduces their risk. However, the economies of size for these enterprises will require most crop farmers to look for joint ventures or cooperatives as a means of entry.

The gains from crop farmers diversifying into bonds or the TSE come only from reduced risk (other than on a net cash return basis) rather than increased net return. The risk reduction is substantial however, especially with bonds, and some crop farmers may want to give this special consideration. The real gains from diversification come to the current investor in the TSE. The data demonstrate that this investor can gain increased total net returns by investing in all of the agricultural enterprises investigated except the cow-calf enterprise. The current TSE investor can also reduce risk by investing in the two hog enterprise types analyzed.

6.7 Policy Implications

The major adjustment both policy formulators and farmers have to make when dealing with facilitating diversification of prairie crop farms is to view the farm as a portfolio of investments. Currently the investment portfolio of most prairie crop farms is very specialized. Investment into other crops does not seem to decrease risk. Livestock enterprises offer some gains from diversification, but these must be of 'threshold' size. Therefore ways must be found to establish these livestock units and encourage crop farmers to participate. In addition, crop farmers need to be encouraged to diversify into bonds and perhaps even stocks rather than continuing to invest in crop agriculture.

The management skills and education of crop farmers will have to be improved in order for them to handle investments into a range of enterprises, including bonds and securities. Finally, some form of capital will have to be made available to farmers that wish to diversify their investment portfolios, whether it be on or off the farm.

Another policy implication that needs to be addressed deals with the apparent gains from diversification that can be made from investing in agriculture by current investors in bonds and the TSE. If the data presented here is correct and investment in agriculture were facilitated by the establishment of equity investment firms or other investment vehicles, there would be a large influx of equity capital into agriculture. This result could have major social and political implications.

APPENDIX A: PERCENTAGE NOMINAL NET RETURNS ON INVESTMENTS

	Crop Rotations														
	1	2	3	4	5	6	7	8	9	10	SaskAvg	12	13	14	15
Year															
1971	0.95	0.27	-0.75	-2.10	-3.79	-5.83	7.77	10.67	10.01	11.27	8.86	4.79	5.73	5.56	4.73
1972	7.94	10.75	13.97	17.60	21.64	26.10	16.77	20.22	27.83	26.96	21.35	11.82	15.48	20.90	27.25
1973	41.34	43.86	46.38	48.90	51.41	53.93	29.75	33.70	37.66	55.78	52.78	35.54	38.78	42.02	45.26
1974	37.15	38.24	39.32	40.40	41.49	42.57	34.60	37.40	40.20	69.27	49.69	35.87	37.82	39.76	41.70
1975	45.05	46.00	46.95	47.90	48.85	49.79	35.56	33.71	31.87	57.25	53.04	40.31	39.86	39.41	38.96
1976	24.17	23.22	21.79	19.89	17.51	14.65	49.19	51.28	53.36	73.46	41.85	39.26	40.30	41.05	41.53
1977	17.46	23.29	25.12	27.10	29.23	31.52	33.57	30.31	27.06	77.41	31.71	25.26	24.38	23.74	23.31
1978	23.45	22.46	22.13	21.88	21.73	21.66	27.66	25.58	23.51	43.02	32.53	26.56	25.44	24.33	23.21
1979	27.65	24.58	26.04	27.68	29.50	31.51	14.83	15.76	16.69	83.48	33.26	17.99	18.61	19.23	19.84
1980	39.81	39.36	38.90	38.45	38.00	37.54	36.56	34.61	32.65	40.82	44.38	38.19	36.98	35.78	34.57
1981	11.17	11.30	11.43	10.84	9.98	8.92	8.89	11.34	13.79	24.67	18.60	10.03	11.32	12.61	13.90
1982	4.02	3.48	2.67	2.18	1.66	1.04	4.23	4.26	4.29	14.72	12.57	5.62	5.73	5.62	5.36
1983	-0.15	1.93	3.82	5.98	8.39	9.93	1.60	6.10	10.60	15.60	4.93	-0.50	2.21	5.14	8.20
1984	-6.25	-7.61	-8.47	-9.32	-10.17	-9.70	-3.06	-3.64	-4.22	-2.43	-2.71	-4.91	-5.63	-6.34	-7.06
1985	-13.81	-13.80	-13.79	-13.78	-13.76	-13.75	-15.75	-15.81	-15.87	6.26	-7.64	-14.78	-14.80	-14.83	-14.85
1986	-8.86	-8.41	-7.96	-7.50	-7.05	-6.60	-6.20	-5.67	-5.14	5.27	-1.50	-7.53	-7.04	-6.55	-6.06
1987	-11.23	-10.86	-10.49	-10.12	-9.74	-9.37	-3.39	-2.10	-0.80	6.23	-2.69	-7.31	-6.48	-5.65	-4.81
AVG.	14.11	14.59	15.12	15.65	16.17	16.70	16.03	16.92	17.85	35.82	23.00	15.07	15.81	16.57	17.36
STD.	19.04	19.28	19.68	20.17	20.79	21.48	18.14	17.92	18.15	27.95	20.44	18.20	18.21	18.37	18.73

	16	17	18	19	20	21	22	23	24	Cow Calf	Beef Feedlot	Hog Weanling	Hog Finishin	TSE 300 Total Return	G of Can Bonds >10yrs
Year															
1971	3.24	1.10	-2.16	-0.42	1.17	3.71	6.38	8.08	9.51	20.04	37.03	-2.18	-3.49	8.01	6.95
1972	34.56	42.80	-1.53	0.04	4.59	6.36	8.43	10.94	14.18	12.23	20.55	17.70	20.00	27.38	7.23
1973	48.49	51.73	27.06	30.58	27.99	31.61	35.59	38.98	42.60	37.94	12.56	25.91	30.83	0.27	7.55
1974	43.64	45.58	37.08	42.50	36.28	40.80	45.83	49.93	54.45	9.63	49.96	13.81	19.96	-25.93	8.87
1975	38.51	38.06	39.98	44.00	38.53	40.56	43.11	44.74	46.77	-36.41	83.49	38.41	42.96	18.48	9.00
1976	41.75	41.71	33.92	40.76	39.06	44.26	49.95	54.83	60.03	2.85	26.34	37.62	38.03	11.02	9.22
1977	23.09	23.08	38.67	50.19	37.03	43.56	50.47	56.81	63.35	9.71	10.40	30.14	31.13	10.71	8.69
1978	22.09	20.97	26.98	30.68	27.23	28.97	31.23	32.56	34.30	31.38	30.44	31.44	26.13	29.72	9.24
1979	20.46	21.08	21.07	37.51	19.00	30.30	42.12	52.80	64.10	66.21	16.83	13.62	11.73	44.77	10.17
1980	33.37	32.16	46.77	44.95	43.38	41.48	40.29	37.79	35.89	31.50	0.95	-8.21	22.65	30.13	12.33
1981	15.18	16.47	18.22	17.59	15.13	15.49	16.68	16.30	16.67	-1.04	31.22	9.10	30.12	-10.25	15.03
1982	4.97	4.43	6.11	7.04	5.50	6.11	7.34	7.38	7.99	-10.85	59.98	29.88	17.88	5.54	14.36
1983	11.40	14.74	-4.19	-2.58	-2.25	0.31	3.35	5.47	8.03	3.18	32.27	14.31	21.42	35.49	11.77
1984	-7.77	-8.49	-8.89	-8.91	-6.95	-7.16	-6.74	-7.57	-7.78	-0.41	8.32	-4.26	29.51	-2.39	12.74
1985	-14.88	-14.90	-9.80	-6.03	-11.77	-9.29	-6.18	-4.31	-1.82	10.43	15.91	-0.04	33.73	25.07	11.11
1986	-5.57	-5.08	-10.40	-8.33	-8.98	-7.44	-5.31	-4.32	-2.78	-0.70	-13.78	24.30	15.87	8.95	9.54
1987	-3.98	-3.15	-12.10	-10.24	-9.18	-7.53	-5.33	-4.18	-2.52	21.84	-3.07	19.21	4.17	5.88	9.95
AVG.	18.15	18.96	14.52	18.20	15.04	17.77	21.01	23.31	26.06	12.21	24.67	17.10	23.10	13.11	10.22
STD.	19.33	20.22	20.22	22.04	19.18	20.08	21.32	22.93	24.72	21.77	23.29	14.15	11.51	17.29	2.29

APPENDIX B: PERCENTAGE REAL NET RETURNS ON INVESTMENT

	Crop Rotations														
	1	2	3	4	5	6	7	8	9	10	SaskAvg	12	13	14	15
Year															
1971	-1.87	-2.54	-3.52	-4.84	-6.49	-8.46	4.75	7.57	6.93	8.15	5.81	1.86	2.77	2.60	1.80
1972	2.99	5.67	8.75	12.21	16.07	20.33	11.42	14.71	21.97	21.14	15.79	6.70	10.19	15.36	21.43
1973	31.32	33.66	36.00	38.34	40.68	43.01	20.54	24.22	27.90	44.73	41.94	25.93	28.94	31.95	34.95
1974	23.67	24.64	25.62	26.60	27.58	28.56	21.36	23.89	26.41	52.63	34.97	22.52	24.27	26.02	27.77
1975	30.93	31.78	32.64	33.49	34.35	35.20	22.36	20.69	19.02	41.93	38.13	26.64	26.24	25.83	25.42
1976	15.42	14.54	13.21	11.45	9.23	6.58	38.69	40.62	42.56	61.24	31.86	29.46	30.42	31.12	31.57
1977	8.85	14.25	15.94	17.78	19.75	21.87	23.77	20.76	17.74	64.40	22.05	16.07	15.26	14.66	14.26
1978	13.44	12.53	12.22	12.00	11.86	11.79	17.30	15.40	13.49	31.42	21.78	16.30	15.27	14.24	13.22
1979	16.90	14.09	15.42	16.93	18.60	20.43	5.16	6.01	6.86	68.03	22.04	8.06	8.62	9.19	9.75
1980	26.87	26.46	26.05	25.64	25.23	24.81	23.92	22.15	20.37	27.79	31.01	25.40	24.30	23.21	22.12
1981	-1.16	-1.05	-0.94	-1.46	-2.22	-3.17	-3.19	-1.02	1.16	10.83	5.44	-2.18	-1.03	0.11	1.26
1982	-6.12	-6.61	-7.34	-7.78	-8.25	-8.81	-5.93	-5.90	-5.88	3.54	1.60	-4.68	-4.58	-4.68	-4.91
1983	-5.58	-3.62	-1.82	0.21	2.49	3.95	-3.93	0.33	4.59	9.31	-0.77	-5.91	-3.34	-0.58	2.32
1984	-9.51	-10.83	-11.65	-12.47	-13.29	-12.84	-6.43	-6.99	-7.55	-5.83	-6.09	-8.22	-8.91	-9.60	-10.29
1985	-17.92	-17.91	-17.90	-17.89	-17.87	-17.86	-19.77	-19.82	-19.88	1.19	-12.05	-18.84	-18.87	-18.89	-18.91
1986	-12.79	-12.35	-11.92	-11.49	-11.05	-10.62	-10.24	-9.73	-9.23	0.73	-5.74	-11.51	-11.04	-10.57	-10.11
1987	-14.64	-14.28	-13.92	-13.57	-13.21	-12.85	-7.10	-5.86	-4.61	2.16	-6.42	-10.87	-10.07	-9.27	-8.47
AVG.	5.93	6.38	6.87	7.36	7.85	8.35	7.81	8.65	9.52	26.08	14.20	6.87	7.56	8.28	9.01
STD.	15.86	16.12	16.53	17.04	17.69	18.41	15.54	15.41	15.74	24.28	17.16	15.29	15.35	15.57	15.99

	16	17	18	19	20	21	22	23	24	Cow Calf	Beef Feedlot	Hog Weanling	Hog Finishin	TSE 300 Total Return	G of Can Bonds >10yrs
Year															
1971	0.35	-1.73	-4.90	-3.21	-1.66	0.81	3.41	5.05	6.44	16.68	33.19	-4.92	-6.19	8.01	6.95
1972	28.39	36.26	-6.04	-4.54	-0.20	1.49	3.47	5.85	8.95	7.09	15.03	12.31	14.50	22.58	2.43
1973	37.96	40.97	18.05	21.32	18.92	22.28	25.97	29.13	32.49	28.16	4.57	16.98	21.55	-7.36	-0.08
1974	29.52	31.27	23.60	28.49	22.88	26.96	31.49	35.19	39.27	-1.15	35.22	2.62	8.16	-36.83	-2.03
1975	25.02	24.61	26.34	29.98	25.04	26.87	29.17	30.64	32.47	-42.60	65.62	24.93	29.03	7.69	-1.79
1976	31.77	31.73	24.49	30.85	29.27	34.10	39.39	43.93	48.76	-4.39	17.44	27.93	28.31	3.44	1.64
1977	14.06	14.06	28.50	39.17	26.98	33.03	39.44	45.31	51.37	1.67	2.30	20.60	21.51	2.80	0.78
1978	12.19	11.16	16.68	20.08	16.91	18.51	20.59	21.81	23.41	20.73	19.86	20.78	15.90	20.89	0.41
1979	10.32	10.88	10.88	25.93	8.98	19.33	30.15	39.93	50.28	52.22	6.99	4.05	2.32	35.58	0.98
1980	21.02	19.93	33.19	31.54	30.11	28.39	27.31	25.04	23.31	19.33	-8.39	-16.70	11.30	19.93	2.13
1981	2.40	3.55	5.10	4.54	2.35	2.68	3.73	3.39	3.72	-12.02	16.65	-3.01	15.68	-22.73	2.55
1982	-5.26	-5.75	-4.23	-3.39	-4.79	-4.24	-3.12	-3.09	-2.54	-19.54	44.39	17.22	6.39	-5.26	3.56
1983	5.35	8.50	-9.40	-7.88	-7.56	-5.14	-2.27	-0.27	2.15	-2.43	25.08	8.10	14.82	29.74	6.02
1984	-10.98	-11.67	-12.06	-12.08	-10.18	-10.39	-9.98	-10.78	-10.99	-3.87	4.55	-7.58	25.01	-5.99	9.14
1985	-18.94	-18.96	-14.10	-10.51	-15.98	-13.61	-10.65	-8.87	-6.50	5.16	10.38	-4.81	27.35	20.06	6.10
1986	-9.64	-9.17	-14.26	-12.27	-12.90	-11.43	-9.39	-8.44	-6.96	-4.97	-17.49	18.95	10.88	4.45	5.04
1987	-7.66	-6.86	-15.48	-13.69	-12.67	-11.08	-8.97	-7.85	-6.26	17.16	-6.79	14.63	0.17	1.89	5.96
AVG.	9.76	10.52	6.26	9.67	6.79	9.33	12.34	14.47	17.02	4.54	15.80	8.95	14.51	5.82	2.93
STD.	16.67	17.64	16.80	18.55	16.01	16.88	18.07	19.64	21.36	20.34	20.05	12.58	9.97	17.95	3.09

APPENDIX C: PERCENTAGE NOMINAL CASH NET RETURNS ON INVESTMENT

	Crop Rotations													
	1	2	3	4	5	6	7	8	9	10	SaskAvg	12	13	14	15
Year															
1971	13.71	13.14	12.23	10.98	9.40	7.46	20.59	23.64	23.09	16.59	14.61	17.59	18.66	18.60	17.88
1972	17.61	20.46	23.71	27.37	31.43	35.89	26.23	29.71	37.25	28.31	23.35	21.40	25.08	30.48	36.80
1973	31.62	33.87	36.11	38.36	40.60	42.85	21.79	25.26	28.72	36.32	34.25	26.71	29.56	32.42	35.27
1974	20.39	21.37	22.35	23.33	24.31	25.29	18.38	20.71	23.04	38.24	23.21	19.38	21.04	22.70	24.35
1975	19.89	20.77	21.65	22.53	23.42	24.30	12.65	11.39	10.14	23.55	20.65	16.27	16.08	15.90	15.71
1976	12.26	11.59	10.53	9.08	7.23	4.99	32.89	34.72	36.55	46.67	20.98	24.71	25.67	26.40	26.91
1977	13.06	18.37	20.14	22.06	24.10	26.29	27.27	24.56	21.85	60.13	19.98	19.94	19.33	18.93	18.71
1978	10.35	9.68	9.55	9.50	9.52	9.61	13.83	12.26	10.69	21.52	12.98	12.93	12.15	11.37	10.59
1979	16.21	13.79	15.15	16.66	18.32	20.13	5.54	6.46	7.37	56.52	15.01	8.17	8.83	9.48	10.14
1980	9.58	9.33	9.08	8.83	8.58	8.33	7.21	5.86	4.51	5.78	8.63	8.40	7.60	6.80	6.00
1981	7.64	7.88	8.11	7.72	7.08	6.27	5.64	7.91	10.18	13.42	8.40	6.64	7.89	9.14	10.40
1982	7.06	6.67	6.02	5.69	5.32	4.85	7.26	7.41	7.56	12.02	10.20	8.57	8.80	8.82	8.70
1983	12.05	14.34	16.45	18.83	21.47	23.21	13.87	18.70	23.53	23.89	12.89	11.68	14.64	17.83	21.15
1984	7.66	6.36	5.60	4.84	4.08	4.72	11.03	10.55	10.08	6.52	6.41	9.07	8.46	7.84	7.23
1985	6.62	6.74	6.86	6.99	7.11	7.23	4.43	4.47	4.52	23.44	8.10	5.53	5.61	5.69	5.77
1986	11.04	11.67	12.30	12.92	13.55	14.18	13.98	14.69	15.40	20.08	12.97	12.51	13.18	13.85	14.51
1987	11.31	11.87	12.43	12.99	13.55	14.12	20.10	21.70	23.29	23.65	14.02	15.71	16.79	17.86	18.94
AVG.	13.42	13.99	14.61	15.22	15.83	16.45	15.45	16.47	17.52	26.86	15.69	14.42	15.26	16.12	17.00
STD.	6.13	6.92	7.80	8.83	10.04	11.29	8.20	8.90	10.24	15.49	7.01	6.26	6.96	7.97	9.25

	16	17	18	19	20	21	22	23	24	Cow Calf	Beef Feedlot	Hog Weanling	Hog Finishin	TSE 300 Total Return	G of Can Bonds >10yrs
Year															
1971	16.50	14.46	10.57	12.44	13.94	16.62	19.24	21.28	22.83	29.01	49.26	11.52	3.68	8.01	6.95
1972	44.03	52.19	8.37	10.01	14.35	16.18	18.10	20.88	24.15	34.91	30.89	27.29	24.39	27.38	7.23
1973	38.13	40.98	19.52	22.61	20.32	23.49	26.67	29.97	33.13	43.95	23.84	37.76	35.56	0.27	7.55
1974	26.01	27.67	20.33	24.75	19.72	23.40	27.08	30.88	34.56	7.95	59.66	26.51	25.39	-25.93	8.87
1975	15.53	15.34	16.01	19.25	14.92	16.62	18.34	20.13	21.83	8.57	100.47	51.57	48.12	18.48	9.00
1976	27.21	27.29	20.30	26.05	24.55	28.94	33.34	37.88	42.27	15.09	39.55	43.35	40.56	11.02	9.22
1977	18.68	18.84	31.77	42.10	30.33	36.25	42.17	48.28	54.20	19.34	22.88	38.03	34.84	10.71	8.69
1978	9.81	9.04	13.27	16.48	13.48	15.07	16.67	18.33	19.92	36.00	44.26	41.43	30.55	29.72	9.24
1979	10.80	11.45	10.73	24.55	9.02	18.56	27.98	37.57	47.10	35.84	27.99	24.90	17.16	44.77	10.17
1980	5.20	4.40	14.67	13.42	12.20	10.88	9.62	8.36	7.04	21.00	11.41	8.12	32.02	30.13	12.33
1981	11.65	12.90	13.83	13.39	11.12	11.56	12.02	12.52	12.95	11.71	41.19	20.34	36.11	-10.25	15.03
1982	8.45	8.07	9.04	10.04	8.47	9.16	9.87	10.61	11.31	13.31	71.96	42.33	23.71	5.54	14.36
1983	24.62	28.24	7.82	9.63	9.86	12.66	15.44	18.30	21.10	14.30	42.58	22.98	26.24	35.49	11.77
1984	6.61	5.99	4.88	4.99	6.94	6.84	6.76	6.70	6.60	17.82	21.47	13.13	40.07	-2.39	12.74
1985	5.86	5.94	11.14	15.49	8.92	11.82	14.71	17.66	20.56	17.04	26.88	15.19	42.89	25.07	11.11
1986	15.18	15.85	9.35	11.76	10.92	12.73	14.56	16.44	18.26	21.01	-3.11	34.95	21.40	8.95	9.54
1987	20.02	21.10	10.34	12.56	13.62	15.60	17.60	19.67	21.65	26.05	6.81	32.15	11.09	5.88	9.95
AVG.	17.90	18.81	13.64	17.03	14.28	16.85	19.42	22.09	24.67	21.94	36.35	28.91	29.05	5.82	2.93
STD.	10.81	12.67	6.29	8.60	6.04	7.28	8.99	10.99	13.11	10.34	24.28	12.30	11.33	17.95	3.09

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