*Managing the Modern Farm Business*

# MEASURING DEGREES OF RISK

*Leonard Bauer*
*and*
*Don Bushe*

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# PREFACE

Why should managers be interested in this series of risk management modules? These self directed learning modules demonstrate the basic tools used in the business world today; they are the language and practice of modern business.

My biases on the importance of having a strong understanding of management concepts come from over a decade spent as a researcher and instructor at the University of Alberta blended more recently by several years as manager of a commodity production business.

I have worked with many excellent business managers and if there is a central theme it is this; they distinguish themselves by their knowledge and ability to apply the principles of economics and risk management. These modules outline the basic principles and give practical insights, through illustrations and exercises, on how the material can be applied in practical situations.

The following modules lay out the basic process of developing and implementing a risk management program. Although the discussion in the modules is restricted to a highly simplified case, the tools can be applied to any business enterprise. Even if a manager does not use the actual detailed methods in every situation, e.g. calculating that the probability of default will drop by five or ten percentage points, there is power in understanding the sources and relative magnitudes of risk associated with various events. It is impossible to build sound strategies without a solid foundation.

I have thoroughly reviewed these materials; I use the principles in my day to day operations. I strongly encourage managers and those who work with and advise managers, in any capacity, to make use of Dr. Len Bauer's work to ensure a clear grasp of the important concepts and tools. The instructional design provided by Don Bushe makes it easy for busy managers to assimilate the ideas efficiently.

In these modules you gain a lot of understanding about important management ideas by working with a simple set of examples; today's managers had better be able to master these methods. Remember, if you fail to apply sound management principles you are inviting the market place to solve your management problems for you.

Frank Novak, Managing Director
Alberta Pig Company

# FOREWORD

Farm business management is the art and science of making decisions about the use of available resources and acting on those decisions in an uncertain world so that the short- and long-term goals of the business owners are as fully satisfied as possible.

This definition is not new, but rather a distillation of the thoughts and philosophies of many writers on the topic. The definition contains several key words. Management is concerned with achieving goals. Decision-making and action are crucial. Resources are limited and the world is uncertain.

As the general manager of your business, you need to plan, organize, control, co-ordinate, and motivate your management team. You must see to it that the details of production, marketing, financing, and personnel management are carried out.

As production manager, you must decide what to produce, how to produce it, and how much of it to produce, and you must set the production process in motion. As marketing manager, you must form expectations of product prices, and you need to carry out the functions of buying inputs and selling the products. As financial manager, you need to decide which assets to acquire, how to raise the funds to acquire them, and also when to exercise financial control. As personnel manager, you need to find and keep the right staff and then make sure they are properly trained to do the job.

'*Managing the Modem Farm Business*' is a series of modules designed to help in developing the necessary concepts and skills essential to effectively manage the production, marketing, financing, and human resource aspects of the farm business. If you are the owner-manager of a farm, these modules will improve your chances of operating a successful business. If you are a farm management advisor, or an instructor, these modules are useful in reviewing and enhancing your understanding of management principles. They also provide an excellent resource of study materials, examples, and exercises for your students and clients.

Management is a process of gathering information, making decisions, and taking action. This module will help you take part in this process.

Leonard Bauer, PAg

Technical Editor

# ACKNOWLEDGEMENTS

The authors acknowledge the contributions of many groups and individuals. The ideas portrayed in these modules were first developed as a tool for teaching introductory farm management. One individual in particular stands out for recognition; Alf Petersen has offered substance and encouragement to the preparation for many of the modules in the '*Managing the Modern Farm Business*' series. Many students at the University of Alberta have provided a worthwhile testing ground for the subject matter and its presentation. Their candid contributions have been invaluable.

Staff members of the British Columbia Ministry of Agriculture, Fisheries, and Food have participated at risk management workshops and have provided useful suggestions for improvement. Their contributions and those of Howard Joynt and Mike Cowley of the British Columbia Ministry have provided practical insights invaluable to this set of modules. The insights of these individuals were incorporated into the first edition in 1993. We acknowledge funding of the first edition by the Province of British Columbia, Ministry of Agriculture, Fisheries and Food in cooperation with Agriculture Canada and the University of Alberta. Furthermore we acknowledge the contributions of Lois Hameister as copy editor, Melanie Eastley as graphic designer and Lu Ziola for electronic page composition.

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Alberta Agriculture, Food and Rural Development provided special funding for the considerable revisions undertaken in the third edition. We gratefully acknowledge this valuable contribution as well as the editorial and substantive contributions of Ted Darling and Dale Kaliel of that organization.

Whilst care has been taken to ensure accuracy of the material the authors freely accept responsibility for any errors remaining.

# TABLE OF CONTENTS

# INTRODUCTION

## *The Risk Management Modules*

Discussing farm risk usually involves reference to poor yields, disastrous events, calamitous markets, and missed opportunities. There is no doubt that bad things happen on the farm. Good things can happen as well: high yields, bountiful markets, and avoided disasters are some examples. But even these good things can have a bad side for the operator who did not anticipate or plan for them and then was unable to seize on the opportunity.

A high price for barley coinciding with a bumper crop is a good thing for the grain farmer who planted barley. It would be a bad thing for the farmer who decided against planting barley. Similarly, a farmer who sprayed for insects would be protected in the case of an infestation; in a year of few insects, he will have spent money unnecessarily. Risk has two major components: the probability of bad things happening, and the consequences of bad things that have happened.

Farm managers need to understand their attitude toward risk. They must develop methods to identify, measure, and control risk to reduce the losses that are a consequence of bad things happening. Effective management can help to improve the chances that good things happen, losses are avoided, and opportunities captured. These are the themes that are developed in each of the modules.

The first module, *Identifying Risk Attitudes*, examines the predisposition to risk of the manager. One must be able to recognize and allow for one's own risk attitude in selecting the "right" course of action. *Identifying Risk Sources* explores the compounding effect that financial risk has on business risk. *Measuring Degrees of Risk* presents methods that the manager can use to calculate risk exposure and make effective comparisons of alternate actions. *Designing Risk Management Strategies* outlines the ways that effective farm managers can reduce overall risk exposure.

## *Measuring Degrees of Risk*

In the module “Identifying Risk Sources” subjective probabilities were used to illustrate the impact of risk on a modern farming business, especially for one that is highly leveraged. In this module we use probabilities in a more objective way. We illustrate the basic concepts in analyzing observations about real world phenomena; we use yields and prices to describe the methods for measuring the degree of risk. We will use the normal distribution, a statistical construct developed by a German mathematician and astronomer, Johann Karl Friedrich Gauss (1777 – 1855). Being able to use concepts like mean and standard deviation will enable the manager to calculate the probability of adverse events occurring so strategic plans can be put in place to better deal with risk.

How is return measured objectively? How is variability measured objectively? What is the probability of a low return? What are the chances of obtaining a high return? These are the problems, questions, and challenges addressed in this module.

You will apply the methods for summarizing historical information available and used in investment decisions to a set of financial statements for a farm business. When you have completed this module, you will be able to:

- visually appraise data as to reliability and relevance
- summarize data from various sources
- calculate the average or mean
- calculate the standard deviation
- calculate the probability of adverse events occurring

# RISK IN THE MODERN FARM BUSINESS

The modern farm business is faced with a variety of risks. Production levels vary from one year to the next and so do prices. There is the chance that the new barn just built will soon be obsolete because new technology makes current production processes obsolete. What about prices; they too are subject to fluctuations. Should we lock in prices, or should we take a chance that the prices will rise. And, what about costs; should we buy fertilizer this fall, or should we take a chance that prices will come down by next spring? What about government policy? Should we lock in interest rates or should we continue with a floating rate? These are but a few of the risks faced by the modern farm business.

The modern farm business involves risk with a greater impact than in the past. Farmers are faced with many decisions: what to grow, how to produce, when to feed, where to plant, how to sell.

Selecting appropriate risk management strategies depends upon a rational comparison of consequences. It requires measuring the degree to which the risk impacts the business.

Knowing when to transfer, avoid, control, or accept risk involves more than the risk attitude of the decision-maker. Whether a person is more or less averse to risk will guide the selection of solutions that are found on the risk efficiency curve. While risk attitude is a key component in the selection of strategies, more critical is the determination of which strategies are available to be considered.

These factors involve a comparison of the situation and the consequences of the solutions to what may be expected in an average situation. The determination of what is average can be compared to "normal" in order to measure the degree of risk that is presented in the situation. Statistical means to calculate these figures are used in the case study example to illustrate how you can use your records to complete similar calculations for your own operation.

## *A Farm Business Case Study*

K&L Farms began seven years ago with an investment of $150,000 in land, buildings and equipment. Kim and Lee, the operators of the business, now have 1,280 acres of land with 1,143 cultivated and in crop (1142.8571 acres to be exact). K&L Farms has a total investment of $725,000, made up of $225,000 in owner's equity held by Kim and Lee and $500,000 in debts held by the mortgage company. They are full time managers of K&L Farms while Kim works part time as an accountant in town and his wife Lee is a high school mathematics teacher. They are concerned by the financial risk exposure of their business, K&L Farms. They understand the financial structure of their business and the sources of risk they are facing, but they would like to measure the extent of risk more objectively. We will follow their discussion as they explore the situation.

## *A Twenty-Year History of Yields*

"We do have more than just our seven year history of running this farm," Kim said to Lee. "When I bought the place, the previous owner gave me his records too."

"That's great Kim," Lee exclaimed. "We should include it with our records. Why don't you organize it into a table?"

Kim proceeded to build a table. "Our information takes us up to year 20," he said, "but look at that year 4."

"I think that looks like a missed decimal point," said Lee. "We better correct it."

Kim drew up a corrected column. "Wow, from the best year to the worst year in one decimal point! That would have really messed up our analysis," Kim noted.

| **Twenty Year Yield (Original)** | | **(Corrected)** |
|---|---|---|
| **Year** | **Bus / Acre** | **Bus / Acre** |
| 1 | 42.5 | 42.5 |
| 2 | 63.0 | 63.0 |
| 3 | 23.0 | 23.0 |
| **4** | **155** | **15.5** |
| 5 | 51.5 | 51.5 |
| 6 | 63.5 | 63.5 |
| 7 | 80.5 | 80.5 |
| 8 | 37.5 | 37.5 |
| 9 | 46.5 | 46.5 |
| 10 | 63.0 | 63.0 |
| 11 | 57.5 | 57.5 |
| 12 | 69.5 | 69.5 |
| 13 | 42.0 | 42.0 |
| 14 | 32.0 | 32.0 |
| 15 | 46.5 | 46.5 |
| 16 | 41.5 | 41.5 |
| 17 | 75.0 | 75.0 |
| 18 | 20.5 | 20.5 |
| 19 | 68.5 | 68.5 |
| 20 | 60.5 | 60.5 |

### *Visual Appraisal of the Data*

It is a good idea to inspect the set of data visually, such as the twenty-year series of yields, when ever practical. Even when a data set is very large it is a good idea to examine it for highs and lows and ranges and for extreme outliers; this will identify obvious nonsensical entries. For example a recorded yield of 155 bushels in year 4 would be an obvious error that should be corrected before proceeding; the error was a missed decimal point which if not corrected would distort the average by 7 bushels per acre.

The lesson; be careful.

*Exercise 1 - A Twenty-Year History of Yields*

Refer to the data in the table to help Kim and Lee answer the question.

In the twenty-year history the lowest yield of **[____]** bushels per acre occurred in year **[____]**. The highest yield occurred in year **[____]**. The yield that year was **[____]** bushels per acre. The range in yields (the spread from high to low) over the twenty years was **[____]** bushels per acre.

*A Twenty-Year History of Yields – Answer*

Check your work and correct any errors. If you had more than one error (less than four correct) you may wish to review this section.

In the twenty-year history the lowest yield of **[15.5]** bushels per acre occurred in year **[4]**. The highest yield occurred in year **[7].** The yield that year was **[80.5]** bushels per acre. The range in yields (the spread from high to low) over the twenty years was **[65.0]** bushels per acre.

## *The Arithmetic Mean*

"You know Kim," Lee stated, "with a bit of work, we can really use that 20 year information to do some pretty sophisticated analysis."

| 20 Year Yield | |
|---|---|
| **Year** | **Bus / Acre** |
| 1 | 42.5 |
| 2 | 63.0 |
| 3 | 23.0 |
| 4 | 15.5 |
| 5 | 51.5 |
| 6 | 63.5 |
| 7 | 80.5 |
| 8 | 37.5 |
| 9 | 46.5 |
| 10 | 63.0 |
| 11 | 57.5 |
| 12 | 69.5 |
| 13 | 42.0 |
| 14 | 32.0 |
| 15 | 46.5 |
| 16 | 41.5 |
| 17 | 75.0 |
| 18 | 20.5 |
| 19 | 68.5 |
| 20 | 60.5 |
| Total | 1000.00 |
| Average | 50.0 |

"Sounds good to me Lee," Kim agreed. "I'm definitely up for some sophistication. So where do we start?"

"Well," she replied, "the first point is to calculate the mean."

"Isn't that just the average of the whole thing?" Kim inquired. "I've also heard it called the 'expected yield'."

"Yes Kim," Lee agreed. "The mean is simply the arithmetic average of all the yields in the series. The calculation is straight forward."

Kim started to add up the series with his calculator. "I simply sum the individual yields …"

"…and then divide by the number in the series," Lee said finishing his statement.

"Sounds good," he said. "I have the 20 year total as 1000."

"Now all you have to do is to divide by the number of entries," Lee advised.

"So the expected yield for K&J Farms would be 50 bushels per acre," Kim stated.

"In other, mathematical terms, the arithmetic mean of the 20-year yield history is 50 bushels per acre," Lee cautioned.

**Calculating the arithmetic mean of any series is a two-step process.**

**Step 1:** Sum the observations (in this case the yields in the series)

**Step 2:** Divide the sum by the number of observations (in this case the number of years in the series)

"The reasoning behind this," Lee went on to explain, "is that as long as the climate doesn't change and we keep farming in the same way, any one of the yields in the twenty year series could occur."

"Now I understand why the average or mean is also called the expected value," Kim replied. "Since we have no special information such as the moisture levels for the next year, all we can expect is the average."

"That's why the expression 'expected value' is used," Lee agreed. "In fact we have drawn a sample of twenty observations from a population of yields, so what we have is really an estimate of the average yield; we don't actually know the true mean yield."

## *Subjective Probabilities*

"You know," commented Kim, "finding the average isn't particularly sophisticated. I was expecting something a bit more challenging."

"Stay with me Kim," Lee advised. "The first thing we need to do is to sort the figures from lowest to highest. That way, we can start to analyze our information."

"Good idea. I'll make two columns, one for the year and the other for the bushels per acre," Kim replied.

"OK I'll stroke out each year as we put it in the table so we don't repeat one," Lee said as she read out the figures.

They proceeded to complete the table sorted from the year of lowest yield to the year of the highest yield in the 20-year history.

| 20 Year History | |
|---|---|
| **Year** | **Bus / Acre** |
| 4 | 15.5 |
| 18 | 20.5 |
| 3 | 23.0 |
| 14 | 32.0 |
| 8 | 37.5 |
| 16 | 41.5 |
| 13 | 42.0 |
| 1 | 42.5 |
| 9 | 46.5 |
| 15 | 46.5 |
| 5 | 51.5 |
| 11 | 57.5 |
| 20 | 60.5 |
| 2 | 63.0 |
| 10 | 63.0 |
| 6 | 63.5 |
| 19 | 68.5 |
| 12 | 69.5 |
| 17 | 75.0 |
| 7 | 80.5 |

In the module *Identifying Sources of Risk* Kim and Lee concluded, subjectively to be sure, that there were three possible yields, poor yields at 25.0 bushels per acre, normal yields at 50.0 bushels per acre and good yields at 75.0 bushels per acre.

"Remember that we felt that a poor yield occurs half as often as a normal yield and equally as often as a good yield," Kim noted as he looked at the finished table.

"That means that 25 % of the yields are in the 'poor', 50 % in the 'normal' and 25 % are in the 'good' yield group," Lee continued. "We'll divide the 20 year history into four groups of equal size. We'll call them 'quartiles' and compare our 'guesstimates' to what was actually found."

"I see," Kim began drawing up a new table. "So the first quarter would be the one for Poor Yields."

"Right," Lee replied. "But you should call it the 'First Quartile'. When we divide into groups like this we name them this way so that there's no confusion with the financial quarters."

| First Quartile | |
|---|---|
| **Year** | **Bus / Acre** |
| 4 | 15.5 |
| 18 | 20.5 |
| 3 | 23.0 |
| 14 | 32.0 |
| 8 | 37.5 |
| Total | 128.5 |
| Number | 5 years |
| Average | 25.7 |

"The bad years in the first quartile are 4, 18, 3, 14 and 8." Kim wrote the values into the table.

"Now," she went on, "we can calculate the average for the First Quartile."

Kim added the values, divided by the number of years, then wrote the figure into the table.

"25.7 bushels per acre," Lee stated, "awfully close to our estimate of 25 isn't it."

"That's right!" exclaimed Kim. "What do I call the next one, the Second Quartile?"

"Actually," Lee advised, "the middle two quartiles of our 20 year series could be grouped together into the middle half."

Kim prepared the table and labeled the entries.

*Exercise 2 - Subjective Probabilities*

Refer to the table to complete the calculations. Then refer to the table to complete the statement.

| $2^{nd}$ & $3^{rd}$ Quartiles | |
|---|---|
| 16 | 41.5 |
| 13 | 42.0 |
| 1 | 42.5 |
| 9 | 46.5 |
| 15 | 46.5 |
| 5 | 51.5 |
| 11 | 57.5 |
| 20 | 60.5 |
| 2 | 63.0 |
| 10 | 63.0 |
| **Total** | **[_____]** |
| **Number** | **[_____]** |
| **Average** | **[_____]** |

Fifty per cent of the twenty-year history of yields on K&L Farm is placed into the second and third quartiles and represent a range of **[____]** bushels per acre to **[____]** bushels per acre. The average of **[____]** bushels per acre was **[higher/lower]** than their subjective feel of 50.0 bushels per acre.

*Subjective Probabilities – Answer*

Compare your work to Kim and Lee's. Correct any errors. If you had more than one error (less than six of seven correct) you may wish to review the section.

| 2nd & 3rd Quartiles | |
|---|---|
| 16 | 41.5 |
| 13 | 42.0 |
| 1 | 42.5 |
| 9 | 46.5 |
| 15 | 46.5 |
| 5 | 51.5 |
| 11 | 57.5 |
| 20 | 60.5 |
| 2 | 63.0 |
| 10 | 63.0 |
| **Total** | **[514.5]** |
| **Number** | **[10 years]** |
| **Average** | **[51.5]** |

Fifty per cent of the twenty-year history of yields on K&L Farm is placed into the second and third quartiles and represent a range of [**41.5**] bushels per acre to [**63.0**] bushels per acre. The average of [**51.5**] bushels per acre was **[higher/~~lower~~]** than their subjective feel of 50.0 bushels per acre.

"Now we only have the last quartile to complete," Kim observed. He began to prepare the final table.

"You're talking like a real mathematician," Lee smiled, "there might be hope for this accountant yet."

"Let's not get cute," Kim commented. "I see that the fourth quartile averaged 71.4 bushels per acre."

| 4th Quartile | |
|---|---|
| **Year** | **Bus / Acre** |
| 6 | 63.5 |
| 19 | 68.5 |
| 12 | 69.5 |
| 17 | 75.0 |
| 7 | 80.5 |
| **Total** | 357 |
| **Number** | 5 years |
| **Average** | 71.4 |

"That is somewhat less than the 75.0 we had estimated subjectively," Lee agreed. "But our subjective feeling about probabilities, that a poor yield occurs half as often as a normal yield and equally as often as a good yield, is consistent with sorting the data into quartiles."

"True enough," Kim observed. "25 % of the yields are in the 'poor', 50 % are found in the 'normal' and 25 % are in the 'good' yield group."

"Well, although our subjective feeling isn't far off from what the data actually revealed," Lee said, "we can do a much more powerful analysis with the information. With very little extra work we can summarize the data by using the standard deviation as well as the mean."

"Now I know that the mean is just the arithmetic average," Kim offered, "but what about the standard deviation?"

"It shows how close the various annual crop yields are to the average," Lee explained. "It's a really useful indicator."

"OK, how do we get the standard deviation?" was Kim's reaction.

## *Standard Deviation*

"The standard deviation is a measure of how close to the mean the various observations are located," said Lee, lapsing into her teacher role again. "It is a measure of central tendency. The lower the standard deviation the closer to the mean the individual observations will be."

| Year | Yield per Acre | Mean Yield | Deviation from Mean |
|---|---|---|---|
| 1 | 42.5 | 50.0 | -7.5 |
| 2 | 63.0 | 50.0 | 13.0 |
| 3 | 23.0 | 50.0 | -27.0 |
| 4 | 15.5 | 50.0 | -34.5 |
| 5 | 51.5 | 50.0 | 1.5 |
| 6 | 63.5 | 50.0 | 13.5 |
| 7 | 80.5 | 50.0 | 30.5 |
| 8 | 37.5 | 50.0 | -12.5 |
| 9 | 46.5 | 50.0 | -3.5 |
| 10 | 63.0 | 50.0 | 13.0 |
| 11 | 57.5 | 50.0 | 7.5 |
| 12 | 69.5 | 50.0 | 19.5 |
| 13 | 42.0 | 50.0 | -8.0 |
| 14 | 32.0 | 50.0 | -18.0 |
| 15 | 46.5 | 50.0 | -3.5 |
| 16 | 41.5 | 50.0 | -8.5 |
| 17 | 75.0 | 50.0 | 25.0 |
| 18 | 20.5 | 50.0 | -29.5 |
| 19 | 68.5 | 50.0 | 18.5 |
| 20 | 60.5 | 50.0 | 10.5 |

"Then, if I understand that right," Kim queried, "the larger the standard deviation the more spread out the data will be?"

"Very good Kim," Lee agreed. "Calculating the standard deviation is a four step process," she wrote the steps on a sheet of paper for Kim's reference.

- **Step 1:** calculate the deviations from the mean.
- **Step 2:** square the deviations.
- **Step 3:** sum the squared deviations to obtain the variance.
- **Step 4:** take the square root of the variance to obtain the standard deviation.

"Let's go for it Lee," Kim agreed.

**Step 1:** The first step is to calculate the deviations from the mean. This requires calculating the difference between the mean yield and actual yield for each of the 20 years of available data.

"OK Lee," Kim said as he wrote the headings Year, Yield per Acre, and Mean Yield onto a table. "The new heading will be 'Deviation from Mean'. What do I do about negative deviations?"

"When the actual yield is less than the mean," Lee advised, "record it with a minus sign."

*Exercise 3 - Deviation from the Mean Yield*

Refer to the table to complete the statement.

The yield in year **[____]** was **[____]** bushels per acre, the lowest yield in the series. The deviation that year was **[____]** bushels per acre. The upper range of yields was achieved in year **[____]** when the yield was **[____]** bushels per acre. The deviation that year was **[____]** bushels per acre.

*Deviation from the Mean Yield - Answer*

Compare your work to Kim and Lee's. Correct any errors. If you had an error you may wish to review this section.

The yield in year **[4]** was **[15.5]** bushels per acre, the lowest yield in the series. The deviation that year was [**-34.5]** bushels per acre. The upper range of yields was achieved in year **[7]** when the yield was **[80.5]** bushels per acre. The deviation that year was **[30.5]** bushels per acre.

"Now we go on to square the deviations," Lee explained. "You can add another column to the table Kim."

"Squared Deviations?" he inquired. "Why do we need to square the deviations?"

Lee recalled her statistics course a few years back. "I don't want to get too theoretical," she replied. "But the variance is defined as the 'second moment of the distribution' that means we raise the deviations to the second power; we square them. The second moment shows how dispersed or variable the distribution is, hence the name variance. For your interest there are other moments as well. The first moment is the mean. The second is the variance as we just said. The third moment measures 'skewness' and tells us how symmetric the distribution is. I can go on."

"I think that's as much as I needed to know." Kim had squared the deviations "What's next?"

"Now we go on to Step 3," Lee advised. "We add up the column of squared deviations to get the total."

"Good thing I kept them all as a running total in memory," Kim pressed the recall memory button. "The total is 6,453.50."

"Write that down Kim," Lee said, "because now we divide it by the number of years less one to get the variance."

| Year | Yield per Acre | Mean Yield | Deviation from Mean | Squared Deviation |
|---|---|---|---|---|
| 1 | 42.5 | 50.0 | -7.5 | 56.25 |
| 2 | 63.0 | 50.0 | 13.0 | 169.00 |
| 3 | 23.0 | 50.0 | -27.0 | 729.00 |
| 4 | 15.5 | 50.0 | -34.5 | 1190.25 |
| 5 | 51.5 | 50.0 | 1.5 | 2.25 |
| 6 | 63.5 | 50.0 | 13.5 | 182.25 |
| 7 | 80.5 | 50.0 | 30.5 | 930.25 |
| 8 | 37.5 | 50.0 | -12.5 | 156.25 |
| 9 | 46.5 | 50.0 | -3.5 | 12.25 |
| 10 | 63.0 | 50.0 | 13.0 | 169.00 |
| 11 | 57.5 | 50.0 | 7.5 | 56.25 |
| 12 | 69.5 | 50.0 | 19.5 | 380.25 |
| 13 | 42.0 | 50.0 | -8.0 | 64.00 |
| 14 | 32.0 | 50.0 | -18.0 | 324.00 |
| 15 | 46.5 | 50.0 | -3.5 | 12.25 |
| 16 | 41.5 | 50.0 | -8.5 | 72.25 |
| 17 | 75.0 | 50.0 | 25.0 | 625.00 |
| 18 | 20.5 | 50.0 | -29.5 | 870.25 |
| 19 | 68.5 | 50.0 | 18.5 | 342.25 |
| 20 | 60.5 | 50.0 | 10.5 | 110.25 |
| Sum | 1000 | | | 6,453.50 |
| Years | 20 | | | |
| Less 1 | 19 | | | |
| Mean | 50.0 | | | |
| Variance | | | | 339.66 |

**Step 3:** The third step in calculating the standard deviation is to add up the column of squared deviations and divide the result by one less than the number of observations in the sample, in this case the number of years less one. The result is called the variance.

"Why do we divide by one less than the number of observations," Kim asked.

"It has to do with the number of independent pieces of information," Lee answered. "If we know the mean and all but one observation in the series we would be able to calculate that missing observation. The variance is a sort of average, the average of the squared deviations."

"So we only need the number of observations less one," Kim commented. He divided the figures and wrote the answer in the table.

**Step 4:** Finally, calculate the square root of the variance. This gives the value for the standard deviation.

"The variance is 339.66," Lee stated. "So now we only have to get the square root to get the standard deviation."

"That's easy enough," Kim replied pressing the square root button on his calculator, "that's step four right? Are we done?"

"That's it Kim," Lee replied. "To summarize what we've done, the sum of the squared deviations is 6,453.50." She pointed to the figures in the table. "When divided by 19, the number of years less one, the variance is 339.66."

"The standard deviation, the square root of the variance, is then calculated to be 18.43 bushels per acre," Lee concluded.

| | Yield / acre | |
|---|---|---|
| **Sum** | 1000 | 6,453.50 |
| **Number of years** | 20 | |
| **Number less one** | 19 | |
| **Mean** | 50.0 | |
| **Variance** | | 339.66 |
| **Standard Deviation** | | 18.43 |

"Ah bushels per acre," Kim exclaimed. "Now it begins to make sense."

"Approximately two-thirds of all the observations in a series will be within a range of one standard deviation above or below the mean," Lee advised. "We can conclude that approximately one-third of the events will be found outside of the standard deviation range."

"So, approximately one-sixth of the observations will be one standard deviation or more above the mean and the other one-sixth of the observations will lie one standard deviation or less below the mean," Kim mused. "This tells us that two-thirds of the time the yield in any year is expected to be 50.00 bushels per acre plus or minus 18.43 bushels per acre."

"Right - that's between 31.57 and 68.43 bushels per acre Kim," Lee had completed the calculation in her head.

*Exercise 4 - Standard Deviation and Crop Expectations*

Refer to the data in the table on the preceding page to complete the following statement.

When Kim and Lee looked at their twenty-year history of yields, they found that there were **[____]** years when yields were below 31.57 bushels per acre and **[____]** years when yields were above 68.43 bushels per acre.

*Standard Deviation and Crop Expectations – Answer*

Compare your observations to Kim and Lee's. Correct any errors. If you had an error, you may wish to review this section.

When Kim and Lee looked at their twenty-year history of yields, they found that there were **[three]** years when yields were below 31.57 bushels per acre and **[five]** years when yields were above 68.43 bushels per acre.

As Lee pointed out earlier, they had drawn a sample of twenty observations from a population of yields. What they calculated are estimates of the average yield and standard deviation. They don't know the true yield pattern so they do not know the value of the true mean or standard deviation, but they have as good an estimate as is possible.

They have, however, learned two important new terms: expected value or mean and standard deviation. These two terms completely describe the twenty-year yield series.

We use the term 'expected value' to denote our best estimate of what the yield will be in any year, next year for example. This means of course that all other things remain the same. In this case, Kim and Lee's cropping practices must remain the same as they were in the past. All other underlying conditions such as environmental factors and climate must be unchanged as well.

We use the term 'standard deviation' to describe the dispersion of the data; through this figure we can determine if the data are widely dispersed or if they lie close to the mean.

## *Applying Statistical Measures*

The two statistics calculated so far, the mean or expected value and the standard deviation, completely describe the so-called normal distribution. These are very powerful measures indeed. By knowing these two statistics, Kim and Lee are able to fully describe the probability of occurrence for crop yields on K&L Farms. The probability is subject to the assumption that underlying conditions stay the same.

We must be grateful to the early mathematicians, like Gauss and others, for figuring out the probability levels. In fact they had the patience to tabulate all the probability values. Their tables appear in the appendix of this module. All we need to do is learn how to apply the principles.

The tables in the appendix are for the standard normal distribution. A standard normal distribution is one with a mean of 0.00 and a standard deviation of 1.00. This means that once we know the mean and standard deviation of any situation we have only to compare ours to the standard to determine the probability values.

"Now, we can use our mean and standard deviation to consider the probability of these things happening," Lee stated. "In effect we have to scale our statistics to conform to the standard and look up the probability in the table."

"That's right," Kim agreed. "We want to know the probability of having a yield of 31.57 bushels per acre or less."

"We need only follow two easy steps Kim," Lee advised. "First calculate the Z-Score and then look up the value in a probability table."

"I'm sure you'll explain what these are when we do them," Kim commented.

**Step 1**
Calculate the Z-Score.

"Of course Kim," Lee continued. "We first calculate the number of standard deviations that the desired quantity is away from the mean. To do this we calculate the Z-Score using this formula."

$$Z = \frac{X - \overline{X}}{s}$$

"In this case," Kim interjected, "the desired quantity is 31.57 bushels per acre."

"That's right Kim," Lee agreed. "We want to find out how far 31.57 is from the mean so we use the formula. '$Z$' is the desired Z-Score to be calculated. '$X$' is the critical value or in this case 31.57 bushels per acre."

"What is this X with the line above it then?" Kim asked.

"It is called 'X bar'," Lee replied. "$\overline{X}$' is our calculated expected value or mean."

"Ah that's the 50.00 bushels per acre," Kim pointed out.

"Right Kim," Lee agreed. "To finish the formula then, '$s$' is the calculated standard deviation or 18.43 bushels per acre. So the Z-Score is …"

**Step 2**
Look up the probability value in the table.

"Minus one," Kim read the figure from his calculator.

$$Z = \frac{31.57 - 50.00}{18.43} = -1.00$$

"OK now we can look that up in the table," Lee said.

"I can do that," Kim said running his finger down the 0.00 column to the -1.00 row. "0.1589," he read pointing to the figure.

| Z-Score | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| **-1.20** | 0.1153 | 0.1133 | 0.1114 | 0.1095 | 0.1077 | 0.1058 | 0.1040 | 0.1022 | 0.1004 | 0.0986 |
| **-1.10** | 0.1359 | 0.1337 | 0.1316 | 0.1295 | 0.1274 | 0.1253 | 0.1232 | 0.1212 | 0.1192 | 0.1172 |
| **-1.00** | **0.1589** | 0.1565 | 0.1541 | 0.1517 | 0.1494 | 0.1471 | 0.1448 | 0.1425 | 0.1403 | 0.1381 |
| **-0.90** | 0.1842 | 0.1816 | 0.1790 | 0.1764 | 0.1738 | 0.1713 | 0.1687 | 0.1662 | 0.1638 | 0.1613 |
| **-0.80** | 0.2119 | 0.2090 | 0.2062 | 0.2034 | 0.2006 | 0.1978 | 0.1950 | 0.1923 | 0.1896 | 0.1869 |

"The probability of having a Z-Score of -1.00 or less is 0.1589," Lee stated. "This means then that there is a probability of 0.1589 or 15.89 % that the yield will be 31.57 bushels per acre or less."

"How different would it be if the yield were 30.0 bushels per acre?" Kim questioned.

*Exercise 5 - Probability of Achieving Selected Z-Scores*

Calculate the Z-Score and use the table to find the probability for 30 bushels or less per acre.

$$Z = \frac{X - \overline{X}}{s}$$

A Z-Score of **[____]** corresponds to a yield of 30.0 bushels per acre. We can find the corresponding probability level by reading down the Z-Score column in the table to **[____]** and then across to the **[____]** column. The entry there is **[____]**. This means that there is a probability of **[____]** or a **[____]** per cent chance of a yield less than 30.0 bushels per acre.

*Probability of Achieving Selected Z-Scores - Answer*

Compare your work to Kim and Lee's. Correct any errors.

$$\mathbf{Z} = \frac{\mathbf{30.00 - 50.00}}{\mathbf{18.43}} = \mathbf{-1.09}$$

A Z-Score of [**-1.09**] corresponds to a yield of 30.0 bushels per acre. We can find the corresponding probability level by reading down the Z-Score column in the table to [**-1.00**] and then across to the [**0.09**] column. The entry there is [**0.1381**]. This means that there is a probability of [**0.1381**] or a [**13.8**1] per cent chance of a yield less than 30.0 bushels per acre.

"This is good Lee!" Kim exclaimed. "We could do this for all critical crop yields."

"We can construct a cumulative probability table for selected crop yields," Lee advised. "In doing so, we'll know the probability of occurrence of the critical crop yields."

"Great!" Kim began to prepare the table. "The critical points we found were 31.57 and 68.43 bushels per acre. We need columns for Critical Yield, Mean, Deviation, and the Z-Score … and what else?"

"Yield intervals of ten on either side of the mean will give a good picture," Lee advised. "We'll also need the probability level to know how likely they are to occur."

*Exercise 6 - Probability Levels*

Use the formula and Z-Score tables to complete the missing calculations.

| Critical Yield | Mean Yield | Deviation | Z-Score | Probability Level | |
|---|---|---|---|---|---|
| | | | | Decimal | Per Cent |
| 10.00 | 50.00 | -40.00 | -2.17 | 0.0149 | 1.49 % |
| 20.00 | 50.00 | -30.00 | -1.63 | 0.0514 | 5.14 % |
| 30.00 | 50.00 | -20.00 | -1.09 | 0.1381 | 13.81 % |
| 31.57 | 50.00 | -18.43 | -1.00 | 0.1589 | 15.89 % |
| 40.00 | 50.00 | -10.00 | -0.54 | 0.2944 | 29.44 % |
| 50.00 | 50.00 | 0.00 | 0.00 | 0.5000 | 50.00 % |
| 60.00 | 50.00 | 10.00 | 0.54 | 0.7056 | 70.56 % |
| 68.43 | 50.00 | [_____] | [_____] | [_____] | [_____] |
| 70.00 | 50.00 | 20.00 | 1.09 | 0.8619 | 86.19 % |
| 80.00 | 50.00 | 30.00 | 1.63 | 0.9486 | 94.86 % |
| 90.00 | 50.00 | 40.00 | 2.17 | 0.9851 | 98.51 % |

The probability of having a yield of 40 bushels per acre or less is **[**_____**]** or **[**_____**]** per cent.
The probability of having more than 40 bushels per acre is **[**_____**]** or **[**_____**]** per cent.

*Probability Levels – Answer*

Compare your work to Kim and Lee's. Correct any errors. If you had an error, you may wish to review this section.

| Critical Yield | Mean Yield | Deviation | Z-Score | Probability Level Decimal | Per Cent |
|---|---|---|---|---|---|
| 10.00 | 50.00 | -40.00 | -2.17 | 0.0149 | 1.49 % |
| 20.00 | 50.00 | -30.00 | -1.63 | 0.0514 | 5.14 % |
| 30.00 | 50.00 | -20.00 | -1.09 | 0.1381 | 13.81 % |
| 31.57 | 50.00 | -18.43 | -1.00 | 0.1589 | 15.89 % |
| 40.00 | 50.00 | -10.00 | -0.54 | 0.2944 | 29.44 % |
| 50.00 | 50.00 | 0.00 | 0.00 | 0.5000 | 50.00 % |
| 60.00 | 50.00 | 10.00 | 0.54 | 0.7056 | 70.56 % |
| 68.43 | 50.00 | **[18.43]** | **[1.00]** | **[0.8411]** | **[84.11%]** |
| 70.00 | 50.00 | 20.00 | 1.09 | 0.8619 | 86.19 % |
| 80.00 | 50.00 | 30.00 | 1.63 | 0.9486 | 94.86 % |
| 90.00 | 50.00 | 40.00 | 2.17 | 0.9851 | 98.51 % |

The probability of having a yield of 40 bushels per acre or less is [ **0.2944** ] or [ **29.44** ] per cent. The probability of having more than 40 bushels per acre is [ **0.7056** ] or [ **70.56** ] per cent.

"Now that we have calculated the mean and standard deviation of yields we have considerable information about the risk faced by K&L Farms," Lee said.

"But," as Kim pointed out, "we need to know something about prices so we can calculate risk in financial terms."

"That'll be our next step," Lee responded.

## *Prices*

Having finished with yields, Kim and Lee now turn their attention to the second major source of risk, prices. Fortunately the twenty-year farm history also included the prices for each year. For the sake of simplicity, we will assume that the effects of inflation have been removed from the series.

| Year | Dollars per Bushel | Mean Price | Deviation from Mean | Squared Deviation |
|---|---|---|---|---|
| **1** | 4.11 | 3.50 | 0.61 | 0.3721 |
| **2** | 2.94 | 3.50 | -0.56 | 0.3136 |
| **3** | 3.43 | 3.50 | -0.07 | 0.0049 |
| **4** | 3.75 | 3.50 | 0.25 | 0.0625 |
| **5** | 2.85 | 3.50 | -0.65 | 0.4225 |
| **6** | 3.22 | 3.50 | -0.28 | 0.0784 |
| **7** | 3.25 | 3.50 | -0.25 | 0.0625 |
| **8** | 4.18 | 3.50 | 0.68 | 0.4624 |
| **9** | 3.12 | 3.50 | -0.38 | 0.1444 |
| **10** | 3.96 | 3.50 | 0.46 | 0.2116 |
| **11** | 3.43 | 3.50 | -0.07 | 0.0049 |
| **12** | 3.68 | 3.50 | 0.18 | 0.0324 |
| **13** | 3.44 | 3.50 | -0.06 | 0.0036 |
| **14** | 2.96 | 3.50 | -0.54 | 0.2916 |
| **15** | 3.78 | 3.50 | 0.28 | 0.0784 |
| **16** | 3.2 | 3.50 | -0.30 | 0.0900 |
| **17** | 4.13 | 3.50 | 0.63 | 0.3969 |
| **18** | 3.49 | 3.50 | -0.01 | 0.0001 |
| **19** | 3.56 | 3.50 | 0.06 | 0.0036 |
| **20** | 3.52 | 3.50 | 0.02 | 0.0004 |
| **Sum** | 70 | | | 3.0368 |
| **Num** | 20 | | | |
| **Mean** | 3.50 | | | |
| **Num -1** | 19 | | | |
| **Variance** | | | | 0.1598 |
| **Standard Deviation** | | | | 0.40 |

Since we have no special information about the future such as a pending famine or a change in economic policy, they are justified as they were in the case of yields, to calculate the mean and standard deviation for the twenty-year history of prices. The reasoning behind this is that, as long as the forces of supply and demand don't change, any one of the prices in the twenty-year series could occur.

Kim and Lee followed the same procedure to calculate the expected price and the standard deviation of price as they did for yields.

"First thing, we have to find the mean or expected price," Kim stated.

"That's right Kim," Lee smiled, "you were paying attention."

"The sum of the twenty year prices is 70, so the expected price will be $3.50 per bushel," he said, "now for the deviations."

"And then we square them," said Lee.

"I'm on it," Kim responded, "now the sum of the squared deviations!"

"Check," said Lee, "and divide by the number less one."

"The variance is 0.1598," Kim stated.

"Standard deviation 0.40," Lee added.

"With this information," Lee observed, "we can now determine what the situation would be if any of these combinations of price and yield occur again."

"The price per bushel and yield per acre combine to give the gross income per acre for each year in the 20-year history," Kim agreed.

## *Gross Income*

In the case of K & L Farms, the 20-year history of prices was combined with yield information in order to calculate return to assets and return to equity positions for the comparisons.

| Year | Yield | Price | Gross |
|---|---|---|---|
| 1 | 42.5 | 4.11 | 174.68 |
| 2 | 63.0 | 2.94 | 185.22 |
| 3 | 23.0 | 3.43 | 78.89 |
| 4 | 15.5 | 3.75 | 58.13 |
| 5 | 51.5 | 2.85 | 146.78 |
| 6 | 63.5 | 3.22 | 204.47 |
| 7 | 80.5 | 3.25 | 261.63 |
| 8 | 37.5 | 4.18 | 156.75 |
| 9 | 46.5 | 3.12 | 145.08 |
| 10 | 63.0 | 3.96 | 249.48 |
| 11 | 57.5 | 3.43 | 197.23 |
| 12 | 69.5 | 3.68 | 255.76 |
| 13 | 42.0 | 3.44 | 144.48 |
| 14 | 32.0 | 2.96 | 94.72 |
| 15 | 46.5 | 3.78 | 175.77 |
| 16 | 41.5 | 3.20 | 132.80 |
| 17 | 75.0 | 4.13 | 309.75 |
| 18 | 20.5 | 3.49 | 71.55 |
| 19 | 68.5 | 3.56 | 243.86 |
| 20 | 60.5 | 3.52 | 212.96 |
| **Total** | 1000 | 70 | 3500.0 |
| **Mean** | 50.00 | 3.50 | 175.00 |
| **Standard Deviation** | 18.43 | 0.40 | 68.89 |

"To build the table, I'll have to multiply the yield by the price to get the gross income that was earned in each year," Kim stated.

"Once you have those done," Lee advised, "we can total up the amounts and calculate the mean for each."

"The total and mean for the yield we did before," Kim said while calculating them for prices.

"That's right," Lee replied, "1,000 and 50 bushels per acre. The standard deviation was 18.43."

"75 is the total and the mean is 3.50," Kim wrote the total and mean for the prices in the table then carried on to calculate the standard deviation.

"There we have it," Lee commented. "The standard deviation for the price is 0.40."

"Now for the Gross Income," Kim began to do the calculations and fill out the column in the table.

"This is getting us closer to what we need," Lee agreed

"The total is 3,500," Kim read from his calculator.

"That means the mean is 175," Lee divided by 20 in her head.

"Right," Kim wrote the number in the table, "now for the standard deviation."

"There we go," Lee said approvingly. "The standard deviation for the gross income is 68.69."

Now that Kim and Lee know the mean and standard deviation they will be able to construct a cumulative probability table for gross income per acre. This will enable them to do an in depth analysis of asset returns.

"You know Kim," Lee observed, "the same way that we calculated the probabilities of the yields, we can find out the probability of the gross income per acre."

"That's the Z-Scores?" Kim inquired. "Let's try it out."

"We should construct a table to include gross income figures in $25.00 per acre increments running from a low of $25.00 to a high of $325.00," Lee advised.

"The mid-point is at $175.00 per acre. Based on the statistics calculated we can read the probability of achieving particular levels," Kim agreed.

"I'll look up the Z-Scores," Lee said.

"That'll speed things up," Kim agreed.

*Exercise 7 - Probabilities*

Complete the missing entries in the table then refer to the table to complete the statement

| Gross Income per Acre | Z-Score | Probability Level |
|---|---|---|
| 25.00 | -2.18 | 0.0146 |
| 50.00 | -1.81 | 0.0349 |
| 75.00 | -1.45 | 0.0735 |
| 100.00 | -1.09 | [_____] |
| 106.11 | -1.00 | [_____] |
| 125.00 | -0.73 | 0.2327 |
| 150.00 | -0.36 | 0.3593 |
| 175.00 | 0.00 | [_____] |
| 200.00 | 0.36 | 0.6407 |
| 225.00 | 0.73 | 0.7673 |
| 243.89 | 1.00 | [_____] |
| 250.00 | 1.09 | 0.8619 |
| 275.00 | 1.45 | 0.9265 |
| 300.00 | 1.81 | 0.9651 |
| 325.00 | 2.18 | 0.9854 |

There is a **[_____]** percent probability of having a gross income per acre of $100.00. Approximately **[____]** of the probability is contained in the range of **[_____]** to **[_____]** based on the standard deviation of $68.89 gross income per acre.

*Probabilities – Answer*

Compare your work to Kim and Lee's. Correct any errors.

| Gross Income per Acre | Z-Score | Probability Level |
|---|---|---|
| 25.00 | -2.18 | 0.0146 |
| 50.00 | -1.81 | 0.0349 |
| 75.00 | -1.45 | 0.0735 |
| 100.00 | -1.09 | **0.1381** |
| 106.11 | -1.00 | **[0.1589]** |
| 125.00 | -0.73 | 0.2327 |
| 150.00 | -0.36 | 0.3593 |
| 175.00 | 0.00 | **[0.5000]** |
| 200.00 | 0.36 | 0.6407 |
| 225.00 | 0.73 | 0.7673 |
| 243.89 | 1.00 | **[0.8411]** |
| 250.00 | 1.09 | 0.8619 |
| 275.00 | 1.45 | 0.9265 |
| 300.00 | 1.81 | 0.9651 |
| 325.00 | 2.18 | 0.9854 |

There is a [ **13.81** ] per cent probability of having a gross income per acre of $100.00. Approximately [ **2/3** ] of the probability is contained in the range of [ **$106.11 ]** to **[ $243.89** ] based on the standard deviation of $68.89 gross income per acre.

## *Measuring Business Risk*

As Kim and Lee found out in the module '*Identifying Risk Sources*' business risk is measurable in terms of Return to Assets. The measurement tools used in this module are more precise and refined than was the subjective approach used before. In that module, the objective was to understand the impact of risk. The per cent Return on Assets is a powerful measure. Knowing its mean and standard deviation are vital for Kim and Lee.

"Now that we have the gross income per acre information," Lee noted, "we can determine the returns for K&L Farms."

"Right," Kim agreed, "currently we have 1142.8571 acres in crop so it will be easy to compute the gross income for the farm. At $175.00 gross per acre that's $200,000 total."

"Then we need to subtract the relevant deductions of $108,835," Lee suggested, "that's the expenses of $134,835 plus $24,000 owner's withdrawals less $50,000 gives us the $108,835."

"That's the average return to assets we would have earned over the twenty year period," Kim agreed. "Then we divide it by the value of the total assets to get the per cent Return to Assets."

"That's $725,000," Lee quoted.

"We would have earned a mean of 12.57 % return on assets over the twenty year period," Kim said, "and the standard deviation around this mean return is 10.86 %."

| Year | Gross Income | | Deduction | Return to Assets | |
|---|---|---|---|---|---|
| | Per Acre | Total | | Dollar | Per Cent |
| **1** | 174.68 | 199,629 | 108,835 | 90,794 | 12.52% |
| **2** | 185.22 | 211,680 | 108,835 | 102,845 | 14.19% |
| **3** | 78.89 | 90,160 | 108,835 | -18,675 | -2.58% |
| **4** | 58.13 | 66,429 | 108,835 | -42,406 | -5.85% |
| **5** | 146.78 | 167,743 | 108,835 | 58,908 | 8.13% |
| **6** | 204.47 | 233,680 | 108,835 | 124,845 | 17.22% |
| **7** | 261.63 | 299,000 | 108,835 | 190,165 | 26.23% |
| **8** | 156.75 | 179,143 | 108,835 | 70,308 | 9.70% |
| **9** | 145.08 | 165,806 | 108,835 | 56,971 | 7.86% |
| **10** | 249.48 | 285,120 | 108,835 | 176,285 | 24.32% |
| **11** | 197.23 | 225,400 | 108,835 | 116,565 | 16.08% |
| **12** | 255.76 | 292,297 | 108,835 | 183,462 | 25.31% |
| **13** | 144.48 | 165,120 | 108,835 | 56,285 | 7.76% |
| **14** | 94.72 | 108,251 | 108,835 | -584 | -0.08% |
| **15** | 175.77 | 200,880 | 108,835 | 92,045 | 12.70% |
| **16** | 132.80 | 151,771 | 108,835 | 42,936 | 5.92% |
| **17** | 309.75 | 354,000 | 108,835 | 245,165 | 33.82% |
| **18** | 71.55 | 81,766 | 108,835 | -27,069 | -3.73% |
| **19** | 243.86 | 278,697 | 108,835 | 169,862 | 23.43% |
| **20** | 212.96 | 243,383 | 108,835 | 134,548 | 18.56% |
| **Mean** | 175.00 | 200,000 | | 91,165 | 12.57% |
| **Standard Deviation** | 68.89 | 78,728 | | 78,728 | 10.86% |

*Exercise 8 - Per Cent Return on Assets*

As the twenty-year table shows, there is a substantial range in this measure of business risk. Help Kim and Lee interpret the data by completing the statement

The lowest per cent return occurred in year **[____]** when the return was **[____]** per cent. The highest return happened in year **[____]** when earnings were **[____]** per cent. There were **[____]** years when returns were negative corresponding to adverse yields and prices, major components of business risk.

*Per Cent Return on Assets – Answer*

Compare your work to Kim and Lee's. Correct any errors.

The lowest per cent return occurred in year [4] when the return was [**-5.85**] per cent. The highest return happened in year [**17]** when earnings were [**33.82**] per cent. There were [**four**] years when returns were negative corresponding to adverse yields and prices, major components of business risk.

Having calculated the mean and standard deviation for return to assets Lee suggested they construct a cumulative probability table for the data. Kim suggested that they also include a gross income per acre column to give the table another element of practicality.

| Gross Income Per Acre | Gross Income Total | Deductions | Return to Assets Dollar | Return to Assets Per Cent | Probability |
|---|---|---|---|---|---|
| 25.00 | 28,571 | 108,835 | -80,264 | -11.07% | 0.0146 |
| 50.00 | 57,143 | 108,835 | -51,692 | -7.13% | 0.0346 |
| 75.00 | 85,714 | 108,835 | -23,121 | -3.19% | 0.0733 |
| 95.23 | 108,835 | 108,835 | 0 | 0.00% | 0.1236 |
| 100.00 | 114,286 | 108,835 | 5,451 | 0.75% | 0.1384 |
| 106.11 | 121,272 | 108,835 | 12,437 | 1.72% | 0.1589 |
| 125.00 | 142,857 | 108,835 | 34,022 | 4.69% | 0.2339 |
| 150.00 | 171,429 | 108,835 | 62,594 | 8.63% | 0.3582 |
| 175.00 | 200,000 | 108,835 | 91,165 | 12.57% | 0.5000 |
| 200.00 | 228,571 | 108,835 | 119,736 | 16.52% | 0.6418 |
| 225.00 | 257,143 | 108,835 | 148,308 | 20.46% | 0.7661 |
| 243.89 | 278,728 | 108,835 | 169,893 | 23.43% | 0.8411 |
| 250.00 | 285,714 | 108,835 | 176,879 | 24.40% | 0.8616 |
| 275.00 | 314,286 | 108,835 | 205,451 | 28.34% | 0.9267 |
| 300.00 | 342,857 | 108,835 | 234,022 | 32.28% | 0.9654 |
| 325.00 | 371,429 | 108,835 | 262,594 | 36.22% | 0.9854 |

"If we're going to do that let's include some critical breakeven values in the table," Lee suggested.

"Well," Kim thought out loud, "it would be useful to know the point at which we would just cover our expenses and the personal withdrawals for our salary. That would be at a gross of $108,835 or $93.23 per acre."

"Yes," Lee agreed, "and it would be nice to know the point where we would just cover these deductions and also the interest payment on the mortgage. That would be at $158,835 in total or $138.98 per acre." They agreed to include these critical levels in the table.

Looking at the table Lee noted, "There is a 12.36 % chance of having a negative return to assets. That's about once every eight years. It's a bit scary, but that means once in eight years we won't be able to pay the interest on our mortgage."

"I guess that's the down side of leverage," Kim replied. "I agree this could be a problem that needs more analysis."

"What do you mean 'it could be'?" Lee retorted!

## *Measuring Financial Risk*

As Kim and Lee noted in their examination of the cumulative probability table business risk is a problem for them. They also recognize that business risk is amplified whenever a business operates using borrowed money. They now turn to an analysis of the financial risk being faced by K&L Farms.

| Year | Return to Assets | Interest | Return to Equity | Per Cent Return on Assets | Per Cent Return on Equity |
|---|---|---|---|---|---|
| **1** | 90,794 | 50,000 | 40,794 | 12.52% | 18.13% |
| **2** | 102,845 | 50,000 | 52,845 | 14.19% | 23.49% |
| **3** | -18,675 | 50,000 | -68,675 | -2.58% | -30.52% |
| **4** | -42,406 | 50,000 | -92,406 | -5.85% | -41.07% |
| **5** | 58,908 | 50,000 | 8,908 | 8.13% | 3.96% |
| **6** | 124,845 | 50,000 | 74,845 | 17.22% | 33.26% |
| **7** | 190,165 | 50,000 | 140,165 | 26.23% | 62.30% |
| **8** | 70,308 | 50,000 | 20,308 | 9.70% | 9.03% |
| **9** | 56,971 | 50,000 | 6,971 | 7.86% | 3.10% |
| **10** | 176,285 | 50,000 | 126,285 | 24.32% | 56.13% |
| **11** | 116,565 | 50,000 | 66,565 | 16.08% | 29.58% |
| **12** | 183,462 | 50,000 | 133,462 | 25.31% | 59.32% |
| **13** | 56,285 | 50,000 | 6,285 | 7.76% | 2.79% |
| **14** | -584 | 50,000 | -50,584 | -0.08% | -22.48% |
| **15** | 92,045 | 50,000 | 42,045 | 12.70% | 18.69% |
| **16** | 42,936 | 50,000 | -7,064 | 5.92% | -3.14% |
| **17** | 245,165 | 50,000 | 195,165 | 33.82% | 86.74% |
| **18** | -27,069 | 50,000 | -77,069 | -3.73% | -34.25% |
| **19** | 169,862 | 50,000 | 119,862 | 23.43% | 53.27% |
| **20** | 134,548 | 50,000 | 84,548 | 18.56% | 37.58% |
| **Mean** | 91,165 | | 41,165 | 12.57% | 18.30% |
| **Standard Deviation** | 78,728 | | 78,728 | 10.86% | 34.99% |

K&L Farms holds $725,000 in assets that are financed by $500,000 of debt and $225,000 of equity that amounts to a 2.2222 leverage ratio. With this information Kim and Lee calculate the per cent return for each combination of yields and prices as indicated for each year in the twenty-year history.

"In year one," Kim stated, looking at his calculations "the return to assets was $90,794. In that year yields were down a bit but price was up making for a rather average year."

"That's 42.5 bushels per acre and $4.11 per bushel," Lee stated, "so gross income was $174.68 compared to the average of $175.00. After deducting the interest to be paid of $50,000 there's $40,794 remaining as a return to equity."

"On a percentage basis," Kim advised, "this works out to be 18.13 per cent." He calculated $40,794 / $225,000 = 0.1813. Kim and Lee proceeded to calculate the per cent return to equity for each year.

Having completed the calculations for each year Kim and Lee were in a position to calculate the statistics for the data. They determined the mean dollar return to equity to be $41,165 with a standard deviation of $78,728. Kim was surprised that the standard deviation was the same, in dollar terms, for return to equity as it was for return to assets and started furiously to check his calculations.

Lee chuckled, “that’s the way it is, Kim. We deducted the same number from each return to asset figure to obtain the return to equity figure, ($50,000 in interest costs). All of the variability in the data is in the return to assets part, so it’s quite understandable that the standard deviation is the same for return to equity as it is for return to assets.”

“Sorry for the panic,” Kim apologized, “but now that I think about it that makes sense. It also shows why financial risk is amplified because of the debt; there’s a smaller base to absorb the same amount of risk.”

“That’s right,” offered Lee, “it shows why the standard deviation for per cent return on equity is 34.99 %;” she had divided 78,728 / 225,000 = 0.3499. “This is triple the 10.86 % figure for the standard deviation for per cent return on assets.” That figure was 78,728 / 725,000 = 0.1086. “It’s interesting that we could have saved some time calculating the standard deviation figures for the per cent return figures if we had known the shortcut.”

Kim and Lee had calculated the standard deviations for the per cent return figures by using the four-step method of squaring the deviations, before they saw the shortcut. Short cuts are good, but one should be wary of using them with out knowing the background very well. In this case Lee’s observation actually helped them understand the concept. It was not a waste of their time that they did it both ways.

## *Per Cent Return on Assets and Equity*

| Gross Income per Acre | Per Cent Return on Assets | Per Cent Return on Equity | Probability Decimal | Probability Per Cent |
|---|---|---|---|---|
| 25.00 | -11.07% | -57.89% | 0.0146 | 1.46% |
| 50.00 | -7.13% | -45.20% | 0.0346 | 3.46% |
| 75.00 | -3.19% | -32.50% | 0.0733 | 7.33% |
| 95.23 | 0.00% | -22.22% | 0.1236 | 12.36% |
| 100.00 | 0.75% | -19.80% | 0.1384 | 13.84% |
| 106.11 | 1.72% | -16.69% | 0.1589 | 15.89% |
| 125.00 | 4.69% | -7.10% | 0.2339 | 23.39% |
| 138.98 | 6.90% | 0.00% | 0.3003 | 30.03% |
| 150.00 | 8.63% | 5.60% | 0.3582 | 35.82% |
| 158.67 | 10.00% | 10.00% | 0.4064 | 40.64% |
| 175.00 | 12.57% | 18.30% | 0.5000 | 50.00% |
| 200.00 | 16.52% | 30.99% | 0.6418 | 64.18% |
| 225.00 | 20.46% | 43.69% | 0.7661 | 76.61% |
| 243.89 | 23.43% | 53.29% | 0.8411 | 84.11% |
| 250.00 | 24.40% | 56.39% | 0.8616 | 86.16% |
| 275.00 | 28.34% | 69.09% | 0.9267 | 92.67% |
| 300.00 | 32.28% | 81.79% | 0.9654 | 96.54% |
| 325.00 | 36.22% | 94.49% | 0.9854 | 98.54% |

“Now we should prepare a cumulative probability table for the return to equity data,” Lee suggested.

“Let’s do it on the gross per acre basis again, just for consistency,” Kim offered, “and lets include some additional critical breakeven values in the table.”

Lee suggested they include the point where they were just covering the mortgage interest as well as the other expenses.

“That would be at $158,835 or $138.98 gross per acre, wouldn’t it?” Kim suggested that it would be interesting to know the level where they would earn the same rate of return on their equity as the mortgage company was earning on its debt.

"That would be at $181,335 of gross income or $158.67 per acre," Lee was quick to reply.

"How did you figure that," Kim asked bewildered by the quickness of his wife.

"Well, if K&L Farms earned a 10.00 % return on assets, and since the mortgage interest rate is 10.00 % everyone would earn the same; the assets, the equity and the debt," Lee replied.

"That makes sense," Kim agreed. "So a 10.00 % per cent return on assets is $72,500 plus the $108,835 for other expenses gives us the breakeven number of $181,335, right."

"Like I said," Lee chuckled.

They added the two more critical values to the table.

As they examined the tables, especially the table showing per cent return on assets, they were humbled by the knowledge that because of financial risk there is a 30.03 % chance that they will have a gross income per acre of less than $138.98. At that level they just break even on a per cent return to equity basis, (their per cent return on equity at this level is 00.0 %) that's nearly once every three years. There is a 40.64 % chance that they will earn less than the mortgage company, for their sweat and risk exposure.

"I think we may have a tiger by the tail here," Lee said, the concern evident in her voice.

"Agreed," said Kim. "Let's see about ways of taming this beast!"

# CONCLUSION

The mean and standard deviation are powerful tools for objectively assessing the risk in particular situations. Knowing the expected return, as measured by the mean, and the risk, as measured by the standard deviation, is an important step in designing management strategies.

The relationship between the standard deviation and the mean describes both the frequency of unfavorable events happening and the consequences when they do happen. This is important for determining your ability to meet expenses and service debt, and for the survival of your business.

Knowing the frequency and severity of unfavorable events is vital to determining whether:

- to accept a particular risk
- to find ways to control it
- to transfer it to a professional risk taker, or
- to avoid it altogether.

With this information, your best guess is now an informed assessment. Which solution you choose of equally viable options depends on your attitude towards risk.

# SELF- CHECK

A potato farmer, Mr. Pomme, has just experienced one of the poorest harvests in the last 10 years. This has prompted him to analyze his risk situation. The cropping practices, seed variety, and harvesting techniques were unchanged over the 10-year period.

Complete the calculations in his table and refer to the table to complete the statement.

| Year | Yield per Acre | Mean Yield | Deviation from Mean | Squared Deviation |
|---|---|---|---|---|
| 1 | 30 | [____] | [____] | [____] |
| 2 | 44 | 36 | 8 | 64 |
| 3 | 52 | [____] | [____] | [____] |
| 4 | 21 | 36 | -15 | 225 |
| 5 | 37 | 36 | 1 | 1 |
| 6 | 57 | 36 | 21 | 441 |
| 7 | 35 | 36 | -1 | 1 |
| 8 | 26 | 36 | -10 | 100 |
| 9 | 34 | 36 | -2 | 4 |
| 10 | [____] | 36 | [____] | [____] |
| **Sum** | 360 | | | [____] |
| **Number of Years** | 10 | | | |
| **Number less One** | [____] | | | |
| **Mean** | 36 | | | |
| **Variance** | | | | [____] |
| **Standard Deviation** | | | | [____] |

The yields of potatoes ranged from a low of **[____]** tonnes to a high of **[____]** tonnes per hectare. The mean yield was **[____]** tonnes per hectare and the standard deviation was **[____]** tonnes per hectare. Mr. Pomme has determined from his records that he needs a yield of at least 30 tonnes per hectare to make his debt payments. The Z-Score of 30 tonnes is **[____]** which means that he stands a **[____]** or **[____%]** probability of defaulting on his debt payments.

# SELF- CHECK - Answer

Compare your work to Mr. Pomme's. Give yourself a point for each correct answer.

| Year | Yield per Acre | Mean Yield | Deviation from Mean | Squared Deviation |
|---|---|---|---|---|
| 1 | 30 | **[36]** | **[-6]** | **[36]** |
| 2 | 44 | 36 | 8 | 64 |
| 3 | 52 | **[36]** | **[16]** | **[256]** |
| 4 | 21 | 36 | -15 | 225 |
| 5 | 37 | 36 | 1 | 1 |
| 6 | 57 | 36 | 21 | 441 |
| 7 | 35 | 36 | -1 | 1 |
| 8 | 26 | 36 | -10 | 100 |
| 9 | 34 | 36 | -2 | 4 |
| 10 | **[24]** | 36 | **[-12]** | **[144]** |
| **Sum** | 360 | | | **[1272]** |
| **Number of Years** | 10 | | | |
| **Number less One** | **[9]** | | | |
| **Mean** | 36 | | | |
| **Variance** | | | | **[141.33]** |
| **Standard Deviation** | | | | **[11.89]** |

The yields of potatoes ranged from a low of **[ 21 ]** tonnes to a high of **[ 57 ]** tonnes per hectare. The mean yield was **[ 36 ]** tonnes per hectare and the standard deviation was **[ 11.89 ]** tonnes per hectare. Mr. Pomme has determined from his records that he needs a yield of at least 30 tonnes per hectare to make his debt payments. The Z-Score of 30 tonnes is **[ -0.50 ]** which means that he stands a **[ 0.3083 ]** or **[ 30.83** % **]** probability of defaulting on his debt payments.

Developing risk management strategies has become a vital issue for Mr. Pomme.

Correct any errors – if you have less than 20 points, you may wish to review the information in the module before proceeding with the module *Developing Risk Management Strategies*.

# APPENDIX

Probability of Achieving Selected Z-Scores

| Z-Score | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| **-4.00** | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| **-3.90** | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| **-3.80** | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| **-3.70** | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| **-3.60** | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| **-3.50** | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| **-3.40** | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 |
| **-3.30** | 0.0007 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0005 |
| **-3.20** | 0.0009 | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| **-3.10** | 0.0012 | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.0010 | 0.0010 | 0.0009 | 0.0009 |
| **-3.00** | 0.0016 | 0.0015 | 0.0015 | 0.0014 | 0.0014 | 0.0014 | 0.0013 | 0.0013 | 0.0013 | 0.0012 |
| **-2.90** | 0.0021 | 0.0020 | 0.0020 | 0.0019 | 0.0019 | 0.0018 | 0.0018 | 0.0017 | 0.0017 | 0.0016 |
| **-2.80** | 0.0028 | 0.0027 | 0.0026 | 0.0026 | 0.0025 | 0.0024 | 0.0023 | 0.0023 | 0.0022 | 0.0022 |
| **-2.70** | 0.0037 | 0.0036 | 0.0035 | 0.0034 | 0.0033 | 0.0032 | 0.0031 | 0.0030 | 0.0029 | 0.0029 |
| **-2.60** | 0.0048 | 0.0047 | 0.0046 | 0.0045 | 0.0043 | 0.0042 | 0.0041 | 0.0040 | 0.0039 | 0.0038 |
| **-2.50** | 0.0063 | 0.0062 | 0.0060 | 0.0058 | 0.0057 | 0.0055 | 0.0054 | 0.0052 | 0.0051 | 0.0050 |
| **-2.40** | 0.0083 | 0.0081 | 0.0078 | 0.0076 | 0.0074 | 0.0072 | 0.0071 | 0.0069 | 0.0067 | 0.0065 |
| **-2.30** | 0.0107 | 0.0105 | 0.0102 | 0.0099 | 0.0097 | 0.0094 | 0.0092 | 0.0089 | 0.0087 | 0.0085 |
| **-2.20** | 0.0138 | 0.0135 | 0.0132 | 0.0128 | 0.0125 | 0.0122 | 0.0119 | 0.0116 | 0.0113 | 0.0110 |
| **-2.10** | 0.0177 | 0.0173 | 0.0169 | 0.0165 | 0.0161 | 0.0157 | 0.0153 | 0.0149 | 0.0146 | 0.0142 |
| **-2.00** | 0.0226 | 0.0220 | 0.0215 | 0.0210 | 0.0205 | 0.0200 | 0.0195 | 0.0191 | 0.0186 | 0.0182 |
| **-1.90** | 0.0285 | 0.0278 | 0.0272 | 0.0266 | 0.0260 | 0.0254 | 0.0248 | 0.0242 | 0.0237 | 0.0231 |
| **-1.80** | 0.0357 | 0.0349 | 0.0341 | 0.0334 | 0.0327 | 0.0319 | 0.0312 | 0.0305 | 0.0298 | 0.0292 |
| **-1.70** | 0.0444 | 0.0434 | 0.0425 | 0.0416 | 0.0407 | 0.0398 | 0.0390 | 0.0381 | 0.0373 | 0.0365 |
| **-1.60** | 0.0546 | 0.0535 | 0.0524 | 0.0514 | 0.0503 | 0.0493 | 0.0483 | 0.0473 | 0.0463 | 0.0453 |
| **-1.50** | 0.0667 | 0.0654 | 0.0642 | 0.0629 | 0.0617 | 0.0605 | 0.0593 | 0.0581 | 0.0569 | 0.0558 |
| **-1.40** | 0.0808 | 0.0793 | 0.0778 | 0.0763 | 0.0749 | 0.0735 | 0.0721 | 0.0707 | 0.0694 | 0.0680 |
| **-1.30** | 0.0969 | 0.0952 | 0.0935 | 0.0918 | 0.0902 | 0.0886 | 0.0870 | 0.0854 | 0.0838 | 0.0823 |
| **-1.20** | 0.1153 | 0.1133 | 0.1114 | 0.1095 | 0.1077 | 0.1058 | 0.1040 | 0.1022 | 0.1004 | 0.0986 |
| **-1.10** | 0.1359 | 0.1337 | 0.1316 | 0.1295 | 0.1274 | 0.1253 | 0.1232 | 0.1212 | 0.1192 | 0.1172 |
| **-1.00** | 0.1589 | 0.1565 | 0.1541 | 0.1517 | 0.1494 | 0.1471 | 0.1448 | 0.1425 | 0.1403 | 0.1381 |
| **-0.90** | 0.1842 | 0.1816 | 0.1790 | 0.1764 | 0.1738 | 0.1713 | 0.1687 | 0.1662 | 0.1638 | 0.1613 |
| **-0.80** | 0.2119 | 0.2090 | 0.2062 | 0.2034 | 0.2006 | 0.1978 | 0.1950 | 0.1923 | 0.1896 | 0.1869 |
| **-0.70** | 0.2419 | 0.2388 | 0.2357 | 0.2327 | 0.2296 | 0.2266 | 0.2236 | 0.2207 | 0.2177 | 0.2148 |
| **-0.60** | 0.2741 | 0.2708 | 0.2675 | 0.2642 | 0.2609 | 0.2577 | 0.2545 | 0.2513 | 0.2482 | 0.2450 |
| **-0.50** | 0.3083 | 0.3048 | 0.3013 | 0.2978 | 0.2944 | 0.2909 | 0.2875 | 0.2841 | 0.2808 | 0.2774 |
| **-0.40** | 0.3444 | 0.3407 | 0.3370 | 0.3334 | 0.3297 | 0.3261 | 0.3225 | 0.3189 | 0.3154 | 0.3118 |
| **-0.30** | 0.3820 | 0.3782 | 0.3744 | 0.3706 | 0.3668 | 0.3630 | 0.3593 | 0.3555 | 0.3518 | 0.3481 |
| **-0.20** | 0.4209 | 0.4169 | 0.4130 | 0.4091 | 0.4052 | 0.4013 | 0.3974 | 0.3936 | 0.3897 | 0.3859 |
| **-0.10** | 0.4604 | 0.4564 | 0.4525 | 0.4485 | 0.4445 | 0.4406 | 0.4366 | 0.4327 | 0.4287 | 0.4248 |
| **0.00** | 0.5000 | 0.4961 | 0.4921 | 0.4882 | 0.4842 | 0.4802 | 0.4763 | 0.4723 | 0.4683 | 0.4644 |

Probability of Achieving Selected Z-Scores

| Z-Score | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.00** | 0.5000 | 0.5039 | 0.5079 | 0.5118 | 0.5158 | 0.5198 | 0.5237 | 0.5277 | 0.5317 | 0.5356 |
| **0.10** | 0.5396 | 0.5436 | 0.5475 | 0.5515 | 0.5555 | 0.5594 | 0.5634 | 0.5673 | 0.5713 | 0.5752 |
| **0.20** | 0.5791 | 0.5831 | 0.5870 | 0.5909 | 0.5948 | 0.5987 | 0.6026 | 0.6064 | 0.6103 | 0.6141 |
| **0.30** | 0.6180 | 0.6218 | 0.6256 | 0.6294 | 0.6332 | 0.6370 | 0.6407 | 0.6445 | 0.6482 | 0.6519 |
| **0.40** | 0.6556 | 0.6593 | 0.6630 | 0.6666 | 0.6703 | 0.6739 | 0.6775 | 0.6811 | 0.6846 | 0.6882 |
| **0.50** | 0.6917 | 0.6952 | 0.6987 | 0.7022 | 0.7056 | 0.7091 | 0.7125 | 0.7159 | 0.7192 | 0.7226 |
| **0.60** | 0.7259 | 0.7292 | 0.7325 | 0.7358 | 0.7391 | 0.7423 | 0.7455 | 0.7487 | 0.7518 | 0.7550 |
| **0.70** | 0.7581 | 0.7612 | 0.7643 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7793 | 0.7823 | 0.7852 |
| **0.80** | 0.7881 | 0.7910 | 0.7938 | 0.7966 | 0.7994 | 0.8022 | 0.8050 | 0.8077 | 0.8104 | 0.8131 |
| **0.90** | 0.8158 | 0.8184 | 0.8210 | 0.8236 | 0.8262 | 0.8287 | 0.8313 | 0.8338 | 0.8362 | 0.8387 |
| **1.00** | 0.8411 | 0.8435 | 0.8459 | 0.8483 | 0.8506 | 0.8529 | 0.8552 | 0.8575 | 0.8597 | 0.8619 |
| **1.10** | 0.8641 | 0.8663 | 0.8684 | 0.8705 | 0.8726 | 0.8747 | 0.8768 | 0.8788 | 0.8808 | 0.8828 |
| **1.20** | 0.8847 | 0.8867 | 0.8886 | 0.8905 | 0.8923 | 0.8942 | 0.8960 | 0.8978 | 0.8996 | 0.9014 |
| **1.30** | 0.9031 | 0.9048 | 0.9065 | 0.9082 | 0.9098 | 0.9114 | 0.9130 | 0.9146 | 0.9162 | 0.9177 |
| **1.40** | 0.9192 | 0.9207 | 0.9222 | 0.9237 | 0.9251 | 0.9265 | 0.9279 | 0.9293 | 0.9306 | 0.9320 |
| **1.50** | 0.9333 | 0.9346 | 0.9358 | 0.9371 | 0.9383 | 0.9395 | 0.9407 | 0.9419 | 0.9431 | 0.9442 |
| **1.60** | 0.9454 | 0.9465 | 0.9476 | 0.9486 | 0.9497 | 0.9507 | 0.9517 | 0.9527 | 0.9537 | 0.9547 |
| **1.70** | 0.9556 | 0.9566 | 0.9575 | 0.9584 | 0.9593 | 0.9602 | 0.9610 | 0.9619 | 0.9627 | 0.9635 |
| **1.80** | 0.9643 | 0.9651 | 0.9659 | 0.9666 | 0.9673 | 0.9681 | 0.9688 | 0.9695 | 0.9702 | 0.9708 |
| **1.90** | 0.9715 | 0.9722 | 0.9728 | 0.9734 | 0.9740 | 0.9746 | 0.9752 | 0.9758 | 0.9763 | 0.9769 |
| **2.00** | 0.9774 | 0.9780 | 0.9785 | 0.9790 | 0.9795 | 0.9800 | 0.9805 | 0.9809 | 0.9814 | 0.9818 |
| **2.10** | 0.9823 | 0.9827 | 0.9831 | 0.9835 | 0.9839 | 0.9843 | 0.9847 | 0.9851 | 0.9854 | 0.9858 |
| **2.20** | 0.9862 | 0.9865 | 0.9868 | 0.9872 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.9890 |
| **2.30** | 0.9893 | 0.9895 | 0.9898 | 0.9901 | 0.9903 | 0.9906 | 0.9908 | 0.9911 | 0.9913 | 0.9915 |
| **2.40** | 0.9917 | 0.9919 | 0.9922 | 0.9924 | 0.9926 | 0.9928 | 0.9929 | 0.9931 | 0.9933 | 0.9935 |
| **2.50** | 0.9937 | 0.9938 | 0.9940 | 0.9942 | 0.9943 | 0.9945 | 0.9946 | 0.9948 | 0.9949 | 0.9950 |
| **2.60** | 0.9952 | 0.9953 | 0.9954 | 0.9955 | 0.9957 | 0.9958 | 0.9959 | 0.9960 | 0.9961 | 0.9962 |
| **2.70** | 0.9963 | 0.9964 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9971 |
| **2.80** | 0.9972 | 0.9973 | 0.9974 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9977 | 0.9978 | 0.9978 |
| **2.90** | 0.9979 | 0.9980 | 0.9980 | 0.9981 | 0.9981 | 0.9982 | 0.9982 | 0.9983 | 0.9983 | 0.9984 |
| **3.00** | 0.9984 | 0.9985 | 0.9985 | 0.9986 | 0.9986 | 0.9986 | 0.9987 | 0.9987 | 0.9987 | 0.9988 |
| **3.10** | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 | 0.9990 | 0.9991 | 0.9991 |
| **3.20** | 0.9991 | 0.9991 | 0.9992 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9993 | 0.9993 | 0.9993 |
| **3.30** | 0.9993 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9995 | 0.9995 | 0.9995 |
| **3.40** | 0.9995 | 0.9995 | 0.9995 | 0.9995 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 |
| **3.50** | 0.9996 | 0.9996 | 0.9996 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 |
| **3.60** | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 |
| **3.70** | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 |
| **3.80** | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |
| **3.90** | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |
| **4.00** | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |

# About the Authors

## *Leonard Bauer*

Len Bauer is Professor Emeritus of Agricultural Business Management in the Department of Rural Economy at the University of Alberta. He joined the faculty in 1977 to assume research and teaching duties in agricultural business management, finance, and production economics. He has served as advisor and consultant to provincial and federal government departments and institutions and to private agencies on matters concerning production, finance, and risk management in agriculture.

He was instrumental in creating the Agricultural Business Management Program at the University and was its first director. Prior to joining the University, he was employed by the Province of Alberta as an extension officer and by the Government of Canada as project leader in the design and implementation of the CANFARM information systems for farm businesses.

He was guest professor at the University of Hohenheim in West Germany and guest lecturer at FINAFRICA in Milan, Italy, and at Curtin University of Technology in Perth, Australia. In 1995 he was workshop leader for agricultural instructors in Ukraine.

Although retired since 1996 Len, together with Don Bushe, continues to develop instructional materials in Agricultural Business Management.

## *Don Bushe*

Don is a consultant, writer, teacher, and designer of interactive instructional materials. His products and publications have received national and international recognition from the European Broadcasting Union, Ohio State Awards of Excellence, National Educational Broadcasters' Association, and the Japan Prize Competitions. His more than 200 broadcast and non-broadcast radio and television productions range from ‘The Parent Puzzle’ series on parenting skills to ‘Listen to the Prairies,’ a radio series for elementary school science.

Don's experiences developing interactive learning materials have ranged from the preparation of video-disc based paramedical emergency services training to CD-ROM and computer delivered training systems for liquids and gas pipeline operators in Argentina, Brazil, Colombia, as well as individual companies in the USA and Canada.

The interactive DVD productions and systems he designed are featured in museums and information systems from the Royal Tyrrell Museum in Alberta to the Visitor Interpretive Center in Arviat (formerly Eskimo Point) in Nunavut. He brought an innovative and unique approach when assisting college instructors and university faculty in Ukraine as they struggled to re-define their economics curriculum in the post-soviet era.

Don and Len have collaborated to develop a number of self-instruction modules in farm management modules for the University of Alberta, Faculty of Extension and the British Columbia, Ministry of Agriculture, Fisheries and Food. Together, they prepared what has the become basis for the standard textbook for agricultural economics in Ukraine.