RETURNS TO RESEARCH

WESTERN GRAINS RESEARCH FOUNDATION

WHEAT AND BARLEY CHECK-OFFS

Funded by

Western Grains Research Foundation

Prepared by:

Terry Scott, Consultant
TESCO Consulting Ltd.
Regina, Saskatchewan

Alper Guzel, Ph. D.,Visiting Professor
Department of Agricultural Economics
University of Saskatchewan

Hartley Furtan, Ph. D.
Department of Agricultural Economics
University of Saskatchewan

Richard Gray, Ph. D.
Department of Agricultural Economics
University of Saskatchewan

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Table of Contents

Appendices

List of Figures

List of Tables

Executive Summary

Introduction

A check-off has been collected by the Canadian Wheat Board on Western Canadian wheat and barley sales since the 1993-94 crop year. The check-off revenue is given to the Western Grains Research Foundation (WGRF) which in turn invests the funds in the development of genetics for the benefit of wheat and barley producers. With 10 years of experience in supporting wheat and barley genetics research and development, the WGRF decided to request an evaluation of the rate of return on the funds invested.

This report responds to the WGRF request for an evaluation. The report presents the results of a study conducted to estimate returns to producers' check-off investments, specifically to estimate the benefit/cost (B/C) ratio and internal rate of return (IRR) to growers on WGRF check-off investments in crop genetics R&D. The report addresses only the check-off investments made by the WGRF and not investments in R&D by the Endowment Fund administered by the WGRF.

Producer Check-off Investments

Between 1995 and 2004, the WGRF administered roughly $40 million of check-off revenue, $33 million from the wheat check-off and $7 million from the barley check-off. Funds have been invested in wheat and barley breeding or germplasm development at Agriculture and Agri-Food Canada research stations (Brandon, Winnipeg, Swift Current, Lethbridge), the University of Saskatchewan Crop Development Centre in Saskatoon, the University of Alberta in Edmonton, the University of Manitoba in Winnipeg, and Alberta Agriculture, Food and Rural Development in Lacombe. With the support of the WGRF administered check-off funds, numerous new varieties have been developed and released.

Benefit/Cost Analysis

Using benefit/cost analysis, the study compares the cost of the check-off paid by producers to the economic benefits generated by the check-off investments. The benefits arise from improvements associated with new crop varieties. The study compares a production and market scenario which includes the impacts of the WGRF check-off investment (i.e., a factual scenario or a scenario 'with WGRF check-off') to a constructed scenario which reflects the production and market situation as it would have existed in the absence of WGRF check-off investments (i.e., a counterfactual scenario or a scenario 'without WGRF check-off'). The difference in producer returns between the scenarios is the return to wheat and barley producer check-off investments in crop genetics R&D.

Benefits to producers are estimated as producer surplus, which is the return to fixed factors of production. The study begins by identifying those varieties developed with check-off assistance that represent significant breakthroughs in genetic technology. By identifying breakthrough varieties and estimating their benefits, it is expected that the bulk of the gains from the crop genetics R&D supported by WGRF investments will have been accounted for in the study's estimated returns to R&D.

Time Line for Benefit/Cost Analysis

The time line for costs in the benefit/cost analysis is the 1995 to 2004 period during which the $40 million of check-off contributions made by Western Canadian wheat and barley producers is invested in crop genetics R&D.

The time line for benefits is the period during which check-off investments to date are expected to produce gains for wheat and barley producers. Because of the time lag between R&D investments and new variety releases, this benefits period begins in 1998 under the study methodology. Because varieties released in 1998 or later can be expected to produce benefits well into the future, the benefits period does not end until 2020, thus resulting in a full benefits time line that extends from 1998 through to 2020.

Identifying and Estimating Impact of Breakthrough Varieties

Annual variety trial results for the three Prairie provinces were used to identify and estimate the production impacts of breakthrough varieties. Yield and other genetic improvements resulting from WGRF supported varieties were estimated relative to varieties already available to producers in the year the new varieties were registered for production. Varieties already available are represented by the standard variety in each crop class at the time of registration. Genetic improvements other than yield increase are estimated as yield equivalent improvements, thus enabling the yield and non-yield improvements to be combined as a total yield per acre improvement for each variety.

Total yield per acre improvements for each variety are multiplied by the estimated number of acres grown annually of each new variety. Acre estimates for each new variety are based on the Canadian Wheat Board variety surveys which have been conducted each year since 1998. Variety acres are forecast to 2020 by extrapolating the CWB data trends. The total annual production increase during the benefits period for all new varieties in a crop class were then estimated by summing the individual supply impacts of each new WGRF supported variety in the class.

The production change due to new varieties is then subtracted from production in the factual scenario (the scenario with WGRF support) which is based on Statistics Canada production estimates and authors' forecasts. This results in a production estimate for the counterfactual scenario (the scenario without WGRF support) prior to accounting for price changes between the factual and counterfactual scenarios. Using Statistics Canada

prices for each crop class and supply and demand elasticities for wheat and barley taken from other research, the authors then estimate the change in producer surplus associated with the production change as we move from the counterfactual (without WGRF) to the factual (with WGRF). Total surplus (producer and consumer surplus) is similarly estimated.

Estimated Benefit/Cost Ratios and Internal Rates or Return

As a final step, the increased producer surplus between the scenario 'without WGRF check-off' and the scenario 'with WGRF check-off' investment is compared to check-off costs incurred by producers. The comparison is performed on a present value basis (net present value of costs compared to net present value of benefits) which adjusts values for inflation and a five percent per year real discount rate to reflect the time value of money. An internal rate of return (IRR) is also calculated on the benefit and cost streams.

The study found significant returns to the WGRF check-off investments for both wheat and barley. The benefit/cost (B/C) ratio for producers for the wheat check-off is estimated at 4.4. to 1, meaning that every dollar of check-off invested generates $4.40 of increased producer surplus for Western Canadian wheat growers. This translates to an internal rate of return (IRR) of 23.8 %. For barley growers in Western Canada, including Alberta growers, the B/C ratio is 12.4 to 1 and the IRR is 36 %. These are clearly strong returns. The results, including the estimates of total surplus returns to both producers and consumers are summarized in the table below.

Table E.1: Benefit/Cost Ratio and Internal Rate of Return for WGRF Wheat and Barley Check-off Investments, 1995 to 2020

	B/C Ratio	IRR (%)
Producer Returns		
Wheat	4.4	23.8
Barley	12.4	36.0
Total Returns		
Wheat	4.6	24.4
Barley	13.1	36.8

Perspectives on the Estimated Returns

The study results do not reflect all of the gains to producers from crop genetics R&D funded by WGRF check-off investments. The large majority of the estimated benefits accrue from a relatively small percentage of all varieties developed with support from wheat and barley check-off funds. These benefits have been captured in the estimation methodology. This does not mean other varieties have failed to contribute to increased producer returns. Not all of the market attributes of each new variety were included in the broad methodology employed. To the extent that some market attributes of varieties are not fully reflected in the analysis, the estimated B/C ratios and IRR's underestimate the true returns from wheat and barley check-off investments. The estimates should therefore be considered as reflecting the minimum return producers can expect from check-off invested by WGRF on their behalf.

The benefits from WGRF check-off investments are just now beginning to affect wheat and barley growers' returns. This is not surprising given the time lag in bringing new varieties to the marketplace once the decision to invest is made. The study's estimated returns are not all reflected in producers' pocketbooks at this point in time. Based on the benefits profile estimated in the analysis, the bulk of the estimated returns to producers' check-off invested thus far by WGRF will have been realized by producers within the next 4 to 5 years.

Chapter 1
Introduction

Improved crop genetics has been a main reason for the economic development and sustainability of Western Canada's commercial grains industry in the last one hundred years. The challenge and the success of crop breeding has been to develop continuously improved plant genetics to address production challenges and market demands.

Two of Western Canada's traditional crops, wheat and barley, have their own story in terms of the development of plant genetics. Red Fife, the variety of wheat found to be most suitable to the crop growing conditions of Western Canada during the late 1800s and early 1900s when the Western grain economy was just beginning to develop, is the foundation variety of the Canadian hard red spring wheat industry.[1] A six-row barley from Russia, of the variety name Mandscheuri, was the basis for the development of OAC 21 which by 1920 had become the dominant barley variety in Western Canada.[2]

Since the time these original wheat and barley varieties were introduced, constant improvement in genetics has been made. Breeding programs have generated varieties with increased yields, better resistance to plant disease, early maturity to deal with Western Canada's short growing season, improved product quality to meet market needs, and other agronomic and product quality improvements. The result has been to increase the competitiveness of the wheat and barley industries in Western Canada.

A recent milestone in the history of wheat and barley breeding in Western Canada was the establishment of the Western Grains Research Foundation (WGRF) in 1981. Beginning as administrator of an Endowment Fund, the Foundation expanded its role in the 1993-94 crop year to become the administrator of voluntary check-offs on Western Canadian wheat and barley sales. The check-off funds are invested by the Foundation on behalf of producers for the purpose of developing new wheat and barley varieties. The check-off is thus a direct contribution by Western wheat and barley producers to development of technology for their business success.

The check-offs on wheat and barley sales are the specific topic of this report. With more than a decade of check-off experience behind it, the WGRF has requested an evaluation of the overall performance of the Foundation's check-off expenditures in developing new wheat and barley varieties and therefore in contributing to increased producer returns.

1.1 Objective of the Study

The report that follows is the result of research and analysis carried out between December, 2004 and July, 2005 by research consultants Terry Scott, TESCO Consulting Ltd.; Alper Guzel, Visiting Professor, Department of Agricultural Economics; Hartley

[1] Slinkard and Knott. 1995, pp. 5-35.
[2] Slinkard and Knott. 1995, pp. 82-84.

Furtan, Department of Agricultural Economics, University of Saskatchewan; and Richard Gray, Department of Agricultural Economics, University of Saskatchewan. The objective of the study is to estimate the economic return to Western Canadian wheat and barley growers from WGRF R&D check-off expenditures on wheat and barley breeding programs. More specifically, the objective is to estimate a benefit/cost (B/C) ratio and internal rate of return (IRR) to growers on these check-off expenditures.

1.2 Organization of the Report

The report is organized as follows.

Chapter Two provides a brief overview of WGRF, focusing on the wheat and barley check-off WGRF administers on behalf of Western producers. Identified are trends in check-off amounts over the last decade, the general manner in which the check-off dollars have been spent for the benefit of producers, and the crop breeding institutions who have been the main WGRF funding recipients.

The methodology for the study is described in Chapter Three. In broad terms the methodology compares benefits and costs for a factual situation (i.e. a scenario where WGRF exists, collects a check-off and spends the monies on R&D) to a counter-factual situation (i.e. a hypothetical scenario in which the WGRF wheat and barley check-off does not exist). The difference between the two scenarios is the benefit and cost impact of the WGRF check-offs. The benefit/cost methodology in Chapter Three describes a four phase plant breeding chain, each phase with its specific benefits and costs. Also outlined is how the check-off on wheat and barley contributes to the innovation process for new crop varieties and therefore generates increased producer surplus or profits.

Chapter Four presents the empirical analysis and results. This includes estimating the benefits and the costs of WGRF crop genetics R&D to arrive at a benefit/cost ratio and internal rate of return (IRR). On the benefits side, the methods and data sources for estimating the value of yield improvements and the value of other genetic improvements are explained. On the cost side, the data sources and process for estimating WGRF costs are described. These benefits and costs are then compared to estimate a benefit/cost ratio and internal rate of return for WGRF check-off investments.

Chapter Five summarizes the study findings and highlights the policy implications associated with these findings, both from the perspective of the WGRF and from the perspective of other industry and government players engaged in or interested in wheat and barley crop genetics R&D.

Chapter 2
Overview of Western Grains Research Foundation
Wheat and Barley Check-offs

2.1 Origin and History

In 1981 the Western Grains Research Foundation (WGRF) was set up to fund and direct agricultural research for the benefit of Western Canadian grain producers. The Foundation was established from a broad cross-section of 12 western agricultural organizations. Its role was to manage an Endowment Fund consisting of a base of nine million dollars in producer funds from the discontinued Prairie Farm Assistance Act.

In the early nineties, breeding programs were suffering as public programs had been downsized and there was little private interest in wheat and barley breeding in Western Canada. At the same time, other major competitors such as Australia had ramped up their breeding programs, leaving Canada at risk of falling behind. To provide additional producer generated research funding, federal legislation (Bill C-50) was passed to set up the Wheat and Barley Check-off Fund program beginning with the 1993-94 crop year. This Bill also gave the WGRF the authority to administer the check-off funds.

Through this system, farmers contribute a portion of their annual Canadian Wheat Board wheat and barley final payments directly to the Check-off Funds. Each year, farmers can choose not to contribute by opting out of the program. Very few actually choose to opt out.[3] Farmers are also eligible to receive a tax credit for the portion of their check-off investment that goes to research. The farmer contributions to both wheat and barley check-off funds combined ranges from $3 to $5 million annually.

Today, there are 18 member organizations representing farmers from Alberta, Saskatchewan, Manitoba and the Peace River area of British Columbia. Each of these organizations is represented by a Director on the WGRF Board. Check-off investments are overseen by this Board. In 2005, the organizations represented on the Board were:

Wild Rose Agricultural Producers
Alberta Winter Wheat Producers
Western Pulse Growers Assoc.
Canadian Canola Growers Assoc.
National Farmers Union
B.C. Grain Producers Assoc.
Canadian Seed Growers Assoc.
Agriculture & Agri-Food Canada
Alberta Soft Wheat Producers Comm.
Saskatchewan Flax Development Commission
Agricore United
Prairie Oat Growers Assn. Inc.
Saskatchewan Wheat Pool
Keystone Agricultural Producers
Western Canadian Wheat Growers Assoc.
Agricultural Producers Assoc. of Saskatchewan
Canadian Wheat Board
Western Barley Growers Assoc.

[3] The percentage of producers opting out is typically only about 5 to 6 % of eligible producers who represent about 12 to 15 % of the potential check-off revenue in the case of the wheat check-off. For barley, the numbers are about the same.

2.2 Funds Administered by WGRF

Annual research funding from both the wheat and barley check-off funds and the Endowment Fund is administered by the WGRF.

2.2.1 The Endowment Fund

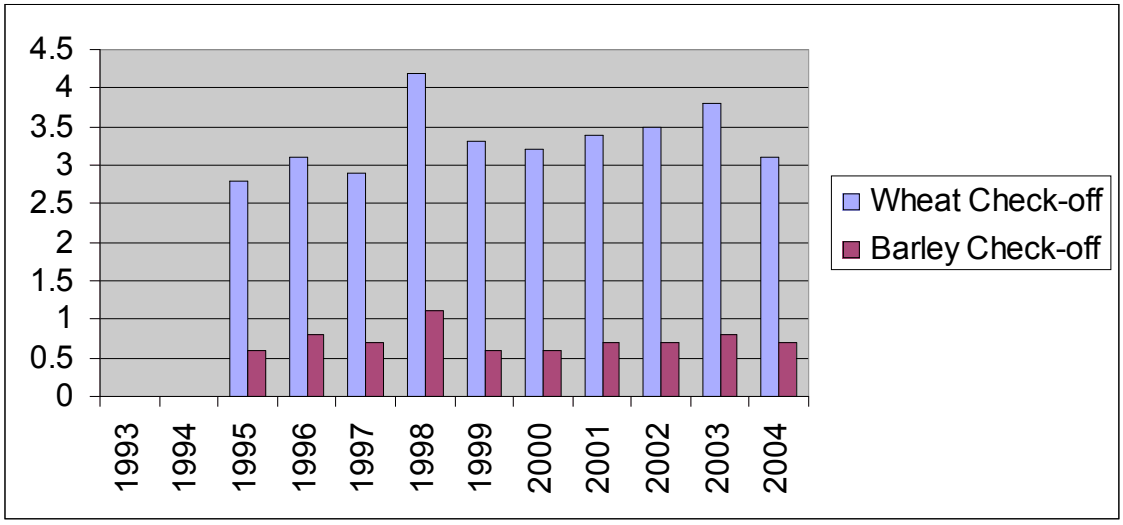
The Endowment Fund has provided over $17.5 million in support to nearly 200 crop research projects since its inception. This Fund provides funding based on interest generated from its core fund of $9 million. In recent years, this has amounted to approximately $700,000 annually that has gone towards crop research projects; in years of high interest rates, this amount was closer to $1 million annually. Although the Endowment Fund is an important R&D funding mechanism, this particular Fund is not the topic of the present study.

2.2.2 Check-off Funds

The bulk of WGRF research funding is derived from the wheat and barley check-off funds. Annually, this amounts to between $3.0 and $5.0 million. The check-off funds are the focus of the present study. Figure 2.1 below shows the annual expenditures from the two Check-off funds since inception, totalling approximately $40 million on behalf of Western Canadian wheat and barley growers ($ 33 million for wheat and $7 million for barley).

Figure 2.1 Wheat and Barley Check-off Fund Expenditures, 1993 to 2004

($ millions)



Source: WGRF Annual Report to Producer Investors, Various Issues.

The check-off funds collected by WGRF have been invested in the development of new wheat and barley cultivars. As new varieties have been released, royalties have been returned to WGRF from the new technology. These royalty revenues are re-invested by WGRF in further research for the continual improvement of wheat and barley genetics. As of the Foundation's 2003 Annual Report to Producers, about $800 thousand dollars of royalty revenue had already been earned on new varieties supported by the Foundation. The annual royalty earnings have been on a steep upward climb, indicating commercial success is being achieved by the varieties supported by WGRF.

2.3 The Barley Check-off Fund

The barley check-off is an annual check-off of $0.40/tonne, deducted from Canadian Wheat Board final payments to producers in Saskatchewan and Manitoba. Alberta barley is covered by a separate barley check-off program administered by the Alberta Barley Commission. Annually, the WGRF barley check-off has generated over $600,000 for barley breeding research. Over 20 new barley varieties have been released since the check-off began, featuring improvements such as higher yield, increased disease resistance and superior quality.

Barley check-off funds are currently allocated to breeding institutions under 10-year funding agreements. Two programs have received funding support since 1993/94: 57% has gone to the University of Saskatchewan Crop Development Centre (U of S CDC) and 43% has gone to the Agri-Food Canada Brandon Research Centre (AAFC Brandon) in Manitoba.[4]

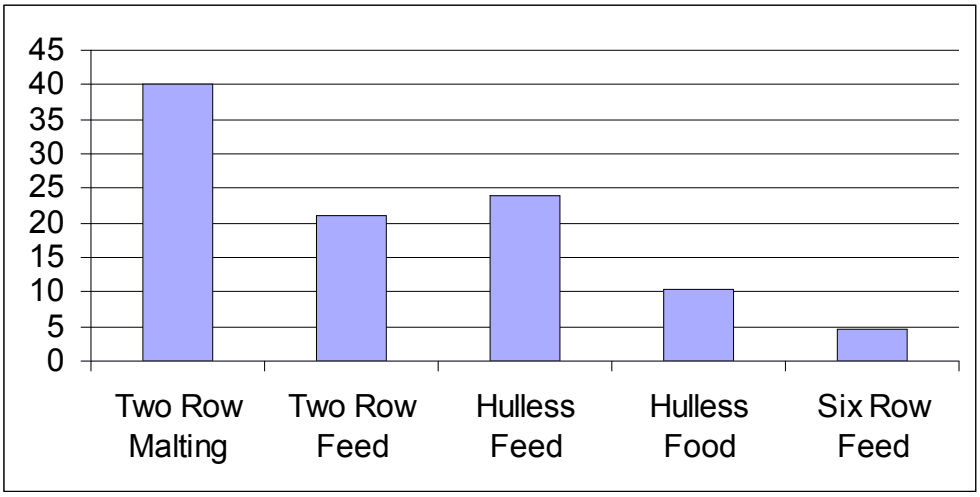
The barley check-off supports barley variety development for malting and brewing, livestock feed and forage, and food and industrial uses. Figure 2.2 illustrates the aproximate funding by barley class.

Approximately 2.3 million tonnes of western Canadian barley are accepted for malting annually. Of this total, Canada's malting industry purchases over 1 million tonnes annually. Two-row malting barley dominates the domestic and much of the export malting barley market. Some of the challenges identified in developing new malting barley varieties include improving resistance to Fusarium Head Blight (FHB), identifying lines with lower levels of DON mycotoxin, and dealing with emerging concerns such as spot blotch and the potential of hulless malt varieties.[5] Malting barley varieties are currently grown on about 70 percent of the Prairie barley acreage.[6] Of malting barley area, 85 percent is in two row varieties.

Despite high area seeded to malting varieties, 80 % of Western Canada's barley ends up in the livestock feed market. About 30 percent of Western barley area is sown to feed varieties. Some of the breeding challenges identified for feed barley include improved

[4] WGRF web-site.
[5] WGRF web-site.
[6] Source: Canadian Wheat Board Annual Variety Surveys

Figure 2.2 Barley Check-off Funding, by Class (% of Total)



Source: WGRF Annual Report to Producer Investors, 2003

yields, uniform test weight, disease resistance, lower phytate content of hulless barley used in hog production, slower rate of dry matter disapearance for cattle, lower and tailored protein content, and improved overall health benefits of barley.[7]

Food markets take less than 5% of Canada's barley crop. Hulless barley is valued for human consumption. The industry sees opportunities in the industrial use of specialty starches since the new "waxy" varieties are high in amylopectin – a stabilizing starch. Potential is also seen for breakfast cereals, noodles, pearled barley for an instant-rice type of product, beta-glucan enhanced food additives and blending flour. Breeders are looking at boosting barley's nutritional components including everything from Vitamin E to "free radical scavengers" – antitoxidants important in the prevention and treatment of diseases.

2.4 The Wheat Check-off Fund

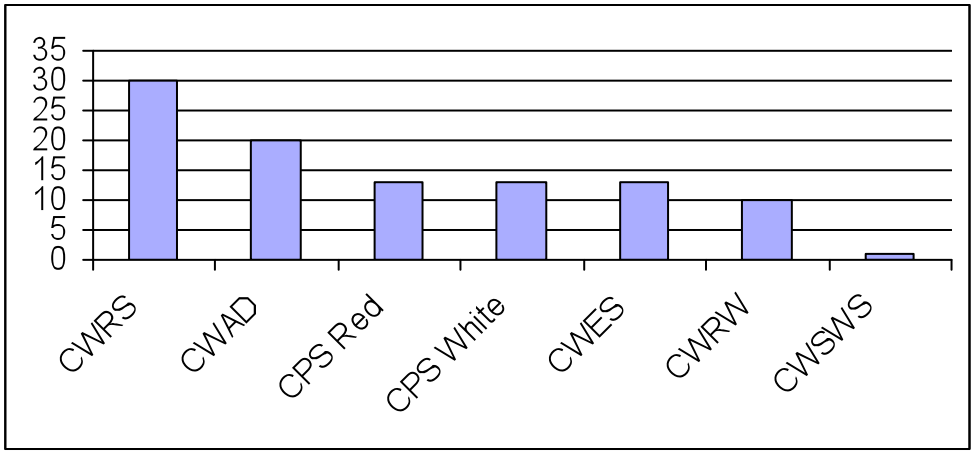
The wheat check-off is an annual check-off of $0.20/tonne, deducted from Canadian Wheat Board final wheat payments to producers. Annually, the check-off has generated between $3 and $4 million for wheat breeding research. As a result, wheat breeding programs supported by the wheat check-off have produced over 25 new wheat varieties. New varieties have provided higher yields and multiple disease and pest resistance, while emerging wheat classes such as Canada Prairie Spring wheats and Canada Extra Strong wheats have seen a boost in development as a result of genetic improvements.

Figure 2.3 below shows the rough percentage allocation of wheat check-off to various classes of wheat. The Check-off Fund supports wheat variety development in wheat

[7] WGRF web-site.

classes including Canada Western Red Spring (CWRS), Canada Western Amber Durum (CWAD), Canada Prairie Spring Red (CPSR), Canada Prairie Spring White (CPSW), Canada Western Red Winter (CWRW), Canada Western Soft White Spring (CWSWS), and Canada Western Extra Strong (CWES).

Figure 2.3 Wheat Check-off Funding, By Class (% ot Total)



Note: CWRS category includes new CWHW.

Source: WGRF Annual Report to Producer Investors, 2003

Wheat Check-off funds are allocated to the following breeding institutions:

- University of Alberta in Edmonton
- Alberta Agriculture, Food and Rural Development at Lacombe
- Agriculture and Agri-Food Canada Research Stations at Lethbridge, Winnipeg and Swift Current
- University of Saskatchewan Crop Development Centre in Saskatoon
- University of Manitoba in Winnipeg

The AAFC breeding institutions receive 73.5 % of WGRF wheat check-off, followed by the University of Saskatchewan CDC at 20.8 %; followed by the University of Manitoba, the University of Alberta, and Alberta Agriculture, Food and Rural Development each of which receive 1.9 % of the wheat check-off funding.[8] These institutions collectively perform two main crop genetics functions – 1) germplasm development which involves production of the raw material breeders depend on to produce new varieties and 2) the actual crop breeding programs which develop the new varieties. The AAFC Research

[8] WGRF web-site.

Centres and the UofS Crop Development Centre are involved in both functions, while the remaining recipients of check-off funds focus on developing germplasm.

Germplasm development concentrates on the early stages of wheat breeding. This involves selecting and improving traits in wheat lines that can eventually be bred into new varieties. Researchers test material from across Western Canada and beyond, and work directly with wheat breeders to feed promising lines into variety-development efforts.

Almost all wheat varieties grown in Western Canada have been developed by centres WGRF supports. Key improvements in varieties include higher yields, increased protein, improved agronomics, unique market quality characteristics, and stronger resistance to insects and disease.

2.5 Check-off Funding Decisions and Agreements

Board decisions on research funding are based on the advice of a Wheat Advisory Committee and a Barley Advisory Committee. Each Committee is comprised of half Foundation members and half representatives from the research and marketing community.

Long-term agreements outline specifically how Check-off funds are to be used by breeding institutions. Annual progress reports from the researchers are submitted to the WGRF Board, and regular reviews are conducted as a basis for long-term planning and adjustments.

This chapter concludes with a listing of the wheat and barley varieties which have been developed in part through the support of the wheat and barley check-offs administered by WGRF. Table 2.1 and 2.2 indicate that in terms of numbers of varieties released, WGRF appears to have been part of some very active variety development programs. This study turns its attention in the following chapters to estimating the impact that these varieties have had on the economic welfare of Western Canadian wheat and barley growers.

Table 2.1 Wheat Varieties Developed With Support by Wheat Check-off Fund

Year	Variety	Description	Centre
2004	Infinity	High-yielding, high protein variety with very strong overall performance.	AAFC Swift Current
2004	CDC Go	High-yielding, medium maturity variety with high test weight and	U of S CDC
		intermediate disease resistance.	
2004	CDC Osler	High-yielding, medium-early maturity variety with standard height,	U of S CDC
		targeted at Parkland production.	
2004	Snowbird	First variety of this new class, which offers preferred colour and higher	AAFC Winnipeg
		flour extract.	
2004	Kanata	Similar to Snowbird, with slightly different quality profile.	AAFC Winnipeg
2004	HY475	Earlier maturity and higher test weight than AC Vista. Seven percent higher	AAFC Swift Current
		yield than Snowbird.	
2004	HY476	Features new gene for resistance to common bunt and higher yield	AAFC Swift Current
		than Snowbird.	
2004	Strongfield	Touted as a successor to AC Avonlea, with lower cadmium content, higher	AAFC Swift Current
		strength, seven percent higher yield, slightly higher test weight and similar	
		disease profile.	
2004	CDC Walrus	Softer, easier-grinding wheat than Glenlea, with 3 – 7 percent higher yield.	U of S CDC
2004	Radiant	High yielding variety with good drought tolerance and resistance to the	AAFC Lethbridge
		wheat curl mite, which carries wheat streak mosaic.	
2003	Lillian	Sawfly-resistant wheat with higher grain yield and protein potential	AAFC Swift Current
		than AC Abbey.	
2002	Lovitt	Early maturing, leaf rust resistant AC Barrie-type with pre-harvest	AAFC Swift Current
		sprouting resistance.	

2002	CDC Rama	CDC Ramacontent and improved disease resistance.	U of S CDC
2002	CDC Buteo	Yield similar to CDC Osprey, with shorter straw than CDC Kestrel,	U of S CDC
		and good lodging resistance.	
2001	Harvest	High yielding variety with improved sprouting resistance. One day	AAFC Winnipeg
		earlier maturing than the checks.	
2000	Superb	Very high-yielding semi-dwarf with short, strong straw and good	AAFC Winnipeg
		sprouting resistance.	
2000	AC 2000	Improved milling properties and gluten strength compared to	AAFC Swift Current
		AC Karma and AC Vista.	
1999	CDC Bounty	High yield potential and higher protein percentage than Neepawa.	U of S CDC
Year	**Variety**	**Description**	**Centre**
1999	Alikat	Adapted to acidic soils and agronomically similar to Neepawa.	U of A
1999	AC Napoleon	Features low cadmium accumulation, along with higher yield and stronger	AAFC Winnipeg
		gluten than AC Avonlea in the Black Soil Zone.	
1999	AC Glenavon	Slightly higher yield, earlier maturity and improved test weight	AAFC Winnipeg
		compared to Glenlea.	
1999	CDC Raptor	High-yielding, winter hardy, strong strawed variety, with superior stem	U of S CDC
		and leaf rust resistance.	
1998	AC Abbey	First semi-dwarf, solid stemmed wheat in this class.	AAFC Swift Current
1998	AC Corrine	Superior sprouting resistance to Glenlea.	AAFC Winnipeg
1998	CDC Falcon	First winter wheat for Western Canada with leaf and stem rust resistance.	U of S CDC
1998	AC Bellatrix	First winter wheat for Western Canada with common bunt resistance.	AAFC Lethbridge
1997	AC Intrepid	High yield, early maturity, strong straw and very large kernels.	AAFC Swift Current

1997	AC Intrepid	High yield, early maturity, strong straw and very large kernels.	AAFC Swift Current
1997	AC Avonlea	High yield, high protein, shorter and stronger straw than Kyle, with	AAFC Swift Current
		improved yellow colour and good cooking quality.	
1997	Laser	Higher yielding than Wildcat.	U of A
1997	AC Tempest	Replacement for the southern Alberta variety AC Readymade, which	AAFC Lethbridge
		corrects the low flour yield problem of that variety. Has stronger straw,	
		high protein and moderate bunt resistance.	
1996	AC Splendor	Very early maturity, very high protein and very good leaf rust resistance.	AAFC Winnipeg
1996	AC Elsa	Higher yield than AC Barrie, with high protein, and improved leaf	AAFC Swift Current
		spot resistance.	
1996	AC Cadillac	High yield, high protein, large kernels, very high test weight.	AAFC Swift Current
1996	AC Morse	Improvements to yield, quality and gluten strength.	AAFC Winnipeg
1996	AC Vista	First in class with sprouting resistance similar to red varieties.	AAFC Swift Current
1996	AC Crystal	Much stronger gluten combined with good performance characteristics.	AAFC Swift Current

Source: WGRF Web-site.

Table 2.2 Barley Varieties Developed With Support of Barley Check-off Funds

Year	Variety	Description – Key Traits	Centre
2003	Rivers	Two-row hulled. Early maturing with moderate yields for the eastern Prairies. Excellent combination of disease resistance. AAFC Brandon.	AAFC Brandon
2003	CDC Fibar	Two-row waxy hulless targeted at food markets. Features nearly 100 percent amylopectin starch, high levels of beta-glucan and acid extract viscosity.	U of S CDC
2003	CDC Rattan	Two-row waxy hulless. Features high test weight and several improvements over CDC Candle, particularly in agronomic performance, disease resistance, levels of beta-glucan and acid extract viscosity. Waxy type with 95 percent amylopectin starch.	
2002	CDC Trey	Two-row hulled. High yielding for the eastern Prairies. Very strong straw, early maturity and very high test weight - higher than CDC Dolly.	U of S CDC
2002	Calder	Two-row, particularly well adapted to Sask. High yielding. Resistance to loose smut, mod.resistance to stem rust, net blotch, surface-borne smuts and FHB.	AAFC Brandon
2001	Newdale	Two-row, outyields Harrington by 24 percent across all soil zones. Shorter and stronger straw than Harrington. Moderate resistance to spot blotch.	AAFC Brandon
2000	CDC Helgason	Two-row hulled. High-yielding, heavy and plump, with disease resistance for the eastern Prairies.	U of S CDC
2000	AC Ranger	Six-row forage. High grain yield potential, good disease resistance for the eastern Prairies and straw strength.	AAFC Brandon
2000	CDC Select	Two-row malting barley with 11 percent high yield potential than Harrington across the Prairies, and with quality tailored to North American brewers. Good kernal weight, plumpness, resistance to lodging, net blotch and stem rust.	U of S CDC
1999	CDC McGwire	Two-row hulless. Features combination of good yield, threshability and disease resistance for Western Canada.	U of S CDC
1999	CDC Speedy	Two-row hulless. Features very early maturity for delayed seeding situations.	U of S CDC
1999	CDC Bold	Two-row semi-dwarf hulled. Improved quality, straw strength.	U of S CDC
1999	CDC Copeland	Two-row featuring high yield, good plumpness, test weight and maturity. A unique malting quality profile. Moderate net blotch and stem rust resistance.	U of S CDC
1999	AC Bountiful	Two-row with high yield, good resistance to the smuts, moderate resistance to net blotch and FHB, and malting quality similar to Harrington.	AAFC Brandon
1999	AC Alamo	Two-row specialty waxy hulless barley, with pure amylopectin starch.	U of S CDC
1998	CDC Freedom	Two-row hulless. Improved threshability, straw strength and net blotch and FHB resistance.	U of S CDC
1998	AC Bacon	Six-row hulless. High yield potential and good disease resistance package.	AAFC Brandon
1997	CDC Gainer	Two-row hulless. Low beta-glucan and good straw strength.	U of S CDC
1996	CDC Fleet	Two-row hulled. Early maturity, good grain quality and strong straw.	U of S CDC
1996	AC Rosser	Six-row feed barley with good yield and disease resistance.	AAFC Brandon
1996	AC Hawkeye	Six-row hulless feed barley with good plumpness. Threshability and yield.	AAFC Brandon

Source: WGRF Web-site.

Chapter Three
Study Methodology

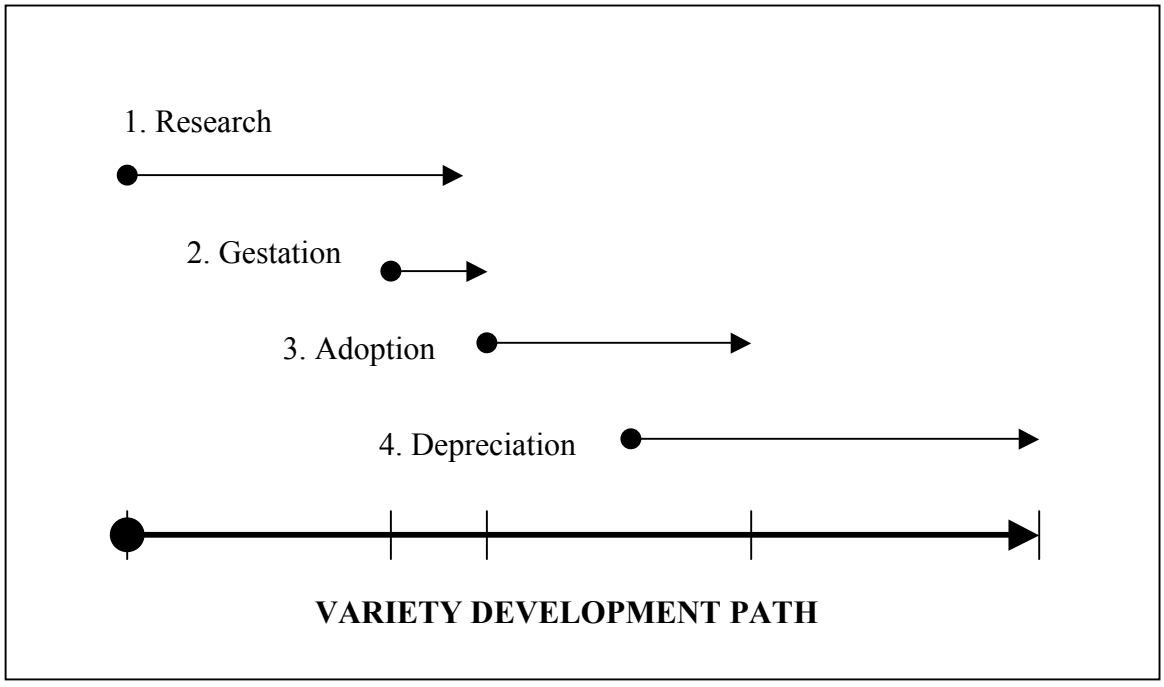
WGRF support for the development of new varieties of wheat and barley is part of an overall innovation process which improves productivity for wheat and barley growers in Western Canada. This chapter outlines this innovation process for new varieties as they proceed from basic research through to commercialization. To estimate the rate of return to wheat and barley check-off expenditures we require an understanding of this process.

Estimating the rate of return to check-off expenditures requires a methodology. This methodology must, among other things, enable the estimation of the productivity benefits brought about by new varieties, estimation of the costs to producers in relation to the check-off and, because wheat and barley growers are not the only parties contributing to the research, attribution of the benefits among the parties. This chapter sets out the methodology that will be used in the study.

3.1 The Innovation Process

Crop genetics R&D expenditures can be explained in the context of the crop variety development path described by Alston, Sexton and Zhang (1997). This development path provides an important perspective for the methodology for estimating rates of return to WGRF research. There are four phases of this development path: i.) the research phase, ii.) the gestation phase, iii.) the adoption phase, and iv.) the depreciation phase. The phases of the variety development path are illustrated in Figure 3.1.

Figure 3.1 The Phases of the Crop Variety Development Path



Source: Based on Alston, Sexton and Zhang (1997)

3.1.1 The Research Phase

The development path for a new variety begins many years before the variety actually appears in farmers' fields. It begins with the research phase where activities are undertaken and costs are incurred to develop variety characteristics to meet specific production and market needs. During this phase, no direct economic benefits result from the research. The research phase involves the basic activity of developing germplasm from which crop breeders develop new varieties as well as the crop breeding activities to develop actual varieties for market introduction. The WGRF supports research in both types of research activity. The purpose is to produce a commercially valuable variety with high yield, strong disease resistance, superb market qualities or other traits required in production or by consumers.

The research phase of the development path is the phase of most interest to the current study from the perspective of estimating the costs of R&D funded by wheat and barley grower check-off administered by WGRF. It is in the research phase that check-off funds are invested in the hopes of eventually paying off in increased grower profits.

3.1.2 The Gestation Phase

Once a new variety is developed it enters the gestation phase. There is still no commercial return generated in this phase, as there remain activities which must be undertaken before releasing the variety for production. Variety testing must be done, regulatory requirements must be satisfied and additional research may be performed. Costs are incurred in the completion of these activities. While the exact point at which gestation begins is somewhat arbitrary, the gestation phase may last two or three years. It ends at the point where the variety is ready for release to pedigreed seed growers.

3.1.3 The Adoption Phase

In the adoption phase, pedigreed seed growers multiply the seed and sell it to commercial growers of wheat and barley. After many years of investment in variety development by WGRF and its partners, the returns to producers begin to take shape, accruing first to the pedigreed seed growers, then to commercial wheat and barley growers. Benefits also accrue to economic sectors connected to wheat and barley production, and finally to end consumers of wheat and barley products. The initial returns are relatively small while seed is being multiplied, but if initial experience in the field and by the trade and consumers is positive, the returns can quickly rise. The variety's presence in wheat or barley fields will at some point peak and then begin to decline as still better varieties are made available for commercial production. Eventually the variety disappears totally from farmers' fields and from the agri-value chain, marking the end of the adoption phase.

The adoption phase is the phase of particular focus in this study from the perspective of the benefits generated by wheat and barley grower check-off expenditures. In this phase it becomes known whether grower investment in R&D pays off in increased productivity and eventual profits for wheat and barley growers.

3.1.4 The Depreciation Phase

The depreciation phase overlaps the adoption phase of the variety development path. For purposes of this study, it is considered to begin roughly at the time the variety begins to decline in importance in farmers' fields and the commercial marketplace. Even after entering the depreciation phase however, the variety may still be grown on a large area of Western Canada's wheat and barley acres. In other words, the depreciation phase overlaps with the adoption phase of the crop variety development path. This period of overlap may last several years.

The rate at which the variety will decline in its commercial importance will depend in large part upon the rate at which other new and superior varieties are brought forward through the crop breeding pipeline. Wheat and barley breeding in Western Canada are currently dominated by public institutions, the same ones that WGRF funds. There is considerable collaboration among these public institutions. The resources and the success of the collaborative efforts are the main determinants of how quickly any specific wheat and barley variety is replaced in this particular Western Canadian market.

All varieties can be expected to eventually disappear from commercial production. At that point, the adoption phase ends. Nevertheless, the depreciation phase continues to reflect a value, although a declining one, for the variety, because the variety has value as part of the genetic stock from which further new varieties are developed. This value is factored into the returns to R&D supported by WGRF in this study.

3.2 Methodology for Estimating Returns

We turn now to the specific methodology for estimating the rate of return to wheat and barley check-off expenditures in the context of the crop variety development path. The framework for the methodology is benefit/cost (B/C) analysis.[9] The end product of this methodology will be an estimated B/C ratio and an internal rate of return (IRR) on growers' check-off funds invested in wheat and barley R&D.

B/C analysis is rooted in economic theory of supply and demand. It estimates the changes in economic surpluses which arise as a result of, in this case, WGRF R&D expenditures on variety development. There are different economic surpluses, but for this study, producer surplus is the most important.

[9] The concepts and principles of benefit/cost analysis are described and discussed in numerous textbooks and publications. For example, see Boardman, Greenberg, Vining and Weimer, 2001.

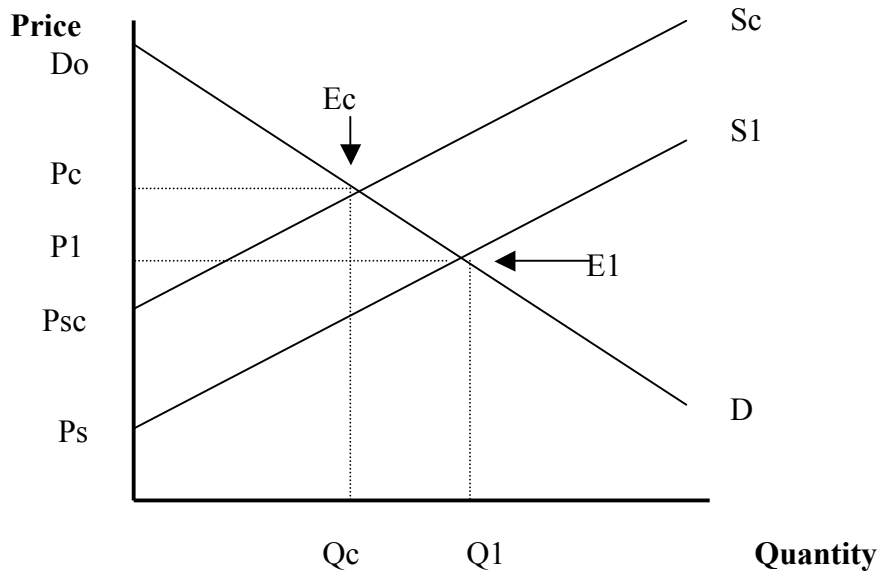
3.2.1 Producer Surplus

Estimating the return on producer check-off funds requires understanding: 1) how producer surplus changes when a check-off is applied on producer sales; and 2) how producer surplus changes as a result of adoption of wheat and barley varieties developed as a result of WGRF expenditure of the check-off funds.

Impact of Check-off on Wheat and Barley Sales:

Producer surplus is the economic profit to firms of an industry. How it changes, first in response to a check-off on sales, can be shown conceptually with a supply and demand illustration for wheat. Figure 3.2 shows a market equilibrium before introduction of the check-off , where the supply curve S1 and demand curve D intersect at E1. This generates corresponding market quantity Q1 and market price P1. Producer surplus is the area Ps,P1,E1. This surplus is the excess revenue for wheat producers over the minimum revenue they would accept in order to keep supplying Q1 of wheat.

Figure 3.2 Cost of Check-off on Wheat Sales



The cost of the check-off is to shift the supply curve from S1 to Sc. This shift occurs because the check-off is the same as an increase in per unit cost of production. Producers' costs of supplying each quantity of wheat at alternative market prices is increased by the $0.20 per tonne check-off. The effect of the shift in supply is to move to a new market equilibrium (where Sc intersects the demand curve D at Ec) and generate a

new level of producer surplus equal to area Psc,Pc,Ec. This new level of producer surplus is less than the previous surplus (Ps,P1,E1) before introducing the check-off on wheat sales. Wheat producers clearly bear a portion of the incidence of the check-off cost.[10] If there were no benefits produced from the check-off the difference between producer surplus before and after the application of the check-off would represent an economic loss to producers.

Impact of Adoption of Variety Technology on Producer Surplus:

The purpose of the check-off is to invest it to create benefits for producers. The check-off invested by WGRF results in new varieties which increase productivity. These varieties have productivity benefits such as increased yield, reduced losses due to disease and other natural crop perils, and improved market quality characteristics. The effect of these productivity improvements can again be illustrated with a market supply and demand illustration for wheat. Figure 3.3 shows a theoretical illustration for a new higher yielding wheat variety.

The initial market equilibrium is the situation that would have existed had WGRF not spent WGRF producer check-off funds to develop the higher yielding variety. This equilibrium is shown at E1 with corresponding market price P1 and market quantity Q1. Producer surplus is area Ps,P1,E1. Now introduce the higher yielding wheat variety. The supply curve shifts from S1 to St because with new technology growers produce more wheat for the same cost. They are willing to supply each alternative quantity of wheat at a price below the price at which they were previously willing to provide that same output. At the new equilibrium Et, the market price is Pt and market quantity is Qt. Producer surplus is now Pst, Pt,Et. This surplus exceeds the producer surplus Ps,P1,E1 which was the producer surplus prior to the introduction of new higher yielding wheat technology.[11]

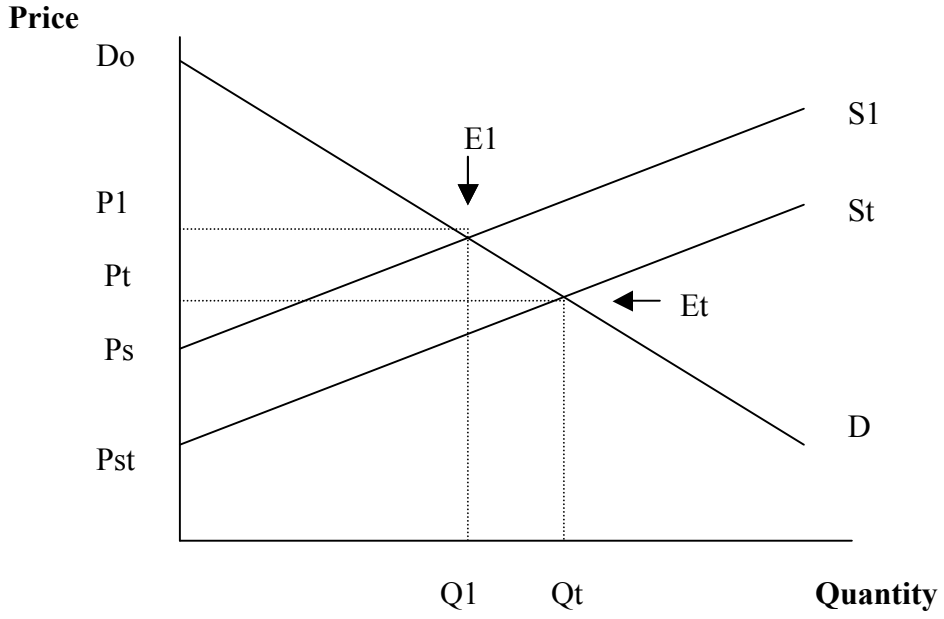
In simple terms, this study grapples with the question of whether increased surplus for Western Canadian producers resulting from new variety technologies developed through wheat and barley check-off investments (Figure 3.3) exceeds, and by how much, the producer surplus decrease experienced as a result of paying the check-off (Figure 3.2).

3.2.2 Consumer Surplus

Although the study focuses on estimating changes to producer surplus, changes to consumer surplus should also be mentioned. Producers and consumers share the gains from research, so it is important to understand the factors that determine how gains are shared. When the check-off is applied to producers' sales (Figure 3.2) and when the new

[10] Consumers also pick up a portion of the cost of the check-off as well in the example shown as will be explained later in section 3.2.2.
[11] Producer surplus increases in this example, but consumer surplus also rises as a result of the new technology adoption. See section 3.2.2.

Figure 3.3 Producer Surplus: Effect From Adoption of a Higher Yielding Variety



wheat variety is introduced (Figure 3.3), the welfare of consumers changes. In Figure 3.2, consumers bear the incidence of a portion of the check-off. This is evident when one compares the consumer surplus before check-off (area P1,Do,E1) to consumer surplus after check-off (area Pc,Do,Ec). The former exceeds the latter by area P1,Pc,Ec,E1.

For new yield increasing technology in Figure 3.3, consumer surplus before the introduction of the variety is area P1,Do,E1 compared with area Pt,Do,Et after the introduction of the technology. The consumer surplus has risen by area Pt,P1,E1,Et. It can therefore be concluded that consumers have an underlying interest in whether the surplus they gain in Figure 3.3 exceeds the reduction they experience in Figure 3.2. For wheat and barley, the consumer interest plays out beyond Western Canada because so much of the wheat and barley produced in Western Canada goes into export markets.

3.2.3 Total Surplus

The combined producer and consumer surplus is the total economic surplus (often referred to in economic theory as social surplus). It can be obtained in Figures 3.2 and 3.3 by simply summing the decreases (increases) for both producers and consumers. The question of whether or not total surplus rises or falls is a relevant one. However, B/C

analysis is typically conducted to determine the rate of return to a particular party or parties who pay direct costs of the investments responsible for producing benefits. In that respect, this study is typical in that the emphasis is on changes to producer surplus for growers who pay the wheat and barley check-offs.

3.2.4 Distribution of the Gains

Given that the main objective is to estimate the returns producers themselves are receiving from their investment, it is important to be aware of the conditions that determine whether producers or consumers benefit most from crop genetics R&D.

The relative gains for producers and consumers are determined by elasticity of supply and elasticity of demand for Western Canadian wheat and barley. Conditions favourable to growers capturing a large share of the benefits can be summarized as: i.) price inelastic supply (supply not very responsive to price changes) and ii.) price elastic demand (demand responds readily to price changes). Conversely, consumers capture relatively large benefits under conditions of: i.) price elastic supply (supply responsive to price change) and ii.) price inelastic demand (demand does not change much when prices do).

Generally speaking, supply is expected to demonstrate sufficient price *inelasticity (*limited factors of production) and demand is expected to demonstrate sufficient price *elasticity* (Western Canada is a small portion of the world markets) that we may expect producers to capture some reasonable share of economic surpluses resulting from their R&D investments. The elasticity estimates used in the study support that proposition.

3.2.5 Factual and Counterfactual Scenarios in Rate of Return Analysis

In estimating how surpluses change in response to wheat and barley check-offs, the concept of the factual and the counterfactual is critical to the analysis. The factual and the counterfactual can best be described again in relation to Figures 3.2 and 3.3.

The factual scenario is, as the name implies, what exists as fact. For example, it is a statement of fact that for more than ten years wheat and barley growers have paid check-offs. Whatever the impacts of that check-off may be, they are part of the production and market results that we have observed in the past, that we observe in the present and will observe in the future. The impacts are embodied in existing yields, prices, acres grown, quantities, and profitablility. In Figure 3.2, the factual market equilibrium, which includes the effect of the check-off, is where supply curve Sc intersects demand curve D. Similarly, the factual market equilibrium in Figure 3.3 is where supply curve St (which includes the impact of the new wheat variety) intersects demand curve D.

The real challenge is to discover the counterfactual. To do this, we must identify what would have been fact had the wheat and barley check-offs never existed. Since we are unable to go back in time and re-run 10 years of production and markets without the

check-offs, we must find an indirect way of identifying the counterfactual. In the context of Figures 3.2 and 3.3, the challenge is to identify the original equilibrium E1, quantity Q1, price P1, and corresponding producer and consumers surpluses. This equilibrium represents the market if there had been no check-off or check-off related research.

In terms of this study, the B/C analysis will describe the factual (i.e., situation with WGRF check-off impacts) through the use of existing data, such as yields, prices, and acres. For each data item, there will be a corresponding counterfactual (i.e., without WGRF check-off impacts) which will be identified indirectly. Once all components of the factual and counterfactual have been established, we subtract the counterfactual from the factual results to arrive at an estimate of the B/C ratio and IRR for check-off funds invested by WGRF on behalf of producers.

A number of other conceptual aspects of the B/C approach undertaken in the study and which will affect the study results are discussed below.

3.2.6 Type of Benefit/Cost Analysis

There are three types of B/C analysis. *Ex ante* B/C is analysis undertaken before a program or project investment is made with a view to determining if the anticipated benefits will justify the expected costs. *Ex poste* B/C analysis is conducted after a program is completed with a view to gaining knowledge (what worked and what did not) to guide future decisions. Neither of these describes the B/C analysis in this study.

The third type of B/C analysis is *in media res* analysis. This is analysis undertaken during the life of a program or project. The objective is to provide information relevant to making ongoing program decisions such as expansion or contraction of the program, re-focussing the program, or ensuring those who are investing resources in the program that they are receiving good returns for their money. The B/C analysis undertaken in this study with respect to wheat and barley check-offs is *in media res* B/C analysis.

3.2.7 Groups With Standing in the B/C Analysis

For any investment where costs are shared and benefits have potential to be widely dispersed, it is necessary in B/C analysis to identify whose costs and benefits matter to the analysis. Those groups whose costs and benefits matter and are therefore estimated in the analysis are said to have *standing*.

On the cost side, Western Canadian producers have standing in the current B/C analysis and their costs in terms of paying the wheat and barley check-off are therefore the key costs in the analysis. These costs are paid by all Western wheat and barley producers with the exception of Alberta barley producers. Other players' costs matter only to the extent that they must be quantified in order to attribute benefits appropriately to the various parties who share the costs of the R&D responsible for generating the new

varieties. To attribute benefits to the appropriate playsers, the authors use a straight proportionality principle - if producer check-off support to wheat and barley breeding programs are ***X*** percent of total resources available to these breeding programs, then ***X*** percent of the benefits are attributed to WGRF check-off expenditures in estimating returns to the check-off investment.

On the benefits side, the study again concerns itself with benefits only for Western Canadian wheat and barley growers. It is possible (indeed probable) that some benefits generated by WGRF check-off expenditures accrue to other growers. This occurs if producers elsewhere in Canada, or beyond Canada, adopt varieties developed with support from WGRF check-off expenditures. These benefits are not included in the estimated rate of return, even though it is worth recognizing the benefits do exist.

A particular issue relating to which parties have standing in the B/C analysis had to be resolved in conducting the study. Alberta growers do not contribute to the barley check-off administered by the WGRF. Alberta grower check-off goes to the Alberta Barley Commission. Even though Alberta check-off amounts are not included on the cost side of the B/C analysis, the benefits that accrue to Alberta growers from WGRF expenditure are included in the estimated returns. Alberta is a key player in barley production and the authors viewed it appropriate to include their benefits in the analysis to gain a more complete picture of WGRF's effectiveness as a contributor to crop genetics R&D.

With respect to consumer surplus generated as a result of WGRF check-off investments, all consumers have standing in the analysis. B/C ratios for total surplus, which includes producer plus consumer surplus benefits, reflect benefits for Western Canadian consumers but also for all Canadian and non-Canadian consumers of varieties developed with the support of WGRF producer check-off monies.

3.2.8 Selecting and Valuing the Benefits

WGRF has allocated producer check-off funds to a variety of institutions and for a variety of crop breeding purposes. The study does not attempt to estimate impacts for each and every specific purpose, for each separate institution in receipt of WGRF funds, or for each specific variety developed in part with check-off support. The approach is to identify the varieties developed by the breeding programs supported by WGRF which represent significant breakthroughs, particularly with respect to yield increases, but also with respect to the other variety traits necessary to protect yield and meet market demand. These breakthroughs are identified by reviewing performance results from variety trials conducted across Western Canada, by reviewing the rate of adoption (seeded acres) of varieties released, and through contacts with industry sources.

3.2.9 Time Period for Measuring Costs and Benefits

Cost Period:

The WGRF began collecting check-off from producers in the 1993-94 crop year. As funds began to accumulate, the Foundation started to allocate those funds for the purpose of supporting crop genetics R&D. The Foundation has continued to invest check-off funds up to the present time. The cost side of the B/C analysis includes the entire time period for which WGRF has collected and spent money on behalf of producers and therefore runs from 1993 to 2004.

Benefits Period:

The time period over which benefits will be estimated does not coincide exactly with the period for which costs are included in the analysis. In fact, the benefits period is quite different.

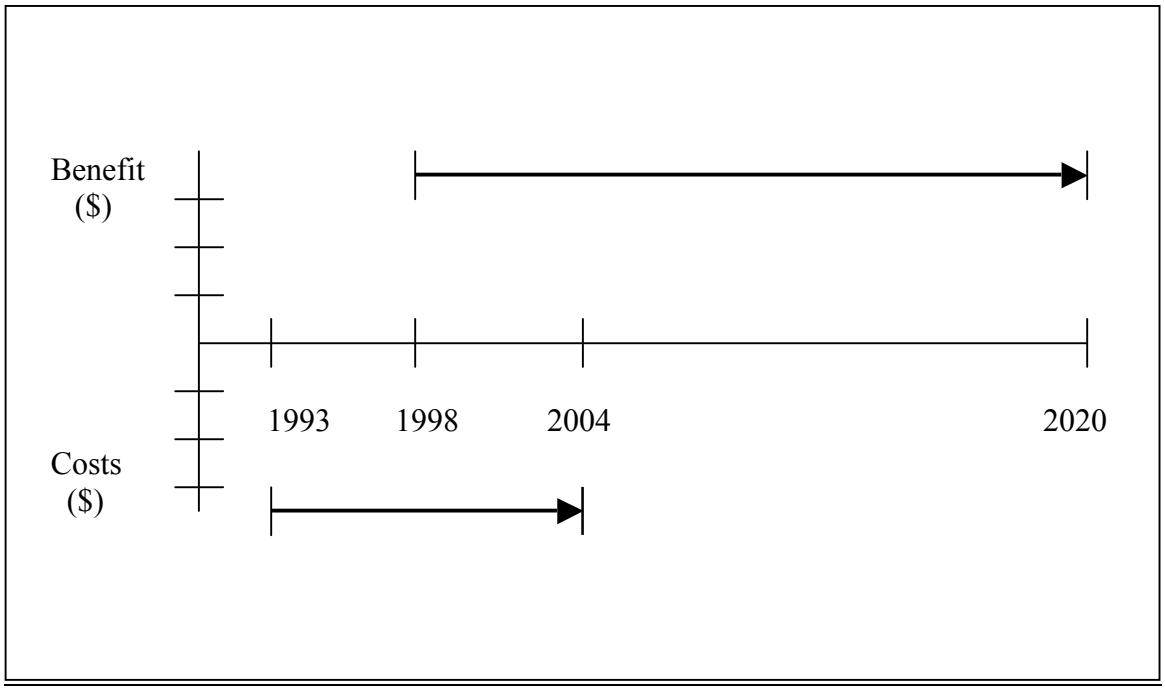
Because of the significant lag between expenditures on variety development and the reaping of commercial benefits from the new varieties, check-off expenditures are not expected to produce immediate benefits for growers. The impact of WGRF expenditures, even though the expenditures began in 1995, would have only gradually emerged over a period of time. Therefore the point at which WGRF can be given credit for new variety releases must be later than 1995.

Rather than using a phase-in formula, the authors have chosen a single point at which to begin crediting WGRF check-off expenditures with a share of the benefits generated by new varieties. The single point chosen is 1998. Any variety registered in 1998 or later is included in estimating benefits. While this does not credit the WGRF with some of the benefits created as a result of 1995 to 1998 expenditures and will over-state the check-off's role for some varieties registered in 1998 or later, the approach overall is expected to appropriately attribute benefits.

The lag between R&D expenditures and the release of new varieties also means it is necessary to account for future benefits in estimating the rate of return to WGRF investments in R&D. The costs incurred prior to 2004 will be responsible for benefits that will arise in the future, because varieties developed and released as a result of check-off support up to 2004 will continue to create surplus increases for producers well beyond 2004. Accordingly the authors take a long term view of these benefits by including a forecast period to year 2020. As a result, the total period for which benefits are estimated is therefore between 1998 and 2020.

Figure 3.4 provides a time line illustrating the period over which costs and benefits are estimated in the B/C analysis conducted in this study.

Figure 3.4 Time Line: Costs and Benefits for WGRF Wheat and Barley Check-offs



3.2.10 Adjusting for Inflation and Use of Discount Rate

The methodology adjusts annual benefits and costs for inflation (using the CPI) to convert benefits and costs to constant 2004 dollars. A five percent real discount rate is then applied to the benefit and costs streams to reflect the time value of money. The effect of the adjustments for inflation and time value of money is to place more weight on benefits and costs which were incurred in the early years of the time line in Figure 3.4. Early years become more important and future years less important in determining the B/C ratio and IRR as a result of these adjustments.

3.2.11 Calculating the Benefit/Cost Ratio and Internal Rate of Return

Using a real discount rate of five percent, the final step in the study's methodology converts the benefit and cost streams to net present values (NPV). By dividing NPV for benefits by the NPV for costs, an estimate of the B/C ratios for wheat and barley check-offs is made. Internal rates of return (IRR's) to WGRF check-off investments in variety development are also presented. The IRR is the rate of interest which, when used to convert benefits and costs to present value terms, equates the present value of the benefits to the present value of costs. The calculation of the estimates of B/C ratios and IRR's completes the study and achieves its stated objective.

3.3 Summary

This chapter has described the innovation process for new variety technology and the methodology which will be employed in the study to estimate the benefits and costs of WGRF check-off investments on behalf of producers. This has included a description of the supply and demand theory underlying the B/C analysis and the various steps that will be taken in estimating returns to research. The rest of the report addresses the empirical investigation to arrive at the B/C ratios and IRR's.

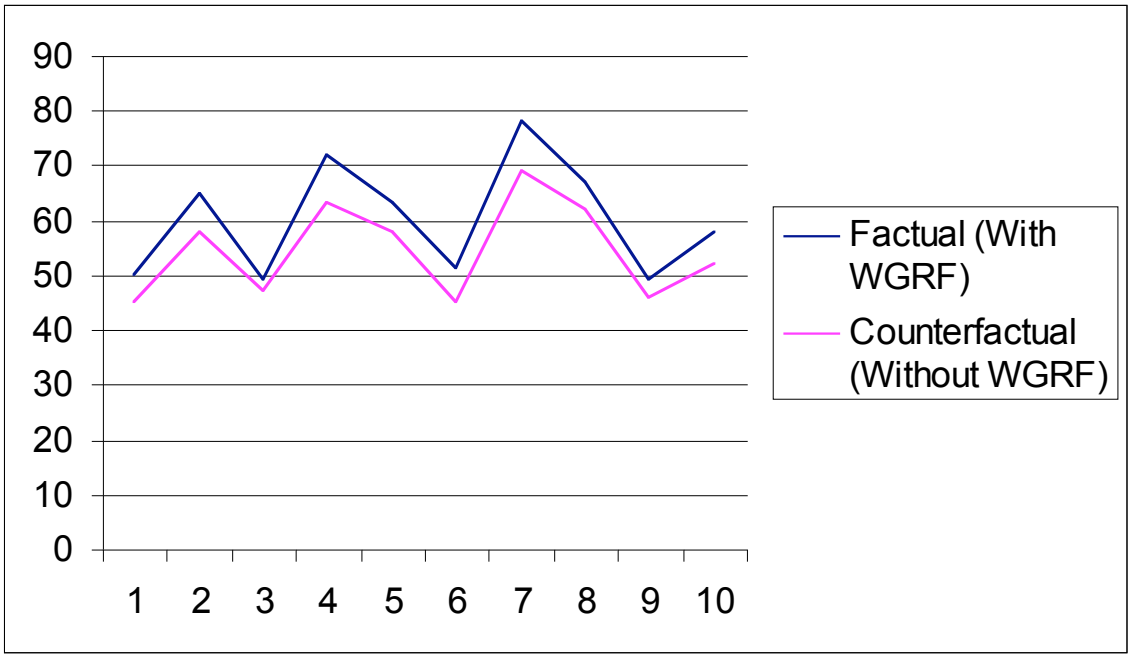
Chapter Four
Empirical Analysis and Results

The theoretical methodology described in Chapter Three is applied in this chapter to estimate the rate of return to WGRF expenditures on wheat and barley breeding. The estimation process is described using examples and illustrations as appropriate. The first part of the chapter focuses on the estimation of benefits, turning later to the cost side of the benefit/cost analysis. The chapter concludes with a summary of the results of the empirical analysis, including an estimate of the benefit/cost (B/C) ratio and internal rate of return (IRR) on WGRF check-off expenditures.

4.1 Estimating the Producer Benefits

The biggest task in the empirical analysis is the estimation of benefits generated as a result of the WGRF check-off expenditures. The previous chapter outlined the concepts of the factual and counterfactual scenarios. The objective in estimating producer benefits is to determine the difference between what producer surplus is under the factual scenario (i.e., with WGRF check-off expenditures) and what producer surplus would have been under the counterfactual scenario (i.e., without the WGRF check-off expenditures). This difference represents the impact of the WGRF expenditures, as illustrated in Figure 4.1.

Figure 4.1 Hypothetical Example: Producer Surplus Factual (With WGRF Exp.) and Counterfactual (Without WGRF Exp.), $ Millions



In each of the ten years shown in Figure 4.1, producer surplus in the factual scenario which includes the impact of WGRF check-off expenditures, exceeds producer surplus that would have existed had WGRF check-off not been invested in wheat and barley R&D. In year ten for example, producer surplus under the factual scenario is $58 million compared to $52 million under the counterfactual scenario. The difference of six million dollars is the benefit to producers in year ten in this hypothetical example.

To estimate the difference in producer surplus between the factual and counterfactual in a real world situation for each of the years 1998 to 2020 requires a number of steps.

4.1.1 Identifying the Variety Breakthroughs

The first step is to identify varieties which are likely to have contributed significantly to increased producer surplus. The study authors examined wheat and barley varieties listed in Tables 2.1 and 2.2 respectively of this report. These are the varieties registered by the research institutions whose wheat and barley breeding programs have been supported by the WGRF check-off. For reasons explained in chapter 3.2.9, varieties registered before 1998 were eliminated from the analysis.

Analysis was conducted for varieties registered in 1998 or later to determine the extent to which each has contributed to increasing producer surplus. The objective was not to estimate the detailed impact of each and every variety, but rather to identify those which appeared to represent a significant breakthrough in terms of new genetic technology. The authors identified, for each variety:

a) whether or not the variety offered yield improvements relative to those already available to growers at the time the variety was registered;
b) whether or not the variety offered improvements in non-yield characteristics relative to varieties already available to growers at the time the variety was registered; and
c) the extent to which the variety was successfully commercialized, as indicated by the acres grown of the variety by Western Canadian wheat and barley growers.

4.1.2 Estimating Yield Improvements of New Varieties

A major factor which affects whether a new variety will contribute to an increase in producer returns is the yield characteristic of the variety. Each new wheat and barley variety developed with WGRF support was compared to the standard variety for its crop class at the time the new variety was registered for production. Yield data for both the standard variety and the new variety were drawn from the crop variety trial results

conducted annually in each of the three Prairie Provinces. These results are published for each province.[12]

The yield analysis was conducted by variety, by province. For example, the Hard Red Spring Wheat variety Superb, registered in 2000, has been part of variety trials in all three Prairie provinces. Superb was compared to the standard AC Barrie. In Saskatchewan, Superb had a seven percent yield increase relative to AC Barrie; in Manitoba, a six percent increase and in Alberta a 10 percent increase in yield relative to AC Barrie. These results are average results over the years the variety was included in variety trials.

The same analysis was conducted for all varieties of Hard Red Spring Wheat, Winter Wheat, Canada Prairie Spring Wheat, Canada Extra Strong, Canada Western Amber Durum, Malting Barley and Feed Barley developed with support from WGRF. The full results are reported in Table 4.1, which shows the standard variety for each crop class to which the new variety's performance was compared. From Table 4.1, the authors were able to identify the varieties most likely to offer a significant yield improvement over varieties already available to producers.

Table 4.1 Yield Performance: Wheat and Barley Varieties Registered by Breeding Institutions in Receipt of WGRF Check-off Fund Assistance, 1998 to 2004

	Reg. Year	Breeding Institution	% Yield Increase Man.	Sask.	Alta.	Standard Variety
Hard Red Spring Wheat:						
AC Abbey	1998	AAFC (S.C.)	n/a	(4.0)	2.0	AC Barrie
Alikat	1999	Univ. of Alta.	(8.0)	n/a	(5.0)	AC Barrie
CDC Bounty	1999	CDC	6.0	5.0	4.0	AC Barrie
Superb	2000	AAFC (Win.)	6.0	7.0	10.0	AC Barrie
Harvest	2001	AAFC (Win.)	5.0	1.0	1.0	AC Barrie
Lovitt	2002	AAFC (S.C.)	3.0	3.0	(2.0)	AC Barrie
Lillian	2003	AAFC (S.C.)	n/a	4.0	0.0	AC Barrie
Infinity	2004	AAFC (S.C.)	n/a	8.0	4.0	AC Barrie
CDC Go	2004	CDC	n/a	3.0	5.0	AC Barrie
CDC Osler	2004	CDC	n/a	2.5	3.0	AC Barrie

[12] See Saskatchewan Agriculture and Food, *Varieties of Grain Crops*; Alberta Agriculture, Food and Rural Development, Varieties of Cereal and Oilseed Crops for Alberta; and Manitoba Agriculture, *Seed Manitoba: A Growers' Guide*.

Table 4.1 Continued …..

Winter Wheat:

AC Bellatrix	1998	AAFC (Leth.)	(12.0)	(2.0)	4.0	CDC Kestrel
CDC Falcon	1998	CDC	1.0	(5.0)	(4.0)	CDC Kestrel
CDC Raptor	1998	CDC	0.0	(1.5)	(1.0)	CDC Kestrel
CDC Buteo	2002	CDC	(2.0)	(4.0)	(3.0)	CDC Kestrel
Radiant	2004	AAFC (Leth.)	n/a	n/a	n/a	CDC Clair

Durum Wheat:

AC Napolean	1999	AAFC (Win.)	12.0	6.0	1.0	Kyle
Strongfield	2004	AAFC (S.C.)	n/a	12.5	2.5	Kyle

Prairie Spring Wheat:

AC 2000	2000	AAFC (S.C.)	----	(9.0)	0.0	AC Karma

Extra Strong Spring Wheat:

AC Corrine	1998	AAFC (Win.)	9.0	(4.5)	1.0	Glenlea
AC Glenavon	1999	AAFC (Win.)	8.0	(2.0)	3.0	Glenlea
CDC Rama	2002	CDC	1.0	0.5	n/a	Glenlea
CDC Walrus	2004	CDC	n/a	(2.0)	n/a	Glenlea

Malting Barley:

AC Bountiful	1999	AAFC (Bran.)	(6.0)	14.0	11.0	Harrington
CDC Copeland	1999	CDC	3.0	14.5	11.0	Harrington
CDC Select	2000	CDC	2.0	11.0	10.0	Harrington
Newdale	2001	AAFC (Bran.)	10.0	19.5	9.0	Harrington
Calder	2002	AAFC (Bran.)	0.0	15.0	n/a	Harrington

Feed Barley:

CDC Freedom	1998	CDC	(3.0)	6.5	(3.0)	Harrington
AC Bacon	1998	AAFC (Bran.)	7.0	11.0	7.0	Harrington
CDC McGwire	1999	CDC	12.0	15.0	7.0	Harrington
CDC Speedy	1999	CDC	n/a	(1.0)	n/a	Harrington
CDC Bold	1999	CDC	8.0	18.0	11.0	Harrington
CDC Helgason	2000	CDC	8.0	12.0	5.0	Harrington

CDC Trey	2002	CDC	11.0	16.0	0.0	Harrington

Table 4.1 Continued …….

Rivers	2003	AAFC (Bran.)	11.0	14.0	1.0	Harrington

Notes to Table:
1. ( ) denotes negative percentage.
2. The standard variety for Manitoba barley for the analysis is Robust, not Harrington.
3. The yield for hulless varieties CDC Freedom, AC Bacon, CDC McGwire and CDC Speedy is adjusted upwards by 10 percent in the analysis because hulls are left in the field. To obtain a more accurate comparison to the standard this adjustment was therefore necessary.
4. Forage barley variety AC Ranger, and food and industrial barley varieties CDC Fibar, CDC Rattan and CDC Alamo have not been included in the analysis.
5. N/A means not available.

Source: Authors' calculations based on data contained in Saskatchewan Agriculture and Food, *Varieties of Grain Crops*, various issues; Manitoba Agriculture, *Seed Manitoba: A Growers Guide*, various issues; and Alberta Agriculture, Food and Rural Development, *Varieties of Cereal and Oilseed Crops for Alberta*, various issues.

4.1.3 Estimating Non-Yield Improvements of New Varieties

Yield improvement, while generally the most important single factor determining whether or not a new variety will be successfully adopted by growers, is, nevertheless, only one of several genetic improvements resulting from wheat and barley breeding programs supported by the WGRF. Resistance to plant diseases such as net blotch, smuts, root rot, stem rust, fusarium head blight, bunt, and others are genetic traits required to support and protect the yield and quality of wheat and barley production. Rapid maturity is a genetic trait necessary to escape damage from early frosts, while increased protein levels are an important market characteristic. Resistance to shattering, lodging and sprouting avoids crop quality and quantity losses.

A detailed analysis of the value of each one of the many genetic improvements in the varieties contained in Table 4.1 would require a research effort well beyond the scope of the present study. Each type of genetic improvement creates value for wheat and barley producers in its own way. Some improvements, such as higher protein content, mean ongoing market benefits for producers, while other traits, such as disease resistance, generate value as and when disease actually threatens wheat and barley crops.

In spite of the limitations of a general overview study such as this one, it is nevertheless important in estimating returns to WGRF expenditures to attribute a value to non-yield

trait improvements. The authors have taken into account a value for these improvements while at the same time being careful not to over-estimate the value and therefore inflate the overall returns to producers' wheat and barley check-off investments. The authors have made what they believe to be reasonable but conservative estimates regarding the value of non-yield trait improvements for purposes of the study.

Based on discussions with crop production experts, review of adoption rates for varieties with non-yield genetic improvements, previous studies, and development of 'what if' scenarios, the authors adopted a *yield equivalent approach* to approximating the economic contribution varieties make with respect to improvements in non-yield traits. Each improvement in a variety's rating for a specific trait is given a one percent yield increase equivalent. Where a variety's rating is below the standard for a trait, a one percent yield decrease equivalent is given to the new variety. This analysis is based on ratings in the variety publications in each of Manitoba, Saskatchewan and Alberta.

The approach with respect to non-yield traits can be illustrated with the variety Superb. Relative to the standard HRS wheat variety AC Barrie, Superb in Saskatchewan rates lower for days to maturity (-1), protein content (-1), loose smut (-1), leaf spot (-1), and fusarium head blight (-1). Superb rates higher than AC Barrie for leaf rust (+1) and rates the same for lodging, shattering, sprouting, stem rust and bunt. Superb is assigned five (-1)'s and one (+1) for a net of four (-1)'s. As a result, Superb is given a negative four percent yield decrease. The same calculation is made based on Alberta and Manitoba data.

The results of similar calculations for all varieties are shown in Table 4.2 under the column "Other Traits". For some varieties, the yield equivalent improvement is small or even negative, while for other varieties the improvements are equivalent to a significant increase in yield. The methodology may overestimate or underestimate the value of the improvements for any specific variety.[13] For the study's purposes however, it is more important to obtain a reasonable estimate of the overall global value, in yield equivalent, of the non-yield trait improvements for all of the varieties examined than it is to accurately estimate the value of each variety trait improvement.

Having estimated the direct yield increase provided by each new variety (Table 4.1) as well as the yield equivalent of other traits, the next step is to combine the two to obtain a total yield based increase (decrease) for each new variety. The yield equivalent for non-yield traits is added to (subtracted from) the variety's direct yield improvement to get the combined impact which is reported under the column "Total Improvement" in Table 4.2. In cases where a yield equivalent reduction for a variety is so large as to essentially offset the direct yield increase, the variety does not appear in Table 4.2.[14]

[13] The methodology is not intended to provide a definitive assessment of the commercial value of traits associated with any specific variety. There may be many reasons a variety has value, including reasons unrelated to the traits mentioned in variety publications.

[14] Again, this does not mean that varieties excluded from Table 4.2 have zero commercial value. Many factors would need to be explored before drawing such a conclusion. The study values only the major breakthroughs using a broad methodological approach.

In determining the "Total Improvement" for feed barley varieties, an adjustment was made to the figures appearing in Table 4.2 in the study's rate of return model. Feed barley improvements were established relative to the standard barley variety in each province. However, the standard barley variety in each case happens to be a malting barley variety. These malting varieties are typically priced, assuming that they can be sold as malting barley, in the vicinity of 50% higher than feed barley varieties.[15] Growers who produce and sell malting barley can expect to achieve the malting barley price only about 27% of the time, reducing the effective price differential between malting and feed varieties to roughly 13.5%. This means feed varieties must yield about 13.5% above malting variety yields to overcome their price disadvantage. To take this fact into account, in comparing new feed barley varieties to the malting standard for purposes of the analysis, only the total improvement (direct yield and yield equivalent improvements) in excess of 13.5% was counted as an improvement relative to the standard malting barley variety. Hence, the figures shown under the "Total Improvement" column in Table 4.2 are not the figures actually incorporated into the model for purposes of estimating R&D returns.

Table 4.2 Yield and Other Trait Improvements in Selected Varieties Registered by Breeding Institutions in Receipt of WGRF Check-off Fund Assistance, 1998 to 2004

	% Yield Increase			*Other Traits Yield Equivalent (%)*			*Total Improvement Yield Equivalent (%)*		
	Man.	Sask.	Alta.	Man.	Sask.	Alta.	Man.	Sask.	Alta.
Hard Red Spring Wheat:									
CDC Bounty	6.0	5.0	4.0	0.0	(2.0)	0.0	6.0	3.0	4.0
Superb	6.0	7.0	10.0	1.0	(4.0)	(5.0)	7.0	3.0	5.0
Harvest*	5.0	1.0	1.0	2.0	1.0	2.0	7.0	2.0	3.0
Lovitt*	3.0	3.0	(2.0)	3.0	3.0	1.0	6.0	6.0	(1.0)
Infinity*	n/a	8.0	4.0	n/a	0.0	(1.0)	n/a	8.0	3.0
Winter Wheat:									
AC Bellatrix	(12.0)	(2.0)	4.0	1.0	(1.0)	2.0	(11.0)	(3.0)	6.0
CDC Falcon	1.0	(5.0)	(4.0)	5.0	4.0	0.0	6.0	(1.0)	(4.0)
CDC Raptor	0.0	(1.5)	(1.0)	3.0	6.0	0.0	3.0	4.5	(1.0)
Durum Wheat:									
AC Napolean	12.0	6.0	1.0	0.0	1.0	0.0	12.0	7.0	1.0
Strongfield*	n/a	12.5	2.5	n/a	0.0	3.0	n/a	12.5	5.5
Extra Strong Spring Wheat:									

[15] This price spread is based on a 10 year comparison of average CWB prices, basis Saskatoon.

AC Corrine	9.0	(4.5)	1.0	1.0	1.0	0.0	10.0	(3.5)	1.0

Table 4.2 Continued …….

AC Glenavon	8.0	(2.0)	3.0	0.0	2.0	1.0	8.0	0.0	4.0
Malting Barley:									
AC Bountiful	(6.0)	14.0	11.0	5.0	11.0	3.0	(1.0)	25.0	14.0
CDC Copeland	3.0	14.5	11.0	0.0	5.0	0.0	3.0	19.5	11.0
CDC Select	2.0	11.0	10.0	3.0	5.0	4.0	5.0	16.0	14.0
Newdale	10.0	19.5	9.0	3.0	5.0	2.0	13.0	24.5	11.0
Calder*	0.0	15.0	n/a	2.0	11.0	n/a	2.0	26.0	n/a
Feed Barley:									
CDC Freedom	(3.0)	6.5	(3.0)	3.0	6.0	3.0	0.0	12.5	0.0
AC Bacon	7.0	11.0	7.0	(1.0)	6.0	2.0	6.0	17.0	9.0
CDC McGwire	12.0	15.0	7.0	2.0	9.0	3.0	14.0	24.0	10.0
CDC Bold	8.0	18.0	11.0	(2.0)	5.0	4.0	6.0	23.0	15.0
CDC Helgason	8.0	12.0	5.0	5.0	8.0	5.0	13.0	20.0	10.0
CDC Trey*	11.0	16.0	0.0	4.0	10.0	7.0	15.0	26.0	7.0
Rivers*	11.0	14.0	1.0	9.0	12.0	4.0	20.0	26.0	5.0

( ) denotes negative percentage.
* These varieties are not included in the base case scenario of returns to WGRF check-off. They are included in scenario 2 which is presented in Appendix A.
N/A means not available.

Source: Calculations based on data in Saskatchewan Agriculture and Food, *Varieties of Grain Crops*, various issues; Manitoba Agriculture, *Seed Manitoba: A Growers Guide*, various issues; and Alberta Agriculture, Food and Rural Development, *Varieties of Cereal and Oilseeds Crops for Alberta*, various issues.

Yield Factual and Counterfactual

The factual and counterfactual yields for each crop class identified in Table 4.2 are fundamental to estimating the rate of return to WGRF check-off expenditures. The factual yields are Statistics Canada actual yields by province for years 1998 to 2004 and the Statistics Canada most recent five year average yield by province for each year of the forecast portion (2005 to 2020) of the benefits period. The counterfactual yields, which are the yields which would have existed had new varieties not been developed, are the factual yields minus the total improvement in yield (including the adjustment for non-yield traits) generated by each of the new varieties shown in Table 4.2. For example, the Saskatchewan yield counterfactual for the variety Superb, which provides a total yield improvement of three percent relative to AC Barrie:

$$= \textit{Factual Sask. Yield Minus } 0.03(\textit{Factual Sask. Yield})$$

The same calculation was made for each variety in each class by province based on the Total Improvement column in Table 4.2. The yields were then applied to an acre base to arrive at factual and counterfactual crop production figures.

4.1.4 Estimating Harvested Acres of WGRF Supported Varieties

The yield increases for new varieties increase returns to growers only on acres of the new varieties actually grown and harvested. To estimate the value to producers of the new varieties which WGRF has helped to develop therefore requires an acre estimate of each variety in Table 4.2. Since 1998, the Canadian Wheat Board has conducted an annual survey of wheat and barley varieties grown by Western Canadian producers. The survey results are used in this study to estimate the total acres grown of each new WGRF supported variety.

The reliability of the CWB survey data was tested by comparing the Saskatchewan portion of the CWB survey results to the seeded acres reported by Saskatchewan wheat and barley growers under the Saskatchewan Crop Insurance Management Plus Program. The results from the Canadian Wheat Board survey and the Saskatchewan Crop Insurance program data are remarkably similar for the varieties compared. Unless these two independent data generating processes have coincidentally produced similar yet inaccurate results, it seems reasonable to conclude that the CWB data is reliable for purposes of this study.

Varieties With Acres Reported in CWB Survey

The CWB survey is used to construct an acre base from 1998 to 2004 for varieties. The survey provides the percentage of total acres of each crop class represented by most of the varieties in Table 4.2. From this acreage base, the authors forecast the variety's acres beyond the 1998 to 2004 base by extrapolating the trend in the 1998 to 2004 period. This process is guided by the characteristics of the variety development path described in Chapter Three.

A variety whose share of total acres for its class was rising between 1998 and 2004 is assumed to rise beyond 2004, reach a peak, and then fall. Once the variety begins to fall, it is assumed to fall at an annual rate of 10 percent of its peak acres until reaching 20 percent of peak acres. The variety's acres are then kept at this 20 percent level for the remainder of the forecast period – through to 2020. This 20 percent floor reflects the variety's continuing value as part of the genetic stock from which future varieties are developed. A variety whose share of total acres for its class falls in the 1998 to 2004 period is assumed to fall post-2004 at the 10 percent annual rate mentioned above until reaching 20 percent of its 2004 acres. It remains at this 20 percent floor until 2020.

Recently Registered Varieties

Some varieties whose development has been supported by WGRF and which appear in Table 4.2 have not been released for a long enough time to establish any significant acre base. This adds uncertainty to the process of estimating and forecasting acres for the purpose of estimating the rate of return to WGRF wheat and barley check-offs. Acres of recent releases are forecast based on variety performance in field trials. A variety which performs relatively well in trials can be expected to more likely find its way into the seeding decisions of producers in future years. Again however, a conservative approach was taken by the authors in making these forecasts to avoid overestimating the impact of the varieties and hence the rate of return to WGRF investments in plant breeding.

The varieties referred to above have not however been included in the base case rate of return to WGRF check-off expenditures which is presented later in this chapter. The base case includes only varieties with at least some acreage reported in CWB survey results to date. In addition to the base case rate of return, a second rate of return is estimated which includes varieties which look promising in terms of contributing to the future returns but which as yet do not register in the CWB survey results. The varieties which are included in the second scenario but not in the base case are identified in the footnote to Table 4.2. The second scenario for rate of return is presented in Appendix A.

Figures 4.2 and 4.3 show two varieties for which acres were estimated and forecasted using CWB survey data. The HRS wheat variety Superb is shown in Figure 4.2 for the Manitoba portion of the analysis and the Malting Barley variety CDC Copeland is shown in Figure 4.3 for Saskatchewan portion of the analysis. For each of these varieties, the pattern is a rise in acre share to reach a peak, with a subsequent decline until a floor is reached at 20 % of the variety's peak acre share.

Figure 4.2 The Variety Superb: % of Manitoba HRS Acres, 1998 to 2020

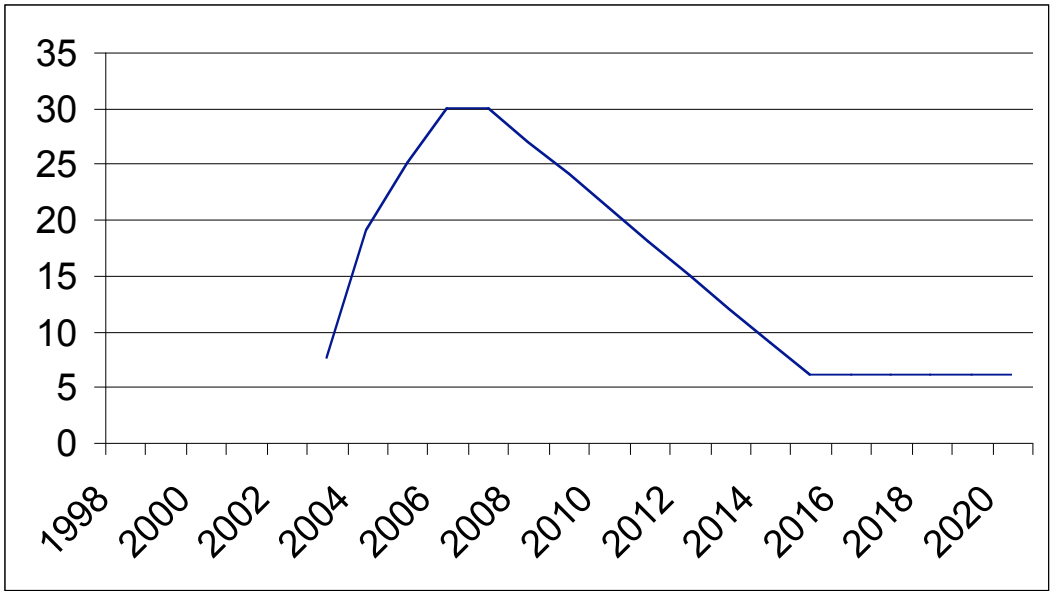
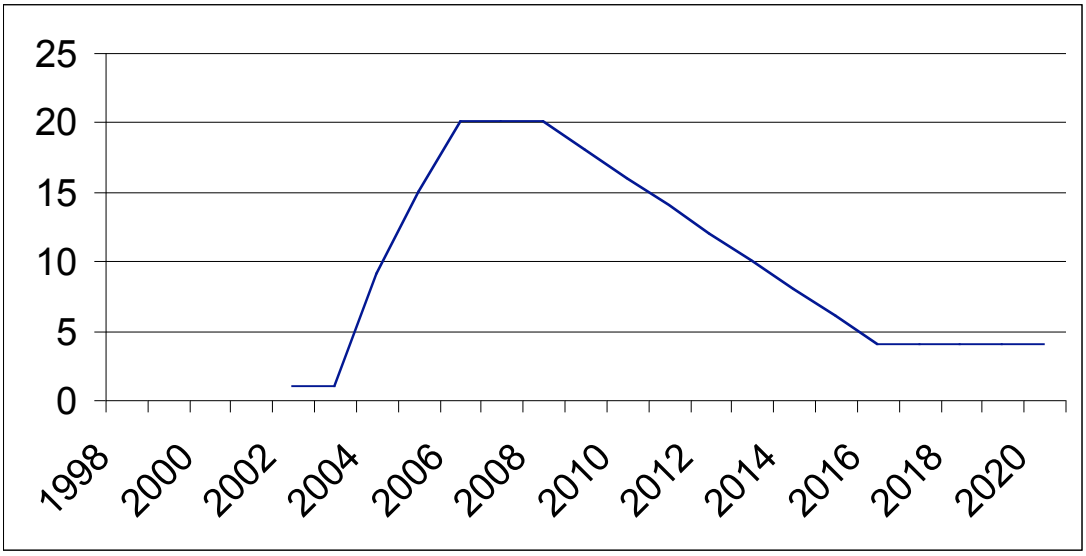


Figure 4.3: Variety CDC Copeland: % of Saskatchewan Barley Acres, 1998 to 2020



Acres of Varieties: The Factual and Counterfactual

In the factual and counterfactual analysis, the factual scenario includes the acres of the varieties mentioned in Table 4.2. These acres were in fact grown by producers in the 1998 to 2004 period or are expected to be grown in the future. For the counterfactual, the acres of the new WGRF supported varieties are essentially replaced by a variety with standard performance characteristics in each crop class, because this is what would have happened in the absence of the new varieties supported by WGRF check-offs.

4.1.5 Estimating Production and Value of Production

Based on yield and acre factuals and counterfactuals, the factual and counterfactual scenarios with respect to total production are straightforward. The production factual is the annual harvested acres for the crop class (including acres grown of new higher performing varieties) times the yield, with yield including the effect of the higher yields on acres seeded to new varieties. The production counterfactual is annual harvested acres for the crop class (with acres of new varieties substituted by acres of a standard variety) times the yield that would have existed in the absence of the new varieties (i.e., the yield of the standard variety). The factual production minus the counterfactual production is the total production impact of new varieties supported by WGRF. Again, these calculations were made for each crop class by province.

If it is assumed there are no price impacts associated with the increased production resulting from the new WGRF supported varieties, the factual and counterfactual with

respect to value of production could also easily be determined. Annual factual and counterfactual production would be multiplied by the actual market price for the relevant class of wheat and barley (based on Statistics Canada price data) and using most recent five year average prices for the forecast period. This would generate a factual value of production and a counterfactual value of production, the difference between them being the additional value of production resulting from the introduction of varieties developed with the support of WGRF. However, because increased production can be expected to have an impact on market price, there is a counterfactual price which must be estimated in addition to the factual price as per Statistics Canada price data.

4.1.6 Adjusting for Price Changes – Supply and Demand Elasticities

When wheat or barley production rises in response to the introduction of a new yield increasing cultivar, market price can be expected to experience some decline, except in the rare case where demand for a commodity is perfectly elastic with respect to price. The market demands for Western Canadian wheat and barley are not likely characterized by perfect price elasticity – hence some decline in wheat and barley prices in response to new cultivars is likely.

The magnitude of the price decline and its effect on producer surplus depends on the relative elasticities of demand and supply for wheat and for barley. Highly price *elastic* demand and highly price *inelastic* supply are conducive to producers receiving a large share of increased surplus resulting from production increases. To estimate the price effect and ultimately the increase in producer surplus resulting from new crop varieties requires an estimate of the demand and supply elasticity for Western Canadian wheat and barley. The estimates used in the study model are shown in Table 4.3 below and are taken from the Iowa State University FAPRI model which provides elasticity estimates for wheat and barley produced in Canada.

Table 4.3 Supply and Demand Elasticity, by Crop (Percentage)

Crop:	Demand Elasticity	Supply Elasticity
Wheat	10.0	0.4
Barley	10.0	0.5

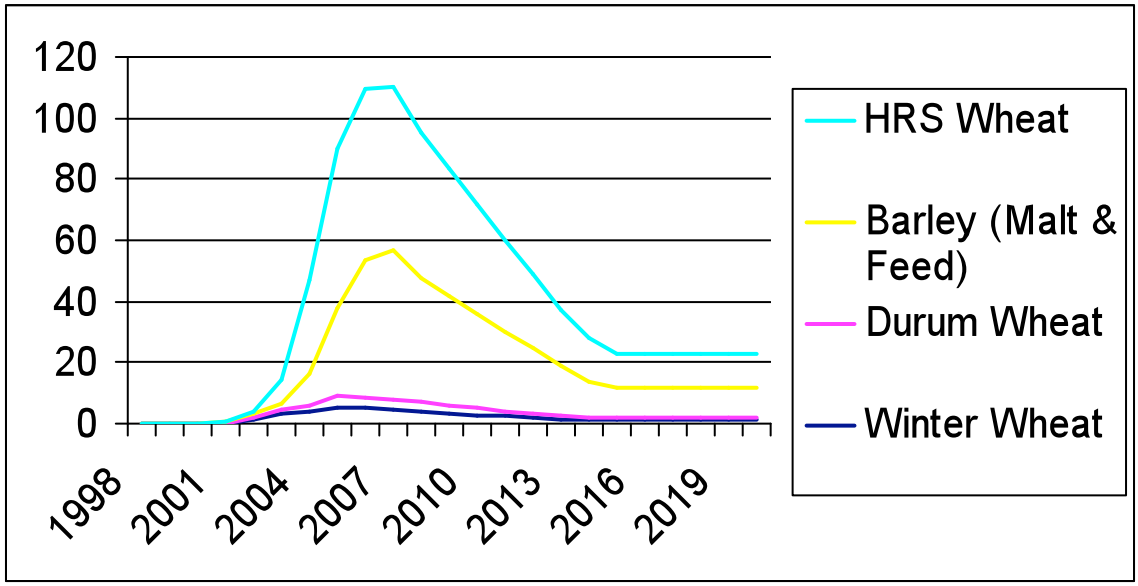
Source: Iowa State University FAPRI Model

Given the relatively small share of the world wheat and feed grain markets Western Canada represents, the price elasticity of demand is high, especially when compared to price elasticity of supply. This means a high portion of the benefits or surplus from increased production due to R&D will accrue as gains to producers. The elasticity estimates are built into the rate of return model and are used to estimate producer and total surpluses resulting from the increased production from the new varieties.

4.1.7 Producer Surplus Increase for Wheat and Barley

Applying elasticity estimates to the factual and counterfactual scenarios for production allows producer and total economic surplus to be estimated for the factual scenario (with new varieties) and for the counterfactual scenario (without new varieties). This achieves the objective as outlined in Figure 4.1 early in this chapter. The difference between the factual and counterfactual for producer surplus is the increase in producer surplus resulting from the new varieties. Figure 4.4 shows the increase in producer surplus by crop class for winter wheat, durum wheat, barley and hard red spring wheat. In Figure

Figure 4.4 Producer Surplus Increase by Crop Class Resulting From New WGRF Supported Varieties, 1998 -2020 ($ Millions)



Note: Figures prior to 2005 not adjusted for inflation and figures not adjusted for time value of money.

4.4, the increases are stacked, starting with winter wheat, then durum, then barley and finally hard red spring wheat. The total increase in producer surplus arising from new varieties in all of the classes is close to $50 million in 2004 and is expected to reach a peak of about $110 million in 2006 and 2007.

Figure 4.4 shows that the impact of the new varieties developed with the support of WGRF is just now beginning to have a significant effect on the returns to producers. This is because of the lag between the time funds begin to be invested and when those funds actually result in new varieties in farmers' fields. Figure 4.4 also shows that the effects of the new varieties gradually diminish after reaching a peak impact. This does not mean that future WGRF R&D funding efforts are expected to be less effective. The study estimates only the impact of R&D and WGRF funding which has already occurred. In other words, Figure 4.4 shows estimated increases in producer surplus which would be expected if R&D stopped at the end of 2004. This of course is unlikely to be the case. There will be R&D in the future and assuming these future R&D efforts are as effective as ones already taken, producer surplus increases will occur at levels much higher than indicated by Figure 4.4 in years leading up to 2020.[16]

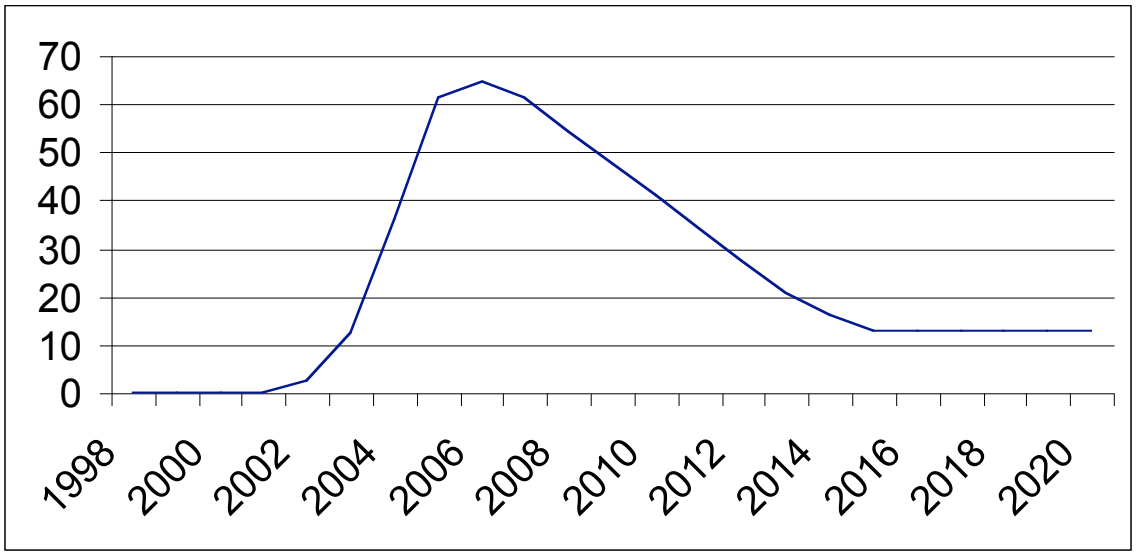
Figure 4.4 shows the largest producer surplus gains occurring in hard red spring wheat and barley. This is to be expected given the large acreage of these crops. A successful variety grown on a large acre base will naturally result in a larger total increase in producer surplus than a successful new variety for a crop with a small acre base. This however is not an argument for abandoning R&D in crop classes with small acre bases. One would need to look at such factors as the amounts of R&D invested in each crop relative to the producer surplus increases, the importance of continuing to strive for new breakthrough crop classes, the production complementarities among crop classes, and a variety of other tangible and intangible factors before reaching such a conclusion.[17]

Figure 4.5 shows the increase in producer surplus from new varieties for all wheat. This includes winter wheat, durum and hard red spring wheat from Figure 4.4. The increase in producer surplus for barley is shown in Figure 4.6, which includes both malting and feed barley varieties.

[16] It is also true that the further into the future one attempts to forecast increases in producer surplus from new varieties the greater are the uncertainties associated with the forecast. This tends toward conservatism in forecasting benefits. For example, the very recently released varieties (2002 to 2004) are likely to generate producer surplus increases but they have not been included in the base case estimation because there is no current acre data and only limited variety performance data to gauge their performance. This conservatism also helps explain the downward trend in the producer surplus increases in Figure 4.4.

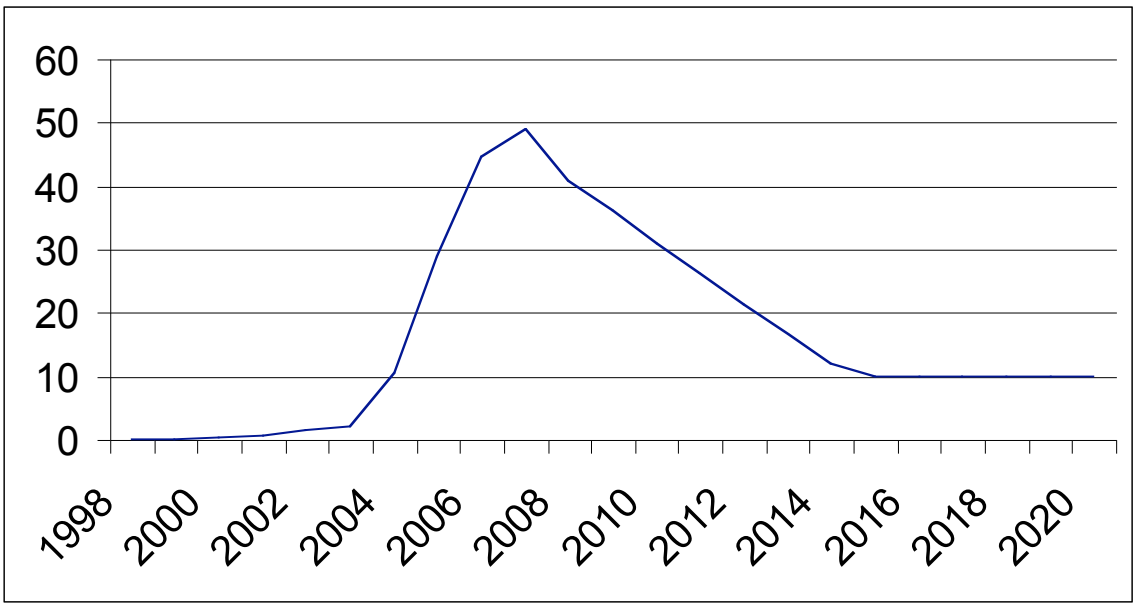
[17] It should be noted that varieties in the Canada Prairie Spring and the Canada Extra Strong wheat classes did not generate measurable benefits for the time period examined and given the particular methodology used in the study. Again, this does not mean that the breeding programs in these crop classes have failed. There are factors beyond the scope and methodology used in this study that could well point to very clear benefits from the R&D in these crop classes.

Figure 4.5 Producer Surplus Increase for Wheat Resulting From WGRF Supported Varieties, 1998 – 2020, $ Millions



Note: Figures prior to 2005 not adjusted for inflation and figures not adjusted for time value of money.

Figure 4.6 Producer Surplus Increase for Barley Resulting From WGRF Supported Varieties, 1998 -2020, $ Millions



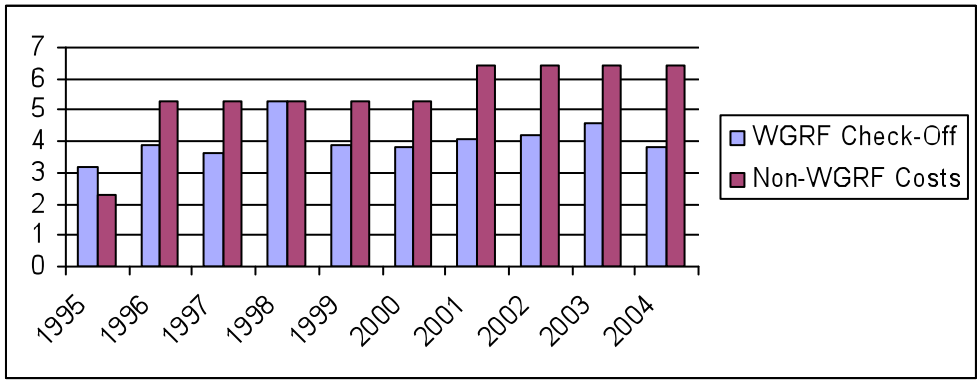
Note: Figures prior to 2005 not adjusted for inflation and figures not adjusted for time value of money.

4.2 Attributing Benefits to WGRF Check-off Expenditures

The WGRF check-off is not the only source of R&D funding for the development of the new varieties responsible for the producer surpluses identified in the previous section. There are a variety of funding sources for research centres funded by the WGRF check-offs. To estimate the rate of return to the WGRF check-off expenditures, it is necessary to estimate the dollar magnitude of the overall R&D effort for wheat and barley crop genetics R&D, estimate the percentage of the overall effort accounted for by WGRF check-off expenditures, and attribute that percentage of the increased producer surplus to the WGRF expenditures.

To establish an estimate of the overall R&D effort on wheat and barley breeding at the research centres supported by WGRF, the study first multiplies an estimated cost per scientist by the number of wheat and barley scientists employed at the research centres. In recent years there have been between an estimated 14.2 and 17.2 scientists (full time equivalent) engaged in wheat and barley breeding activities at all centres combined. At an estimated $375 thousand per scientist, this results in a cost in the range of $5.3 million to $6.5 million, depending on the year.[18] WGRF check-off funding is then added to this total to establish an estimate of the overall cost of the R&D. Figure 4.7 shows annual results generated by this methodology for wheat and barley breeding costs combined.

Figure 4.7 WGRF Check-Off and Non WGRF Costs Of Wheat and Barley Breeding Programs Combined, 1995 – 2004, ($ Millions)



Note: Costs not adjusted for inflation or time value of money.
Source: WGRF check-off from WGRF annual reports to producers.

In terms of attributing the producer surplus benefits from the new varieties generated in part as a result of WGRF check-off investments, the percentage of total WGRF and non-WGRF costs represented by WGRF for wheat and barley were calculated based on the figures shown in Figure 4.7. On a present value basis, the WGRF wheat check-off

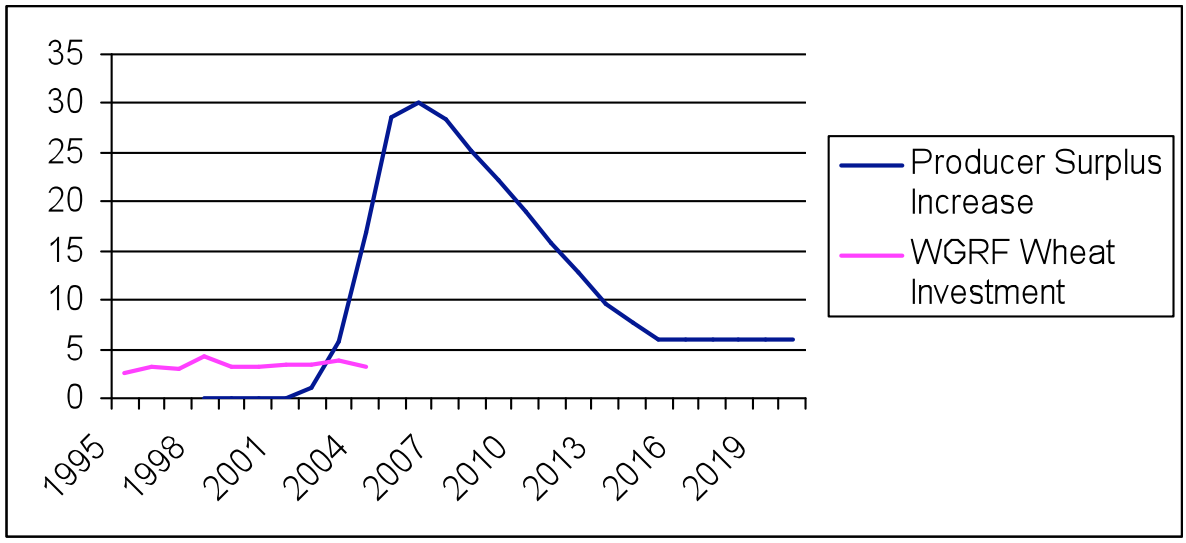
[18] The estimated annual cost of $375,000 per scientist was made based on information from research centres.

represents 46.4 percent of total wheat R&D expenditures for the 1995 to 2004 period. The WGRF barley check-off accounts for 40.0 percent of the total barley R&D expenditures. Therefore, 46.4 percent of the producer surplus benefits for wheat (shown in Figure 4.5) and 40.0 percent of the producer surplus benefits for barley (shown in Figure 4.6) are attributed to WGRF in estimating WGRF's rate of return.

4.3 The Benefit/Cost Ratio and Internal Rate of Return

Having estimated the benefits stream for the period 1998 to 2020 for wheat and barley varieties developed with WGRF support and having arrived at a percentage of the benefit stream to attribute to the WGRF check-off investments, the final step in the analysis is to compare the benefits stream attributable to WGRF investment to the WGRF check-off investment. Figure 4.8 shows the portion of the producer surplus benefits attributable to WGRF as well as the annual check-off investment by WGRF with respect to wheat.

Figure 4.8 Wheat Producer Surplus Increase Attributable to WGRF Check-off Compared to the WGRF Wheat Check-off Investment, 1995-2020, ($ Millions)

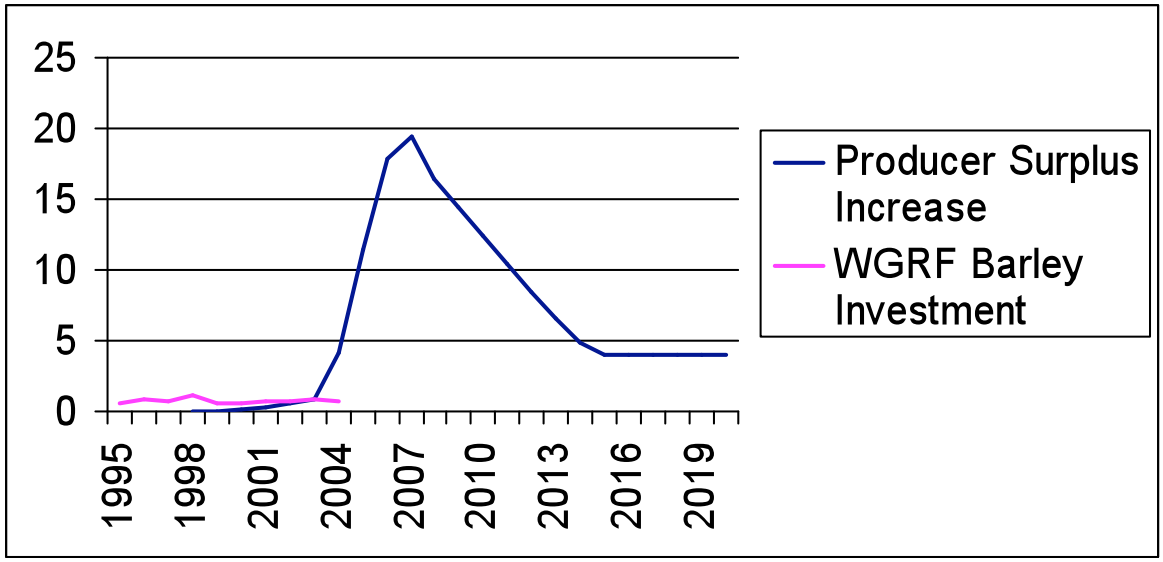


Note: Figures not adjusted for inflation or time value of money.

The producer surplus increase for Western wheat growers is considerably larger than the wheat check-off investment that brought about the increase in surplus. Annual check-off expenditures in the range of $3 to $4 million annually are expected, based on the study analysis, to bring about annual increases in producer surplus as high as $30 million. In fact, in every year of the benefits period up to 2020, the producer surplus expected to be generated by the check-off investment exceeds annual check-off cost.

Figure 4.9 shows the same comparison of annual producer surplus increase to check-off investment with respect to barley. Once again, the annual surplus increases expected to be generated in the benefits period of the study significantly exceed the annual check-off.

Figure 4.9 Barley Producer Surplus Increase Attributable to WGRF Check-off Compared to WGRF Barley Check-off Investment, 1995-2020, ($ Millions)



Note: Figures not adjusted for inflation or time value of money.

The benefit/cost ratios and internal rates of return for wheat and barley check-off investment by WGRF are calculated from the annual benefits (producer surplus) and check-off investments shown in Figures 4.8 and 4.9 for wheat and barley respectively. In each case, the benefit stream from 1998 to 2020 is being compared with costs from 1995 to 2004. To make the comparison, the benefits and costs are adjusted for inflation and the benefits and WGRF investment costs are stated in net present value (NPV) terms using a 5.0 percent real discount rate. The NPV of benefits (producer surplus) divided by the NPV of the WGRF R&D investment costs yields the estimated benefit/cost ratio. The estimated internal rate of return for both wheat and barley is also calculated. The results are shown in Table 4.4.

The return to producers reported in Table 4.4 is quite significant. The benefit/cost ratio for WGRF wheat check-off investment is 4.4 which means that every dollar of check-off generates $ 4.40 of producer surplus benefits. The internal rate of return (IRR) to producers for wheat check-off investment is 23.8 percent. For barley, the benefit/cost ratio is 12.4 while the IRR is 36.0 percent.

Table 4.4 Present Value Benefit/Cost Ratio and Internal Rate of Return for WGRF Wheat and Barley Check-off Investments, 1995-2020

	B/C Ratio	IRR (%)
Producer Surplus:		
Wheat	4.4	23.8
Barley	12.4	36.0
Total Surplus:		
Wheat	4.6	24.4
Barley	13.1	36.8

The total return, which includes the return to consumers, is also shown in Table 4.4. Because of the price elastic demand for Western Canadian wheat and barley, total surplus is only marginally higher than the surplus gained by producers, resulting in very little difference to the benefit/cost ratios and IRRs when the consumer portion of surplus is included in the estimates.

4.4 Chapter Summary

This chapter has presented the empirical analysis conducted to estimate the return to research expenditures by WGRF from wheat and barley check-offs paid by Western wheat and barley growers. This has involved estimating the benefits of R&D which WGRF has supported, attributing an appropriate portion of the benefits to the WGRF, and then comparing the benefits attributed to WGRF to the dollar value of wheat and barley check-offs. This results in the estimated benefit/cost ratios and internal rates of return to wheat and barley check-offs summarized in Table 4.4.

The next chapter provides a brief summary of the report and presents conclusions and some policy implications of the study's findings.

Chapter Five
Study Summary and Conclusions

The WGRF has collected $ 33.4 million of check-off revenue from Western Canadian wheat growers and $ 7.3 million of check-off revenue from Western Canadian barley growers since the implementation of the wheat and barley check-offs in 1993. The WGRF began investing funds in crop genetics R&D in 1995 and investments have continued up to the present time. This study has estimated the rate of return to Western Canadian wheat and barley growers as a result of the check-off funds invested by WGRF.

Based on the research conducted, some conclusions, observations and implications are presented below:

1. ***The authors estimate producer benefit/cost ratios of 4.4 for wheat and 12.4 for barley as a result of WGRF investments. In terms of percentage return on investment, the IRR for wheat check-off investment is estimated at 23.8 percent and the IRR for barley check-off investment is estimated at 36.0 percent.***

The central conclusion is that the producer return to WGRF check-off investment is substantial. Given the time lag between investment in crop genetics R&D and actual commercialization of new varieties, it is not surprising that returns are just recently beginning to register in a major way from WGRF check-off investments. Using variety performance data from crop variety trials and forecasting acres of new varieties based upon emerging trends indicated by the CWB variety survey, indicates a very healthy return to Western wheat and barley growers on their check-offs.

2. T*he estimated returns are in effect based on the performance, adoption and commercialization of varieties which have been released in the very short period between 1998 and 2001.*

Varieties registered between 1995, when WGRF began to support crop genetics R&D through the check-offs, and 1997 were not included in the base case estimation. It was concluded by the study authors that it would not be reasonable to suggest WGRF had significant responsibility for these variety releases given the lag between investment in crop genetics R&D and eventual release of new cultivars. Varieties released between 2002 and 2005 have not had time to establish an acre base and therefore have been excluded from the base case scenario.

3. ***In spite of not including them in the base case results, there have been numerous wheat and barley varieties developed with the support of WGRF check-off investments which have been released between 2002 and 2005.***

Assuming these varieties generate any significant yield or other improvements in farmers' fields and in markets, the returns indicated by the base case scenario will end up underestimating the true returns to the WGRF wheat and barley check-off investments.

Appendix A of the Report presents a second scenario of producer returns including releases in the 2002 to 2005 period. This Appendix A scenario is based on very conservative assumptions about performance of recent releases and a conservative forecast of variety adoption. If more liberal assumptions were made, such that the varieties released from 2002 to 2005 were as successful as varieties released in the four year period from 1998 to 2001, then returns to wheat and barley check-off investments would be much higher than indicated by the base case scenario presented in Table 4.4.

4) ***The bulk of the returns using the methodology employed in the study are in fact generated by a relatively small number of new varieties in a small number of crop classes.***

While it was not the objective of the study to estimate returns to specific varieties, it is apparent that the benefits are fairly concentrated among varieties. However, in using strictly variety performance data there will be benefits that are not fully captured in the analysis. For example, the market may differentiate between malting barley varieties for reasons unrelated to published performance data. This can affect price and quantities for producers. While the study methodology identifies a concentration of benefits in a few varieties, this should not necessarily be taken as a negative comment on other varieties.

5) The estimated return to barley check-off investment reflects check-off costs of Manitoba, Saskatchewan and British Columbia barley growers but reflects benefits from new varieties to all Western Canadian growers, including Alberta growers.

The return estimated for barley would be lower if benefits were estimated only for growers from provinces actually paying the WGRF check-off. However, the authors judged the benefits to Alberta growers to be important given the fact that both the R&D conducted through WGRF funding and the R&D conducted through support from the Alberta Barley Commission check-off both provide mutual benefit to all growers.

6) There could be a significant return to investing additional funds in wheat and barley genetics R&D compared with alternative investments available to producers, governments, and other R&D funding providers.

The study findings raise interesting policy questions for producers, crop breeding institutions, public funding agencies and other players interested in wheat and barley genetics. Given the estimated return to R&D in wheat and barley genetics, the question is begged as to whether there are currently sufficient resources invested in crop genetics R&D. Based on the estimated returns, investment in wheat and barley genetics has not reached the point where the marginal benefit of investing an additional dollar in R&D has diminished to a level equal to the marginal cost of R&D. This means economic surplus can be created by investing additional resources in the activity.

Appendix A:
Scenario Two Results

The following table presents the producer rate of return to wheat and barley check-off expenditures when recent variety releases (2002 to 2004) are included in the analysis along with varieties in the base case scenario reported in Table 4.4 of the Report. The recently released varieties were not included in the base scenario due to the limited performance data and lack of CWB acre data.

Only one-half of the total improvement (yield plus non-yield trait equivalent improvement) for additional varieties included in scenario two was factored into the calculation of economic improvements for scenario two. This is because of uncertainty associated with the limited variety trial information upon which to base variety performance estimates. Seeded acre forecasts for the recently released varieties were made based upon seeded acre experience of previously released varieties with similar yield and non-yield trait improvements.

For comparison purposes, results for the base case scenario are shown in brackets alongside the scenario two B/C ratios and internal rates of return in the table below.

Scenario Two: Net Present Value Benefit/Cost Ratio and IRR, WGRF Wheat and Barley Check-offs

	B/C Ratio	**IRR (%)**
Producer Surplus:		
Wheat:	6.8 (4.4)	27.5 (23.8)
Barley:	14.5 (12.4)	37.6 (36.0)

Appendix B: WGRF Check-offs and Producer Surplus Generated, 1995-2020
($ Thousands)

Year	Wheat Check-off	Producer Surplus (Wheat)	Barley Check-off	Producer Surplus (Barley)
1995	2,758		630	
1996	3,102		759	
1997	2,892		721	
1998	4,211		1,128	
1999	3,330	16	570	11
2000	3,235	14	564	79
2001	3,407	72	692	304
2002	3,545	936	706	586
2003	3,815	5,555	846	773
2004	3,119	16,451	700	4,275
2005		27,633		11,607
2006		29,942		18,066
2007		28,498		19,716
2008		25,370		18,526
2009		22,242		16,529
2010		19,114		14,533
2011		15,986		12,537
2012		12,857		10,541
2013		9,729		8,545
2014		7,719		6,686
2015		6,034		4,827
2016		6,034		4,018
2017		6,034		4,016
2018		6,034		4,014
2019		6,034		4,014
2020		6,034		4,012

Note: Figures prior to 2004 are not adjusted for inflation. Also, figures are not adjusted for the time value of money – i.e., no real discount rate has been applied to the numbers.

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