Manitoba Seed Production: An Econometric Analysis of Value Added

by
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for the Degree of
Master of Science

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Winnipeg, Manitoba

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MANITOBA SEED PRODUCTION: AN ECONOMETRIC ANALYSIS OF VALUE ADDED

BY

BRENDA CHORNEY

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirement of the degree of

MASTER OF SCIENCE

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Abstract

A study was completed in July, 2000 for the Manitoba Seed Growers Association (MSGA), assessing the value added economic impact of the pedigreed seed industry on Manitoba’s economy. The study, entitled *Manitoba Seed Industry: Value Added Economic Impacts, (The MSGA Study)*, was based on a survey of the province’s seed growers, and provided aggregate measures of the economic impact of the various seed crops. The present study was intended to build on the *MSGA Study*, by taking a more microeconomic perspective and examining the factors that affect the value added attained by the individual seed growers.

This study was based on the survey information collected through the *MSGA Study*. Econometric modelling was used to analyse value added per acre for three crops, Canada Western Hard Red Spring (CWRS) wheat, barley, and flax. Some attempts were also made to analyse forages and the whole pedigree seed production operation.

From the results of the analyses, several observations, conclusions, and recommendations were made, as summarized below:

- Elasticities at the means indicate that seed grower’s value added per acre is most sensitive to changes in the price of seed, and flax and barley are more sensitive than CWRS wheat. This is important considering producers make choices of not only the types of seed crops to grow, but also the varieties and classes of seed to grow in a given year, for selling in the following commercial crop year. Even small changes in price between years will have significant impact on value added, holding all other variables constant.
- Value added increases with acres in total crop production, significantly so for wheat. Also, CWRS wheat and barley producers are able to increase their value added per acre for these crops as they specialize in seed production.

- The percent of the producer's seed crop that is sold as seed is a significant determinant of value added per acre. The amount of the producer's seed that is actually sold as seed is highly variable, as illustrated by the high standard deviations and coefficients of variation. Further study should be made on sales and marketing arrangements of seed growers, including growers that grow and sell various seed types and varieties under various scenarios (such as, for example, small and large growers, grower/processors, and growers that grow under contract to seed companies or other growers).

- The ability of producers to anticipate the demand for a specific variety by commercial producers also was shown to be important in terms of the percent of the seed that is then sold as seed, rather than as commercial grain, and which will then affect the producer's value added and income. Seed producers need full information on not only the crops that will be in demand, but also the variety. Considering the sensitivity of value added to seed prices and the importance of producer's ability to anticipate demand for specific varieties, it would be of use to initiate some studies on price analysis of seed varieties and how producers might make use of such information for forecasting demand for specific varieties.

- With only 13 of the respondents growing canola seed, there were not enough observations to perform an analysis for canola. Although 30 of the respondents grew forage, an analysis for forages was also difficult, given the variability of types of forages grown and
the few observations for each type of forage. Given the importance of both canola and forages to the seed industry, efforts need to be made for further study of both. In particular, studies on the diffusion of genetically modified (GM) canola and its impact on the seed industry could shed light into what to expect when genetically engineered wheat is available.

- Alberta and Saskatchewan have both expressed interest in a study of value added impact of the seed industry in their respective provinces, similar to the MSGA Study for Manitoba. If these potential studies go forward, the recommendations from the current study can be used to improve the estimation of the seed growers contribution to value added in Alberta and Saskatchewan.
Acknowledgements

I’d like to express my sincere appreciation to my committee members, Dr. Jim MacMillan, Dr. Barry Coyle, and Dr. Anita Brûlé-Babel, for their time and assistance with this project. To my advisor, Dr. Jim MacMillan, thank-you Jim for your guidance and gentle prodding to get this finished. Also, thanks for all the opportunities you’ve provided me during the years I did contract work with the Department on a variety of different projects. It has been an excellent learning experience. Thank-you Barry for your patience with all my econometric questions. And thank-you Anita for providing the perspective from a plant scientist’s point of view and for your excellent comments in the thesis draft.

I’d also like to thank my good friend Bonnie Warkentine, for all her support and for so often being my sounding board.

To my husband, Harvey, and my kids, Emily and Michael, thanks for being patient with Mom as I put myself and the three of you through this process. I tried to make minimal disruption to the family life, but I know there were times that even if I was there in body my mind was elsewhere. Your patience and support was an enormous help.
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1 Introduction

Canada is known for the high quality of crops produced for the domestic and export market. This high quality is the result of years of breeding research and development to produce crop varieties that maximize yield, disease resistance and quality characteristics. The pedigreed seed industry contributes to the technology transfer of high quality varieties through breeding and development research, as well as through pedigreed seed production, processing, cleaning and sales.

A common measure of the contribution of one sector of the economy to the overall economy is through its value added. Value added measures the "contribution of each industry to the total value of production in the economy" (Statistics Canada 1987). Measures of value added include only the incremental value after the value of inputs, excluding labour, has been deducted.

A study was completed in June, 2000, by the University of Manitoba, in cooperation with the Manitoba Seed Growers Association (MSGA), that assessed the value added impact of Manitoba's pedigreed seed industry on the province's economy. This study, entitled Manitoba Seed Industry: Value Added Economic Impacts (MacMillan et al. 2000a), will hereafter be referred to as the MSGA Study. A companion document to the MSGA Study, is the Manitoba Seed Industry: Value Added Economic Impacts Grower Survey Results (MacMillan et al. 2000b), which gives detailed tables on the economic impacts of Manitoba seed growers to the province,
including production, sales/income, production costs, labour, assets, and other information on a crop and aggregate basis. A summary of the results to the MSGA Study is given in Appendix A.

The MSGA Study is a unique analysis of the contribution of the seed industry to the gross domestic product (GDP) of Manitoba. The overall objective of the study was to profile the value of the seed industry to the provincial economy, in order to facilitate and encourage strategy and policy development as well as investment opportunities. The goals for accomplishing this objective of assessing the value of the seed industry to Manitoba were to:

- estimate the 1997 value of on-farm seed production, processing and sales at the farm gate, based on aggregating information into 10 seed crop types (Canada Western Hard Red Spring (CWRS) wheat, durum wheat, winter wheat, other wheat, barley, special crops, flax, canola, pulse crops, and forages),
- estimate the value of industry involvement in pedigreed seed,
- assess growers’ perspectives on the industry, and
- make use of grower and industry survey results, as well as other available information, to identify and discuss the seed industry’s strengths, weaknesses, opportunities and threats (SWOTS analysis).

There are two main groups contributing to the value added of the province through seed related activities. One group includes the producers that grow the seed, and the other includes companies and research agencies involved in seed related activities such as breeding, development, and sales. While the MSGA Study considered and profiled the value added of both groups, this present study focusses on the former, the value added contributed to Manitoba’s economy by the producers of pedigreed seed.
Seed producers produce value added through pedigreed seed production, as well as through seed processing activities. In the latter instance, some seed growers have their own seed processing facilities on-farm for cleaning and treating their own crop. These producers can earn additional revenue from these facilities by custom cleaning or treating seed for other producers, as well as through purchasing seed from other producers and reselling the cleaned and treated seed.

The MSGA Study made use of mailout surveys to collect the required information for estimating value added by seed producers and seed related companies. The producer survey was designed to capture a detailed and comprehensive account of the producers' seed growing and processing operations, to assist in achieving the objectives of the overall study.

Several distinctions need to be made regarding how pedigreed seed production differs from other production types. First, pedigreed seed production is distinct from commercial crop production. While commercial production includes crops produced for commercial sale, such as wheat seed for flour, or canola seed for oil, pedigreed seed is produced and sold to be used as seed to grow more crops. Pedigreed seed is also distinct from common, or “bin run”, seed. The latter is produced from a previous commercial crop, and is usually saved by a commercial producer to be used as seed the following year. Pedigreed seed, on the other hand, is grown on acreage licensed and inspected for seed production, and bears tags that assure the seed has genetic and quality characteristics unique to the variety.

1.1 Problem Statement

The data compiled through the survey process was used to provide an aggregate estimate of value added for the province’s seed growers. The Canadian Seed Growers Association
(CSGA) data base contains information on acres of pedigreed seed by variety. Total value added estimates for the MSGA Study were based on value added per acre sampling ratio estimates, by crop type. Also of interest, however, are the factors which affect the value added attained by the individual growers, and the importance of these factors in their effects on value added. In addition, it is of interest to determine how processing facilities contribute to value added for the individual producers. The comprehensive data set developed to make the aggregate estimates for the MSGA Study holds information to enable a more microeconomic study of the variables at play in determining value added and their interrelationships. While economic theory provides us with expectations of the various parameters that should impact value added, an empirical estimation through model construction and data analysis will provide the basis through which we can evaluate and interpret the theory. While the aggregate estimates in the MSGA Study provided estimates of the overall value of the industry to Manitoba’s economy, a microeconomic examination will provide an indication of the various factors which contribute to the aggregate values, thus building upon the results from the MSGA Study.

1.2 Goals

The goals of the present study are to:

- Determine which factors have an effect on the estimated value added attained by the survey respondents and the importance of these effects. While it would be expected that the factors of importance to value added for seed producers would include those same factors which affect commercial crop production (e.g. price and yield), there may also be additional factors unique to the seed industry.
• Identify the importance of the above findings to the MSGA and the seed growers in terms of operational, investment and policy decisions.

1.3 Objectives

The objectives to accomplish these goals are to:

• Develop econometric models to examine value added for certified seed crops, on an individual crop basis as data permits.

• Develop an econometric model to examine value added for the seed growers’ whole pedigreed seed operation, and to determine the importance of processing facilities in the economic production of the operation.

• Discuss how the results from the above analyses might be of use to seed growers and for determining the potential direction for further study.
2 Background on Value Added and the Manitoba Seed Industry

2.1 A Description of Value Added

Value added (VA) has become a very popular term, with everything and everyone seeming to be defined by the value they add. However, value added is a term that often seems to be thrown around freely as the latest trendy buzzword, with little indication as to its true meaning in an economic sense. Value added is, essentially, one means of measuring the economic production of a country, region, industry or company. Value added considers the final value of the products sold by firms (Statistics Canada 1990). The final value of production is the difference between gross sales and costs of production. Statistics Canada uses the value added approach to measure the Gross Domestic Product (GDP), which gives the “value of the total unduplicated production of goods and services,” (Statistics Canada 1990). Costs of production deducted from gross sales to give value added do not include labour costs or rents, and thus value added represents the sum of economic returns to all factors of production, including employees, landlords, and business operators. Therefore, GDP, or value added, for Canada and Manitoba, in a macroeconomic or national income concept, is the sum of labour and business income as well as returns to capital.

Value added in common usage can also be defined relative to the supply chain from producer to consumer. The supply chain description of value added in the case of the farmer who purchases, for example, $1.00 of seed and other inputs to produce wheat that is then sold to a
miller for $2.00. The value added at this stage is $1.00, the difference between the input costs and selling amount. The miller then mills the wheat into flour and sells $2.00 of flour as a final product to consumers and $3.00 of flour to a bakery. The value added at this stage, assuming the only input is the $2.00 of wheat, is $3.00 ($2.00 of final product to the consumer plus $3.00 of flour to the bakery minus the $2.00 it cost to buy the wheat). The bakery then makes bread with the flour and sells to the consumer for $4.00. The value added at this stage is $1.00, again assuming the only input is the $3.00 of flour. The total value added to the economy from the whole process is $5.00 ($1.00 + $3.00 + $1.00).

In terms of Manitoba pedigreed seed growers, the value added for an individual producer would be that producer’s gross sales of production from pedigreed seed acreage, plus sales and services from their processing industry if applicable, minus their costs of production in the form of purchases from other firms, and their costs for the processing facilities. Summing the value added for individual producers gives the direct value added contribution of pedigreed seed production in Manitoba. This gives seed producers, the MSGA, interested industry representatives, as well as government policymakers, an estimate of the economic contribution made by the pedigreed seed industry in 1997.

The value added at market prices gives the return to the factors of production, labour and capital. Factor incomes can be apportioned into wages and salaries, profits or net income before taxes, interest and miscellaneous investment income, indirect taxes and capital consumption allowance. Value added at market prices has indirect taxes (such as land taxes) as a component of the value added figure, but does not include subsidies, in comparison to value added at factor cost, whereby indirect taxes are deducted from and subsidies are added into the value added
figure. Indirect taxes include municipal, sales and other sundry taxes which are considered a cost of business and which, therefore are usually factored into the market price of the good, whereas subsidies decrease the market price (Statistics Canada 1990).

Apportioning value added of pedigreed seed production into the appropriate factors of production will give an indication of the contributions of pedigreed seed production to rural Manitoba’s labour market, as well as returns to the capital owned by producers.

2.2 The Seed Industry in Manitoba

Western Canada is known for producing high quality crops with the characteristics required by end users. This high quality is the result of a number of factors including, skilled commercial crop producers that make use of the latest and best crop production technologies, favourable climate and soil characteristics for the chosen crops, developmental research to produce crop varieties with desirable disease resistance and quality characteristics, and a highly developed quality assurance system overseeing registration of varieties and acceptance of crops for pedigreeing (MacMillan et al. 2000a). Manitoba’s seed industry is a vibrant, dynamic industry with a long history of contributing to the high value commercial crops produced in this province.

2.2.1 The Seed Growers

Pedigreed seed producers, as shown in Figure 2.1, have an important position at the beginning of the chain of production. Seed producers are the mechanism by which high quality seed, the result of years of breeding research and development, is delivered to commercial crop producers. Seed producers register land on which they grow seed crops with the Canadian Seed
Crop/variety development was geared primarily to commercial producer requirements
Crop/variety development now becoming more responsive to processor/consumer demands -
development of identity preserved (IP) products

(CSGA - Canadian Seed Growers Association; CSTA - Canadian Seed Trade Association; PBR - Plant Breeders Rights)

Figure 2.1: Seed Growers in the Chain of Production for Western Canadian Crops
Growers Association (CSGA), indicating the crop type, variety and acres grown. Crops are grown with the requisite attention and inputs to prevent weed, insect or disease infestation and to ensure optimal supply of nutrients. Crops accredited with pedigreed status by a certified inspector, and which meet the grading requirements as assessed by a licensed grader, can be sold as certified seed (CSGA Circular 6-94). Certified seed is sold in bags with labels attesting to its certified status, guaranteeing the seed possesses the quality and genetic characteristics of that variety.

There were 861 pedigreed seed producers registered in Manitoba in 1997. Seed producers are a diverse and varied group, with seed crop acreage ranging from less than 100 acres to thousands of acres. Some producers specialize in seed growing, devoting most or all of their crop acreage to seed, and on a long term basis, while others are mainly commercial crop producers, with only a small proportion of their total acreage devoted to seed, and for some on only a short-term basis. A form of vertical integration has occurred within the seed growers; most start out devoting only a portion of their acres to pedigreed seed, with some gradually increasing until the larger portion of their crop is pedigreed seed, as well as some specializing into seed processing and/or contracting other growers to grow for them (CSTA 1995).

Seed growers produce a variety of seed crops, including cereals, oilseeds, pulses, lentils and forage seed. Respondents to the MSGA Study survey grew from 1 to 7 of the 10 crop types considered in the study, with 56.7 percent of respondents growing one to two of the crop types, 36.6 percent growing three to five crop types, and only 6.6 percent of respondents growing six to seven crop types. Also, seed producers may grow several classes and varieties within each crop
type. As with commercial crop production, Canada Western Hard Red Spring (CWRS) wheat is the most commonly grown seed crop.

Manitoba’s 861 pedigreed seed producers in 1997 had 325,363 acres in pedigreed seed production; Table 2.1 gives acres of pedigreed seed by crop. Of the total acreage, 144,783 acres (or 44.4% of total seed acreage) was wheat, and of the wheat acreage, 114,698 acres was CWRS wheat (79% of the wheat acreage and 35% of total seed acreage). Next to wheat, the type of seed crop with the most acreage was certified forage seed (47,502 acres), then barley (36,341 acres), and then flax (32,194 acres). Looking at distribution of acreage by crop type one would expect a similar crop mix for pedigreed seed as for commercial production. As given in Figure 2.2, the proportion of total crop acreage that each individual crop comprises is similar between pedigreed seed and commercial crops for most crops, with the most notable exception being canola. Whereas canola made up close to 25% of Manitoba’s commercial acreage in 1997, only 6% of pedigreed seed acreage was planted to canola seed. A large proportion of Manitoba’s commercial canola is produced from seed imported from other provinces, plus canola has a low per bushel seeding rate relative to other crops.

Manitoba seed producers are leaders in seed production. Manitoba and Saskatchewan have the greatest number of acres planted to pedigreed seed production, followed by Alberta and Ontario (Figure 2.3). These four provinces together have consistently accounted for close to 95% of Canada’s pedigreed seed acreage (CSGA, Annual Reports, various years). Respondents to the MSGA survey were asked to give Manitoba’s competitive advantages in seed production. The advantages cited by respondents included:

- the diversity of crops that can be grown in Manitoba,
Table 2.1:  Manitoba Pedigreed Seed Growers and Acres Grown, by Crop, 1997

<table>
<thead>
<tr>
<th>Crop</th>
<th>Number of Growers</th>
<th>Acres Grown</th>
<th>Percent of Total (excluding forages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>405</td>
<td>114,698</td>
<td>41.3</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>37</td>
<td>6,053</td>
<td>2.2</td>
</tr>
<tr>
<td>Other Wheat(^1)</td>
<td>147</td>
<td>24,033</td>
<td>8.6</td>
</tr>
<tr>
<td>Total Wheat</td>
<td></td>
<td>144,784</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>210</td>
<td>36,341</td>
<td>13.1</td>
</tr>
<tr>
<td>Flax</td>
<td>213</td>
<td>32,194</td>
<td>11.6</td>
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<tr>
<td>Canola</td>
<td>118</td>
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<td>Oats</td>
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<td>Canary Seed</td>
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<td>0.6</td>
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<tr>
<td>Other Specials(^2)</td>
<td></td>
<td>2,798</td>
<td>1.0</td>
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<tr>
<td>Pulses</td>
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<tr>
<td>Peas</td>
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<td>25,524</td>
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</tr>
<tr>
<td>Beans</td>
<td>20</td>
<td>1,249</td>
<td>0.5</td>
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<td>Other Pulses(^3)</td>
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<tr>
<td>Forages</td>
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<tr>
<td>Timothy</td>
<td>152</td>
<td>18,143</td>
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<tr>
<td>Alfalfa</td>
<td>107</td>
<td>14,804</td>
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<tr>
<td>Ryegrass</td>
<td>74</td>
<td>5,628</td>
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<tr>
<td>Trefoil</td>
<td>52</td>
<td>4,972</td>
<td>-</td>
</tr>
<tr>
<td>Other Forages(^4)</td>
<td></td>
<td>3,955</td>
<td>-</td>
</tr>
<tr>
<td>Total Forages</td>
<td></td>
<td>47,502</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>861</td>
<td>325,363</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\)Other wheats include winter wheat, Canadian Prairie Spring and Canadian Western Extra Strong.
\(^2\)Other specials include rye, mustard seed, buckwheat and triticale.
\(^3\)Other pulses include fababeans, lentils and soybeans.
\(^4\)Other forages include fescue, clover, canary grass, wheatgrass, bentgrass, bluegrass, orchard grass and brome grass.

Figure 2.2: Percent of Manitoba 1997 Seed and Commercial Acreage in each Crop

Sources: Table 2.1 and Manitoba Agriculture Yearbook 1997
Figure 2.3: Distribution of Canada’s 1.25 Million Acres Planted to Pedigreed Seed Crops in 1997, by Province

Source: CSGA Annual Report, 1997
the more favourable growing conditions in Manitoba that reduce the risk of crop failure and increase the likelihood of attaining pedigreed status,

- the high transportation costs for commercial grains from Manitoba, which provides an incentive to look for a crop that can be processed locally, and
- Manitoba's relatively close proximity to US export markets for seed.

2.2.2 **Regulatory Agencies**

There are numerous associations, regulatory agencies, public and private institutions, and individuals involved in the pedigreed seed industry.¹ The Canadian Seed Growers Association (CSGA) has been Canada's official seed pedigreeing agency since 1904. The CSGA's certification process ensures the varietal purity of seed produced by its members. Standards are set by the CSGA; producers must register their seed producing land with the CSGA, which issues crop certificates for seed that meets pedigreed status (except for potatoes). The Manitoba Seed Growers Association (MSGA) is the provincial arm of the CSGA, acting as a liaison with the national organization, and providing promotional and extension activities.

Various offices of the Canadian Food Inspection Agency (CFIA) are involved in numerous seed related activities including administration and enforcement of the Seeds Act and Regulations, and registering crop varieties. Registration of new varieties in Canada is a detailed process, with recommending committees analysing new varieties based on how they perform relative to checks.

¹A summary of the seed industry's major players and their roles is given in *Manitoba Seed Industry: Value Added Impacts*, MacMillan, Sabourin and Chorney, 2000a.
Canada’s variety registration system and seed certification system are two essential components of the quality assurance system for producing high value commercial crops for domestic and export purposes. Manitoba seed producers make important contributions to the value chain for production of Canada’s commercial crops. The critical steps of this quality assurance system as outlined in the MSGA Study are:

- Plant breeders breed new varieties with improved yield, hybrid vigour, disease resistance, other production traits, and market characteristics relative to variety checks.
- New varieties are compared with variety checks, assessed by recommending committees and recommended for variety registration and commercial production.
- Varieties recommended for approval by the recommending committees are formally approved by the CFIA’s Variety Registration Office. The Canadian regulatory system approves the registration of new varieties based on genetic purity of new seed varieties, nutritional food safety of products for human consumption and animal feed, and environmental impact assessments.
- Certified seed for commercial production is grown by CSGA members under rigorous regulations established by the CSGA. Prior to sale, seed is processed under standards established by the CSGA and administered by the Canadian Seed Industry (CSI).
- In Manitoba, performance of new varieties under growing conditions at several locations across the province is evaluated by the Manitoba Crop Variety Evaluation Team (MCVET), for the benefits of commercial producers, with results published annually in Seed Manitoba.
- Crop producers purchase pedigreed seed varieties for commercial production.
• Seed industry products are marketed in domestic and export markets consistent with World Trade Organization (WTO) trade rules and phytosanitary requirements.

2.2.3 Growing Pedigreed Seed

There are various classes of pedigreed seed that seed producers may grow, with class here referring to the generation of the pedigreed seed. The classes available are (CSGA, Circular 6-94):

• breeder seed is seed produced by a recognized plant breeder and is the source of initial and recurring increases of seed for the other pedigreed classes,

• select seed is the approved progeny of either select or breeder seed and is not a seed of commerce,

• foundation seed is the approved progeny of breeder or select seed and is the highest class of seed of commerce,

• registered seed is the approved progeny of breeder, select or foundation seed, and

• certified seed is the approved progeny of breeder, select, foundation or registered seed, and is the seed class recommended for use for commercial crop production.

Seed growers must follow specific practices and adhere to specific regulations to grow a pedigreed seed crop. This includes keeping records of previous land use of the parcel to be sown for seed, following specific guidelines for the crop type regarding previous land uses, maintaining isolation guidelines for each crop, use of appropriate pedigreed seed for sowing the seed crop (i.e. certified seed cannot be used to sow a seed crop), and maintaining the growing crop to ensure uniformity of stand and to control for weeds and diseases (CSGA, Circular 6-94).
Once the producer has sown a pedigreed seed crop, application must be made to the CSGA for membership and crop inspection. The CFIA arranges for crop inspection to take place at a specific time and which must be while the crop is still standing. Acceptance or denial of pedigreed status is determined solely by the CSGA based on the crop report and information provided by the grower. There are numerous reasons why a crop may be denied pedigreed status, including: an excess of other crop kinds, other varieties, or weeds within the stand; nonconformance with previous land use; insufficient isolation; the crop was sown with ineligible seed; and cutting of the crop prior to inspection. The acreage that is not approved for pedigreed status by CSGA is very low, ranging from 1 to 2 percent of inspected acres (CSGA annual reports, various years).

If a grower's crop is accepted as pedigreed seed a crop certificate is issued by the CSGA certifying that the crop meets the requirements for varietal purity and crop standards and shows the pedigreed status (Select, Foundation, Registered, Certified) for which the seed is eligible (CSGA, Circular 6-94). The seed then must be inspected and graded by a licensed grader at an authorized establishment. If the seed passes inspection for germination, freedom from weed seeds and other crop kinds, and for general quality, a label is issued confirming the class of seed and grade.

2.2.4 Varietal and Seed Research and Development

In the past, almost all varietal development research was publicly funded (Leask and Anderson 1998) by the federal government through Agriculture and Agri-food Canada (AAFC), with research occurring at various research centres and universities across the country. Crop
development research was focussed on varietal development, with primary consideration given to the needs of the commercial producer and the processor (Leask and Anderson 1998).

With the advances in biotechnology, more emphasis is expected to be placed on developing varieties tailored specifically to the needs of the processor and end consumer (see Figure 2.1). Although seed has always been an essential beginning point of the production chain, demand for identity preserved (IP) products will place even greater emphasis on delivering technology through the seed. This is producing considerable change within the industry, of which the seed industry is at the forefront of these changes (Leask and Anderson 1998).

Private industry has had increasing involvement in research and development of crops, with this involvement being partially the result and partially the cause of the changes occurring in crop research and development. In Western Canada this shift to greater private investment has been occurring since the mid-1990s (Hart 1999). Private industry is attracted to the potentials of biotechnology, provided there is an opportunity to see an eventual return on investment. Governments dealing with fiscal restraints have reduced spending on research; in the 1995 budget the federal government announced reductions to agricultural research of 20 percent over three years (Klein and Kerr 1995). In particular, large multinational corporations have focussed investment in research and development at the seed stage, to the extent that private investment in this area now far outweighs public investment for some crops. According to Rausser (1999), private investment for plant genomics research and development in the US has reached levels of up to 30 times larger than that of the US federal government.

The changes and developments in the crop development industry have, in turn, created pressures on the regulatory bodies to be responsive to these changes (Leask and Anderson 1998).
While Canada's regulatory system has contributed to the high quality of the varieties available to commercial producers, as well as to the international recognition of this quality, it has also been seen as an impediment in terms of the amount of time required to gain approval for biotechnology products (Klein et al. 1998). Also, the variety registration process, which requires that new varieties have similar quality characteristics to a varietal standard, places impediments on developing varieties to respond to specific customer requirements. There is no variety registration process in the US, companies sell their varieties based on merit, with the general consensus that if a variety does not perform it will not be accepted by the market. Some stakeholders in Canada's agricultural industry are of the belief that major changes are required in our variety registration process, with some asserting that the process is no longer required. In fact, the whole variety registration process has recently come under review (FAAR 1999), with as yet no clear definition of the changes that will be instituted.

2.2.5 Biotechnology and Multinational Companies

Biotechnology advances that enabled development of crops with resistance to pests or specific herbicides has provided crop producers with an additional crop management tool, with the potential of decreasing their input costs and increasing their returns. Such advances were made possible by using recombinant DNA technology (introducing genes from one plant species into an unrelated species) to produce these genetically engineered organisms, or transgenics. Such organisms are commonly referred to by the media as genetically modified organisms (GMO's or just, for example, GM canola).\(^2\) While investments in such areas in the US have

\(^2\)From CSGA (April 2000), GMOs include organisms produced by mutation as well as by more traditional breeding methods, while organisms produced through recombinant DNA technology are more correctly labelled genetically engineered organisms.
focussed on BT corn (hybrids with the *Bacillus thuringiensis* or BT gene) with resistance to the European corn borer, and herbicide resistant soybeans, in Western Canada, the emphasis has been on herbicide resistant canola. According to Marks et al. (1999), 40 percent of the developments for agricultural biotechnology in Canada have been in Saskatchewan and have focussed on input trait characteristics for canola. Herbicide resistant canola rapidly gained popularity with Canadian commercial producers. First introduced in 1994, by 1999 about 55 percent of the canola crop was seeded with a genetically modified canola (Canadian Canola Growers Association 1999).

Initial application of biotechnology to agricultural crops has been for modification of inputs (for example, herbicide tolerance and insect and disease resistance), with two other areas of promise being modification of output characteristics (for example, improved nutritional value or improved flavour), and enhanced performance traits (for example, increased tolerance to drought or temperature extremes; Klein et al. 1998). There has been considerable public concern over transgenic crops, particularly in Europe. According to Rausser (1999), with development and commercialization of output characteristics for which consumers can perceive a direct benefit should come less public resistance to GMO crops, and, in fact, he hypothesizes that had development of output characteristics preceded input characteristics, public concerns of GMO crops would not be of the same magnitude that they currently are in some areas of the world.

Multinational corporations, seeing the potential of capturing value in the seed have poured huge amounts of research and development funds into these new technologies, and have instituted changes that have resulted in considerable restructuring of the industry. Mergers and acquisitions by these multinationals have resulted in both horizontal and vertical integration.
(Kalaitzandonakes and Bjornson 1997, Hayenga 1998). Marks et al. (1999) give a value of over $22 billion spent by biotechnology firms in acquisitions from 1995 to 1999, mainly between biotechnology and seed industries. Also, some of the large chemical companies have turned their emphasis from chemicals to what they term the life sciences (Rausser 1999), which includes seed development and developments in the areas of nutraceuticals and functional foods. Leading the acquisitions is Monsanto, which has acquired numerous seed and biotechnology firms to become a life science company. Dupont has also turned itself into a life science company with its purchase of Pioneer Hi-bred. Mergers between chemical and pharmaceutical companies to form life science companies include Ciba Geigy and Sandoz to form Novartis, Hoechst and Rhone Poulenc to form Aventis, and Astra and Zeneca to form AstraZeneca (Marks et al. 1999).

Biotechnology developments and mergers and acquisition have been concentrated in the United States. While major multinationals have established research programs in Canada, the commercialization of the biotechnology industry has not apparently (yet) occurred to the degree it has in the US due in part to the much smaller market, the emphasis on two main export crops (canola and wheat), and the strong public sector involvement in crop development (Marks et al. 1999). In 1998, 74% of the transgenic crops planted globally were located in the US, as compared to 10% in Canada (Marks et al. 1999).

Although biotechnology research for Western Canada initially focussed on canola, movement has been made into other crops, with transgenic wheat expected within the next three years. Advances made in seed technology for canola are seen as indicators for what to expect for other Canadian crops (Country Guide 1999).
With the increasing involvement of private industry in seed research and development, and because of the considerable costs of bringing a new innovation through the various stages to market, comes the need to receive an adequate return on investment. In Canada, unlike the US, patent protection cannot be given for plants. Companies protect their investments through plant breeders rights (PBRs), or through patenting of the gene or the process of creating the GMO, or, as in the case of Monsanto and glyphosate tolerant canola, through technical use agreements (TUAs) with the crop producer. Plant breeders rights are legislated through the Plant Breeders’ Rights Act of 1990, which, unlike patents, does not give the breeder exclusive ownership of their invention but rather gives sole rights for selling propagating material or seed for the protected variety (Carew 2000). Under the PBR Act, farmers may save and use the crop of a protected variety for their own seed. In the case of Monsanto’s TUAs, producers growing Roundup Ready canola must sign a technical use agreement with Monsanto that they will not use any of the Roundup Ready canola that they produce for commercial sales as seed. Vertical integration has enabled these companies to look at a variety of means of recouping their investments and protecting their proprietary rights. Patents are thought by some to provide an inadequate form of protection, as evidenced by the number of patent infringement cases that have not held up in court, and thus companies protect their investments through mergers and acquisitions (Kalaitzandonakes 1998).

A number of consultations and task forces have examined the opportunities of biotechnology. The major findings of these various reports have been outlined in AAFC’s Investing in Life’s Basic Building Blocks. According to AAFC, the conclusive findings of these reports are that genomics, “the area of science that deals with understanding the structure,
function and interrelationships of the genes contained in living organisms,” is the opportunity of the coming century, of which Canada must be a player, with significant roles to be played by both private and public institutions. Further to these findings, seed is seen as the means by which farmers access the work of scientists, and certified seed is the means by which farmers can ensure they are accessing the latest technology (Country Guide 1999).

Biotechnology has been identified by Kindinger (1998) as a defining technology for agriculture, akin to the adoption of mechanical power, hybrid seeds and pesticide usage, with the discoveries and applications to date being only the “tip of the iceberg.” Many changes will occur throughout the industry, with biotechnology driving these changes. Freiberg (1998) tempers this optimism by pointing out that many past technological breakthroughs resulted mainly in production surpluses with little increases in added value at the farm level. However, according to Freiberg (1998) there is considerable potential for biotechnology in developing a value added grain production system through enhanced output trait characteristics.

Increased emphasis on output trait characteristics, however, will likely bring escalated vertical integration by large companies, giving them control of the product from the breeding stage through to harvest and delivery to the end customer (USDA 1999), quite possibly including the processing stage (Freiberg 1998). In such a scenario, seed companies and farmers (and thus one would expect seed growers as well) may become “contract growers” for these giant multinationals (Freiberg 1998). Contracts through the various levels of the production and supply chain will be a necessity to keep these identity preserved products segregated and to capture the added value (Hayenga 1998). Other issues that need to be settled include determining the price discovery mechanisms and marketing arrangements for these crops,
ensuring there is equitable sharing of the value added of these crops between all the stakeholders, development of appropriate identification and detection procedures for ensuring the crop has the expected output trait, and attaining public acceptance of genetically engineered crops (USDA 1999). Ebbertt (1998) claims that to date these value enhanced grains haven’t delivered the expected value added to producers or processors, but they have definitely impacted the way business is done.

2.2.6 Private Industry, Past and Present

Prior to the involvement of multinationals in seed research and development, the seed industry in western Canada consisted of breeders, mainly at public institutions, numerous seed growers, some of whom also processed and retailed their own seed products, as well as companies involved in processing and retailing seed. Most varieties were public varieties, available to any seed grower. Processing and retailing of seed has been done at a variety of levels along the seed production chain, including: seed growers with their own processing facilities; small local firms and larger firms involved explicitly in seed processing and retailing; and grain companies with seed sales as only one of the sales and services offered to producers.

From a history of the seed trade industry by the CSTA (1995), the major companies involved in the seed trade were initially located in eastern Canada, with their major crops being forages and grasses. Producers accessed cereal seed mainly from their previous years’ commercial crops or obtained seed from other producers or small local merchants; high transportation costs apparently rendered cereal seed trade unprofitable. Initially, in the 1920s and 30s, most seed production occurred in Ontario, but by the 1950s’ forage seed production shifted to western Canada such that the west became the major producer of certified forage seed. The
US was and continues to be an important market for western Canadian forage seed. From this history and the results of the industry survey for the MSGA Study, forage seed has always been a mainstay of companies involved mainly in seed retailing.

With the availability of hybrid varieties, Plant Breeders’ Rights legislation, and particularly with the trend towards embedding technology in the seed, not only in the form of GMO technology, but also in terms of seed treatments, there have been changes in the structure of the industry in terms of seed availability and seed retailing. With PBRs, the originator of a variety has the right to collect royalties on sales of seed of that variety, with the belief that these proprietary rights will stimulate research and development of new and improved varieties which will benefit all of agriculture (CSTA 1995).

2.2.7 Primary Issues of Concern to Seed Growers

Technology has produced opportunities and challenges to seed producers. With involvement of multinationals and the embedding of technology in the seed and the concomitant intellectual property rights, access to varieties has become an issue of concern to producers. Furthermore, the trend has been for public varieties to be tendered, with the party receiving the tender having the property rights to the variety, which has added to the access to varieties issue.

A further issue to growers is the trend of chemical and grain companies to bundle seed sales with other sales and services. This makes it difficult for the independent seed grower to compete, forcing them to look for new markets, including sales to these same companies they are competing against, or to enter into contract growing agreements with these companies.

The widespread use of common seed by commercial producers has always been an issue of concern to seed producers. Commercial wheat producers will normally try to use their own
seed for two to three years after purchasing pedigreed seed. Common seed takes advantage of the technology and research that has been invested into seed development, but is available to producers at a cheaper price than pedigreed seed.

Pedigreed seed producers also face the same issues common to all crop producers in the form of cyclical commodity prices, high input prices, and acceptance of GM crops. Low commodity prices further exacerbates the common seed problem in that commercial producers looking for ways to reduce their costs of production will be more likely to choose common seed over pedigreed seed.
3 Theoretical Framework

As indicated in Chapter 2, value added represents the sum of economic returns to all factors of production, including employees, landlords and business operators. Value added for the seed industry then is gross returns from all seed related activity in Manitoba minus the operating costs of firms producing this activity. Value added was used in the MSGA Study to indicate the contribution of the seed industry to Manitoba’s economy. Results from surveys of Manitoba’s seed producers and of companies involved in the seed industry were extrapolated to represent all seed growers and seed companies in operation in Manitoba in 1997. Thus, the MSGA Study examined value added at the aggregate level.

This present study examines the value added from the perspective of the individual pedigreed seed producers. Companies involved in seed related activities are not included in this present study, nor are growers of common forage seed, as the latter were not included in the grower surveys. Of interest is to determine what factors will affect the value added attained by producers and how these might vary between producers.

The common practice of economists is to develop theoretical models which can be used to understand reality and to explain an economic unit’s behaviour and decisions (Nicholson 1985). The validity of such theoretical models is then empirically tested with real world data. Thus, this chapter describes the theoretical model used here to describe the individual seed producers value added from pedigreed seed production and from on-farm seed processing.
activities. The theoretical model is then tested using the information collected through the grower survey for the MSGA Study.

3.1 Modelling Value Added

From the theory of the firm the basic assumption used by economists is that the goal of the firm is to maximize profits (Varian 1984). Firms must make many decisions regarding level of output, and types and levels of inputs for accomplishing their goal of profit maximization. For firms with multiple outputs such decisions become more complex. Seed producers, for example need to make decisions regarding what types of seed crops to grow and the number of acres to allocate to each type as well as the types and levels of inputs that will enable them to maximize their profits. Furthermore, many seed growers grow commercial crops as well as seed crops, and so further decisions need to be made on allocating their total acreage between commercial crops and seed crops. The assumption of microeconomics is that a competitive firm will optimize its actions so as to maximize profits, subject to any technological and market constraints and with prices given (Varian 1984).

The model developed here uses data collected through the survey process to explain value added. The underlying assumption of the model, however, is that seed producers are attempting to maximize their profits from seed production as well as from commercial crop production. The profit maximizing equation for the individual seed producer’s seed production operation then would be

\[ \pi = \sum_{i=1}^{m} (P_i \cdot Q_i - C_i) + (\sum_{k=1}^{d} p_k \cdot q_k - c_{pr}) \]
where

\[ \pi \quad = \quad \text{profits from the seed operation} \]
\[ m \quad = \quad \text{number of seed crops grown} \]
\[ P_i \quad = \quad \text{price of seed crop } i \]
\[ Q_i \quad = \quad \text{quantity of seed crop } i \text{ produced} \]
\[ C_i \quad = \quad \text{all costs associated with producing seed crop } i, \text{ including variable and fixed costs} \]

and where, for producers with a processing operation

\[ d \quad = \quad \text{number of seed crops processed by the producer’s processing operation} \]
\[ p_k \quad = \quad \text{price charged for processing seed crop } k \]
\[ q_k \quad = \quad \text{quantity of seed crop } k \text{ processed} \]
\[ c_{pr} \quad = \quad \text{all costs associated with the processing operation, including variable and fixed costs} \]

The value added maximizing equation then is very similar to the profit maximizing equation, except that costs, \( C_i \) and \( c_{pr} \), are operating costs only, excluding labour, rent and indirect taxes.

\[
3.2) \quad va = \sum_{i=1}^{m} (P_i \cdot Q_i - C_i^*) + \left( \sum_{k=1}^{d} p_k \cdot q_k - c_{pr}^* \right)
\]

Where

\[ va \quad = \quad \text{value added} \]
\[ C_i^* \quad = \quad \text{operating costs for producing seed crop } i, \text{ excluding labour, rent and indirect taxes} \]
\[ c_{pr}^* \quad = \quad \text{operating costs for the processing operation, excluding labour, rent and indirect taxes} \]
And therefore

3.3)  \( va = \pi + (\text{labour} + \text{rent} + \text{indirect taxes} + \text{depreciation} + \text{opportunity costs} + \text{payments to management}) \)

And since, from the theory of the firm the competitive producer will attempt to maximize profits and minimize costs (including costs for labour, rent, and indirect taxes), then the competitive producer will also be attempting to maximize value added, subject to the constraint of minimizing all the cost components of value added. If the owner/operator seed grower does not supply all the required labour, value added from the perspective of the firm will differ from the macroeconomic concept by the amount of the hired labour operating expense. In other words, the owner/operator would be interested in payments to the operation’s factors of production.

The producer attempts to maximize value added and value added is a function of the price and level of output, as well as the price, level and type of inputs. Level of output (or production) in turn is a function of some factors that are under the producer’s control, such as level and type of inputs, and some that are not, such as weather or soil characteristics. Weather and soil characteristics will vary according to the location of the seed growing enterprise. For a competitive, profit maximizing firm, prices of output and inputs are considered to be given and therefore firms are concerned with the profit maximizing levels of outputs and inputs (Varian 1984).

The value added and profits of the seed producers are determined not only by the price attained for the seed crop, but also the proportion of their crop that is sold as seed and how much has to be sold as commercial crop. Producers may not be able to sell all, or in some cases any, of
their seed crop as seed, for a variety of reasons, and thus must sell it as a commercial crop for a reduced price. Thus, equation 3.2 may be modified to account for this by

\begin{equation}
va = \sum_{i=1}^{m} (P_i \cdot Q_i \cdot %S_p + P_{oi} \cdot Q_i \cdot (1 - %S_p) - C_r^i) + \left( \sum_{k=1}^{d} p_k \cdot q_k - c_{pr}^* \right)
\end{equation}

where

\begin{align*}
%S_p &= \text{the percent of the seed crop sold as pedigreed seed} \\
1-%S_p &= \text{the percent of the seed crop that is sold as a commercial crop (with a small proportion also sold as screenings)} \\
P_{oi} &= \text{the price received for other sales}
\end{align*}

and where all other variables are as in equation 3.2. Of note is that, regardless of how much or how little of the producer’s seed crop was actually sold as seed, costs remain the same, and in most cases are greater than costs of production for commercial crops. For example, survey respondents were asked to give costs per acre for each of their pedigreed crops, and also estimate costs as if the acreage had been used for a commercial crop instead of a seed crop. Using CWRS wheat as an example, in all cases seed crop costs were higher, with the increase ranging from 2.2% to 46.7% above commercial crop costs, and with an average increase of 23.0%.

3.2 Direct and Indirect Impacts

While prices, costs, yields and the proportion of the crop sold as pedigreed seed will have a direct impact on value added, also of interest are those factors which will have an indirect impact on value added through their effects on the direct impact variables. As with many economic studies, this study is limited to making use of secondary data. The MSGA survey was designed with the objectives of gaining the information required to make aggregate estimates of value added by the seed industry to Manitoba’s economy. Thus, we are constrained by the data.
available in determining which factors to consider in the function for value added. The factors of interest and for which information could be accessed through the survey are:

- Value added may be a factor of the size of the production operation, and also by the extent to which the operation focusses on pedigreed seed production. Economies of size and specialization may come into play through increased yields, decreased costs, or marketing advantages.

- In the *MSGA Study*, seed producers were divided into either the large or small size group, with producers placed in the large producer group if they had acres in the top 30 percent for any one of their seed crops. Therefore, it is of interest to determine if there are any differences in value added for these two producer groups.

- Also of interest is whether experience plays an important factor in success of seed production and marketing.

- A further area of interest is to examine how producer owned seed processing facilities contribute to the operation’s value added.

- The location of the seed operation may have impacts on value added through long- and short-term weather conditions, soil characteristics and access to output and input markets.

- Varieties grown by the seed grower may also affect value added, in terms of yield and market potential of the varieties grown. The producer makes decisions regarding which varieties to grow one year, without full information as to which varieties will be in demand by commercial producers for the following crop year.

- Producer’s may contract grow for other producers or a seed company, which may provide them with advantages in terms of prices or a guaranteed market for their product.
Value added then, can be expressed as a function of these direct and indirect impact variables, or

\[(3.5) \quad VA = f(P, C, Y, PSP, A, DP, X, PCA, G, L, V, CT)\]

Where

- **VA** = value added per acre for seed crop i
- **P** = price received for the seed crop
- **C** = production costs for the pedigreed crop (excluding labour, rent and property taxes)
- **Y** = yield for the pedigreed crop
- **PSP** = percent of quantity of seed crop sold as pedigreed seed
- **A** = total acres the producer has in crop production (seed production and commercial crop production combined)
- **DP** = the extent to which the producer has specialized into seed production
- **X** = experience of the producer in growing pedigreed seed
- **PCA** = the producer’s involvement in seed processing
- **G** = whether the respondent is from the large or small producer group
- **L** = location of the seed growing operation
- **V** = proportion of producer’s seed crop i that is seeded with variety j
- **CT** = whether or not the producer grows seed on contract

Adapting the theoretical model given in equation 3.5 to a linear equation for value added, which would be analysed by ordinary least squares (OLS), would give an equation as below

\[(3.6) \quad VA = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki} + e_i\]
where

\[ X_{i1} \ldots X_{ik} = \text{explanatory variables 1 to } k \]

\[ \beta_0 \ldots \beta_k = \text{coefficients indicating the marginal impact of a change in each of the explanatory terms, holding all other variables constant, with } \beta_0 \text{ being the intercept} \]

\[ e_i = \text{the disturbance term} \]

An assumption of ordinary least squares (OLS), however, is that all explanatory variables are exogenous to the system, that is they are predetermined and will not covary with the disturbance term, \( e_i \). The disturbance term is a random variable that indicates the difference between the measured value of the dependent variable and the value predicted through the equation, and includes the impacts of all variables not included in the equation (i.e. the missing variables). As such, explanatory variables that are determined within the system, or are endogenous, will also be affected by these missing variables and, therefore, will covary with the disturbance term. When explanatory variables covary with the disturbance, the coefficient estimates are both biased and inconsistent (i.e. the expected value of the estimated coefficient does not equal the true value of the coefficient, even in large samples) (Griffith et al. 1993).

For equation 3.5, costs, \( C_i \), yield, \( Y_i \), and the percent sold pedigreed, \( PSP_i \), are assumed to be endogenous. For example, weather conditions are not completely captured in the location variable and would show their effect through the error term. Weather conditions will affect yield, and also possibly costs and, therefore, these two variables would covary with the error term. Also, the percent of the producer’s seed crop that is sold as pedigreed seed will be a factor of management and marketing decisions as well as other unknowns, some of which will be captured in the error term. The producer is assumed to be a price taker making prices exogenous.
The remaining variables in expression 3.5 are expected to affect value added indirectly through their impact on costs, yields or percent sold as pedigreed. These indirect impact variables are assumed to be exogenous. With regards to the proportion of the producer's total acreage in seed crops, most respondents had been growing pedigreed seed for a number of years (average of 20 years for CWRS wheat growers), plus the number of acres in Manitoba planted to pedigreed seed crops is fairly stable from year to year. Thus, it is assumed that on a yearly basis the respondents individually kept approximately the same proportion of their total acreage in pedigreed seed crops, and therefore, this can be assumed to be an exogenous variable.

The percent of their crop acreage used for a specific seed crop, for example CWRS wheat, was not a variable in the equation, as the proportion of their total seed acreage allocated between various crops could change yearly and show covariance with the disturbance term.

Variety was considered a predetermined, or exogenous, variable. This variable represents the proportion of the grower's 1997 seed crop that was planted with varieties that were the most popular commercial varieties for that crop for 1998. Seed growers make decisions on which varieties to plant for 1997 without full knowledge as to which varieties will be most popular to commercial producers in 1998, and therefore this variable is treated as a predetermined variable.

### 3.3 Two Stage Least Squares Regression

A two stage least squares (2SLS) analysis accounts for the endogenous nature of some explanatory variables by first expressing the endogenous variables as functions of the exogenous variables (Johnston 1984). For example, if the structural equation for value added, giving the theoretical hypothesis of value added, was as below

3.7) \[ VA = \beta_0 + \delta_i Y_i + \beta_i X_{it} + \ldots + \beta_k X_{kt} + e_i \]
where

\[ Y_i = \text{an endogenous explanatory variable} \]
\[ \delta_i = \text{the marginal impact of } Y_i \text{ on } VA/\text{acre} \]
\[ X_{k1}..X_{ki} = \text{exogenous explanatory variables 1 to } k \]
\[ \beta_0..\beta_k = \text{the coefficients indicating the marginal impact for the exogenous explanatory variables} \]
\[ e_i = \text{the disturbance term} \]

both of the endogenous variables, VA and \( Y_i \), could be given as a function of only the exogenous variables in a reduced form equation. If \( Y_i \) was a function of a number of variables, some of which are included in equation 3.7, for example, \( X_1 \) and \( X_2 \), plus some additional variables, for example \( Z_1 \) and \( Z_2 \), then

3.8) \[ Y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 Z_{1i} + \alpha_4 Z_{2i} + u_i \]

The reduced form equation for VA would look like

\[ VA_i = \beta_0 + \delta_i(\alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 Z_{1i} + \alpha_4 Z_{2i} + u_i) \]
\[ + \beta_1 X_{1i} + \ldots + \beta_k X_{ki} + e_i \]

3.9) \[ = \gamma_0 + \gamma_1 X_{1i} + \gamma_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_k X_{ki} \]
\[ + \gamma_3 Z_{1i} + \gamma_4 Z_{2i} + v_i \]

where value added per acre is now modelled as a function of the exogenous variables only. With 2SLS the endogenous explanatory variables are estimated as functions of the exogenous variables. The predicted values of the endogenous explanatory variables are then used to estimate the parameters of the structural model (Griffiths et al. 1993). In this case, the predicted values of \( Y_i \) in equation 3.8 will be used to estimate the structural parameters of equation 3.7.
The 2SLS estimates can be shown to be consistent. A requirement of 2SLS, however, is that there be enough information such that the reduced form equations provide a unique solution to the structural model; this is called the identification problem.

Making use of 2SLS enables us to not only deal with the problem of endogenous explanatory variables, but also that some of the variables of interest will have an indirect effect on value added.

3.3.1 The Structural Equation for Value Added

An identity is an economic equation with no parameters, for example, A = B + C, or, in this case repeating equation 3.4

\[ v_a = \sum_{i=1}^{m} (P_i Q_i \%S_p + P_o Q_i (1 - \%S_p) - C'_i) + (\sum_{k=1}^{d} P_k q_k - c'_k) \]

and which provides us with no additional behavioural information on how various factors affect value added. The structural model used is a modification of the above identity. The variables of interest are prices of pedigreed seed, yield, the percent of seed sold as pedigreed seed, and costs of operation. Modelling equation 3.4 into a structural equation on a per acre by crop basis, and replacing the quantity with yield, gives

\[ VA_i = \beta_0 + \beta_1 Y_i + \beta_2 C_i + \beta_3 PSP_i + \beta_4 P_i + e_i \]

where $\beta_0$ to $\beta_4$ are the parameters indicating the marginal impact of a change in explanatory variable $k$, holding all other variables constant, $P_i$ is the exogenous explanatory price variable, and where yield, $Y_i$, costs per acre, $C_i$, and percent of crop sold as pedigreed seed, $PSP_i$, are endogenous explanatory variables. The endogenous explanatory variables are each estimated as
functions of the exogenous variables and the parameters of equation 3.10 are estimated through 2SLS, as explained in the previous section. Using CWRS wheat as an example, the reduced form equation for costs, $C_i$ is as below:

$$C_i = \alpha_0 + \alpha_1 P_i + \alpha_2 A_i + \alpha_3 A_i^2 + \alpha_4 DP_i + \alpha_5 X_i + \alpha_6 X_i^2 + \alpha_7 B_i + \alpha_8 D_i + \alpha_9 PCA_i + \alpha_{10} G_i + \alpha_{11} L_{1i} + \alpha_{12} L_{2i} + \alpha_{13} L_{3i} + \alpha_{14} CT_i + e_i$$

3.11)

The reduced form equations for value added, yield and percent sold as seed would be as above, and, therefore, the corresponding reduced form equation for value added per acre for wheat is:

$$VA_i = \delta_0 + \delta_1 P_i + \delta_2 A_i + \delta_3 A_i^2 + \delta_4 DP_i + \delta_5 X_i + \delta_6 X_i^2 + \delta_7 B_i + \delta_8 D_i + \delta_9 PCA_i + \delta_{10} G_i + \delta_{11} L_{1i} + \delta_{12} L_{2i} + \delta_{13} L_{3i} + \delta_{14} CT_i + u_i$$

3.12)

where:

$P_i$ = the price variable, is an index to incorporate the prices of the various varieties of the seed crop grown by producer $i$ into one price index

$A_i, A_i^2$ = total acres the producer has in production, including both seed crop and commercial crop acreage and its squared term, respectively

$DP_i$ = the percent of the producer’s total acres in production, $A$, that is planted to a seed crop

$X_i, X_i^2$ = experience of the producer in growing pedigreed seed, and its squared term, respectively

$B_i$ = the proportion of the respondent’s CWRS wheat crop that is planted with the variety AC Barrie, one of the two most popular 1998 commercial varieties
\( D_i \) = the proportion of the respondent’s CWRS wheat crop that is planted with the variety AC Domain, the second of the two most popular 1998 commercial varieties

\( PCA_i \) = a dummy variable equalling one if the producer is involved in seed processing, and zero otherwise

\( G_i \) = a dummy variable equalling one if the producer is from the large producer group and zero if from the small producer group

\( L_{ai} \) = dummy variables, where \( a = 1 \) to \( 3 \); \( L_1 = 1 \) if producer is from the Northwest region and zero otherwise; \( L_2 = 1 \) if producer is from the Central region and zero otherwise; and \( L_3 = 1 \) if producer is from the Eastern or Interlake region and zero otherwise

\( CT_i \) = 1 if the respondent grows seed under contract, and 0 otherwise

\( e_i \) = the disturbance term

\( \beta_2 .. \beta_{14} \) = coefficients indicating the marginal impact of a change in explanatory term \( i \) (i=2..14); with \( \beta_0 \) being the intercept
4 Methodology and Data Description

4.1 Data Description and Treatment

The data used for the present study are the grower responses to the survey for the MSGA Study. The CSGA maintains a database of all seed growers for Manitoba, including their seed crop types, varieties, and acres. The sample for the MSGA Study was based on the Manitoba seed grower population for 1997, as accessed through the CSGA database.

Because large growers tend to exhibit more variability than smaller growers, it was determined that to obtain a reliable data set for the MSGA Study more large growers needed to be sampled. Producers were segregated into small or large producers for each crop type during the initial survey process. The grower database of all Manitoba seed growers was segregated into small and large producers based on their acreage in each of the 10 crop types described earlier (CWRS wheat, durum wheat, winter wheat, other wheat, barley, special crops, flax, canola, pulse crops, and forages). Large producers for a crop type were defined as those producers in the top 30 percent of that crop type on an acreage basis. If a producer qualified as a large producer for at least one crop type, then the producer's operation was considered a large operation. All other producers were defined as a small producer. Therefore, if a producer was defined as a small producer, then none of the crops grown by that producer were within the top 30 percent of acreage (i.e. the producer was not considered a large producer for any crop). All producers within the large group were sampled and producers within the small group were randomly sampled at a rate of 34 percent of the small grower population.
Producers were mailed an extensive survey asking for information on their 1997 seed operation including: production, purchases, and sales and marketing information; detailed per acre production costs; for those producers operating a processing facility, details on quantities and charges for custom cleaning and input costs for their processing facility; labour and salary information; and market value of land, buildings and equipment used for seed production and processing.

The response rate for the large producer group was 57 respondents of 305 surveys mailed (18.7 percent). Response rate for the small producer group was 33 responses of 186 mailed (17.7 percent). The total of 90 respondents gives an overall response rate of 18.3 percent. These survey responses formed the basis of the *MSGA Study*, and are used in this study. One response was not used, as the producer had only two acres of seed crop and received an unusually high price. An explanation of treatment of missing data is provided in Appendix B.

4.2 Value Added Calculations

Respondents to the *MSGA Study* were asked to give information that enabled calculation of:

- gross returns from crop production for each of the crops and varieties of the crops grown,
- costs per acre for the crop types (i.e. not by varieties),
- gross returns by crop from processing, and
- total processing costs.

For pedigreed seed growers, value added then is calculated from the survey results as

\[ va = \text{gross revenue (GR)} - \text{operating costs} \]
where

\[ GR = \text{value of all crops grown on pedigreed seed acreage} + \text{value of any change in inventory} + \text{resale value of any seed purchases} - \text{cost of seed purchased for resale} + \text{value of seed custom processed} \]

and

\[ \text{operating costs} = \text{operating costs for seed production and processing, excluding costs for labour, land rent and property taxes} \]

The gross revenue calculations includes the value of all crop production from land planted to produce pedigreed seed. Thus, the value of all seed grown on pedigreed seed acreage in 1997 could include:

- seed sold as pedigreed seed,
- seed that, while grown on land intended for a pedigreed seed crop, for some reason was unable to be sold as pedigreed seed (e.g. seed was not of pedigreed quality or the producer could not find a market) and had to be sold as commercial seed (e.g. grain to be used for flour),
- the value of screenings, and
- the value of any change in inventory between the beginning and end of the year, in order to account only for seed produced in 1997.

Also, if the producer bought and resold any grain, the difference in value between purchase and resale is part of the gross revenue. If the producer owned a processing facility, any revenues from custom cleaning or treating seed for other producers is included as gross revenue.

Processing costs were only requested as a total, as it would have been difficult for producers to apportion processing costs to individual crops. For the present study, in order to be able to estimate processing value added on a per crop basis, processing returns net of processing
operating costs (excluding labour, land rent and property taxes) were allocated to the various crops on the basis of the proportion of total acreage accounted for by the various crops. For example, if 60 percent of a producer’s total acreage was in pedigreed CWRS wheat, then 60 percent of the processing net returns were allocated to wheat, regardless of how much of the processing returns actually came from processing wheat. The rationale for assigning processing net returns after operating to acreage in this manner, rather than assigning them to the specific crop processed, is that the processing component of the individual farm operation is assumed to be in existence due to the seed production component. The operation custom processes seed for other operations because it has the processing facilities first for their own operation. Therefore, the net returns from processing should be allocated on the basis of the acreage of the crops grown. Also, because value added is examined here on a per acre basis for crops produced, allocating net returns by crops grown solves the problem of how to allocate processing returns for crops processed but not grown by the operation. With this information, value added and value added per acre was calculated for each producer that responded to the survey.

If on the other hand, the respondent’s operation was mainly for seed processing either purchased seed or other producer’s seed, with only a few acres devoted to seed production, then apportioning the value added from processing to these acres may give a disproportionately high value added per acre. However, of the respondents with processing facilities, 74 percent were from the large producer group, indicating these producers had a number of acres in seed production.
4.3 Econometric Analysis

4.3.1 Value Added Per Acre

Table 4.1 gives the number of producers responding for each of the small and large groups, and the numbers in each of these groups growing each crop type. As the goal is to examine value added on a per crop basis, from Table 4.1 it was determined that the crops for which there were enough respondents for analysis were CWRS wheat, barley, flax and forages. The econometric analysis will first consider the value added per acre for each of these crops separately, and then on a whole pedigreed operation basis.

Table 4.1: Number of Producers in Large and Small Groups and Numbers Growing Each Crop Type in 1997

<table>
<thead>
<tr>
<th>Producer Group</th>
<th>Large</th>
<th>Small</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of producers</td>
<td>57</td>
<td>33</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number Growing</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CWRS Wheat</td>
<td>34</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other Wheat</td>
<td>18</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>Any Wheat</td>
<td>40</td>
<td>18</td>
<td>58</td>
</tr>
<tr>
<td>Barley</td>
<td>18</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Oats/Specials</td>
<td>11</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Flax</td>
<td>25</td>
<td>13</td>
<td>38</td>
</tr>
<tr>
<td>Canola</td>
<td>10</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Pulses</td>
<td>14</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Forages</td>
<td>20</td>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>
A 2SLS regression was run using the structural equation 3.10, with the exogenous variables used as the instruments. An OLS regression was also run using the same variables as in equation 3.10 to compare to the 2SLS results. If the 2SLS and OLS results are very similar, either result could be used. However, where there are large differences, it is preferable to use the 2SLS results. The 2SLS regression results are generally less precise than OLS, because 2SLS coefficient standard errors will be larger, but they are consistent.

The reduced form equations were also estimated for each of the endogenous variables, including the endogenous dependent variable, value added, to determine how well the exogenous variables explained the endogenous variables. These series of regressions were done for each of CWRS wheat, barley and flax.

For forages, because of the variability between types of forages and therefore variability in terms of yields, prices, and operating costs, no price, yield or costs variable was included. Also, all forage seed is sold as seed (i.e. there is no commercial crop for forage seed) and thus no percent sold as pedigreed variable. Therefore, all variables are exogenous and OLS was used for the forage regression analysis.

4.3.2 Description of Equation Variables and Expected Coefficient Signs

The source and treatment for each of the equation variables are described below for CWRS wheat. It is indicated wherever the variables differ for either of barley, flax, or forages. The expected signs of the estimated coefficients are hypothesized.

Endogenous Variables

Value added per acre was calculated for each crop as described in section 4.2.
Yields were calculated as a weighted average of the yields for each variety grown for each crop and the acres of each variety; the coefficient is expected to be positive.

The operating costs per acre are taken directly from the survey results. Producers were asked to provide per acre operating costs for each crop type. Costs per acre are common for a crop type (i.e. costs would not differ for different varieties of CWRS wheat). Labour costs, as well as land rent and indirect taxes are excluded from costs per acre. As explained earlier, these are included as value added, because value added is the returns to factors of production. The coefficient is hypothesized to be negative; value added should increase as producers are able to decrease their operating costs per acre.

As noted previously, not all seed grown on land intended for pedigreed seed is able to be sold as pedigreed seed. A number of factors may affect the resulting quality of the seed to the point that would prohibit its use and approval as a pedigreed seed. Such factors might include weather, or insect or weed infestations, with the latter two may or may not being a result of inadequate management by the operator. In addition, the producer may have pedigreed quality seed, but may not be able to find a buyer for the seed. In such cases, the producer will have to sell the seed as a commercial crop, at a price lower than the certified seed price, or hold onto the seed as inventory for the following year. It is expected that value added per acre will increase as the percent of the crop that the producer is able to sell as pedigreed seed increases. Percent sold as pedigreed seed is calculated as below, with all values in quantity.

\[
\text{% Sold Pedigreed} = \frac{(seed \ sales + seed \ kept \ for \ own \ use + ending \ inventory)}{(Beginning \ inventory + seed \ purchases + seed \ harvested)}
\]
In the *MSGA Study*, ending inventory net of beginning inventory was treated as though it was sold as pedigreed seed. It was assumed that ending inventory was kept as a seed inventory, with the intention to sell the stock as pedigreed seed. Therefore, this same assumption is applied here.

**Exogenous Variables**

The price index was constructed in order to use one value for price, even though one producer may grow up to six varieties of the same crop. For example, producer i may have grown 5 varieties of CWRS wheat in 1997, each with its own price. One alternative would have been to use a weighted price for each observation, using the number of acres of variety j divided by the total acres of all varieties as a weight. However, by using this method the weighted price coefficient then would not give a measure of the price effect alone, but a composite of the price and acre effect together. By constructing a price index, using a common base for all producers, the coefficient then should give a measure of just the price effect.

The price index for each producer was calculated by constructing a price weight for each possible variety grown and using this common price weight for variety j for all producers. The price index for producer i was then found by multiplying the price producer i received for variety j by the appropriate price weight and then summing these up to give one price index. The price weight for variety j was calculated by finding the average amount of variety j sold by all producers (including those producers that did not sell variety j) divided by the sum of the averages for all varieties.

Another problem with price, however, is that in addition to growing different varieties of the same crop, there are also different classes of pedigreed seed, and a grower may be growing a certain class of a certain variety of CWRS wheat. Therefore, the price index does not indicate
the price effect for a common commodity, but rather a combination of the price the producer was able to obtain for that crop as well as the variety and class effect together. It is expected that the price index will have a positive effect on value added.

The acres variables are included to indicate a returns to scale for the producer’s total crop production operation. It is hypothesized that the coefficient for acres is not a constant, but will depend on the acres variable (A), and that VA/acre will increase with increasing acres but at a decreasing rate. Therefore, the acres squared term (A²) is introduced, and the coefficient is hypothesized to be negative. As the size of the crop production operation increases, the size and types of equipment and machinery available to the larger operation may result in increased efficiencies to the larger operation. Also, larger operations purchasing inputs in larger quantities may be able to purchase inputs at lower rates, or have marketing advantages. Signs of the acres coefficient (A) are expected to be positive for the value added, yield, and percent sold as seed equations, and negative for the cost equation.

Specialization into seed production, with the degree pedigreed variable, DP, representing the proportion of respondent’s crop producing acres used for pedigreed seed production, may provide the producer with advantages through the ability to focus their attention on seed production and processing, if applicable. While it is hypothesized that the coefficient for this parameter will be positive for value added, yield, and percent sold as seed, there is also the possibility that the extra costs incurred with seed production may discount any such benefits, particularly if a large proportion of the crop is not sold as pedigreed seed.

Experience and skill is expected to be an important consideration in growing and marketing pedigreed seed crops successfully. While there was no measure available for skills,
the number of years the respondents have been growing pedigreed crops was used as a measure of experience. The coefficient for experience is expected to be positive for value added, yield and percent sold as seed, and negative for costs. A squared term was also provided for this term, as it is expected that growth in VA/acre with experience will reach a maximum.

The two most popular CWRS wheat varieties for commercial crop producers in 1998 were AC Barrie and AC Domain. The variables, B_i and D_i, represent the proportion of the respondent's seed CWRS wheat acres were planted to each of these variables, respectively. The signs of the coefficients for these variables is not hypothesized. For barley the two most popular varieties were Excel (E) and Robust (R). There were three flax varieties that comprised the largest percentage of commercial crop acreage, these being Norlin, Flanders and AC Emerson, and the percent planted to these three varieties are combined into one variable termed Variety (V).

The value added per acre used here is a measure of the value added attained by both the production and processing side of the farm operation. It is of interest to find out if involvement in seed processing increases the value added per acre of the operation; 23 of the 89 respondents used for the analyses had a processing facility. The processing assets variable is a dummy variable which will take the value of one for those producers with processing facilities and the value of 0 for those producers that do not have a processing facility. This will change the intercept if the coefficient for PCA is significant. For example, the intercept coefficient for the reduced form equation 3.12 is

\[ \delta_0 + \delta_9 \]

if the producer does not have processing facilities \((PCA_i=0)\)

\[ \delta_0 \]

if the producer has processing facilities \((PCA_i=1)\)
It is hypothesized the coefficient for this variable will be positive.

The variable for size group ($G$) was set up as a dummy variable where $G = 1$ if the respondent is from the large producer group and $G = 0$ if the respondent is from the small producer group. As was noted previously, producer’s were placed in the large or small group based on any one of their seed crops falling within the large producer group for that crop. Therefore, in the case of CWRS wheat, a producer may not necessarily fall within the criteria for large producers for CWRS wheat, but was designated a large producer because another of their seed crops, for example, canola, fell into the large group criteria. It is expected that producers in the large producer group would be able to attain greater value added per acre. This variable, too will affect the intercept, where the intercept is

$$\delta_0$$ - if respondent is from the small producer group

$$\delta_0 + \delta_{10}$$ - if respondent is from the large producer group

Agricultural productivity varies across the province due to soil and climate characteristics, and which would be expected to have an impact on value added attained by the seed producers. Plus, certain areas of the province may have experienced out of the ordinary or extreme weather conditions in 1997. These and other unidentified location factors may account for productivity variability between various areas of the province and which may affect value added per acre for the seed growers. To account for location the province was divided into five areas based on the five crop regions used by Manitoba Agriculture, these being the Southwest, Northwest, Central, Interlake and Eastern regions. Dummy variables were introduced for the intercept where, using CWRS wheat as an example,

$$L_1 = 1$$ if producer is from the Northwest crop region, otherwise equals 0
$L_2 = 1$ if producer is from the Central crop region, otherwise equals 0

$L_3 = 1$ if producer is from the Interlake or Eastern region, otherwise equals 0.

The Interlake and Eastern regions were combined for CWRS wheat because of the few respondents from these regions. Introduction of these dummy variables then introduces a varying intercept depending on crop region, where the intercept is

$\delta_o$ - if respondent is from the Southwest crop region

$\delta_o + \delta_{11}$ - if respondent is from the Northwest crop region

$\delta_o + \delta_{12}$ - if respondent is from the Central crop region

$\delta_o + \delta_{13}$ - if respondent is from the Interlake or Eastern crop region.

These coefficients are not hypothesized to have any particular sign. Also, the location variables differ somewhat between CWRS wheat, barley, flax, and forages due to differences in the number of respondents from each region for each crop. These differences are explained in the corresponding results section.

The variable for whether or not the respondent grew seed under contract in 1997 is also a dummy variable, with $CT=1$ if the respondent does grow under contract. The survey asked this as a general question relating to the respondent’s seed operation, and therefore, if the respondent indicated they did produce under contract, this doesn’t necessarily mean the respondent produced the seed crop under consideration, e.g. CWRS wheat, under contract. The sign for this variable is not hypothesized.

4.3.3 Whole Pedigreed Operation

It was also of interest to look at the value added per acre attained by the whole pedigreed operation. Value added per acre was estimated for the whole pedigreed operation (i.e. includes
all pedigreed crops). The model for the whole pedigreed operation uses the exogenous variables of the structural equations, excluding the price index variable and the variables for varieties. The equation for the whole pedigreed operation is:

\[ VA = \beta_0 + \beta_1 A_i + \beta_2 D_{Pi} + \beta_3 X_i + \beta_4 P_{CA_i} + \beta_5 L_{1i} + \beta_6 L_{2i} + \beta_7 L_{3i} + \beta_8 L_{4i} + \beta_9 G_i + \beta_{10} C_{Ti} + \epsilon_i \]

There are four location dummy variables now, where \( L_1 \) is for respondents from the Northwest region, \( L_2 \) for respondents from the Central region, \( L_3 \) for respondents from the Southwest region and \( L_4 \) is for respondents from the Interlake, with no dummy for respondents from the Eastern region to avoid the dummy variable trap\(^3\).

A separate analyses was done to determine if there were any differences for those producers that have processing operations. In this case a dummy variable was introduced for each variable in the model and which would take the value of one for producers with a processing facility, and the value of zero otherwise.

4.4 Assumptions of Linear Regression

Making use of linear regression for econometric analysis is based on a number of standard assumptions. Some of these assumptions and their treatment in the analysis are briefly discussed below.

One of the assumptions, exogenous explanatory variables, has been discussed. Another assumption is that explanatory variables are linearly independent. Often the case is that there is not an exact linear relation, but there will be high correlations between explanatory variables, or

---

\(^3\)An assumption of least squares analysis is that no exact linear relation exists between explanatory variables. If a dummy variable was added for each region, the sum of all dummy variables would equal 1, and therefore would equal the constant for the intercept coefficient, which equals one.
what is known as multicollinearity. Auxiliary $R^2$s were done for each of the reduced form equations by regressing each of the independent variables on the other independent variables to give an indication of collinearity between the variables. When there is multicollinearity between the regressors, the OLS estimators are still unbiased, but the variances of the estimated coefficients are large. Ordinary least squares uses only the variation that is unique to a regressor to estimate the effect of the regressor on the independent variable, and, therefore, variation that is shared between collinear regressors is not used (Kennedy 1996). This decrease in useable variation, in effect, increases the variation in the OLS estimates (i.e. less information goes into the OLS estimates and therefore their efficiency decreases).

The impact of high collinearity on the variance of the OLS estimators can be seen by the equation below, whereby (from Griffith et al. 1993) the variance of the $k$th coefficient estimate is equal to

$$\text{var}(b_k) = \sigma^2 / \sum \hat{\epsilon}_i^2$$

4.4)

When each independent variable is regressed against the other variables there is a residual, $\epsilon$, that makes up the difference between the independent variable and the estimated equation. When there is a highly linear relation between the independent variables, these differences will be small, the denominator of the above equation will be small, and the variance of the estimate will be large.

Another assumption of classical linear regression is constant variance between observations, or homoskedasticity, and when this assumption is violated, heteroskedasticity exists. Heteroskedasticity tests were done on the reduced form equations to check if the variance is constant between observations. The Breusch-Pagan (BP) statistic is computed as
4.5) \[ BP = \frac{SSR}{2(\Sigma \hat{e}^2 / T)^2} \]

where

SSR - regression sum of squared errors from regressing the least squares residuals on the independent variables

\( \hat{e} \) - least squares residuals

\( T \) - sample size

and the BP statistic has a Chi-squared distribution. When variances are not homoskedastic the estimated coefficients can still be shown to be unbiased, however, hypothesis testing breaks down because the variances for the estimated coefficients are no longer minimum variance.

One way to deal with the heteroskedasticity problem would be to use Generalized Least Squares (GLS); to transform the data such that the transformed data has constant variance. If it is known which variables are producing the heteroskedasticity and if the relation between these variables and the variance is also known, this relation could be used to weight the data. What this weighting does is to reduce the size of the observations with large variation (reduce their weight) and increase the size of the observations with small variation (increase their weight), reducing the variation in the variances (i.e. reducing heteroskedasticity; Kennedy 1996).

Another assumption is that there is no covariance in the error term between observations. When such a covariance exists, there is said to be autocorrelation. Autocorrelation is a problem that is likely to occur with time series data. Since the present study is dealing only with cross-sectional data, autocorrelation is not expected to be a problem. However, the Durbin-Watson statistics, which gives a measure of autocorrelation is checked for each reduced form equation.
5 Analysis Results

5.1 Regression Assumptions

Auxiliary R²'s for variables in reduced form equations were found to be high only for those variables with squared terms, as well as for the squared terms, indicating multicollinearity. When correlations were checked between the variables, it was found that the high correlations existed only between variables and their squares (i.e. for the acres and experience variables and their squared variables). Some explanatory variables had auxiliary R²'s in the 0.5 to 0.7 range, indicating some collinearity for these variables as well. Since none of these variables showed high correlations with any one other variable, the correlation was likely with a combination of variables. For CWRS wheat, the explanatory variable indicating the proportion of pedigreed acres planted to the variety AC Domain showed a positive correlation with acres planted to AC Barrie of 0.70.

Heteroskedasticity tests on each of the reduced form equations using the BP statistic as given in previous chapter indicated homoskedasticity, except for the costs equations for CWRS wheat and flax, and the yield equation for barley.

The Durbin-Watson statistics for all equations tested for each of CWRS wheat, barley, flax and forages indicated no autocorrelation.
5.2 CWRS Wheat

5.2.1 Value Added for CWRS Wheat

Table 5.1 gives the results for the 2SLS regression of the structural equation for CWRS, as well as OLS results for the same equation (from equation 3.10). The $R^2$'s, estimated coefficients, standard errors, t-ratios and elasticities at the means are reported in Table 5.1.

The $R^2$ statistic, or the coefficient of determination, gives the percent of the total squared variation in the dependent variable that is provided by the squared variation of the estimated value. This indicates how well the independent variables explain the dependent variable. The $R^2$ for CWRS wheat was 0.56 for the OLS regression and 0.53 for the 2SLS regression. $R^2$'s are generally expected to be lower in cross-sectional data as opposed to time series data. Time series data are normally aggregated data, where variation has been averaged out leading to higher $R^2$ values (Johnson et al. 1987).

Table 5.1: 2SLS and OLS Regression Results for Structural Equation for CWRS Wheat

<table>
<thead>
<tr>
<th># producers</th>
<th>2SLS Regression</th>
<th>OLS Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.53</td>
<td>0.56</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_i$</td>
<td>40.276</td>
<td>13.24</td>
<td>3.04*</td>
<td>2.84</td>
<td>38.99</td>
<td>12.52</td>
<td>3.11*</td>
<td>2.75</td>
</tr>
<tr>
<td>$c_i$</td>
<td>-0.84</td>
<td>0.42</td>
<td>-2.02*</td>
<td>-1.13</td>
<td>-0.82</td>
<td>0.24</td>
<td>-3.40*</td>
<td>-1.11</td>
</tr>
<tr>
<td>$y_i$</td>
<td>3.90</td>
<td>1.09</td>
<td>3.57*</td>
<td>1.66</td>
<td>4.52</td>
<td>0.68</td>
<td>6.64*</td>
<td>1.92</td>
</tr>
<tr>
<td>$PSP_i$</td>
<td>0.94</td>
<td>0.31</td>
<td>3.02*</td>
<td>0.56</td>
<td>0.74</td>
<td>0.21</td>
<td>3.49*</td>
<td>0.44</td>
</tr>
<tr>
<td>Constant</td>
<td>-251.90</td>
<td>106.0</td>
<td>-2.38*</td>
<td>-2.93</td>
<td>-258.01</td>
<td>85.90</td>
<td>-3.00*</td>
<td>-3.00</td>
</tr>
</tbody>
</table>

*Indicates significant at 0.05 level of significance
The estimated coefficients, standard errors, t-ratios and elasticities are similar between the OLS regression and the 2SLS regression, indicating that, for CWRS wheat, either could be used to explain value added per acre without a loss in precision or consistency. All coefficients are significant, as was expected, since this equation comes very close to an identity equation, and all signs are as expected.

The price index, costs, and yield variables all have elasticities at the means greater than one (in terms of absolute value) indicating an elastic effect (i.e. a one percent increase in any of these variables will create a greater than one percent change in value added), while the percent pedigreed variable is inelastic, with an elasticity less than one (i.e. a one percent increase in this variable will bring about less than a one percent increase in value added). From the elasticities, a percentage change in the price index would have the greatest impact on value added, followed by yields, then costs and then percent sold as seed. The negative elasticity for costs indicates a one percent increase in costs would create a greater than one percent decrease in value added per acre.

The reduced form equations were estimated for each of the endogenous variables including the dependent value added variable. The results for each of value added, yield, percent sold pedigreed, and costs are given in Table 5.2. Of particular interest is how well the exogenous variables explain value added, and the coefficients of significance, and also how well the exogenous variables explain percent sold as seed, and the coefficients of significance.

The value added equation has an $R^2$ of 0.41, which is reasonable for cross-sectional data. The price index variable is similar to that for the 2SLS regression, although the standard error has increased. The estimated coefficient is still significant, as are the acres and acres
## Table 5.2: Regression Results for Reduced Form Equations for CWRS Wheat (49 Producers)

<table>
<thead>
<tr>
<th></th>
<th>Value Added</th>
<th>Percent Sold Pedigreed</th>
<th>Yield</th>
<th>Costs per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>36.65</td>
<td>18.15</td>
<td>2.02*</td>
<td>-1.50</td>
</tr>
<tr>
<td>PCA</td>
<td>4.94</td>
<td>19.54</td>
<td>0.25</td>
<td>16.24</td>
</tr>
<tr>
<td>G</td>
<td>-37.76</td>
<td>20.31</td>
<td>-1.86</td>
<td>-1.64</td>
</tr>
<tr>
<td>A</td>
<td>0.08</td>
<td>0.02</td>
<td>3.68*</td>
<td>0.02</td>
</tr>
<tr>
<td>A²</td>
<td>-0.9x10⁻⁵</td>
<td>0.3x10⁻⁵</td>
<td>-3.32*</td>
<td>-0.2x10⁻⁵</td>
</tr>
<tr>
<td>DP</td>
<td>1.04</td>
<td>0.40</td>
<td>2.62*</td>
<td>0.05</td>
</tr>
<tr>
<td>X</td>
<td>3.95</td>
<td>2.50</td>
<td>1.58</td>
<td>-0.47</td>
</tr>
<tr>
<td>X²</td>
<td>-0.10</td>
<td>0.05</td>
<td>-2.03*</td>
<td>0.002</td>
</tr>
<tr>
<td>L₁ (NW)</td>
<td>32.24</td>
<td>26.38</td>
<td>1.22</td>
<td>23.55</td>
</tr>
<tr>
<td>L₂ (C)</td>
<td>27.34</td>
<td>21.98</td>
<td>1.24</td>
<td>2.99</td>
</tr>
<tr>
<td>L₃ (I/E)</td>
<td>30.41</td>
<td>34.58</td>
<td>0.88</td>
<td>-8.40</td>
</tr>
<tr>
<td>B</td>
<td>0.13</td>
<td>0.33</td>
<td>0.39</td>
<td>0.10</td>
</tr>
<tr>
<td>D</td>
<td>-0.13</td>
<td>0.32</td>
<td>-0.40</td>
<td>-0.37</td>
</tr>
<tr>
<td>CT</td>
<td>-15.17</td>
<td>18.69</td>
<td>-0.81</td>
<td>0.22</td>
</tr>
<tr>
<td>Constant</td>
<td>-302.76</td>
<td>124.6</td>
<td>-2.43*</td>
<td>39.25</td>
</tr>
</tbody>
</table>

*Estimated coefficient tested significant at 0.05 level of significance
squared variables, the degree pedigreed variable, and the squared term of the experience variable. The F-tests for joint significance testing indicate the acres and acres squared term are jointly significant, and the experience term and its square are jointly insignificant. The location variables were jointly insignificant as were the proportion of acreage planted to AC Barrie and AC Domain. Most signs of the coefficients are as expected, except the dummy variable for size group is negative, indicating that the producers in large producer group have a lower intercept than those in the small producer. The t-ratio of -1.86 with a probability value of 0.07 is close to the critical value of -2.03 at 5% significance level.

From the elasticities at the means (not shown but given in Appendix C, Table C2), a one percent change in the price index again has the greatest impact on value added, followed by the total acres in production, with both being elastic (elasticities of 2.59 and 1.4, respectively), and then the proportion of the producer’s total acres in seed production, with an inelastic effect (elasticity of 0.59).

When the variables with very low t-ratios were dropped from the equation after testing as jointly insignificant (PCA, L1, L2, L3, B, D, CT), the standard errors decreased for the remaining variables. The estimated coefficients for the remaining variables decreased by only a small amount, except the size group (G) and experience (X) variables increased by a small amount. The experience variable now tested significant, and the experience variable and its square were jointly significant.

5.2.2 Percent of CWRS Wheat Seed Sold as Seed

The result of the regressions on the reduced form equation for percent sold pedigreed is also given in Table 5.2. The R² for this regression is 0.48. The only variable that tested
significant at the 0.05 level was the variable for the proportion of seed acreage planted to AC Domain. This had an estimated coefficient of -0.37, indicating that increasing the proportion of acreage planted to AC Domain had a negative impact on percent sold as seed. The dummy variable for the Northwest region of the province had a t-ratio that was close to the critical t-value of 2.03. The positive value of this coefficient indicates that respondents in the Northwest region of the province had a higher intercept than those from other areas of the province. For all values of the explanatory variables, the percent sold as seed was higher for respondents in the Northwest region of the province, although not significantly. No other location variables were significant.

The variables for acres in production and the dummy variable for processing were not significant at the 0.05 level of significance, but had probability values of 0.095 and 0.08, respectively. When the variables with very low t-ratios were dropped from the equation after testing as jointly insignificant (P, G, DP, X, X^2, L_2, L_3, CT), the standard errors decreased for the remaining variables. The dummy variable for proportion of acres in AC Barrie was not dropped because of its high correlation and joint significance with AC Domain. The estimated coefficients decreased by only a small amount, except the coefficient for the L_1 dummy variable increased a small amount, and the estimated coefficient for AC Barrie (B) decreased to 0.056 from 0.097. The acres variable (A) now tested significant, but the acres variable and its square still tested jointly insignificant.

5.2.3 Yield and Costs per Acre for CWRS Wheat Seed

The R^2 for the yield equation was 0.36. The coefficient for the processing dummy variable was negative, indicating a lower intercept for respondents with a processing facility, but
tested insignificant. The coefficients for the acres variable and its squared term were both significant, as well as jointly significant. The intercept for respondents in the Interlake and Eastern regions was increased by 12.12, with a probability value of 0.06.

The results of the equation for costs are also given in Table 5.2. The $R^2$ was 0.32, which is the lowest of the reduced form equations for CWRS wheat. Only the dummy variable for the Northwest region, variable $L_1$, tested significant, with an estimated value of 30.17. This indicates that for all values of the other variables, costs for respondents in the Northwest region were higher than for respondents in the other locations.

Dropping variables with low t-ratio values had little effect on the yield and costs equations in terms of significance of estimated coefficients.

5.3 Barley

5.3.1 Value Added for Barley

The barley equation is as for CWRS wheat with a few exceptions. Only two dummy variables were used for location. Because there were only four respondents from the southwest region, it was combined with the northwest region, and there is no dummy variable for these regions. Also, the varieties used for barley are Excel (E) and Robust (R). Results for barley for the 2SLS regression of the structural equation and of the OLS regression for the same equation are given in Table 5.3. The $R^2$ for the OLS regression was 0.59 and for the 2SLS regression was 0.56. As with wheat, the coefficient values and elasticities at the means were fairly similar between the two regressions. Standard errors were higher for the 2SLS regression.
Table 5.3: 2SLS and OLS Regression Results for Structural Equation for Barley

<table>
<thead>
<tr>
<th></th>
<th>2SLS Regression</th>
<th>OLS Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td># producers</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>R²</td>
<td>0.56</td>
<td>0.59</td>
</tr>
<tr>
<td>P_i</td>
<td>148.53</td>
<td>71.72</td>
</tr>
<tr>
<td>C_i</td>
<td>-1.49</td>
<td>0.71</td>
</tr>
<tr>
<td>Y_i</td>
<td>2.84</td>
<td>0.69</td>
</tr>
<tr>
<td>PSP_i</td>
<td>0.91</td>
<td>0.47</td>
</tr>
<tr>
<td>Constant</td>
<td>-530.24</td>
<td>319.8</td>
</tr>
</tbody>
</table>

*Indicates significant at 0.05 level of significance

The signs of the coefficients were as expected. All were significant for the 2SLS regression, at a 0.05 level of significance except for the PSP coefficient, but the probability value was 0.07. As with wheat, price index, cost, and yield were elastic while the percent sold as pedigreed was inelastic; also greatest elasticity was for price, then yield, then costs.

The results of the regressions for the reduced form equations are given in Table 5.4. The value added reduced form equation had an $R^2$ of 0.83, which is high, particularly for cross-sectional data. For the value added equation, all signs of the coefficients are as expected, except the price index coefficient and the coefficient for the large size group dummy variable are both negative, but are both insignificant. The estimated DP coefficient indicates that value added per acre for barley increases as the proportion of the respondent’s total acreage used for seed production increases, i.e. as the producer specializes into seed production. The significance of both experience variables shows that experience has a positive effect on value added for barley.
<table>
<thead>
<tr>
<th>Coeff.</th>
<th>Value Added</th>
<th>Percent Sold Pedigreed</th>
<th>Yield</th>
<th>Costs per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>0.83</td>
<td>0.45</td>
<td>0.74</td>
</tr>
<tr>
<td>P</td>
<td>-28.14</td>
<td>78.69</td>
<td>-0.36</td>
<td>44.13</td>
</tr>
<tr>
<td>PCA</td>
<td>48.48</td>
<td>20.26</td>
<td>2.39*</td>
<td>2.94</td>
</tr>
<tr>
<td>G</td>
<td>-1.77</td>
<td>28.00</td>
<td>-0.06</td>
<td>38.33</td>
</tr>
<tr>
<td>A</td>
<td>0.02</td>
<td>0.02</td>
<td>1.07</td>
<td>-0.01</td>
</tr>
<tr>
<td>A²</td>
<td>-0.3x10⁻⁵</td>
<td>0.3x10⁻⁵</td>
<td>-1.16</td>
<td>-0.1x10⁻⁵</td>
</tr>
<tr>
<td>DP</td>
<td>1.49</td>
<td>0.56</td>
<td>2.65*</td>
<td>-0.02</td>
</tr>
<tr>
<td>X</td>
<td>12.57</td>
<td>3.46</td>
<td>3.63*</td>
<td>0.06</td>
</tr>
<tr>
<td>X²</td>
<td>-0.28</td>
<td>0.08</td>
<td>-3.38*</td>
<td>-0.006</td>
</tr>
<tr>
<td>L₁ (C)</td>
<td>36.15</td>
<td>21.25</td>
<td>1.70</td>
<td>14.68</td>
</tr>
<tr>
<td>L₂ (E/I)</td>
<td>107.72</td>
<td>25.37</td>
<td>4.24*</td>
<td>2.94</td>
</tr>
<tr>
<td>E</td>
<td>0.51</td>
<td>0.27</td>
<td>1.88</td>
<td>-0.30</td>
</tr>
<tr>
<td>R</td>
<td>0.15</td>
<td>0.26</td>
<td>0.55</td>
<td>0.28</td>
</tr>
<tr>
<td>CT</td>
<td>50.60</td>
<td>18.56</td>
<td>2.73*</td>
<td>21.40</td>
</tr>
<tr>
<td>Constant</td>
<td>-120.06</td>
<td>286.1</td>
<td>-0.42</td>
<td>-152.99</td>
</tr>
</tbody>
</table>

*Estimated coefficient tested significant at 0.05 level of significance
The change in value added with a change in experience is

5.1) \[ \frac{\partial VA}{\partial X} = 12.57 - 0.28X \]

indicating that the estimated parameter for the experience effect is not constant, but rather depends on the value of experience. As experience increases, so too will value added for barley but at a decreasing rate. Respondents with a processing facility, as well as respondents in the Eastern/Interlake region had an intercept significantly higher than respondents from the other regions. Also, respondents that grow seed under contract have a significantly higher intercept than those that do not.

Of the variables that showed significance, the experience variable shows elasticity, with the elasticity at the means of 1.4. The other significant variables were inelastic.

When variables with low t-ratio values (P, G, A, A^2, R) were dropped from the equation after testing as jointly insignificant, the estimated values of the remaining coefficients remained similar as in Table 5.4; the coefficient for Excel (E) now tested as significant.

5.3.2 Percent of Barley Sold as Seed

The R^2 for the reduced form equation for percent sold as pedigreed was 0.45. The signs of the coefficients are not as expected for the acres and degree pedigreed variables, but all estimated coefficients are insignificant at the 0.05 level of significance. The size group variable, while insignificant at the 0.05 level of significance has a probability value of 0.107. It is possible that there is too much interaction between variables. There was correlation between the variables for degree pedigree, the acres variables, the processing dummy variable and the size group variable in the 0.6 to 0.67 range. All of these except for the size group variable were tested for joint insignificance and dropped from the equation. The coefficients and the R^2 remained
similar, but the size group dummy variable now tested significant at the 0.05 percent level. Also, the auxilliary $R^2$'s dropped for all the remaining variables.

5.3.3 Yields and Costs per Acre for Barley Seed

From the results of the OLS regression on yield, producers were able to increase their yields with experience, as was the case with value added. Producers in the Eastern/Interlake region, had greater yields, as was the case with value added. Also, the proportion of the respondent’s acreage planted with the variety Excel had a positive impact on yields.

For the regression analysis on costs per acre for barley, the acres variable and its square had a significant effect, indicating that costs per acre decrease as acres increase, but the marginal impact of a change in acres is not constant and depends on the acres. The degree pedigreed variable, while not significant at the 0.05 level, had a probability value of 0.103.

Dropping variables with low t-ratio values (after testing for joint insignificance) for the reduced form equations for percent sold as seed, yield, and costs had little effect on the remaining coefficients in terms of significance testing, for each of the equations.

5.4 Flax

5.4.1 Value Added for Flax

The location dummy variables for flax were the same as for wheat. According to Manitoba Crop Insurance Corporation records, there were three flax varieties comprising the majority of commercial flax acres in 1998, these being Norlin, Flanders and AC Emerson. Rather than a separate variable for each of these, one variable was used called Variety, and representing the proportion of the respondents’s flax acres planted to any of these three varieties.
Table 5.5: 2SLS and OLS Regression Results for Structural Equation for Flax

<table>
<thead>
<tr>
<th></th>
<th>2SLS Regression</th>
<th></th>
<th>OLS Regression</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># producers</td>
<td>38</td>
<td></td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>R²</td>
<td>0.58</td>
<td></td>
<td>0.68</td>
</tr>
<tr>
<td>P_i</td>
<td>62.65</td>
<td>28.22</td>
<td>2.22*</td>
<td>5.67</td>
</tr>
<tr>
<td>C_i</td>
<td>-0.26</td>
<td>0.40</td>
<td>-0.64</td>
<td>-0.23</td>
</tr>
<tr>
<td>Y_i</td>
<td>12.59</td>
<td>3.12</td>
<td>4.04*</td>
<td>2.00</td>
</tr>
<tr>
<td>PSP_i</td>
<td>-0.01</td>
<td>0.43</td>
<td>-0.32</td>
<td>-0.007</td>
</tr>
<tr>
<td>Constant</td>
<td>-872.89</td>
<td>382.1</td>
<td>-2.27*</td>
<td>-6.44</td>
</tr>
</tbody>
</table>

*Indicates significant at 0.05 level of significance

The results of the 2SLS regression of the structural equation for flax and the OLS regression for the same equation are given in Table 5.5. The greatest difference between these two equations is with the variable for percent sold pedigreed. The estimated coefficient is negative for the 2SLS regression, the standard error is high and the coefficient tests as insignificant at the 0.05 level of significance, as does the coefficient for costs. The elasticity value is also considerably lower than for the OLS regression. Price and yield had the expected significant positive impact on value added.

For the reduced form OLS regression for value added (Table 5.6), several of the signs of the coefficients are not as expected and none of the variables are significant at the 0.05 level of significance.
Table 5.6: Regression Results for Reduced Form Equations for Flax (38 Producers)

<table>
<thead>
<tr>
<th></th>
<th>Value Added</th>
<th>Percent Sold Pedigreed</th>
<th>Yield</th>
<th>Costs per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.32</td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Coeff.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>-11.98</td>
<td>40.39</td>
<td>-0.30</td>
<td>11.76</td>
</tr>
<tr>
<td>PCA</td>
<td>15.70</td>
<td>27.71</td>
<td>0.57</td>
<td>-8.36</td>
</tr>
<tr>
<td>G</td>
<td>23.34</td>
<td>35.53</td>
<td>0.66</td>
<td>14.24</td>
</tr>
<tr>
<td>A</td>
<td>-0.02</td>
<td>0.04</td>
<td>-0.35</td>
<td>-0.03</td>
</tr>
<tr>
<td>A²</td>
<td>0.4x10⁻⁵</td>
<td>0.9x10⁻³</td>
<td>0.40</td>
<td>-0.2x10⁻³</td>
</tr>
<tr>
<td>DP</td>
<td>0.49</td>
<td>0.55</td>
<td>0.88</td>
<td>0.13</td>
</tr>
<tr>
<td>X</td>
<td>-2.75</td>
<td>3.46</td>
<td>-0.80</td>
<td>0.60</td>
</tr>
<tr>
<td>X²</td>
<td>0.32</td>
<td>0.07</td>
<td>0.46</td>
<td>-0.02</td>
</tr>
<tr>
<td>L₁ (NW)</td>
<td>-24.08</td>
<td>33.44</td>
<td>-0.72</td>
<td>2.36</td>
</tr>
<tr>
<td>L₂ (C)</td>
<td>-13.19</td>
<td>29.09</td>
<td>-0.45</td>
<td>12.98</td>
</tr>
<tr>
<td>L₃ (I/E)</td>
<td>60.99</td>
<td>43.16</td>
<td>1.41</td>
<td>-4.42</td>
</tr>
<tr>
<td>V</td>
<td>-0.29</td>
<td>0.29</td>
<td>-0.99</td>
<td>0.22</td>
</tr>
<tr>
<td>CT</td>
<td>-30.82</td>
<td>32.00</td>
<td>-0.96</td>
<td>-5.77</td>
</tr>
<tr>
<td>Constant</td>
<td>327.86</td>
<td>502.8</td>
<td>0.65</td>
<td>-94.38</td>
</tr>
</tbody>
</table>

*Estimated coefficient tested significant at 0.05 level of significance
5.4.2 Percent Sold as Seed, Yields and Costs per Acre for Flax

The only variable that showed significance for percent sold as pedigreed was the variable for the proportion of the respondent's seed acreage that consisted of the top three commercial varieties for 1998, and which had a positive impact on percent sold as pedigreed seed. The signs of the coefficients were not as expected for the processing and contract growing dummy variables, or for the acres variables, although none were significant.

None of the estimated coefficients for the explanatory variables showed significance for either the yield equation or the costs equation, although the dummy variable for the Northwest region had a probability value of 0.07 in the costs equation. Also, the $R^2$ of 0.25 for the yield equation was the lowest of any of the equations. The coefficient signs in the yield equation were not as expected for the acres, degree pedigree, or experience variables.

Given the insignificance of the estimated coefficients, the reduced form equations do not have very good explanatory power for flax, and which could explain the unexpected results for the 2SLS equation. It appears that either the data or the specification of the equation does not provide a satisfactory explanations of value added for flax. Because of the low t-ratio values for most of the coefficients for all of the reduced form equations for flax, dropping jointly insignificant variables had little effect on the significance of the remaining variables.

5.5 Elasticities

Elasticities at the means for the value added 2SLS regression for each of CWRS wheat, barley and flax are taken from Table 5.1 and summarized in Table 5.7 for each of the coefficients found to be significant.
Table 5.7: Elasticities for 2SLS Value Added Regression for Explanatory Variables with Significant Estimated Coefficients for CWRS Wheat, Barley and Flax

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elasticities at Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CWRS Wheat</td>
</tr>
<tr>
<td>$P_i$</td>
<td>2.84</td>
</tr>
<tr>
<td>$C_i$</td>
<td>-1.13</td>
</tr>
<tr>
<td>$Y_i$</td>
<td>1.66</td>
</tr>
<tr>
<td>$PSP_i$</td>
<td>0.56</td>
</tr>
</tbody>
</table>

n.s. - estimated coefficient tested not significant
*Significant at 0.10 level of significance not at 0.05 level

Elasticities are useful for indicating the expected percentage change in the dependent variable with a 1% change in the explanatory variable of interest, and it is of interest to compare elasticities between the crops examined.

Price, yield and costs were elastic in each case given. A one percent increase in the price index had the greatest impact on value added per acre for barley and flax. This would be a factor of yield and prices. Barley has lower average prices but considerably higher average yields and therefore a small increase in price will have a greater impact on value added. Flax, on the other hand had considerable lower average yield, then both barley and CWRS wheat, but because of the higher average price index, a small change in relative price has a greater impact on value added. The percent sold pedigreed was inelastic for both CWRS wheat and barley.

Elasticities at the means for significant variables of the reduced form equations are given in Appendix C.
5.6 Comparisons Between Crops

A number of statistics are summarized in Table 5.8 for the variables of the structural equation, for each of CWRS wheat, barley, and flax. Included are the means, standard deviations, and minimum and maximum values, for each of value added, the price index, yield, cost per acre, and percent sold as pedigreed seed. Also included for each is the coefficient of variation, CV, which is a sample’s standard deviation as a percentage of the mean. Dividing the standard deviation by the mean removes the effects of magnitudes of values and measurement.

Table 5.8: Statistics for Structural Equation Variables for CWRS Wheat, Barley and Flax

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Coeff. of Variation</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>85.91</td>
<td>55.40</td>
<td>64.5%</td>
<td>-21.28</td>
<td>276.51</td>
</tr>
<tr>
<td>Barley</td>
<td>99.88</td>
<td>75.92</td>
<td>76.0%</td>
<td>-41.00</td>
<td>319.58</td>
</tr>
<tr>
<td>Flax</td>
<td>135.65</td>
<td>64.38</td>
<td>47.5%</td>
<td>-0.74</td>
<td>320.58</td>
</tr>
<tr>
<td>Price Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>6.06</td>
<td>0.45</td>
<td>7.4%</td>
<td>4.96</td>
<td>7.24</td>
</tr>
<tr>
<td>Barley</td>
<td>3.88</td>
<td>0.15</td>
<td>3.9%</td>
<td>3.28</td>
<td>4.16</td>
</tr>
<tr>
<td>Flax</td>
<td>12.27</td>
<td>0.30</td>
<td>2.4%</td>
<td>11.69</td>
<td>13.16</td>
</tr>
<tr>
<td>Costs/Acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>115.55</td>
<td>26.46</td>
<td>22.9%</td>
<td>51.22</td>
<td>199.8</td>
</tr>
<tr>
<td>Barley</td>
<td>114.68</td>
<td>20.55</td>
<td>17.9%</td>
<td>64.59</td>
<td>167.11</td>
</tr>
<tr>
<td>Flax</td>
<td>119.92</td>
<td>32.45</td>
<td>27.1%</td>
<td>60.9</td>
<td>196.12</td>
</tr>
<tr>
<td>Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>36.52</td>
<td>9.46</td>
<td>25.9%</td>
<td>9.95</td>
<td>51.79</td>
</tr>
<tr>
<td>Barley</td>
<td>62.14</td>
<td>18.26</td>
<td>29.4%</td>
<td>19.03</td>
<td>99.97</td>
</tr>
<tr>
<td>Flax</td>
<td>21.55</td>
<td>5.47</td>
<td>25.4%</td>
<td>8.50</td>
<td>35.30</td>
</tr>
<tr>
<td>%Sold as Seed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWRS Wheat</td>
<td>51.3</td>
<td>27.3</td>
<td>53.2%</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Barley</td>
<td>52.4</td>
<td>33.9</td>
<td>64.7%</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Flax</td>
<td>64.4</td>
<td>24.7</td>
<td>38.4%</td>
<td>0</td>
<td>93.8</td>
</tr>
</tbody>
</table>
units, and provides a measure of the relative variation, for which to compare variables (Griffiths et al. 1993). Similar statistics are summarized in Appendix C for all variables of the structural and reduced form equations for each of CWRS wheat, barley, flax, forages, and the whole seed operation.

From Table 5.8 flax had the highest mean value added per acre of the three crops examined. Barley had the highest standard deviation for value added as well as the highest coefficient of variation, meaning barley showed the greatest relative variation. This is evident from examining the minimum and maximum values for barley. The range between the minimum and maximum values were high for all three crops, although even more so for barley, which had a range in values from -$41 to $321 per acre.

Costs per acre were similar between the three crops, as were the standard deviations and the coefficients of variation, although flax’s CV of 27.1% was the highest of the three. Barley had the highest standard deviation for the yield variable, but again, the CV’s were similar between the three.

The mean for the percent sold pedigreed variable, PSP, ranged from 51.3% in CWRS wheat to 64.4% in flax. Flax had the highest mean but lowest standard deviation, and thus, also the lowest CV value. Barley had the greatest relative variability for the percent of the crop that was actually sold as seed. The percent of their seed crop actually sold as pedigreed seed varied for respondents from none to all or almost all for all three crops, meaning that some producers sold none of their seed crop as seed (all sold as commercial crop instead) and some producers were able to sell all of the crop as seed.

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Overall, flax showed the least relative variability for value added, the price index, yield and percent sold as seed, while barley showed the greatest variability for value added, yield and percent sold as seed, although, again, relative variability for yield was similar for all three crops. From the coefficients of variation, and the minimum and maximum values, the variation for value added per acre and the percent sold as seed was high for all three crops.

5.7 Forages and the Whole Pedigreed Operation

Results for the forage analysis showed unexpected coefficient signs for some variables, and no significance for any of the estimated coefficients. Because of the variability between the different types of forages grown by seed producers, in terms of prices and yields, no price index or yield variables were used for the forage analysis. Also, as there is no commercial crop for forage seed, there is no percent sold as seed variable. Misspecification, missing variables, or too much variation between forage types may prevent identification of any relation between the independent variables and value added per acre. Results for the forage analysis are given in Appendix D.

Similarly, the only variables testing significant for the whole pedigreed operation analysis were the acres variable and its square. The $R^2$ of 0.17 for the whole operation analysis was the lowest of any of the regressions. When dummy variable were introduced for each of the explanatory variables to test for structural differences between operations with and without processing facilities, again the $R^2$ was low (0.18), all coefficients were insignificant, plus the dummy variable coefficients tested as jointly insignificant. The results for the whole pedigreed operation are also given in Appendix D.
6 Findings and Conclusions

The 2SLS regressions demonstrated the expected outcome that price, yields and input costs are important components to determining value added per acre. The results of the 2SLS regressions also demonstrated the importance of maximizing the proportion of the crop sold as seed rather than as commercial crop. The elasticities illustrated that respondent’s attainable value added per acre were most sensitive to changes in seed price. Since prices are assumed to be taken by the respondents, and the price index here is a function of not just price but the variety and class of seed grown, the producer’s choice of variety and/or class of seed will affect price and thus value added. If such was the case, then an incorrect assumption may have been made that the price index is an exogenous variable.

The acres of the respondent’s total crop production operation (including seed and commercial crop acreage) was shown to be a positive contributing factor to value added for CWRS wheat only. Yields for seed CWRS wheat were also shown to increase with the size of the total crop production operation, which would, in turn, contribute to the acres effect for value added.

For both CWRS wheat and barley, specialization in seed production had a positive effect on value added per acre. For both CWRS wheat and barley, however, specialization did not appear to significantly increase the percent sold as seed or yield, or decrease costs per acre. The impact of specialization may have been felt through some other efficiencies in operation or marketing. It is also possible that as specialization and/or the size of the total crop production
increases so too do per acre labour requirements, which are a component of value added and thus would increase the per acre value added.

As respondents increased the proportion of their acreage of CWRS wheat planted to AC Domain, they experienced decreased success at selling their seed crop as seed. Figure 6.1 shows the percent of growers' 1997 seed acreage planted to the top three 1998 commercial varieties, as well as Manitoba Crop Insurance Corporation (MCIC) figures for the percent of commercial acreage planted with the same varieties in 1997 and 1998. Although AC Domain was the most popular commercial CWRS wheat variety in 1997, it dropped to second place in 1998. AC Barrie was the third most popular in 1997, but rose to first place in 1998. This and the negative coefficient for AC Domain on percent sold as seed shows the importance of seed producers' ability to anticipate the demand for specific varieties. AC Barrie is a new variety which became the most widely grown CWRS wheat variety across the prairies by 1998, only two years after its commercial release (Meristem 1999).

Similar results were found for flax, where percent sold as seed increased with the proportion of the producers' seed flax acres planted to one of the top three commercial varieties for 1998. Norlin was the most popular 1998 variety to commercial producers, and Emerson and Flanders were about equally popular. It may have been preferable to have Norlin as one variable by itself and Emerson and Flanders together, to determine if there were any differences. It would be of interest to examine how seed growers determine which varieties to grow and how they anticipate the demand for varieties.
While it was hypothesized that producers with seed processing facilities would experience greater value added per acre, this effect was shown to be significant only for barley. Also, contract growing had a significant positive effect on value added only for barley. Since the variable for contract growing only indicates whether or not the respondent does contract growing and not whether the crop in question was grown under contract, it may be necessary to have more specific information to fully determine the impact of contract growing.

Although it was attempted to add a location factor to account for differences in soil and weather characteristics, few differences were detected for location. The variables used may not have provided a distinct enough measure of productivity differences in the province in 1997. The results did indicate that the Eastern/Interlake region of the province had greater barley yields in
1997. According to Manitoba Agriculture data, the Interlake region had the highest average 1997 barley yields (61.5 bushels per acre) of the five crop regions (Manitoba Agriculture 1997).

The experience variable, as represented here, showed significance only for value added and yield for barley. It would be expected that skill at growing pedigreed seed would increase with experience. While the results for flax were insignificant in general, it would have been expected to see significance for CWRS wheat and the whole pedigreed operation, for which there were the greatest number of observations. It is possible that the number of years growing pedigreed seed, which was used to indicate experience, is not a sufficient measure of skill, and that some other variable or variables should be used. However, it was the best measure that could be derived from the survey data. Also, examining the data indicated that the average number of years growing seed for the CWRS wheat producers was 20 years and the average for the whole pedigreed operation was 18 years. It could be there was not enough variation from the responses to provide a good measure of the effect of experience. However, the standard deviation was 11.0 and the CV was 61.1%, indicating a good deal of variation in the experience term.

The insignificance of the coefficients from the forage and the whole pedigreed operation analysis suggests several possibilities. One possibility is that there is too much variability between VA/acre and the various independent variables to identify a distinct relation between VA/acre for forages or the whole pedigreed operation and the variables identified as important in determining value added. This may indicate that a better approach is to examine the individual crops separately, as was done for CWRS wheat, barley and flax. For forages, this would mean obtaining more information on the specific forage crops to enable analysis of these crops. Also,
the low $R^2$'s indicates there is a good deal of variation not explained by the independent variables. This suggests there could be important variables, such as the price, cost, and yield variables, which have not been included in the analysis, and which, therefore, are showing up in the error term.

6.1 Data Problems and Limitations

The value added per acre calculations and the independent variables are all based on survey data. The surveys were sent to participants in December, 1998, and January, 1999, requesting information on cropping procedures and details for 1997. As with any survey that relies on the respondent's ability to recall and accurately report past events, this produces possibilities for data errors. Many producers, however, keep detailed records of their previous crop years, which should decrease these type of measurement errors. Also, with mail out type surveys there is always the potential for self-selection responses, where a certain segment of the target population has certain traits that make them more motivated to respond.

A limitation to the data is that it is cross-sectional based on only one year of data. Variations between producers that may be a factor of some time specific variation are not captured here. For example, bad weather in certain parts of the province may have reduced yields and thus value added for these producers. Also, with cross section data it is not possible to determine if differences in value added are due to, for example, weather anomalies or to differences in individual producers technical or marketing efficiencies. It was not feasible to request more than one year of data from the respondents. The surveys were already lengthy, if any additional information was requested the response rate would have decreased. Also, as
mentioned above, we were already requesting participants to remember events from over a year ago. Requesting years from further back would increase the possibilities for response errors.

This study made use of linear regression to analyse data collected from the survey process. As with any econometric analysis, there is always the possibility of wrong functional form, errors in variables, or misspecification.

6.2 Suggestions for Further Study

The fact that so much of the respondent's seed crop is sold as commercial crop rather than as seed needs further investigation. It was assumed here that it was because the producer could not find a market for the seed, and thus there was an excess supply. Seed producers must compete with common seed which is available to commercial producers at a lower price. It would be of interest to find out if 1997 was a representative year for the amount of seed sold as commercial grain, and whether this proportion follows a cyclical pattern similar to that of commodity prices. Alberta and Saskatchewan seed growers have expressed an interest in a study of their seed industry similar to what was done for Manitoba. If such studies go forward, it is recommended that questions be incorporated into the survey to determine how much of the producer's seed they sell, on average, as seed, versus, as commercial crop, and what factors they feel determine the amount of their seed that sells as seed. It would be interesting to compare these factors between producers that sell the majority as seed versus those that sell more as a commercial crop.

Of the 10 crop types used in the MSGA Study, there were enough observations to analyse three of these crops for the present study, with an analysis also attempted for forages. Next to CWRS wheat, forages contributed the highest amount in farm gate sales in 1997 ($20.7 million
in farm gate sales for pedigreed and common forage seed combined; see Figure A1, Appendix A). Canola was third in farm gate sales, and first for seed company sales. Also, canola had the highest value added per acre of the 10 crops types ($244 per acre). Given the importance of forages and canola, efforts should be made for further study of both. It is recommended that if the above studies in Alberta and Saskatchewan go forward, efforts be made to increase the numbers of responses for both of these crops. Furthermore, each of these two crops could form the basis of their own individual study, and would be worthwhile projects for graduate level students. In particular, given the rapid adoption of GM canola varieties, an indepth analysis of the acceptance and diffusion of GM varieties may prove useful for what to expected with GM varieties of other crops. GM wheat is expected to be available in the next few years, and given the importance of wheat to both commercial and seed growers, this could have a very big effect on the seed industry. The impact of GM crops on seed producers is important in terms of not only value added, but also such factors as accessibility of varieties, the need to enter into contract growing arrangements with seed companies, and how much the seed growers would benefit from any increased usage of certified seed, or if most of the benefit would go to the seed companies.

Given the sensitivity of value added to changes in the price index, it may be useful to look at how seed price changes with variety. Although the survey collected information on varieties grown, a closer inspection of the survey data would be required to determine if the necessary information could be obtained in terms of both variety and class. Also, considering the sensitivity of value added to seed prices and the importance of producer's ability to anticipate demand for specific varieties, it would be of use to initiate some studies on price analysis of seed
varieties and how producers might make use of such information for forecasting demand for specific varieties.

The significance of the acres variables for CWRS wheat and the specialization variable for both wheat and barley brings to question which components of value added are most responsive to an increase in size or in specialization. Increases in value added that are mainly the result of an increase in hired labour requirements would not benefit the producer. Modelling value added into its various components and performing the similar analyses as was done here for the aggregate value added might provide some insight into this question.

A great deal of useful and interesting information was collected through the survey process. The present study makes use of econometrics to provide an initial look into what is important in determining value added in pedigreed seed production in Manitoba, and provides some direction for further and more detailed analyses.

6.3 Summary

Several statements may be made regarding the results of the analyses performed here:

- Elasticities at the means indicate that seed grower’s value added per acre is most sensitive to changes in the price of seed, and flax and barley are more sensitive than CWRS wheat. This is important considering producers make choices of not only the types of seed crops to grow, but also the varieties and classes of seed to grow in a given year, for selling in the following commercial crop year. Even small changes in price between years will have significant impact on value added, holding all other variables constant.

- Value added increases with acres in total crop production, significantly so for wheat. Also, CWRS wheat and barley producers are able to increase their value added per acre
for these crops as they specialize in seed production. Further study is required to
determine if the increase in value added is the result of increased benefits to the producer,
or due to increased payments to labour.

- The percent of the producer's seed crop that is sold as pedigreed seed is a significant
determinant of value added per acre. The amount of the producer's seed that is actually
sold as seed is highly variable, as illustrated by the high standard deviations and
coefficients of variation. Further study should be made on sales and marketing
arrangements of seed growers, including growers that grow and sell various seed types
and varieties under various scenarios (such as, for example, small and large growers,
grower/processors, and growers that grow under contract to seed companies or other
growers).

- The ability of producers to anticipate the demand for a specific variety by commercial
producers also was shown to be important in terms of the percent of the seed that is then
sold as seed, rather than as commercial grain, and which will then affect the producer's
value added and income. Seed producers need full information on not only the crops that
will be in demand, but also the variety. Considering the sensitivity of value added to seed
prices and the importance of producer's ability to anticipate demand for specific varieties,
it would be of use to initiate some studies on price analysis of seed varieties and how
producers might make use of such information for forecasting demand for specific
varieties.

- With only 13 of the respondents growing canola seed, there were not enough observations
to perform an analysis for canola. Although 30 of the respondents grew forage, an
analysis for forages was also difficult, given the variability of types of forages grown and the few observations for each type of forage. Given the importance of both canola and forages to the seed industry, efforts need to be made for further study of both. In particular, studies on the diffusion of GM canola and its impact on the seed industry could shed light into what to expect when GM wheat is available.

If the potential studies of the seed industry in Alberta and Saskatchewan go forward, the recommendations for this current study can be used to improve the estimation of the seed growers contributions to value added in Alberta and Saskatchewan.
7 References


Canadian Seed Growers Association, Annual Reports, Various Years.


Canadian Seed Growers Association, *Regulations and Procedures for Pedigreed Seed Crop Production*, Circular 6-94.


Appendix A: The MSGA Study Results

A study was completed in July, 2000 for the Manitoba Seed Growers Association (MSGA), assessing the value added economic impact of the pedigreed seed industry on Manitoba’s economy. The study, entitled Manitoba Seed Industry: Value Added Economic Impacts, (The MSGA Study), was based on surveys of the province’s seed growers and seed related companies, and provided aggregate measures of the economic impact of the various seed crops. The grower and industry survey responses were used to estimate farm gate and company sales, and estimates were then made of direct and indirect value added contributions by the seed industry to Manitoba’s economy.

A1. Survey Highlights

Highlights of the survey results indicated that in 1997:

- Farm gate sales for growers (includes sales from seed acreage and from processing activities) was an estimated $92.4 million, and company sales net of seed costs were an estimated $89.3 million, to give total sales of $182.23 million (Figure A1).

- The $92.4 million of farm gate sales consisted of $77.15 million from crops produced on pedigreed seed acreage, $6.5 million from producer owned processing facilities and $8.71 million from sales of common forage seed.

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4Sales from pedigreed seed acreage included all crop sales from land intended to produce pedigreed seed. This included sales from seed that had to be sold as commercial crop because it either did not pass inspection for pedigreed seed, or because a seed market could not be found, as well as screenings sales.

5Common forage seed production was not estimated through the survey results, but due to the importance of common forage seed to the forage seed industry, estimates were made with information from the Manitoba Forage Seed Association and included in the survey results.
Wheat and forage seed accounted for the largest proportion of farm gate sales, whereas canola accounted for the majority of seed company sales (see Figure A1).

Dispersal of farm gate sales from pedigreed acreage was 69.5% as seed sales, 17.6% as commercial crop sales, 8% as screenings sales, and 4.9% as change in inventory.

Certified forages and canola had the largest percent of farm gate sales as seed, while the wheats and dry peas had the lowest (Figure A2).
Figure A2: Dispersal of $77.15 Million of Farm Gate Sales from Manitoba Seed Acreage, 1997, by Crop

(Source: Figure 1.5, The MSGA Study)

A2. Economic Impacts

Economic impacts were estimated as direct and indirect value added impacts. Direct value added impact is the value of commodities produced by an industry minus the value of inputs for production of those commodities. Indirect value added is contributed through input
purchases from supplier companies, which in turn produces value added from these companies. Indirect value added was calculated by applying a multiplier to the value of inputs.\(^6\)

Total economic impacts are given in Table A1 and are summarized below:

- The total direct and indirect value added impact from the seed industry in 1997 was $110.37 million, including $54.33 million from pedigreed seed growers, $4.92 million from common forage growers and $51.12 million from seed companies.
- Total direct value added was estimated at $67.73 million, including $36.91 million from pedigreed seed growers and growers/processors, $2.67 million from common forage growers, and $28.15 million from seed companies.
- Total indirect value added was estimated at $42.64 million, including $17.42 million from pedigreed seed growers, $2.25 million from common forage growers and $22.97 million from seed companies.
- Wages and salaries for direct employment was $16.68 million, with 406 full-time paid employees (251 employed by seed growers and 155 by seed companies) and 899 part-time and seasonal employees (employed by the pedigreed seed growers). No wage or salary information was available for common forage seed growers.
- Unpaid full-time equivalents for the pedigreed seed growers was 1,026 in 1997.\(^7\)
- Research expenditures were calculated as $19.37 million, plus another $3.53 million from pedigreed producers for royalty and levy payments (total of $22.9 million).

\(^6\)See The MSGA Study for details on estimation of direct and indirect value added.

\(^7\)Of the 861 seed growers producing seed in 1997, some are accounted for as full time paid employees and the remainder as unpaid full-time equivalent.
### Table A1: Seed Industry Total Impacts on Manitoba Economy, 1997

<table>
<thead>
<tr>
<th></th>
<th>Certified Seed Growers</th>
<th>Common Forage Growers</th>
<th>Seed Companies</th>
<th>Total Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value Added Impacts ($ million)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Value Added (GDP)</td>
<td>$36.91</td>
<td>$2.67</td>
<td>$28.15</td>
<td>$67.73</td>
</tr>
<tr>
<td>Indirect Value Added</td>
<td>$17.42</td>
<td>$2.25</td>
<td>$22.97</td>
<td>$42.64</td>
</tr>
<tr>
<td>Total Value Added Impact</td>
<td>$54.33</td>
<td>$4.92</td>
<td>$51.12</td>
<td>$110.37</td>
</tr>
<tr>
<td><strong>Direct Employment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages &amp; Salaries ($million)</td>
<td>$9.41</td>
<td>n/a</td>
<td>$7.27</td>
<td>$16.68</td>
</tr>
<tr>
<td>Full-time Paid Employees</td>
<td>251</td>
<td>n/a</td>
<td>155</td>
<td>406</td>
</tr>
<tr>
<td>Part-time and Seasonal Employees</td>
<td>899</td>
<td>n/a</td>
<td>n/a</td>
<td>899</td>
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<tr>
<td>Unpaid FTE</td>
<td>1026</td>
<td>n/a</td>
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</tr>
<tr>
<td><strong>Direct Investment ($million)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Investment</td>
<td>$337.65</td>
<td>n/a</td>
<td>n/a</td>
<td>$337.65</td>
</tr>
<tr>
<td>Planned Investment (1998 - 2002)</td>
<td>$69.68</td>
<td>n/a</td>
<td>n/a</td>
<td>$69.68</td>
</tr>
<tr>
<td><strong>Research ($million)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public and Private Research</td>
<td></td>
<td></td>
<td></td>
<td>$19.37</td>
</tr>
<tr>
<td>Royalties/Levies</td>
<td></td>
<td></td>
<td></td>
<td>$3.53</td>
</tr>
</tbody>
</table>

Source: Table 1.1, *The MSGA Study*. Numbers may not all add due to rounding. n/a - not available

### A3. Strategic Analysis of Manitoba’s Seed Industry

A strategic analysis of the seed industry in Manitoba was performed to assist the MSGA and its members in defining strategies to promote and further develop the seed industry. The strategic analysis examined the industry’s strengths, weaknesses, opportunities and threats (SWOTS). A number of strengths and opportunities were identified and discussed in the areas of
quality assurance and regulatory arrangements, biotechnology and seed research, and use of branding and identity preserved products (Figure A3). The SWOTS analysis is given in detail and summarized in the *MSGA Study*; several of the points from the summary are given below:

- As indicated earlier, Canada’s quality assurance program has two essential control points, variety registration and seed certification, which maintain the high quality standards for crops.

- Research strengths come in the form of the high level of expertise found in Western Canada’s public research institutions (both government and Universities), which have traditionally made the greatest contributions to seed and variety development innovations in Canada.

- These same strengths in the public institutions are attracting private expenditures from multinational corporations for joint research arrangements.

- The CSGA pedigreed seed system, which is in itself an identity preserved (IP) system, is well positioned to take advantage of the growing trend for identity preserved products, in particular if an IP system is based on starting with certified seed to ensure the product is sown with seed of documented origin.

- Other opportunities for increased use of certified seed include, the trend towards use of branded products, development of the nutraceutical and functional foods areas, contracting between food processors and growers, and increased pressure by consumers for food labeling regarding GMO products.

- The majority of the wheat crop in Western Canada is planted with common seed, which represents lost market for certified seed producers. GMO wheat is expected to become
available in the next five years, and if it becomes as popular to commercial producers as GMO canola, there is great opportunity for seed growers to increase the proportion of the wheat crop grown with certified seed rather than common seed.

- The major weaknesses and threats include the high proportion of the commercial crop planted with common seed, and the lack of information on the extent of common seed versus certified seed usage, the lack of information on interprovincial, and to some extent international, trade of seed, capital constraints for the development of market opportunities, and banning of GMO products by international markets.
**MSGA Strategies and Action Plans**
- Organization
- Communication
- Production
- Marketing

**Strengths:**
- Quality Assurance/Regulations (variety registration and seed certification)
- Identity preserved markets
- Research and expansion of research facilities in Manitoba

**Weaknesses:**
- Problems associated with increasing IP marketing
- Distribution of new variety information could improve
- Usage of common versus certified seed
- Capital constraints for market development

**Opportunities:**
- Variety branding and seed certification
- GMO cereal varieties
- Develop IP markets with certified seed
- Biosafety Protocol

**Threats:**
- Development of IP markets without seed certification requirement
- Removal of variety registration
- Regulatory bottlenecks
- Spread of restricted access of GMO canola to other countries
- Biosafety Protocol

Figure A3: Manitoba Seed Industry - Strengths, Weaknesses, Opportunities and Threats
(Source: Figure 1.9, The MSGA Study)
Appendix B: Treatment of Missing Data

With survey data there is always the problem of what to do with missing data. The extent to which the respondents filled in all the questions was high, partially because there were call backs to respondents to confirm and request any missing information. There were a few observations, however, that did not provide some of the required information. It is desirable to find some value to substitute into the missing data, in order to keep the observations in the data set. Greene (1997) discusses a zero order regression, in which missing observations of the regressors are replaced with their means, and thus this will not affect estimated equations when missing observations are not used. This creates problems, however, if the observations that are missing are representative of one segment of the target population, and thus the computed mean is not accurate.

For the present study, missing costs of production are replaced with weighted averages of those producers that reported costs for that crop, using as the weights acres of crop $i$ by producer $j$ divided by the sum of acres of crop $i$ grown by all producers that provided costs of production. The rationale for using this calculation was that a straight average would place too much weight on those producers that grow only a few acres of CWRS wheat. However, the weighted average used here does not account for any changes in cost of production with scale of operation for those producers with missing data. The same weighted average cost per acre is used for any missing observation, regardless of the number of acres of that crop grown by that producer.
There were also a few observations that did not give the price received for their pedigreed seed crop. In such cases a representative industry price for that variety was used.
Appendix C: Statistical Summaries for Equation Variables

Table C1: Statistics for Equation Variables for CWRS Wheat, Barley, Flax, Forages and the Whole Operation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Coeff. of Variation</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CWRS Wheat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value Added (VA)</td>
<td>85.9</td>
<td>55.4</td>
<td>64.5%</td>
<td>-21.3</td>
<td>276.5</td>
</tr>
<tr>
<td>Price Index (P)</td>
<td>6.1</td>
<td>0.5</td>
<td>7.4%</td>
<td>5.0</td>
<td>7.2</td>
</tr>
<tr>
<td>Costs (C)</td>
<td>115.6</td>
<td>26.5</td>
<td>22.9%</td>
<td>51.2</td>
<td>199.8</td>
</tr>
<tr>
<td>Yield (Y)</td>
<td>36.5</td>
<td>9.5</td>
<td>25.9%</td>
<td>10.0</td>
<td>51.8</td>
</tr>
<tr>
<td>% Sold as Seed (PSP)</td>
<td>51.3</td>
<td>27.3</td>
<td>53.2%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total Crop Acres (A)</td>
<td>2062.7</td>
<td>1391.8</td>
<td>67.5%</td>
<td>400.0</td>
<td>7838.0</td>
</tr>
<tr>
<td>% of Ac. in Seed (DP)</td>
<td>48.8</td>
<td>28.7</td>
<td>58.7%</td>
<td>6.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Experience (X)</td>
<td>20.6</td>
<td>11.3</td>
<td>55.0%</td>
<td>3.0</td>
<td>50.0</td>
</tr>
<tr>
<td>% AC Barrie (B)</td>
<td>50.1</td>
<td>35.4</td>
<td>70.8%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>% AC Domain (D)</td>
<td>30.1</td>
<td>35.1</td>
<td>116.5%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Barley</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value Added (VA)</td>
<td>99.9</td>
<td>75.9</td>
<td>76.0%</td>
<td>-41.0</td>
<td>319.6</td>
</tr>
<tr>
<td>Price Index (P)</td>
<td>3.9</td>
<td>0.2</td>
<td>3.9%</td>
<td>3.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Costs (C)</td>
<td>114.7</td>
<td>20.6</td>
<td>17.9%</td>
<td>64.6</td>
<td>167.1</td>
</tr>
<tr>
<td>Yield (Y)</td>
<td>62.1</td>
<td>18.3</td>
<td>29.4%</td>
<td>19.0</td>
<td>100.0</td>
</tr>
<tr>
<td>% Sold as Seed (PSP)</td>
<td>52.4</td>
<td>33.9</td>
<td>64.7%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total Crop Acres (A)</td>
<td>2000.2</td>
<td>1518.6</td>
<td>75.9%</td>
<td>73.0</td>
<td>7838.0</td>
</tr>
<tr>
<td>% of Ac. in Seed (DP)</td>
<td>54.1</td>
<td>28.1</td>
<td>52.0%</td>
<td>6.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Experience (X)</td>
<td>21.1</td>
<td>10.2</td>
<td>48.5%</td>
<td>1.0</td>
<td>37.0</td>
</tr>
<tr>
<td>% Excel (E)</td>
<td>13.7</td>
<td>31.6</td>
<td>230.2%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>% Robust (R)</td>
<td>27.9</td>
<td>42.5</td>
<td>152.1%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Flax</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value Added (VA)</td>
<td>135.7</td>
<td>64.4</td>
<td>47.5%</td>
<td>-0.7</td>
<td>320.6</td>
</tr>
<tr>
<td>Price Index (P)</td>
<td>12.3</td>
<td>0.3</td>
<td>2.4%</td>
<td>11.7</td>
<td>13.2</td>
</tr>
<tr>
<td>Costs (C)</td>
<td>119.9</td>
<td>32.5</td>
<td>27.1%</td>
<td>60.9</td>
<td>196.1</td>
</tr>
<tr>
<td>Yield (Y)</td>
<td>21.6</td>
<td>5.5</td>
<td>25.4%</td>
<td>8.5</td>
<td>35.3</td>
</tr>
<tr>
<td>% Sold as Seed (PSP)</td>
<td>64.4</td>
<td>24.7</td>
<td>38.4%</td>
<td>0.0</td>
<td>93.8</td>
</tr>
<tr>
<td>Total Crop Acres (A)</td>
<td>1710.9</td>
<td>1032.8</td>
<td>60.4%</td>
<td>250.0</td>
<td>4550.0</td>
</tr>
<tr>
<td>% of Ac. in Seed (DP)</td>
<td>54.8</td>
<td>29.2</td>
<td>53.2%</td>
<td>82.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Experience (X)</td>
<td>21.0</td>
<td>12.3</td>
<td>58.5%</td>
<td>3.0</td>
<td>50.0</td>
</tr>
<tr>
<td>% Top 3 Varieties (V)</td>
<td>54.6</td>
<td>45.7</td>
<td>83.8%</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table C1, Continued:

<table>
<thead>
<tr>
<th>Variable Description:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VA = value added per acre for seed crop i</td>
<td></td>
</tr>
<tr>
<td>P = price received for the seed crop</td>
<td></td>
</tr>
<tr>
<td>C = production costs for the pedigreed crop (excluding labour, rent and property taxes)</td>
<td></td>
</tr>
<tr>
<td>Y = yield for the pedigreed crop</td>
<td></td>
</tr>
<tr>
<td>PSP = percent of quantity of seed crop sold as pedigreed seed</td>
<td></td>
</tr>
<tr>
<td>A = total acres the producer has in crop production (seed production and commercial</td>
<td></td>
</tr>
<tr>
<td>crop production combined)</td>
<td></td>
</tr>
<tr>
<td>DP = the extent to which the producer has specialized into seed production</td>
<td></td>
</tr>
<tr>
<td>X = experience of the producer in growing pedigreed seed</td>
<td></td>
</tr>
</tbody>
</table>
\[B = \text{percent of respondent's CWRS wheat crop planted with AC Barrie}\]

\[D = \text{percent of respondent's CWRS wheat crop planted with AC Domain}\]

\[E = \text{percent of respondent's barley crop planted with Excel}\]

\[R = \text{percent of respondent's barley crop planted with Robust}\]

\[V = \text{percent of respondent's flax crop planted with Norlin, Flanders, or AC Emerson}\]

\[T = \text{percent of respondent's forage crop planted that was timothy}\]

\[A = \text{percent of respondent's forage crop planted that was alfalfa}\]
Table C2: Elasticities at the Means for Reduced Form Equations for CWRS Wheat, Barley, and Flax for Significant Coefficients

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>CWRS Wheat Equations</th>
<th>Barley Equations</th>
<th>Flax Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value Added</td>
<td>% Sold as Seed</td>
<td>Yield</td>
</tr>
<tr>
<td>P</td>
<td>2.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1.39</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>DP</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D*</td>
<td></td>
<td>-0.22</td>
<td></td>
</tr>
<tr>
<td>E*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Elasticities are given only for coefficients that tested significant at 0.05 level of significance. For flax, only the percent sold as seed equation had any significant coefficients; for CWRS wheat only a location dummy variable tested significant for Costs equation; for barley no coefficients tested significant for %Sold as Seed equation.

*Variable D (AC Domain) for CWRS wheat only; Variable E (Excel) for Barley only; Variable V (Variety) for Flax only.
Appendix D: Analysis for Forages and the Whole Pedigreed Operation

D1 Forages

There were 30 respondents for the forage analysis; 20 from the large producer group and 10 from the small producer group. The price index variable is not included in the forage equation. A number of types of forages were grown by respondents, including alfalfa, bentgrass, canary grass, fescues, orchard grass, ryegrass, trefoil and timothy, with alfalfa and timothy comprising the majority of acreage. Within each of these types of forages were a number of varieties, making construction of a price index difficult. Also, the meaningfulness of such an index would be questionable considering the number of types of forages involved, each with a wide range of prices. There is no variable for percent sold as seed, as all of the seed growers’ forage seed was sold as seed. No yield variable was used as well, due to the variability between forage types. Also, only two location dummy variables are included here with

$L_{1i} = 1$ if producer is from the Eastern crop region, otherwise equals 0

$L_{2i} = 1$ if producer is from the Interlake crop region, otherwise equals 0

There were only four respondents from the northwestern crop region growing forages and seven from the central crop region; the location effect for these producers are captured within the intercept (i.e. both $L_{1i}$ and $L_{2i}$ will equal 0). There were no forage respondents from the southwestern crop region.

Value added for forage was run as an OLS regression, with the results given in Table D1. From the low $R^2$ and insignificance of all coefficients it can be concluded that the defined
equation does not provide a satisfactory description for forages. Beyond the multicollinearity problems, there may be too much variation between forage types, preventing identification of any relation between the dependent variables and value added per acre. Breaking forages down into types is not an alternative as there is not enough data for analysis of any one type. Alfalfa and timothy were the forages most frequently grown by respondents, with 16 and 14 of the 30 forage respondents growing each, respectively.

Table D1: OLS Regression Results of Forage Data

<table>
<thead>
<tr>
<th># producers</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>Est. Value</th>
<th>Std. Error</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA</td>
<td>-36.72</td>
<td>115.3</td>
<td>-0.32</td>
</tr>
<tr>
<td>G</td>
<td>-4.01</td>
<td>95.98</td>
<td>-0.04</td>
</tr>
<tr>
<td>A</td>
<td>-0.01</td>
<td>0.16</td>
<td>-0.08</td>
</tr>
<tr>
<td>Aₕ²</td>
<td>0.1x10⁻⁴</td>
<td>0.4x10⁻⁴</td>
<td>0.31</td>
</tr>
<tr>
<td>DP</td>
<td>1.40</td>
<td>1.60</td>
<td>0.88</td>
</tr>
<tr>
<td>X</td>
<td>-10.35</td>
<td>14.29</td>
<td>-0.72</td>
</tr>
<tr>
<td>X²</td>
<td>0.21</td>
<td>0.37</td>
<td>0.58</td>
</tr>
<tr>
<td>L₄</td>
<td>-49.53</td>
<td>102.2</td>
<td>-0.48</td>
</tr>
<tr>
<td>L₂</td>
<td>5.30</td>
<td>83.89</td>
<td>0.06</td>
</tr>
<tr>
<td>T</td>
<td>105.22</td>
<td>103.0</td>
<td>1.02</td>
</tr>
<tr>
<td>AL</td>
<td>-140.09</td>
<td>85.92</td>
<td>-1.63</td>
</tr>
<tr>
<td>CT</td>
<td>-77.42</td>
<td>92.11</td>
<td>-0.84</td>
</tr>
<tr>
<td>Constant</td>
<td>140.67</td>
<td>167.2</td>
<td>0.84</td>
</tr>
</tbody>
</table>

*Indicates significant at 0.05 level of significance
D2. Value Added Analysis of the Whole Pedigreed Operation

A Generalized Least Squares (GLS) regression was used to analyse the whole pedigreed seed operation, as the BP-statistic of 46.9 indicated that heteroskedasticity was a problem when using OLS. The GLS regression results are given in Table D2.

Table D2: GLS Regression Results of the Whole Pedigreed Seed Operation

<table>
<thead>
<tr>
<th></th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td># producers</td>
<td>89</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.17</td>
</tr>
<tr>
<td>Coeff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Est.</td>
</tr>
<tr>
<td>A</td>
<td>0.05</td>
</tr>
<tr>
<td>$A_1^2$</td>
<td>-0.7x10^{-5}</td>
</tr>
<tr>
<td>DP</td>
<td>0.35</td>
</tr>
<tr>
<td>X</td>
<td>-0.97</td>
</tr>
<tr>
<td>$X^2$</td>
<td>-0.01</td>
</tr>
<tr>
<td>PCA</td>
<td>16.86</td>
</tr>
<tr>
<td>G</td>
<td>-12.16</td>
</tr>
<tr>
<td>$L_1$ (NW)</td>
<td>-46.054</td>
</tr>
<tr>
<td>$L_2$ (C)</td>
<td>-32.32</td>
</tr>
<tr>
<td>$L_3$ (SW)</td>
<td>-8.81</td>
</tr>
<tr>
<td>$L_4$ (I)</td>
<td>23.40</td>
</tr>
<tr>
<td>CT</td>
<td>-5.02</td>
</tr>
<tr>
<td>Constant</td>
<td>95.31</td>
</tr>
</tbody>
</table>

*Indicates significant at 0.05 level of significance

The $R^2$ was low for the whole pedigreed operation analysis. The sign of the coefficient is not as expected for both the experience variable and the size group variable, but the coefficients tested as insignificant. Coefficients tested significant only for the acres variable and its squared
term. From these estimated coefficients, as the size of the total crop production operation increases, value added for the whole pedigreed seed operation will increase, but not at a constant rate as given by

$$\frac{\partial VA}{\partial A} = 0.05 - 0.000007A$$

Another model that may be interesting to examine is one which incorporates a dummy variable for processing, and which can then be used to determine if there is a difference between those producers that own processing facilities and those that do not own such facilities. The model is estimated for the whole pedigreed operation (i.e. VA/acre for all pedigreed crops together). A dummy variable was introduced for each of the explanatory variables in Table D2, including the constant, where

$$d_i = 1 \text{ if the producer owns a processing facility}$$

$$d_i = 0 \text{ otherwise}$$

This will enable the model to capture any differences in the marginal effects of the variables between those producers that have processing facilities and those that do not. The analysis was done on the the whole pedigreed operation, and a GLS regression was again necessary due to heteroskedasticity. The $R^2$ for this regression was low, at 0.18, and no coefficients were significant, plus they were jointly insignificant.