ECONOMIC ANALYSIS OF BLUEBERRY INVESTMENT IN BRITISH COLUMBIA

by

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Abstract

The objective of this thesis is to investigate reasons for boom-and-bust cycles of blueberries in British Columbia as a case study by performing financial analysis, estimating a price elasticity of blueberry supply, and simulating changes in the price and acreage of blueberries. In order to achieve the above stated objectives, three models will be constructed.

First, a business planning spreadsheet model is constructed in order to analyze the profitability of blueberry investment in British Columbia. The model studies the profitability of blueberry production with high prices during the boom period and low prices during the bust period. The results demonstrate that farmers make fairly good returns on investment during times of high prices in the blueberry boom, while the returns in the bust period can barely cover their production costs.

Second, the dynamic supply response model of Nerlove (1958) is adopted in order to estimate a reduced form supply function for blueberry producers in British Columbia. The results show that blueberry farmers had an inelastic response to price changes in the short run and a highly elastic response to price changes in the long run. These findings help to explain why the acreage of blueberries has rapidly expanded over the past decade.

Third, on the basis of the estimated price elasticities of blueberry supply, the cobweb model is used in order to simulate boom-and-bust cycles in the price and acreage of blueberries. The simulation adopts the convergent type of cobweb because the demand elasticity of blueberries is expected to be elastic. The result of simulations indicates that the more elastic the demand curve is, the quicker the price and acreage of blueberries converge to a steady state.

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Lastly, I dedicate this thesis to my parents, Xuezhen Fu and Qiyong Yang, for their support and encouragement throughout my studies in Canada.

Chapter 1: Introduction

1.1 The Boom-and-bust Cycle in British Columbia's Agriculture

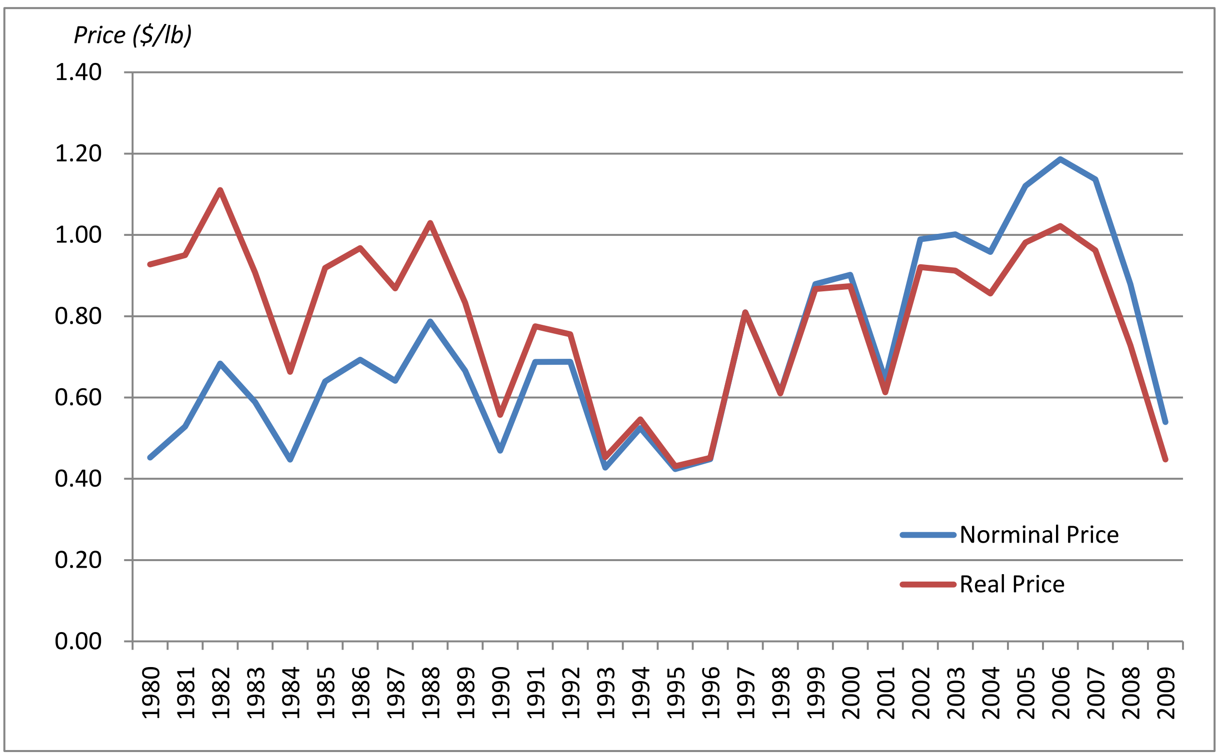
A boom-and-bust cycle often refers to a continuous surge in the price of a particular commodity, subsequently followed by a sudden fall in the commodity price due to a change in economic circumstances or the collapse of unrealistic price expectations. Usually, most economic booms are followed by busts. And it seems that the greater the boom, the greater the bust that follows. An example of a typical boom-and-bust cycle can be observed in the housing market. The significant rise and sudden decline in house prices over time has been both a national and global phenomenon. In this chapter, we will discuss three boom-and-bust problems in British Columbia (B.C.) including ginseng, fallow deer, and, most recently and importantly, the boom-and-bust cycle of the blueberry crop.

Commercial ginseng production in B.C. began in the fall of 1982 in Botanie Valley near Lytton (Ginseng Factsheet, 2003). Ginseng is an herbaceous perennial that is primarily used as medicine. It dates back at least 3,000 years in China, where ginseng still is considered the most important herb in traditional Chinese medicine. Medicinal functions of ginseng include reducing stress, enhancing blood flow, increasing physical stamina, stimulating the immune system and acting as an antioxidant (Ginseng Factsheet, 1999). Besides its high value in medical uses, it also can be consumed in forms of tea, soup, candy, capsule or tablet. Although B.C. is a latecomer to ginseng production, its interior is well suited for growing ginseng because its dry climate reduces the risk of fungal and other potential diseases. Moreover, the clean air, water and soil found in B.C. provide better growing conditions for producing high quality ginseng. With a rapidly increasing market demand both domestically and internationally, ginseng was a lucrative business for B.C. farmers (Ginseng Factsheet, 2003). This “gold rush” industry expanded very fast with over 130 growers by 1994 and with an annual production of over 2 million pounds (Associated Ginseng Growers of British Columbia (AGGBC)). However, the ginseng boom was followed by a bust. Due to oversupply not only in B.C., but also in other areas of North America, the price of ginseng fell nearly close to or even below the cost of production by 1999 (AGGBC). As a result, most growers were forced to leave the industry.

Fallow deer were introduced to B.C. in 1987 from Central Asia and Europe. They quickly gained popularity by provincial game farmers due to their low aggressiveness and their ease of handling. Fallow deer adapt very well to farming or ranching operations and are noted for their quality lean red meat with excellent taste and texture. In addition, fallow deer have low labour requirements and need less feed compared to other livestock. In response to all these attractive benefits, fallow deer production increased significantly. In 1990, most of venison sold in B.C. was imported from New Zealand. In 1996, approximately 80% of the venison market was supplied by B.C. fallow deer farmers (B.C. Ministry of Agriculture and Lands (BCMAL)). There were 74 fallow deer farms in B.C. which in Canada was the largest number of fallow deer farms (BCMAL). However, bust came soon after the fallow deer boom. With such a tremendous rise in fallow deer farming, supply grew more rapidly than demand and prices of venison started to fall. Prices bottomed out at levels below the average cost of production in 2004, causing many producers to leave the industry (Game Farms, 2004).

Blueberry is the latest industry that fell to the boom-and-bust problem. As shown in figure 1, both nominal and real prices of blueberries have been fluctuating over time however with an increasing trend overall. The nominal prices of blueberries are calculated through annual farm values divided by the annual production. The annual farm values include sales from the fresh on-farm, the wholesales and the processing. The real prices of blueberries are calculated through the nominal average prices divided by the consumer price index (chained on 1997) of British Columbia.

Figure 1: Blueberry's Nominal & Real Prices in British Columbia, 1971-2009



Source: Statistics Canada, CANSIM Table 001-0009 and Table 326-0021.

Figure 1 shows that the B.C. blueberry industry experienced a significant bust in 1995 and then the price started to rise, peaking in 2006. However, both the nominal and real prices of blueberries collapsed in 2009 after a consistent boom since late 1990's when scientists first discovered the significant health values in blueberries (Joseph, 1999). The average price (nominal) per pound of blueberries paid to farmers for overall sales historically fluctuated between $0.40 and $0.80 until 1999. In 2006 the average price soared up to $1.19 per pound; then it fell to $0.88 per pound in 2008 and to approximately $0.60 in 2009. The blueberry boom was mainly due to the scientific discovery of substantial health benefits of blueberries, especially the discovery of its high content of antioxidants. Nevertheless, the consistently growing expansion of blueberry's acreage planted in Canada, the United States and other countries led to the bust both in B.C. and international blueberry industry due to oversupply.

1.2 Problem Statement

Agricultural farmers face two critical issues each year. The first issue is the problem of determining how intensively they should farm existing acreage. The second issue is the problem of determining how many new acres they should plant. A rise in the expected price of a particular crop would encourage farmers to farm more intensively and/or extensively. With the existing boom-and-bust problems in agriculture, however, farmers have to take a second thought when making decisions on investing in new crops or expanding the acreage of existing crops. The boom-and-bust problem thus forces farmers to face the problem of deciding how to respond to an increase in the price or other economic incentives of a particular crop when making a new investment.

The blueberry boom has initially been positive for the local farmers, although the price paid to farmers recently crashed due to over production. At present, there exist no econometric studies of the supply response for the B.C. blueberry industry. Supply response of commodities is critical to policy analysis and the price of agricultural products is one of the key factors that determine production of agricultural commodities and farmer's income. It is important that the price responsiveness of blueberry farmers be known in order to determine the impact of relevant policies on farmer's income and other agricultural issues. Apart from the importance of estimating a price elasticity of supply for blueberries, it is critical for farmers to know the existence and mechanism of boom-and-bust cycles in the blueberry industry.

1.3 Research Objectives

In this study, the first objective is to elaborate on the boom-and-bust cycles in the B.C. blueberry industry and to construct a farm level business planning model for investing in blueberry production. This study will conduct break even analysis, net present value analysis, leverage and tax analysis and sensitivity analysis, in order to modify or update new information related to enterprise budgets of blueberry investment, developed by British Columbia Ministry of Agriculture and Lands (BCMAL).

The second objective is to construct a supply model that focuses on price expectations. The study will estimate supply response in the B.C. blueberry industry. A structural approach developed by Marc Nerlove (1958) will be applied to derive a reduced form supply function for the B.C. blueberry farmers. The study covers the period 1988-2009 due to the data deficiency of blueberry acreage. In the past there has been controversy as to whether or not farmers in traditional agricultural activities react to prices and other economic incentives. The results of the econometric model will be applied as a tool for examining this controversy.

The third objective is to use the derived price elasticity of blueberry supply and apply it to simulate B.C. blueberry's boom-and-bust cycles by analyzing a cobweb model. A simulation model of blueberry price and acreage will be used to show boom-and-bust cycles diagrammatically. The simulation will also predict where the industry is most likely to trend in the coming years. Moreover, the simulation will show the sensitivity of fluctuations to elasticities of supply and demand.

Achieving the above presented research objectives will provide a clearer picture of the boom-and-bust cycles in the B.C. blueberry industry. Furthermore, the research results will provide information and knowledge that are directly beneficial for the B.C. blueberry farmers. In addition, the analytic framework of this thesis could be applied to case studies of boom-and-bust problems in other industries.

1.4 Thesis Outline

The thesis is organized into six chapters. Chapter 2 describes the boom-and-bust problems in blueberries, which consists of an industry overview of blueberries in B.C., blueberry's production and sales, health benefits and industry support for blueberries, as well as challenges and trends. Chapter 3 presents a spreadsheet model developed for blueberry investment in British Columbia. In the same chapter, a series of financial analyses, including break-even analysis, net present value analysis, and leverage and tax analysis, will be constructed. Chapter 4 presents a literature review on theory of supply response model as applied to blueberries, and then develops the supply response model for the B.C. blueberry industry. In the same chapter, the data used in the model and the empirical results of the blueberry supply analysis will also be discussed. In chapter 5, a cobweb model is constructed in order to simulate changes in the price and acreage of blueberries in B.C. from the current period to 30 periods in the future. The empirical results of the simulation will also be discussed. The final chapter presents a summary, conclusion and recommendations for the future study.

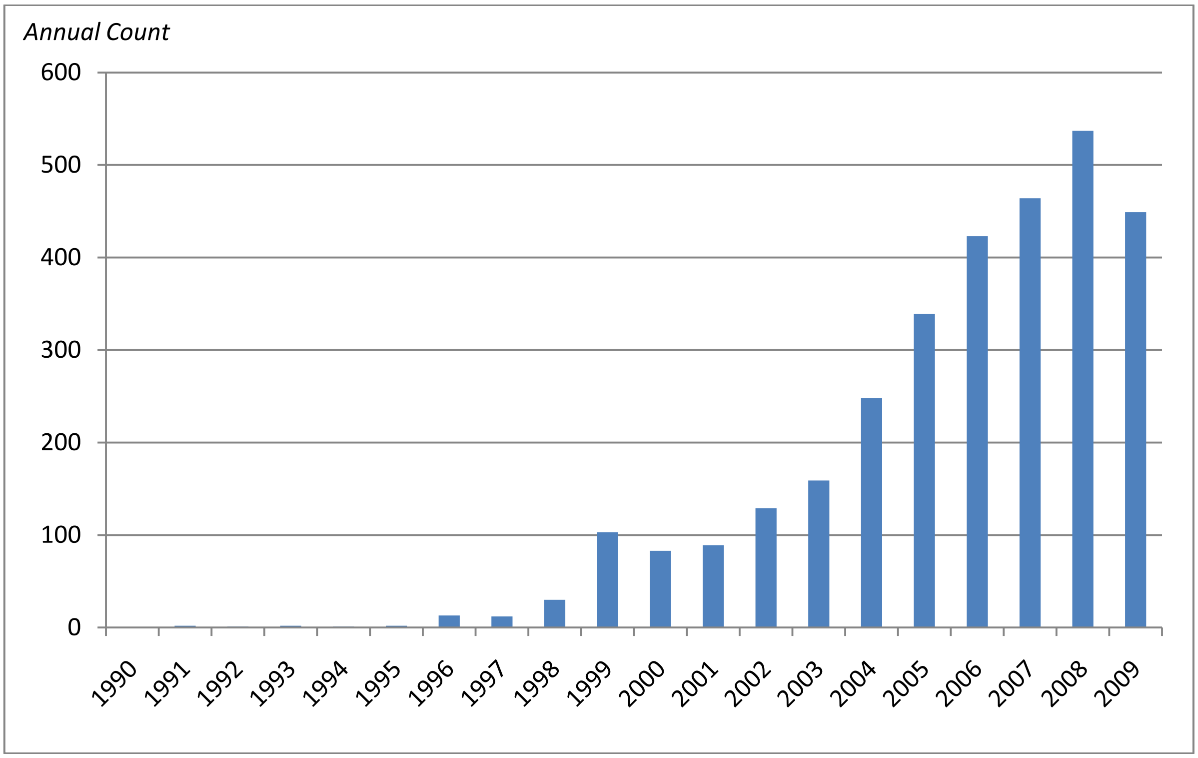
Chapter 2: Blueberry Boom-and-bust Cycle

2.1 Overview of Blueberry Industry in British Columbia

Blueberries (highbush blueberries) were first planted in B.C. in the early 1920's by the Johnston brothers who brought its seedlings from Nova Scotia. In order to expand the blueberry market, growers began to import named varieties from New Jersey during the 1930's (B.C. Blueberry Council). At present, B.C. is the largest producer of cultivated blueberries in Canada and the second largest in the world (after Michigan in the United States). The province accounts for approximately 95% of Canadian highbush blueberry production. Around 99% blueberries and 95% of berries in B.C. are produced in the Lower Fraser Valley (BCMAL). The remaining berries are produced in Vancouver Island and the Interior. By 2003, there were approximately 450 blueberry farms in B.C., their acreage ranging from just a few acres to over 300 acres. Approximately 70% of the farms in 2003 were smaller than 20 acres, and roughly 50% of the total acreage was held by 30 blueberry farmers who farmed at a relatively large scale (Blueberry Factsheet 2003, BCMAFF).

The blueberry boom in B.C. began when scientists discovered that the antioxidants content of blueberries have a possible health benefit of preventing cancer and natural progressing of cell damage that leads to aging. The first scientific study of antioxidants in blueberries was published in the September 1999 issue of the Journal of Neuroscience (Joseph, 1999). The study suggested that blueberries have the highest content of antioxidants among antioxidant-rich fruits and vegetables. The research team of this study led by James Joseph of the United States Department of Agriculture's Human Nutrition Research Center on Aging declared blueberries to be one of the world's most healthful foods. The media took notice and started to publish numerous reports attributing wide-ranging health benefits to blueberries.

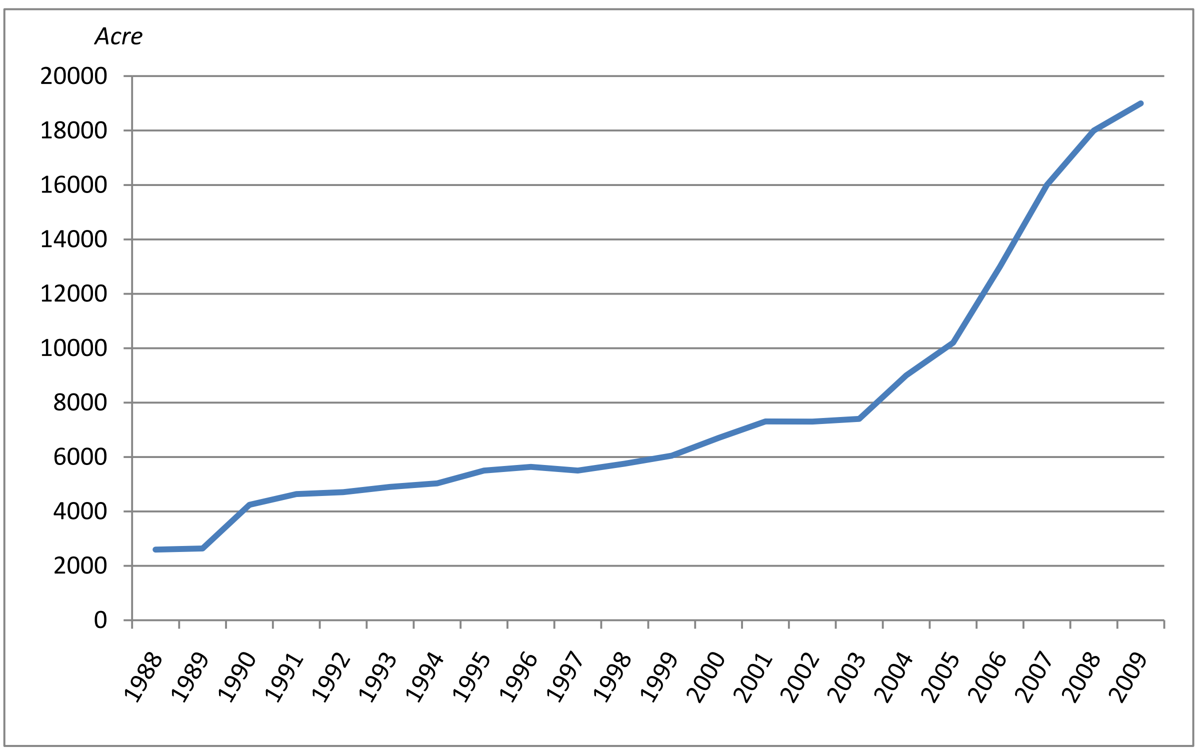
Figure 2: Appearances of "blueberry and antioxidant" in World Newspapers and News Wire Services, 1990-2009



Source: Lexis-Nexis.
Note: Data cover January 1st to December 31st for each year.

Figure 2 shows a yearly count since 1990 of stories incorporating the words "blueberry and antioxidant" in major newspapers, newswires and press releases in the English language around the world. The data is obtained from Lexis-Nexis. The notion of "blueberry and antioxidant" had virtually no currency until 1999 when scientists proclaimed the substantial health benefits in blueberries. However, the usage of this term was fairly steady until 2003 and suddenly took off in 2004, peaking in 2008. In response to such a massive inflow of public news connecting blueberries and antioxidants, the consumer demand for blueberries grew rapidly and the price increased significantly. Farmers then responded by increasing blueberry production at a much higher level. In fact, the statistical data of planted acreage of blueberries in B.C. matches up to the above argument. As seen in figure 3, planted acreage of blueberries in B.C. expanded at a steady rate from 1988 through 2003, notably, the acreage increased at a much higher rate after 2003 when the media began rapidly increased reporting stories of "blueberry and antioxidant".

Figure 3: Blueberry's Planted Acreage in British Columbia, 1988-2009



Source: Statistics Canada, Catalogue 22-003.

Board director of British Columbia Blueberry Council (BCBC), Mark Sweeney, pointed out that: "we are now swimming in blueberries." In response to the increasing price of blueberries and expectation of larger demand for blueberries in the future, ranches were ploughed up, less lucrative crops were uprooted, and farmers eventually shifted their focus on producing only blueberries (B.C. Blueberry Council). This occurred not only in North America, but also countries from China to Chile. However, the price of blueberries crashed in 2009 due to over production and the blueberry boom fell into a bust.

2.2 Blueberry Production and Sales

Blueberry is a long-term crop. A blueberry plant can eventually grow up to 2 to 2.5 meters tall and can live up to 50 years. Blueberries are harvested 3 years after plantation. However, blueberries cannot reach peak production for 6 or more years. Well-drained and acidic soil is required for high yields in blueberry production. Drainage and irrigation systems for raising planting beds and sawdust mulches are used in order to optimize ideal growing conditions. In order to effectively facilitate blueberry pollination, it is important to bring honey bee colonies into the blueberry fields during the blossom period. Blueberries are harvested either by hand or by machinery. The dominant harvesting method is hand-picking, which is very labour intensive. On the other hand, blueberries harvested by machine often gets damaged, thus machinery harvest used to be practiced mainly for processing berries. Nowadays, machines are being updated in order to pick fresh berries without damaging them. However, this new machinery reduces the shelf-life of harvested blueberries. Instead of the two-week shelf life of hand-picked berries, the machine picked berries' shelf life may be reduced to approximately one week. Thus, machine-harvested berries have to be consumed immediately. Major blueberry operating costs are labour and inputs including fertilizers, pesticides, sawdust mulches, and repairment and maintenance of machinery. Labour costs vary according to hand or machine harvest. Often, berry farmers tend to choose hand-picked harvesting in order to achieve a higher overall level of profit. A detailed analysis of blueberry farm's operating costs will be discussed in chapter 3.

B.C. blueberry sales are not regulated by marketing boards. Most blueberries are sold in the processing sector. However, in order to gain a higher return, many growers prefer to sell their berries directly to consumers through farm stands, roadside sales, farmer's markets, and U-picks. The percentage of blueberries sold in the fresh market has increased sharply due to the rapid growth of consumer demand for fresh fruits. Over 50% of B.C. blueberries have been sold to fresh markets in the past few years, while less than 30% has been sold fresh in the early 1990's (Blueberry Factsheet 2003, BCMAFF). The remaining percentage of blueberries has been sold in the processing sector. For instance, frozen blueberries have been used in numerous value-added products including jams, bakery, dairy, juice, yogurts and beverage products.

Blueberry prices have been volatile over time. Hence, farmers were required to plan for significant fluctuations in returns. The Canadian Agricultural Income Stabilization (CAIS) was developed to help farmers withstand this difficulty. The CAIS offers farmers protection from income losses caused by volatile product prices and weather. The prices of blueberries are primarily determined by the supply of highbush (cultivated) and lowbush (wild) blueberries throughout North America. Notably, berry supply from Michigan has a key influence on the international market price since it accounts for a relatively large international production of highbush blueberries. Most of B.C. fresh and processed blueberries are exported out of the province and are sold in foreign markets, such as the United States, Japan, Europe (mainly Germany), and Australia. In 2003, B.C.'s exports to the United State accounted for approximately 70% of fresh blueberries and over 90% of frozen blueberries imported to the United States (Blueberry Factsheet 2003, BCMAFF).

2.3 Health Benefits and Industry Support

Nowadays, consumers are becoming increasingly aware of the health value of food and beverage products. As part of this trend, more and more consumers are starting to appreciate the health and nutritional values of blueberries. Blueberries are highly rich in vitamins A and C, minerals, dietary fiber and very low in fat and sodium. Most importantly, research finds out that the substantial antioxidant content in blueberries can reduce risk of cancer, heart disease, diabetes and the natural progression of cell damage that leads to disease and aging (The Epoch Times, 2009). Moreover, other research suggests that blueberries may also be beneficial for eyesight and memory. In the late 1990's, when those health benefits of blueberries were discovered, the production and demand for blueberries exploded. Before that, blueberries were just an ordinary berry for pie (B.C. Blueberry Council).

Numerous organizations support the blueberry industry. Firstly, the B.C. Blueberry Council, a non-profit organization that conducts promotional activities, funds research projects, sponsors grower education programs, and provides other forms of aid in solving other issues that impact B.C. blueberry producers. The organization is funded by a grower levy collected from packers and processors. Secondly, the North American Blueberry Council, a non-profit association which represents highbush blueberry producers and marketers in Canada and the United States, encourages seasonal blueberry use by attracting new blueberry users and promoting new blueberry products. Thirdly, the B.C. Agriculture Council supports the blueberry industry by providing leadership in representing, promoting and advocating the collective interests of all agricultural producers in the province.

2.4 Challenges and Trends

The blueberry boom is expected primarily due to the emerging realization of blueberry health benefits by consumers. However, despite this positive trend and current bust in the blueberry industry, B.C. blueberry farmers face challenges such as the acute shortage of field labour, rapid expansion of acreage producing blueberries, and intense competition with eastern Canada and several regions in the United States. As many young blueberry plants reach full production in the next few years, there will be a greater increase in blueberry supplies, such increase most likely will lead to a further decline in blueberry prices. Besides the competition from eastern Canada and the United States, many other blueberry growing regions, such as China, Chile, Eastern Europe, are becoming significant blueberry producers which may have an impact on the international market. Apart from the domestic and international market competition, bird and pest control is a big concern of B.C. blueberry growers. In some cases, birds and pests can ruin up to 50% of the blueberries produced in an individual farm (small size) and thus substantial control efforts and costs are required in order to prevent such damages.

Although the B.C. blueberry industry is facing numerous challenges, consumer demands for blueberries are increasing both domestically and internationally (B.C. Blueberry Council). In order to successfully respond to this rapidly expanding demand, producers are required to develop strategies that would increase and maintain the seasonal workforce. One of the goals of B.C. Blueberry Council is to introduce blueberries to the large Chinese community. Meanwhile, there also exists an ongoing current of innovative value-added product development by chefs and processors such as blueberry bakery, blueberry beverage and blueberry flavoured wine.

Chapter 3: Blueberry Farm-level Business Planning Model

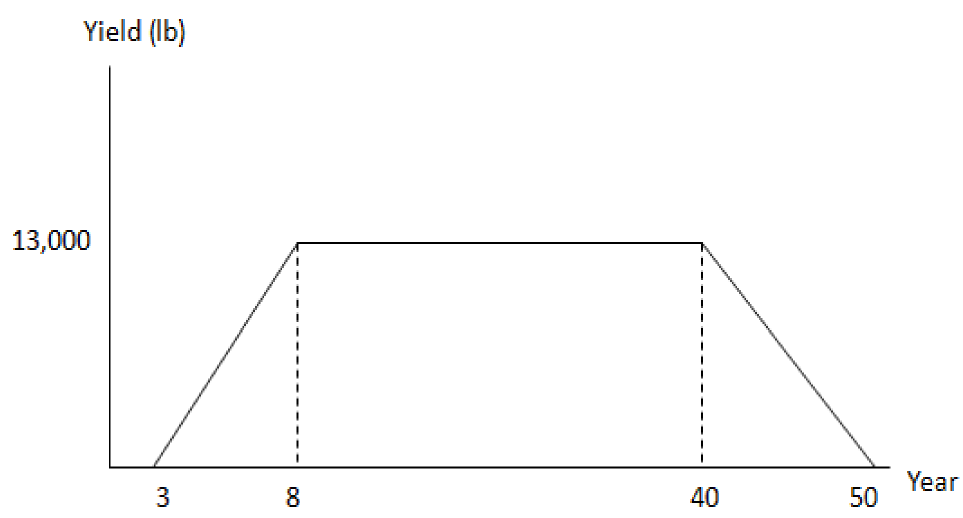
3.1 Spreadsheet Model

The Planning for Profit Enterprise Budget Series published by the B.C. Ministry of Agriculture and Lands (BCMAL) has been developed to encourage and facilitate B.C. farmers to create enterprise budgets for projecting costs and profits, specifically to their own farm operations. These budgets have been used as a general guide for farm financial planning purposes. The Enterprise Budget Series mainly consists of the following sections: Market Price Analysis, Required Capital Investment, Production Plan, Indirect Costs, Labour Cost, Gross Margin Analysis and Sensitivity Analysis. In this chapter, we will develop a more comprehensive series of blueberry enterprise budgets with a period of 40 year's production cycle. In order to do so, relevant financial analyses will be conducted.

In 2007 the BCMAL constructed an enterprise budget for a 40-acre blueberry farm from establishment to full production in Fraser Valley. In 2008 a similar enterprise budget was developed by the BCMAL for 5-acre mixed berry operations on Vancouver Island including blueberry, strawberry, raspberry and blackberry. Both budgets didn't include land costs and depreciation expenses, while prices of inputs required for blueberry production had similar values across these two areas. The BCMAL Enterprise Budget Series hasn't built a complete net farm income spreadsheet model considering depreciation expenses, fixed costs, interest expenses and income taxes. Thus, a more comprehensive spreadsheet model of annual net farm income for a blueberry farm is constructed in this chapter. Most information used in the model is taken from the two enterprise budgets that were referred to earlier. However, some adjustments and new information are added to the spreadsheet model in order to obtain a more complete picture of the farm's financial situation. For instance, depreciation expense is included in the spreadsheet model, and interest and income payments associated with different levels of debts leveraged will be taken into account during the financial analysis.

A 5-acre blueberry farm is projected in this spreadsheet model. Following the "Five Acre Mixed Berry Operation" generated by BCMAL, $102,200 is the required capital investment and $300,000 ($60,000 per acre) is the budgeted land cost for the 5-acre blueberry farm that is modeled in this study. A modest annual yield of blueberries (Fraser Valley) at full production equal to 13,000 pounds per acre is used throughout the analysis. In this spreadsheet model, as shown in figure 4, production of blueberries is assumed to begin in year 3, and production is assumed to gradually reach a peak in year 8 and then remain constant until year 40.

Figure 4: Blueberry's Projected Yield Curve



The study also assumes that all the production expenses such as fertilizers, pesticides, and labour costs will remain equal to 2008's values. In order to compare the profitability of blueberry investment between the boom and bust periods, as presented in table 1, high and low prices of blueberries sold to different markets are assumed throughout the following spreadsheet models. Here, for the sake of simplicity, the percentages of blueberry sales to target markets are assumed to be fixed.

Table 1: Projected Blueberry's Prices and Percentage of Sales

Target Markets	% of annual sales	Prices in Boom ($/pound)	Prices in Bust ($/pound)
Fresh Farm Gate	5%	2.50	2.00
Fresh Wholesale	70%	2.00	1.50
Processing	25%	1.20	0.60

Source: British Columbia Annual Horticultural Statistics.

Sensitivity analysis of blueberry prices will be considered in the section of financial analysis. With all the information and assumptions stated above, a spreadsheet model can now be constructed for blueberry investment over a 40-year period, which is roughly the life cycle of a blueberry farm. Tables 2 and 3 in the following pages present the projected annual net farm income over 40 years with high prices as the boom scenario and low prices as the bust scenario, respectively. The projected annual net farm income does not take interest payment, income tax, investor's opportunity cost of land, and return to management (investor's time) into account. As indicated above, interest and income tax payments will be taken into account for the financial analysis.

Table 2: Projected Blueberry's 40-year Annual Net Farm Income per Acre – The Boom Scenario

5 Acre Bluebrry Farm	Propagation		Hand Harvested							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 to 40
Yield(lbs/acre)	0	0	4,000	7,000	10,000	11,000	12,000	13,000	13,000	Present Value
Fresh Farmgate	0	0	500	875	1,125	1,375	1,500	1,625	1,625	
Fresh Wholesale	0	0	5,600	9,800	12,600	15,400	16,800	18,200	18,200	
Processing	0	0	1,200	2,100	2,700	3,300	3,600	3,900	3,900	
Total Revenue	**0**	**0**	**7,300**	**12,775**	**16,425**	**20,075**	**21,900**	**23,725**	**23,725**	
Production Cost[2]	7,982	1,036	2,537	2,286	1,773	2,023	2,037	2,051	2,051	
Labour Cost[3]	1,046	307	3,281	5,416	7,508	6,518	7,031	7,543	7,543	
Total Variable Cost	**9,028**	**1,343**	**5,818**	**7,702**	**9,281**	**8,541**	**9,068**	**9,594**	**9,594**	
Gross Margin[4]	*(9,028)*	*(1,343)*	*1,482*	*5,073*	*7,144*	*11,534*	*12,832*	*14,131*	*14,131*	
Fixed Cost[5]	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	
Depreciation Expense[6]	503	503	503	503	503	503	503	503	503	
Net Farm Income[7]	**(12,851)**	**(5,166)**	**(2,341)**	**1,250**	**3,321**	**7,711**	**9,009**	**10,308**	**10,308**	**160,724**

Note:

1. All the revenues, expenses, costs and income in the above table are calculated on a per-acre basis.
2. The production cost consists of fertilizers, pesticides, fuel, irrigation, machinery repairment & maintenance and other associated expenses.
3. Labour cost includes production labour, machine labour and labour for hand harvest (the primary labour after year 2).
4. Gross Margin = Total Revenue – Production Cost – Labour Cost.
5. Fixed cost includes utilities, property tax & insurance, banking and accounting, office supplies, telephone and postage, small tools and other supplies.
6. Depreciation expense is calculated as **10%** of the remaining value of required capital investment ($102,000). The annual depreciation expense in the table above is calculated by spreading the total depreciation expense over **40** years and then allocating it on a per-acre basis.
7. Net Farm Income = Gross Margin – Fixed Cost – Depreciation Expense. The net farm income is **before** tax, interest expense, returns to land (opportunity cost) and owner's time of management (annual salary).
8. **160,724** is the total net farm income accounting the present value of year 10 to 40 at the period of 10. The discounted rate used to calculate the present value is **5%** (a general opportunity cost in the financial analysis).

Table 3: Projected Blueberry's 40-year Annual Net Farm Income per Acre – The Bust Scenario

5 Acre Bluebrry Farm	Propagation		Hand Harvested							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 to 40
Yield(lbs/acre)	0	0	4,000	7,000	10,000	11,000	12,000	13,000	13,000	Present Value
Fresh Farmgate	0	0	400	700	1,000	1,100	1,200	1,300	1,300	
Fresh Wholesale	0	0	4,200	7,350	10,500	11,550	12,600	13,650	13,650	
Processing	0	0	600	1,050	1,500	1,650	1,800	1,950	1,950	
Total Revenue	**0**	**0**	**5,200**	**9,100**	**13,000**	**14,300**	**15,600**	**16,900**	**16,900**	
Production Cost[2]	7,982	1,036	2,537	2,286	1,773	2,023	2,037	2,051	2,051	
Labour Cost[3]	1,046	307	3,281	5,416	7,508	6,518	7,031	7,543	7,543	
Total Variable Cost	**9,028**	**1,343**	**5,818**	**7,702**	**9,281**	**8,541**	**9,068**	**9,594**	**9,594**	
Gross Margin[4]	*(9,028)*	*(1,343)*	*(618)*	*1,398*	*3,719*	*5,759*	*6,532*	*7,306*	*7,306*	
Fixed Cost[5]	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	
Depreciation Expense[6]	503	503	503	503	503	503	503	503	503	
Net Farm Income[7]	**(12,851)**	**(5,166)**	**(4,441)**	**(2,425)**	**(104)**	**1,936**	**2,709**	**3,483**	**3,483**	**54,303**

Note: The financial definitions of variables with subscripted numbers in the above table are the same with table 2.

As table 2 shows, the annual net farm income for blueberries during the boom period grows rapidly after the first three years of negative income. Specifically, the annual net farm income reaches $10,300 per acre at full production. On the other hand, table 3 presents a rather different stream of net farm income due to low prices of blueberries during the bust period. The annual net farm income starts to be positive after year 6 however the income is as low as $3,483 per acre even during the full production. Both tables show that it costs approximately $18,000 per acre in order to establish the 5-acre blueberry farming operation before harvesting in year 3. It takes approximately 7 years to cover all negative income and to gain positive income during the boom period, whereas during the bust period it takes at least 13 years to break even when accounting for the previous negative flows of income.

Apart from comparing annual net farm income between scenarios of boom and bust, the 5-acre blueberry farm's operating costs on a per-pound basis is projected in order to analyze the cost structure of blueberry operation. The numbers and information used to calculate the operating costs in the following table are from the "Five Acre Mixed Berry Operation" of BCMAL in 2008.

Table 4: Projected Blueberry's Operating Costs per Pound

Item/Production Year	Year 3	Year 4	Year 5	Year 6	Year 7	Full Production
Production Cost	$0.63	$0.33	$0.18	$0.18	$0.17	$0.16
Labour Cost	**$0.82**	**$0.77**	**$0.75**	**$0.59**	**$0.59**	**$0.58**
Total Variable Cost	$1.45	$1.10	$0.93	$0.78	$0.76	$0.74
Fixed Cost	$0.83	$0.47	$0.33	$0.30	$0.28	$0.26
Total Operating Cost	**$2.28**	**$1.57**	**$1.26**	**$1.08**	**$1.03**	**$0.99**
% of Labour in Total Cost	35.91%	49.14%	59.58%	54.95%	56.76%	58.41%

Note: Blueberry's yield reaches full production after year 7.

In table 4, the operating costs of blueberries on a per-acre basis decrease as yields increase. During full production, it costs $0.99 to produce each pound of blueberries in B.C.. Here, most notably, labour cost accounts for $0.58 per pound, which is nearly 60% of the total operating cost. The high labour cost in producing blueberries is primarily related to the intensive labour involved in hand-picked harvesting. In addition, a shortage in seasonal field workers and the rising wage rates further increase the labour cost for blueberry farming (Blueberry Factsheet, 2003). This lines up with the fact that over 95% of B.C. farms (BCMAL, 2009) are operated by families, many of which are not able to afford the high labour costs. Furthermore, during the bust period, typically, one or more members of a typical blueberry farm family will work off-farm in order to supplement the family's income stream. Furthermore, blueberry farming is a long term investment. Hence it is difficult for farmers to shift to the production to a more profitable crop in a short time. This is because farmers are committed to the high land cost and large capital investment in their production of blueberries.

Tables 2, 3 and 4 do not include the interest and income tax payments. Moreover, the investor's opportunity cost should be considered when evaluating the profitability of a business investment. Therefore, in order to further investigate the profitability of blueberry investment in B.C., a series of financial analysis is conducted in the following section, including break-even analysis, net present value analysis and leverage and tax analysis.

3.2 Financial Analysis

In table 5, a series of financial terms and formulas are defined in order to better perform the financial analysis. The net farm income is already defined in tables 2 and 3, however the time value of money (discount rate) was not taken into account. Thus, net present value will be used to analyze the profitability of blueberry investment considering discount rates. In order to show farmer's annual income in present value, the equivalent annualized net farm income is used. This annualized income measures the equivalent net farm income per year over the blueberry farm's entre lifespan taking the owner's opportunity cost into account. As presented in table 5, the equivalent annualized net farm income is calculated through the net present value of all annual net farm income in the future 40 years divided by an annuity factor of the present value.

Table 5: Definitions of Financial Terms and Formulas

Financial Term	Definition and Formula
Net Farm Income (NFI)	Total Revenue – Total Variable Cost – Fixed Cost – Depreciation Expense
Net Present Value	$\sum_{t=1}^{N} \frac{NFI_t}{(1+r)^t}$
Annuity Factor	$\frac{1-\frac{1}{(1+r)^t}}{r}$
Equivalent Annualized Net Farm Income	$\frac{\text{Net Present Value}}{\text{Annuity Factor}}$
Total Assets	The Required Capital Investment + Land Value
Return on Assets (ROA)	$\frac{\text{Equivalent Annualized NFI}}{\text{Total Assets}}$
Interest Expense	Debt* Interest Rate
Income Tax	Equivalent Annualized NFI * Tax Rate
Owner's Equity	Total Assets – Total Debt
Return on Equity (ROE)	$\frac{\text{Equivalent Annualized NFI} - \text{Interest Expense} - \text{Income Tax}}{\text{Owner's Equity}}$

Note: r is the discount rate and t is the time period of the net farm income flow.

Return on assets (ROA) is a key financial indicator which measures the company's ability to generate profits before leverage (with its own assets) and it is used for comparing performance of companies in the same industry. Generally, the higher the ratio is, the more effective the company is in utilizing its assets. In table 5, the net farm income in the formula of computing return on assets is before interest and tax payments. The total assets budgeted for the 5-acre blueberry farm is fixed and hence the ROA is not affected by the level of leverage. In contrast, return on equity (ROE) is mostly determined by the amount of purchased debt and its interest rate. This ratio is calculated through the net farm income after interest and tax expenses divided by the owner's equity. ROE is also an important financial indicator which measures how efficient the company is in generating profits from the owner's equity. The relationship between ROA and ROE will be further discussed in the section of leverage and tax analysis.

Farmers can either buy or rent the farmland, which means that the growth of land value will influence their decisions on investment according to the financial indicators such as ROA and ROE. Specifically, a rise in land value will increase the denominator of both ROA and ROE and thereby will decrease both ratios. However, for the sake of simplicity, in this study we assume that the rate of growth in land value over time is zero.

3.2.1 Break-even Analysis

Break-even analysis is identified to be a simple and straightforward way of performing financial analysis. It is an essential decision making tool which shows us what price per unit must be set, or how many units of a product must be sold, in order to cover the total cost of producing this product. The firm starts to generate profits only after cross the break-even point. Break-even point is a point where the total revenue equals to the total cost associated with the sale of the product (Horngren et al., 2002). Break-even price tells us which level of price per unit is needed to even off the total variable cost and the fixed cost. The formula for calculating break-even price is expressed as:

$$\text{Break} - \text{even price} = \frac{\text{Total Variable Cost} + \text{Fixed Cost}}{\text{Total Quantity Produced}}$$

Both the variable cost and the fixed cost are cash expenses, whereas depreciation expense is a non-cash expense which is not comprised in the above formula. Hence, the computed break-even price is on a cash flow basis and is lower than if depreciation is included. However, farmers need to be aware of the depreciation cost since the value of building and machinery are diminishing over time. Now, aggregating the total variable cost, the fixed cost and the total quantity of blueberries produced over 40 years, and then substituting the resulting figures into the above equation, we obtain:

$$\text{Break} - \text{even price} = \$1.06/\text{pound}$$

This means that the average price of blueberries must be at least $1.06 per pound in order to make a profit. With current low price of blueberries (less than $1 per pound in 2009), clearly, farmers are not able to cover their total operating cost.

The above break-even price doesn't incorporate the percent of return on capital such as land value and the required capital investment. Thus, we define break-even target price as the level of price that must be reached in order to pay off the total operating cost and to gain a percent of return on capital. Its formula is presented below:

$$\text{Break} - \text{even target price} = \frac{\text{Total Variable Cost} + \text{Fixed Cost} + \%\ \text{Return on Capital}}{\text{Total Quantity Produced}}$$

Here, the break-even target price is calculated on an annual basis. The total variable cost, the fixed cost and the quantity during full production are used to determine the break-even target price. The total capital calculated in the above equation consists of land value and the required capital investment. The results are presented in the following table.

Table 6: Sensitivity Analysis of Break-even Price at % Return on Capital

Target % of Capital	Break-even Target Price
1%	$1.09
3%	$1.22
5%	$1.34
10%	$1.65
15%	$1.96
20%	$2.27

Note: The price is on per-pound basis.

As table 6 shows, during full production the break-even target price increases as the percent of return on capital increases. Especially, at least 10% of return on capital is generated if the average price of blueberries per pound is higher than $1.60 which was the price in 2006. However, theses returns on capital are before interest and tax payments, and the salary for the time of owner's management is not contained.

Break-even quantity tells us how many units of the product must be sold in order to cover the total operating cost. The formula for calculating break-even quantity is depicted as:

$$\text{Break} - \text{even quantity} = \frac{\text{Total Variable Cost} + \text{Fixed Cost}}{\text{Price per unit}}$$

Here, break-even quantity is also computed on a yearly basis. The total variable cost and the fixed cost during full production are used to obtain the break-even quantity. A range of target prices of blueberries are selected for analyzing the sensitivity of break-even quantities. The results are presented in table 7.

Table 7: Sensitivity Analysis of Break-even Quantity at Target Prices

Target Prices	Break-even Quantity
$0.80	16,143
$1.00	12,914
$1.20	10,762
$1.40	9,224
$1.60	8,071
$1.80	7,174
$2.00	6,457

Note: The price on a per-pound basis and the quantity is on yearly basis.

As seen in the above table, the break-even quantity decreases as the target price increases. When the target price is $1.00 per pound, the annual break-even quantity is approximately 13,000 pounds which is the yield at full production. When blueberry's price is higher than $1.00 per pound, extra revenues will be generated if farmers still produce at peak production (13,000 pounds). On the contrary, if blueberry's price is less than $1.00 per pound, a much larger yield than the full production is required in order to break even.

Although break-even analysis is an essential decision making tool, all the values are calculated in nominal terms and the owner's opportunity cost is not taken into account. As an improvement to the break-even analysis, the net present value analysis is discussed in the following section.

3.2.2 Net Present Value Analysis

An investor's opportunity cost is often considered when investigating the profitability of a business venture. In this regard, the net present value analysis (Lin & Nagalingam, 2000) of net farm income for blueberries over **40 years** is developed first for a high price as the boom scenario and then for a low price as the bust scenario. For the sake of simplicity, we assume that the commodity price inflation is zero throughout the period of 40 years in the following analysis. The equivalent annualized capital cost (EACC) is introduced in the following tables 8 and 9 in order to derive the internal rate of return on assets (IRRA). It is computed through the total capital cost per acre multiplying by the discount rate ranging from 1% to 9%. IRRA is the discount rate in which the equivalent annualized net farm income (EANFI) is equal to the EACC. It means that the annual net farm income generated from blueberry farming is just enough to pay off the annual interest expense of the budgeted capital. Moreover, ROA equals IRRA at the equilibrium of EANFI and EACC. Clearly, it would be profitable for farmers to make the investment in blueberry farming when the ROA is greater than the discount rate (the investor's opportunity cost).

The net present value of net farm income over a 40-year period is calculated on a per-year basis (annualized), as shown in the "EANFI" column of table 8. Both EANFIs and ROAs decrease as the discounted rate increases. Distinctly, the EACC increases as the discount rate decreases. With the high prices offered during the boom of the blueberry industry, the EANFI per acre ranges from a low of $4,608 to high of $8,119 as the discount rate ranges from 9% down to 1%. The EANFI breaks even with the EACC at the discount rate of 6.87% where the ROA is identical to the IRRA. Therefore, as table 8 shows, blueberry farming is profitable when the interest rate of purchasing capital is lower than 6.87%. This implies that, during the boom period, it is relatively less risky to invest in blueberry production compared to other alternative business opportunities, when the investor has a low discount rate (< 6.87%).

Table 8: Blueberry's Net Present Value Analysis over 40 Years – Boom

Discount rate	Annuity Factor	Net Present Value	EANFI	EACC	ROA
1%	32.8347	$266,582	$8,119	$804	10.09%
3%	27.3555	$167,703	$7,255	$2,413	9.02%
5%	17.1591	$109,129	$6,360	$4,022	7.91%
6.87%	**13.3317**	**$74,800**	**$5,526**	**$5,526**	**6.87%**
9%	10.7574	$49,574	$4,608	$7,240	5.73%

Note: All the figures above are calculated on a per-acre base. The bold rate is also the internal rate of return on assets.

Table 9: Blueberry's Net Present Value Analysis over 40 Years – Bust

Discount rate	Annuity Factor	Net Present Value	EANFI	EACC	ROA
1%	32.8347	$69,900	$2,129	$804	2.65%
2.25%	**27.3555**	**$47,470**	**$1,814**	**$1,814**	**2.25%**
5%	17.1591	$18,469	$1,076	$4,022	1.34%
7%	13.3317	$7,010	$526	$5,631	0.65%
9%	10.7574	-$153	-$14	$7,240	-0.02%

In contrast to table 8, table 9 presents the net present value analysis based on the low prices of blueberries during the bust period. The EANFIs and ROAs are much lower than those ones in table 8 and they even turn to negative values when the discount rate is 9%. The EACCs remain the same with values in table 8 since the total capital is fixed both in the boom and bust scenarios. As a result, a relatively low IRRA of 2.25% is derived at the equilibrium between the EANFI and EACC. Hence, in the bust scenario, blueberry farming is only profitable when the discount rate is lower than 2.25%. In fact, the interest rate of loans is most likely to be higher than 2.25%. This means that it is very risky to invest in blueberry production during the bust period. Furthermore, the EANFIs and ROAs presented in tables 8 and 9 do not include interest and tax payments.

Since blueberry prices fluctuate over time, the changes in average prices of blueberries must be taken into account. This is especially important in the analysis of return on assets because the results would directly influence the investor’s decision on whether or not to invest in blueberry farming.

Table 10: Sensitivity Analysis of ROA at Prices and Discount Rates

Prices/rates	1%	3%	5%	7%	9%
$0.80	-4.54%	-4.78%	-5.06%	-5.37%	-5.68%
$1.00	-1.68%	-2.09%	-2.53%	-2.99%	-3.45%
$1.20	1.17%	0.61%	0.00%	-0.62%	-1.23%
$1.30	2.60%	1.95%	1.26%	0.57%	-0.12%
$1.50	5.45%	4.64%	3.79%	2.94%	2.11%
$1.80	9.74%	8.68%	7.59%	6.50%	5.45%
$2.00	12.59%	11.38%	10.12%	8.88%	7.68%

Note: The prices in the above table are the average blueberry prices of farm gate, fresh wholesale and processing.

In table 10, regardless of different discount rates, negative ROAs are generated when the average blueberry prices are lower than $1.30 per pound. On the other hand, if the average price is higher than $1.30 per pound, positive ROAs are produced as the discount rate ranges from 1%

to 9%. If the blueberry's price spikes to $1.50 or higher (as it happened in 2006), at least 2% of ROAs will be gained with both high and low discount rates. Notably, at least 7% of ROAs will be earned if the blueberry price even rises to $2.00. This explains why so many farmers rush into blueberry farming when the blueberry's price is high.

3.2.3 Leverage and Tax Analysis

As discussed earlier in this chapter (p.17), we assume that $102,200 of the required capital investment and $300,000 land costs are budgeted for the 5-acre blueberry farm. The return on equity analysis is conducted on a per-acre basis and thereby a total capital investment of $80,400 per acre is leveraged as debts. A range of debt percentages are considered in the leverage analysis. The annual return on equity (ROE) is computed through the equivalent annualized net farm income after interest and tax payments divided by the owner's equity. Interest expenses are calculated with different levels of debt associated with various rates of real interest. And the income tax payments are calculated with a range of income tax rates which is obtained from Canadian Revenue Agency (2009). The ROEs in tables 11 and 12 are produced respectively based on the prices of blueberries in the boom and bust scenarios.

In comparison with ROA, ROE shows how much return the investors will receive on each dollar they invest in the business. In order to further evaluate the relationship between ROE and ROA, the following formula is derived resulting from the formulas of ROE and ROA in table 5.

$$\mathrm{ROE} = \left(1 - \mathrm{T} - \frac{\mathrm{r} * \mathrm{D}}{\mathrm{NFI}}\right) * \left(\frac{\mathrm{A}}{\mathrm{A} - \mathrm{D}}\right) * \mathrm{ROA}$$

where:

T is the income tax rate,

r is the real interest rate which is also discount rate,

NFI is the net farm income before interest and tax expenses,

D is the total debt and A is the total assets.

As the above formula shows, a rise in the tax rate or the interest rate will increase the ROE, holding the net farm income constant. The ROA remains the same for a fixed level of net farm income because the total assets financed for the 5-are blueberry farm doesn't change and thus the ROA is only determined by the net farm income. $\frac{A}{A-D}$ is the leverage ratio which is the total assets divided by the owner's equity. If farmers purchase no debts (D = 0), the ROE equals the ROA before tax (ROE = (1-T)*ROA). As the amount of debts increases (the leverage ratios increases), the ROE would increase provided a fixed level of net farm income.

From table 11, as expected, the annual ROEs decrease as the interest rate or the tax rate increases. Horizontally, ROEs increase as the level of debts increases. This means that the higher the leverage ratio is, the higher returns are gained on each dollar invested. Negative ROEs are generated only when the interest rate is higher than 7% and the percentage of purchased debts is larger than 70%. Therefore, overall, farmers make considerable returns on their investment during the blueberry boom period. Specifically, farmers can receive at least 12% return on their investment when carrying high levels of debts (> 80%) and low rates of interest

Table 11: Blueberry's Annual Return on Equity Analysis during the Boom

Annual Return on Equity		Debts as % of total investment					
		0%	30%	50%	70%	80%	90%
Tax Rate	Real Interest Rate	$0	$24,120	$40,200	$56,280	$64,320	$72,360
10%	1%	9.09%	9.99%	12.55%	17.18%	27.96%	81.88%
10%	3%	8.12%	8.69%	10.32%	13.24%	20.07%	54.22%
10%	5%	7.12%	7.35%	8.03%	9.24%	12.06%	26.19%
10%	7%	6.12%	6.02%	5.74%	5.24%	4.07%	-1.79%
10%	9%	5.16%	4.73%	3.51%	1.32%	-3.80%	-29.41%
20%	1%	8.08%	8.87%	11.11%	15.16%	24.60%	71.79%
20%	3%	7.22%	7.69%	9.03%	11.44%	17.06%	45.19%
20%	5%	6.33%	6.48%	6.90%	7.66%	9.43%	18.28%
20%	7%	5.44%	5.27%	4.77%	3.88%	1.80%	-8.59%
20%	9%	4.59%	4.09%	2.69%	0.17%	-5.72%	-35.15%
30%	1%	7.07%	7.74%	9.67%	13.14%	21.23%	61.69%
30%	3%	6.32%	6.69%	7.74%	9.63%	14.06%	36.17%
30%	5%	5.54%	5.60%	5.77%	6.07%	6.79%	10.37%
30%	7%	4.76%	4.51%	3.80%	2.52%	-0.46%	-15.39%
30%	9%	4.01%	3.46%	1.87%	-0.98%	-7.63%	-40.88%

and tax. On the contrary, if farmers possess absolute no debts, optimistically, only 9% of ROE is made. Although the ROEs are higher than those with lower levels of debts, there are risks associated with having high percent of debts since farmers, for instance, might not be able to pay off the high interest expenses during a bad year of blueberry market (e.g. price or yield crashes). Again, during the boom period of blueberry industry, it is certain that there are incentives and evidence for B.C. blueberry farmers continue to keep in the production or new farmers to invest in the blueberry business.

In contrast to table 11, table 12 shows the annual ROEs resulting from the low prices of blueberries during the bust period. The ROEs are overall much lower compared with table 11 and even turn to negative when the real interest rate is equal or higher than 3%. If farmers carry

Table 12: Blueberry's Annual Return to Equity Analysis during the Bust

Annual Return on Equity		Debts as % of total investment					
		0%	10%	30%	50%	70%	90%
Tax Rate	**Real Interest Rate**	$0	$24,120	$40,200	$56,280	$64,320	$72,360
10%	1%	2.38%	2.54%	2.98%	3.77%	5.61%	14.83%
10%	3%	1.81%	1.68%	1.30%	0.62%	-0.96%	-8.88%
10%	5%	1.20%	0.78%	-0.42%	-2.59%	-7.65%	-32.95%
10%	7%	0.59%	-0.12%	-2.16%	-5.82%	-14.37%	-57.11%
10%	9%	-0.02%	-1.02%	-3.88%	-9.03%	-21.05%	-81.16%
20%	1%	2.12%	2.24%	2.60%	3.24%	4.73%	12.18%
20%	3%	1.61%	1.46%	1.02%	0.22%	-1.63%	-10.89%
20%	5%	1.07%	0.63%	-0.61%	-2.86%	-8.10%	-34.29%
20%	7%	0.52%	-0.20%	-2.25%	-5.95%	-14.59%	-57.77%
20%	9%	-0.01%	-1.02%	-3.88%	-9.03%	-21.05%	-81.14%
30%	1%	1.85%	1.95%	2.22%	2.71%	3.84%	9.53%
30%	3%	1.41%	1.23%	0.73%	-0.18%	-2.30%	-12.91%
30%	5%	0.94%	0.49%	-0.80%	-3.13%	-8.54%	-35.63%
30%	7%	0.46%	-0.27%	-2.35%	-6.08%	-14.81%	-58.42%
30%	9%	-0.01%	-1.01%	-3.87%	-9.02%	-21.04%	-81.12%

no debts, approximately 2% of ROEs are generated when both the real interest rate and the tax rate are low. On the other hand, if farmers carry 90% of debts and both interest and tax rates are low, nearly 15% of return on their investment can be produced however it is significantly lower than 82% (table 11) obtained in the boom scenario. Moreover, farmers can lose at least 3% of their investment when the interest rate is higher than 5% and the level of debts is higher than 50%. Clearly, farmers can hardly make profits during the blueberry bust period, however most farmers keep in the production for the purpose of achieving a long-term profitability overall.

In this chapter, we have thoroughly examined the profitability of blueberry investment in B.C. from the scenarios of boom and bust. During the boom period, it is evident that there are economical incentives for farmers to invest in the blueberry business. On the other hand, the profits are just enough to cover the total production cost during the blueberry’s bust period. The above argument plays a critical role for farmers who seek to make a decision on whether or not to invest in blueberries. Moreover, it is very important that the profitability associated with changes in prices of that crop be known in order to determine what decisions are better to make. Therefore, it is necessary to derive the price elasticity of supply response in the B.C. blueberry industry in order to further investigate the boom-and-bust problems. In addition, it is also important for policy makers to know the supply response of that crop when determining relevant policies on farmer’s income and other agricultural issues related to that crop. Therefore, these findings lead to the following chapter. In chapter 4, a dynamic structural supply response model for blueberry investment will be constructed in order to study the boom-and-bust cycles of blueberry from an econometric point of view.

Chapter 4: Blueberry Supply Response Model

In this chapter, we present a literature review on theory of supply response model as applied to blueberries, and then develop the supply response model for the B.C. blueberry industry. Short-run and long-run price elasticities of blueberry supply will be derived based on the empirical results of the estimation of supply functions.

4.1 Literature Review

Most econometric studies of agricultural supply response models follow the Nerlovian model, which is considered to be one of the most influential and successful in the literature (Askari and Cummings, 1977). Marc Nerlove examined the dynamic structure of agricultural supply in his seminal work in 1956 and 1958. The Nerlovian model hypothesizes farmer's reactions in terms of price expectations and planted area. It has been adopted, modified and extensively revised by numerous later authors in estimating supply response. The surveys of Askari and Cummings (1976, 1977) provide clear evidence. Askari and Cummings summarize over one hundred empirical studies in the Nerlovian model, even though they are restricted to the English literature. Among these numerous studies, there are some improvements addressed for the traditional Nerlove model. For instance, Wickens and Greenfield (WG, 1973) point out that there are difficult connections in the Nerlovian model: the ad hoc nature of the model and the fact that the dynamic has been added to a static optimising model. Wickens and Greenfield note that the pivotal factor determining potential production or acreage planted of an agricultural crop is the level of past investment. Both investment and harvesting decisions are primarily based on the expected future prices. Thus, Nerlovian supply response function describes desired supply as a function of expected prices. The function is based upon a set of ad hoc behavioural relationships, in which the difference between the investment and harvesting decisions are ignored (WG, 1973).

Nerlove (1979) admits that a number of difficulties in connection with the study of many perennial crops are found from his earlier developed supply response model. More specifically, perennial crops, once planted, take several years to mature and output is gradually forthcoming, and yields are dependent upon the age structure of the perennials. Therefore, the Nerlovian function, to a certain extent, fails to adequately capture the dynamics of the supply of perennial crops such as blueberries. As a solution to this problem, Wickens and Greenfield develop a more satisfactory method that derives the reduced form supply function through solving the optimization of an investment function. The supply response of perennial crops suits this approach well due to long lags of propagation between planting and harvesting. However, the data historically available for perennials have not been detailed enough to allow modeling of the investment function.

Recently, econometric research has been focused on supply response analysis where agriculture is viewed as a multi-input and multi-output industry (Ball et al., 2003). Most models of agricultural supply response in the past focused on aggregate supply or on its own price response for one commodity. Ball et al., use disaggregated output and input data in order to develop a restricted profit function, which is approximated by the transcendental logarithmic (translog) formula. Through estimation of the translog function, supply elasticities of multiple outputs and demand elasticities of multiple inputs are determined. Similar methodology has been used by Mundlak (1963), S. Ray (1982), Antle (1984, 1999), Binswanger (1987), Shumway (1984, 1988), Ball (1988), Chambers and Just (1989), Fulginiti and Perrin (1990), etc. Although it is an elegant solution to estimate supply responsiveness, we will not follow this procedure due to the restriction of data.

Although there are some improvements suggested for the traditional Nerlove's agricultural supply response model, the Nerlovian model does capture the farmer's reactions to changes in price expectations. This feature makes the model suitable for the purpose of examining the boom-and-bust cycles of blueberries. Moreover, price, quantity and acreage are normally the only data collected, which lead to the estimation of a Nerlovian response model. Therefore, this thesis will follow the Nerlovian model for the purpose of deriving a reduced form of supply response function for blueberries in B.C.. However, some relevant improvements and modifications will be made in order to develop an appropriate supply response model for the B.C. blueberry industry.

4.2 Supply Response Model for B.C. Blueberries

In this section, we follow the Nerolvian model in order to construct a reduced form supply function for B.C. blueberry producers.

Nerlove's model consists of three equations:

$$A_t^* = \alpha_0 + \alpha_1 P_t^e + \alpha_2 Z_t + u_t; \quad (1)$$

$$A_t - A_{t-1} = \theta(A_t^* - A_{t-1}), \ 0 \leq \theta \leq 1; \quad (2)$$

$$P_t^e - P_{t-1}^e = \beta(P_{t-1} - P_{t-1}^e), \ 0 \leq \beta \leq 1. \quad (3)$$

where:

A_t^* = acreage desired or long-run equilibrium acreage at time t,

A_t = actual acreage under cultivation at time t,

P_t = actual price per unit at time t,

P_t^e = expected price per unit at time t,

Z_t = other exogenous factor(s) affecting desired acreage at time t,

u_t = random errors containing acreage uprooted or abandoned, and

θ and β are coefficients of expectation and adjustment.

θ and β are the adjustment and expectation coefficients which reflect the responsiveness of expectations to observed prices and acreage. Low values of θ and β imply that farmers are not responsive to changes in the price and acreage, respectively. On the contrary, high values of θ and β means that farmers are highly responsive to changes in the price and acreage. In order to derive a reduced form supply function, we need to eliminate the unobservable variables, namely, the desired acreage and expected price from equation (1) to (3).

Substituting equation (1) into equation (2) results in:

$$A_t = \theta\alpha_0 + \theta\alpha_1 P_t^e + (1 - \theta)A_{t-1} + \theta\alpha_2 Z_t + \theta u_t \tag{4}$$

Now, substituting equation (3) for P_t^e into equation (4) yields:

$$A_t = \theta\alpha_0 + \theta\beta\alpha_1 P_{t-1} + \theta(1-\beta)\alpha_1 P_{t-1}^e + (1 - \theta)A_{t-1} + \theta\alpha_2 Z_t + \theta u_t \tag{5}$$

Taking the lag of equation (4) by one period gives:

$$A_{t-1} = \theta\alpha_0 + \theta\alpha_1 P_{t-1}^e + (1 - \theta)A_{t-2} + \theta\alpha_2 Z_{t-1} + \theta u_{t-1} \tag{6}$$

Multiplying through equation (6) by $(1-\beta)$ results in:

$$(1-\beta)A_{t-1} = \theta(1-\beta)\alpha_0 + \theta(1-\beta)\alpha_1 P_{t-1}^e + (1 - \theta)(1-\beta)A_{t-2} + \theta(1-\beta)\alpha_2 Z_{t-1} + \theta(1-\beta)u_{t-1} \tag{7}$$

In order to eliminate the term $\theta(1-\beta)\alpha_1 P_{t-1}^e$, subtracting equation (7) from equation (5) and rearranging the resulting equation yields:

$$A_t = \theta\beta\alpha_0 + \theta\alpha_1\beta P_{t-1} + (2-\theta - \beta)A_{t-1} - (1 - \theta)(1-\beta)A_{t-2} + \theta\alpha_2 Z_t + \theta(1 - \beta)\alpha_2 Z_{t-1} + \theta u_t + \theta(1 - \beta)u_{t-1} \tag{8}$$

Now, simplifying equation (8), we obtain:

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 Z_t + b_5 Z_{t-1} + U_t \tag{9}$$

where:

$b_0 = \theta\beta\alpha_0$, $b_1 = \theta\beta\alpha_1$,

$b_2 = (2 - \theta - \beta)$,

$b_3 = -(1 - \theta)(1 - \beta)$,

$b_4 = \theta\alpha_2$,

$b_5 = \theta(1 - \beta)\alpha_2$,

$U_t = \theta u_t + \theta(1 - \beta)u_{t-1}$.

The variable Z in the model expresses non-market factors affecting crop supply. Nerlove (1958) notes that the variable Z is used as a means of avoiding the problem of identification in the econometric process of estimating the structural parameters. In this study, a price index of other crops in B.C. will be used as a proxy to capture non-market effects on the blueberry acreage. This is because farmers do consider all the crops available in the market and compare their prices and profitability when making an investment decision. The inclusion of other crops' price will also be used to detect the substitution of production between blueberries and other crops. This is one way that our model differs from the traditional Nerlovian model. Thus, equation (9) can be rewritten as:

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 P^o_{t-1} + V_t \tag{10}$$

where:

$$P^o_{t-1} = \text{price index of other crops at time } t-1,$$

$$V_t = \text{random error term.}$$

Equation (10) is the final reduced form equation for the blueberry supply. Theoretically, we expect b_2 to be positive since an increase in the expected price would increase the planted acreage of blueberries. According to Nerlove's theory, the sign of the coefficient b_3 is expected to be negative however it is often not in practice (Wickens and Greenfield, 1973). The coefficient sign of P^o_{t-1}, b_4 , is expected to be negative, implying that there is a negative effect on farmer's decision of investing in blueberries when the price of other crops increases.

As discussed earlier in chapter two, the planted acreage of blueberries in B.C. started to increase at an extremely rapid rate after 2003, due to the increasing price of blueberries. This was because the demand for blueberries grew sharply as the media's positive reports for blueberries rapidly increased since the first scientific discovery of significant health benefits in blueberries. In order to capture this trend break, a dummy indicator should be included in the supply model in order to differentiate changes of the supply curve before and after year 2003. Year 2003 will be used as the point of trend break in our dummy variable. However, there are two ways of setting the dummy variable. One is to put the dummy on the intercept. This is because the supply curve is expected to shift in response to the demand shock in blueberry industry after the discovery. Clearly, farmers would like to have higher acreage in order to be in a good position of supplying blueberries in the future at a higher price. The inclusion of this intercept dummy will add forward thinking mechanism to the supply model, while the traditional Nerlove's model does not allow for forward thinking however in the reality farmers would look ahead in the market. The other way of setting dummy is to include a time trend starting in 2003. The time trend dummy will capture the non-market effect of the announcement on the planted blueberry acreage after 2003. Taking all the arguments stated above into equation (10), the following four models are developed.

Model 1: Without the price of other crops and the dummy variable

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + V_t \tag{11}$$

Model 2: With the price of other crops

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 P^{o}_{t-1} + V_t \tag{12}$$

Model 3: With the dummy on the intercept

$$A_t = (b_0 + D) + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 P^{o}_{t-1} + V_t \tag{13}$$

Model 4: With the dummy on the time trend

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 P^{o}_{t-1} + DT + V_t$$

(14)

T is the time trend variable and D is the intercept dummy. D = 1, when T > 16 (the year 2003) and D = 0 otherwise. DT in equation (13) is the time trend dummy that takes effect after year 2003. Model 1 is used as a comparison with model 2 in order to identify the impact of the price of other crops on the planted acreage. Equations (11) to (14) will be estimated with regression using Ordinary Least Square.

By theory, the short-run supply price elasticity is determined as:

$$\varepsilon_S = b_1 \times \frac{\bar{P}}{\bar{A}}$$

(15)

In order to derive the long-run price elasticity, we need to set $A_t = A_{t-1} = A_{t-2}$. Therefore, the long-run price elasticity of blueberry supply is expressed as:

$$\varepsilon_L = \frac{b_1}{1 - b_2 - b_3} \times \frac{\bar{P}}{\bar{A}}$$

(16)

where $\bar{P}$ and $\bar{A}$ are the averages of historical data on prices and acreage under cultivation, respectively.

4.3 Data

The data used in the estimation of supply response functions for the B.C. blueberry farmers include annual data for blueberry's real prices and the planted acreage for the period 1988-2009. All data were obtained from Statistics Canada, CANSIM Table 001-009, Table 002-0022, Table 326-0021 and Catalogues 22-003. The real prices of blueberries were obtained through nominal prices divided by the consumer price index. The real prices of blueberries and other crops are projected in our developed supply models for the estimation. This is because real prices help the data to rule out the effect of price inflations.

Consistent time series data for inputs used in blueberry production, for instance capital, labour, machinery expenses, pesticides and fertilizers, are not available. In this regard, with current availability of data source, the reduced form of Nerlovian supply function seems to be the best methodology for estimating blueberry supply responsiveness.

4.4 Empirical Results

In this section, the regression results of estimated coefficients for the blueberry supply functions will be discussed. A most suitable short-run price elasticity will be employed in order to construct a cobweb model for simulating changes in the price and acreage of blueberries in chapter 6. All regression results are estimated with the Stata program using Ordinary Least Square.

Table 13: Regression Results for B.C. Blueberry Supply Response, 1988-2009

Independent Variables	Model 1 A_t	Model 2 A_t	Model 3 A_t	Model 4 A_t
P_{t-1}	2,723.9519***	2,618.0362***	1,858.0289**	2,059.5000***
	[3.4154]	[3.0531]	[2.6215]	[3.2500]
A_{t-1}	1.4781***	1.5178***	1.1467***	0.9309***
	[7.3865]	[6.7029]	[5.4540]	[4.1821]
A_{t-2}	-0.4984*	-0.5662*	-0.2086	-0.3619
	[-2.0571]	[-1.9042]	[-0.8125]	[-1.6420]
P^{o}_{t-1}		708.1085	-1,508.7000	2,115.9711
		[0.4167]	[-1.0121]	[1.6585]
D			1,602.8127***	
			[3.2590]	
DT				867.4600***
				[3.8692]
Intercept	-1,452.1730**	-1,905.1970	722.1148	-755.5754
	[-2.5043]	[-1.5369]	[0.5734]	[-0.8037]
Observations	20	20	20	20
Adjusted R^2	0.9835	0.9826	0.9894	0.991
Durbin's h-test	NO	NO**	NO	NO
F-statistic	378.81	269.48	355.98	434.6

Note:

1. t-statistics in brackets; *** P<1%, ** P<5%, * P<10%.
2. "YES" and "NO" represents there exists or does not exist autocorrelation in the disturbance term, respectively.

As presented in the above table, the signs of all the coefficients are as predicted in theory. In each model, both the real price lagged one period and the acreage lagged one period exert a positive influence on blueberry production, while the acreage lagged two periods exerts a negative influence. The positive coefficients of real price and acreage lagged one period suggest that an increase in price or output will increase the blueberry acreage in the subsequent period. This is primarily due to farmers' commitment to covering their fixed capital and land costs. Moreover, farmers are observed to be price takers and thereby positive economic incentives will encourage them to invest more, plant more acreage, or farm more intensively.

From the above table, the adjusted R^2 values are all above 98% for each model, implying that a very high percentage of the variation in blueberry acreage is explained by the independent variables. The high F-statistic values for each model indicate the wellness of overall significance of estimated coefficients. In the estimation procedure, the presence of autocorrelation in the residuals is possible. The Durbin-Watson statistic is commonly used to detect the presence of autocorrelation. However, this test is not appropriate when the equations contain lagged dependent variables. This is because Durbin-Watson statistic for the first-order autocorrelation is biased toward the value 2 and has reduced power. In order to solve this problem, Durbin (1970) developed the Durbin's h-statistic which is used to test for the possible presence of serial correlation in the residuals when there are lagged dependent variables in the estimated function. As table 13 shows, all the four models do not have autocorrelation in the disturbance term. Notably, the possibility of existing an autocorrelation in model 2 is found to be less than 5%.

Model 1 is estimated without the price index of other crops and the dummy variable. All the coefficients have the expected signs. The coefficients of price and acreage lagged one period are both statistically significant at 1%. The coefficient of acreage lagged two periods is only significant at 10% however it is not often in practice. In contrast to model 1, model 2 is estimated with the price index of other crops included the supply function. The significant levels of coefficients of the lagged price and the lagged acreage of blueberries are the same with model 1. Despite that the coefficient of the lagged price of other crops is not statistically significant; the effect of the price of other crops on blueberry's acreage is very low compared to the effect of blueberry's price.

In comparison with model 2, models 3 and 4 are both estimated with the dummy variable included. Both the coefficients of the intercept dummy and the time trend dummy are statistically significant at 1%. The inclusion of the dummy variable reduces the coefficient values of the lagged price and the lagged acreage. However, the changes are not significant, which won't have a big impact of deriving short-run price elasticities of blueberry supply. The coefficients of lagged price and acreage by one period are statistically significant at 5% or better, while the coefficients of the acreage lagged by two periods in models 3 and 4 are not significant. As compared with model 2, the coefficient value of the lagged price of other crops increases significantly. The negative sign of the coefficient of P_{t-1}^{o} indicates that there exist production substitutions between blueberry crops and other crops. That is, a price increase in other crops will reduce the planted acreage in blueberries.

The significant coefficient value of the intercept dummy (D) in model 3 suggests that the supply curve shifted up after year 2003. As discussed earlier in page 40, the supply curve shifted because farmers would desire more acres of blueberries in order to be in a good position to supply blueberries when the price is higher. Since blueberry is a perennial crop which takes several years to reach the full production, it is reasonable that farmers would look ahead in the market and start to plant more acres in response to higher prices of blueberries. This argument adds forward thinking dynamic to our supply response model, whereas the traditional Nerolivan model does not allow for forward thinking. The positive sign of the time trend dummy means that there is a positive non-market effect on the blueberry acreage after year 2003. That is, as the time period moves forward, farmers would like to have more acreage. This finding may be due to the farmer's merging realization of bigger demand for blueberries and thus they expect the price of blueberries to rise in the future.

Substituting the values of b_1, b_2 and b_3 of each model from table 13 into equations (15) and (16), the short-run and long-run price elasticities of blueberry supply in B.C. can be obtained. The results are presented in the following table.

Table 14: Price Elasticities of Blueberry Supply for British Columbia

Price Elasticities	Model 1	Model 2	Model 3	Model 4
Short-run Price Elasticity	0.26	0.25	0.18	0.20
Long-run Price Elasticity	12.89	5.20	2.88	-

Note: The long-run supply elasticity for model 4 is not calculated due to the effect of the time trend variable.

From the above table, the short-run price elasticities of blueberry supply are fairly inelastic which imply that B.C. farmers were not very responsive to price changes in the short run. The values of these four short-run price elasticities are very close to each other. This indicates that our estimation may be close to the accurate short-run supply elasticity of blueberries in B.C.. On the other hand, the long-run price elasticities of blueberry supply are significantly elastic which means that B.C. farmers were highly responsive to price changes of blueberries in the long run. The long-run supply elasticity for model 4 is not derived because the acreage will never reach to a steady stage due to the inclusion of the time trend variable. Nevertheless, only the short-run price elasticity will be employed in order to simulate cycles in the price and acreage of blueberries. However, we don't know which supply response model is most suitable for the B.C. blueberry farmers. Hence, an average of short-run price elasticities from the four models, that is 0.22, will be adopted in the simulation.

Since there haven't been any econometric studies of blueberry supply elasticities, we are not in a position to compare our empirical results with historical supply elasticities in the B.C. blueberry industry. However, based on the surveys of Askari and Cummings (1976, 1977) over one hundred empirical studies of agricultural supply response, most perennial crops had inelastic supply elasticities. For instance, Jones (1961, 1962) estimated supply elasticities of strawberries, raspberries and blackcurrants for United Kingdom during the period of 1946-1958. The short-run supply elasticities of these crops are 0.30, 0.21 and 0.29, respectively. The long-run supply elasticities were all elastic. Thus, our estimated supply elasticities match with the historical supply elasticities of perennial crops. In the following chapter, we will apply the short-run price elasticity of 0.22 in order to construct a cobweb model for the purpose of simulating boom-and-bust cycles of the price and acreage of blueberries.

Chapter 5: Simulation

5.1 Cobweb Model

With the derived short-run price elasticity of blueberry supply in chapter 4, we can now construct a cobweb model in order to show the boom-and-bust cycles of blueberry's price and acreage diagrammatically. Since we don't have enough data to estimate a price demand elasticity of blueberries in B.C., a sensitivity analysis of simulations to demand elasticities will be discussed in this chapter.

In the rational expectations literature, farmers are assumed to understand the supply-demand mechanism (Muth, 1961). One of the major criticisms of the adaptive expectations (i.e. cobweb) model is that rational farmers will correctly anticipate the equilibrium price for the following periods. This would violate the principal of cobweb model, however, in reality we do observe that supply increases and decreases in response to price changes. Thus, it is evident that farmers are at least somewhat adaptive rather than rational.

The cobweb model is considered to be an adaptive dynamic model. It is well suited to agricultural markets, since there is a lag between planting and harvesting. The cobweb model is used as a means to explain why prices have periodic fluctuations which link back to our earlier discussion of boom-and-bust cycles of blueberry industry. The model assumes that farmer's price expectations are based on observations of previous prices. The basic principal of the cobweb model can be depicted as following equations (Kaldor, 1934):

$$Q_t^S = a + b * P_{t-1},\ b>0; \tag{17}$$

$$Q_t^D = c - d * P_t,\ d>0; \tag{18}$$

$$Q_t^S = Q_t^D. \tag{19}$$

Equation (17) is the supply function which states that the quantity of a product supplied is determined by the price of the product from last time period. Equation (18) is the demand function which means that the quantity of the product demanded is determined by the current price of this product. Equation (19) shows the condition of finding the market equilibrium, that is, the supplied quantity equals to the demand quantity.

Substituting equation (17) and (18) into (19), solving for P_t results:

$$P_t = \frac{c-a}{d} + \left(-\frac{b}{d}\right) * P_{t-1} \tag{20}$$

Solving for P_t using difference equation yields:

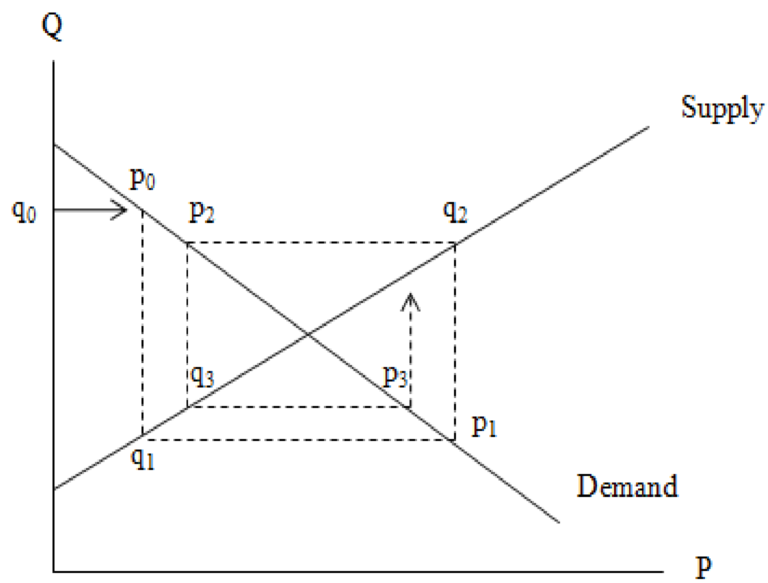
$$P_t = \left(-\frac{b}{d}\right)^t * (P_0 - P^*) + P^* \tag{21}$$

where:

$$P^* = \frac{c-a}{b+d}$$

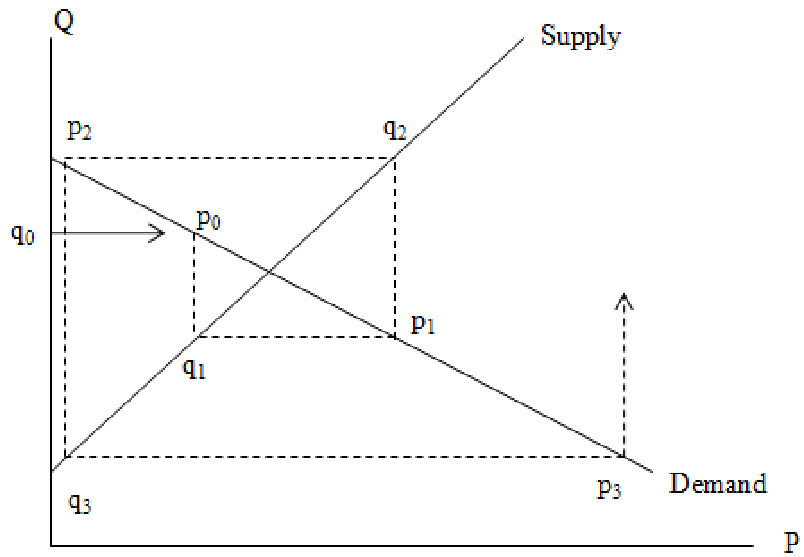
P^* is the equilibrium price and t is the time period. P_0 is the current price given Q_0 - the supply at current period. P_0 determines the quantity supplied one period later, which is denoted Q_1.With Q_1, P_1 is obtained through the demand function, and so on. With different values for $\left(-\frac{b}{d}\right)$, there are three types of cobweb model, namely, the convergent fluctuation, the divergent fluctuation and the continuous fluctuation.

Figure 5: Cobweb Model Convergent Fluctuation



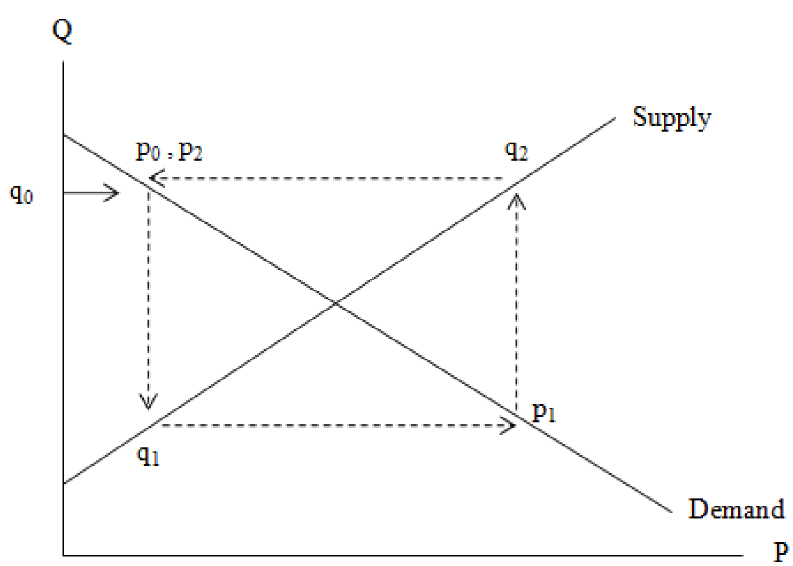
As shown in the diagram above, if $\left|-\frac{b}{d}\right| < 1$ – the slope of supply curve is flatter than the demand curve's, both price and quantity converge to a steady equilibrium at (P^*, Q^*). This is also the equilibrium resulting from the derived supply and demand functions.

Figure 6: Cobweb Model Divergent Fluctuation



As figure 6 shows, when $\left|-\frac{b}{d}\right| > 1$ - the slope of supply curve is steeper than the demand curve's, both price and quantity diverge away from the equilibrium price and quantity.

Figure 7: Cobweb Model Continuous Fluctuation



In figure 7, when $\left|-\frac{b}{d}\right| = 1$ - the slope of supply curve equals demand curve's, the P and Q oscillate continuously between two values, (p_0, q_0) and (p_1, q_1), in even and odd time periods.

Given equation (17) and (18), price supply elasticity and price demand elasticity are expressed as:

$$\varepsilon^S = b \times \frac{P}{Q} \tag{22}$$

$$\varepsilon^D = -d \times \frac{P}{Q} \tag{23}$$

P and Q are the equilibrium price and quantity. Dividing (22) by (23), we have:

$$\varepsilon^S/\varepsilon^D = -\frac{b}{d} \tag{24}$$

Now, we need to construct the supply and demand functions for blueberries in order to develop the cobweb model as applied to blueberries. The average of short-run price elasticities estimated from the four models in chapter 5, 0.22, is adopted in order to derive the supply function. The price and quantity of year 2008 reflecting the marginal profitability in the B.C. blueberry industry is used as the market equilibrium of the supply and demand functions. However, the price elasticity of demand for blueberries has to be assumed, due to the lack of data and the unavailability of historical econometric research in blueberries. Equation (24) states the relationship between the supply elasticity and the demand elasticity. According to the three types of cobweb models with different values of $\left(-\frac{b}{d}\right)$, therefore, we have the following three scenarios:

$\varepsilon^{D} < -0.22$, when it is convergent fluctuation;

$\varepsilon^{D} > -0.22$, when it is divergent fluctuation;

$\varepsilon^{D} = -0.22$, when it is continuous fluctuation.

Note: $\varepsilon^{D} < 0$.

In the reality, we expect the demand elasticity of blueberries to be elastic since blueberries have many other competitive crops. When the price of blueberries goes up, consumers can choose to buy strawberries, raspberries and other fruits. In theory, the blueberry's price is expected to converge to a steady state since most agricultural products are observed to be profit marginal. Particularly, agricultural business in B.C. is highly competitive because of the cheaper imports. Hence, in the long run, the B.C. blueberry industry is most likely to adopt the cobweb model of the convergent fluctuation. Therefore, it is safe to assume $\varepsilon^{D} < -0.22$.

In order to perform the sensitivity analysis of simulations to different demand elasticities, we set the demand elasticity in two scenarios: the inelastic demand elasticity and the elastic demand elasticity. In this study, for the sake of simplicity, we pick -0.30 as the inelastic demand scenario and -1.20 as the elastic demand scenario. As indicated earlier, we select the equilibrium P and Q in year of 2008 (the price approximately equals to the total production cost) where it is before the current bust in the B.C. blueberry industry.

5.2 Empirical Results

In this section, we present the results of the simulation for B.C. blueberry's price and acreage from period 0 to 30. Both price and acreage of blueberries converge to a steady state after a series of boom and bust cycles. The simulation results are developed first for the inelastic demand elasticity scenario and then for the elastic demand elasticity scenario.

In figure 8, the real prices of blueberries fluctuate significantly at the beginning periods and then gradually converge to a constant price which is the equilibrium price $0.72 per pound. As shown in figure 9 (the flowing page), after a sequence of fluctuations, the acreage of blueberries slowly converges to a steady state where the acreage is 18,000.

Figure 8: Cobweb Model Simulation for Pricing B.C. Blueberries-Inelastic Demand Scenario

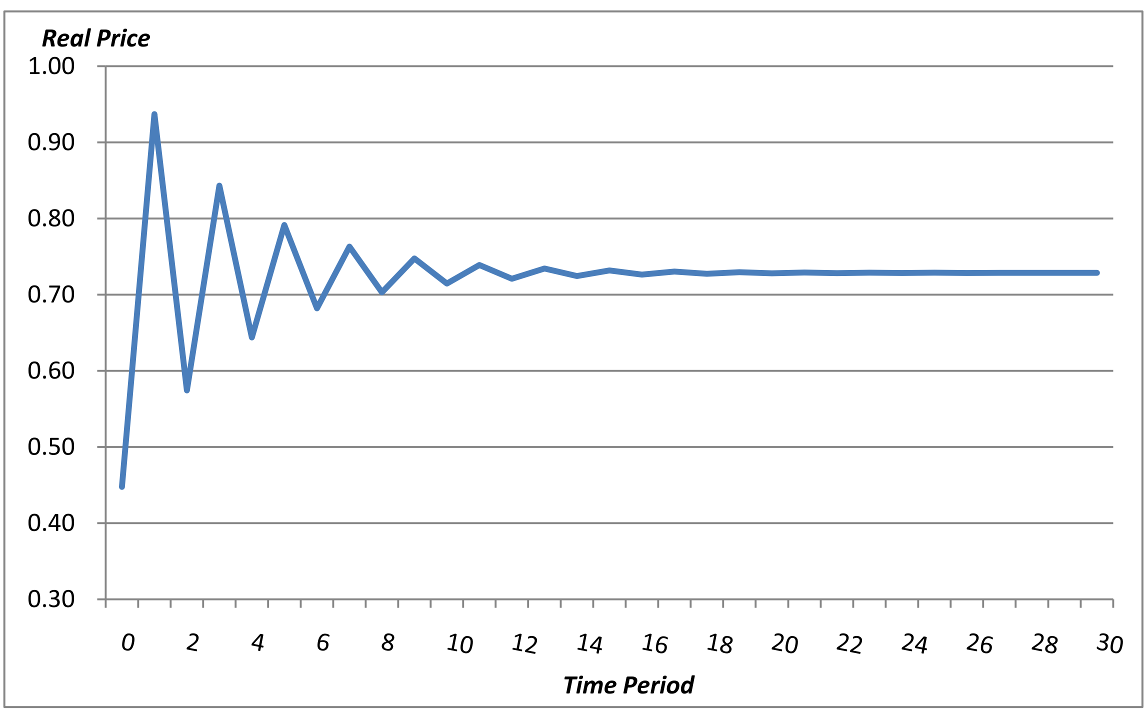


Figure 9: Cobweb Model Simulation for Acreage of B.C. Blueberries - Inelastic Demand Scenario

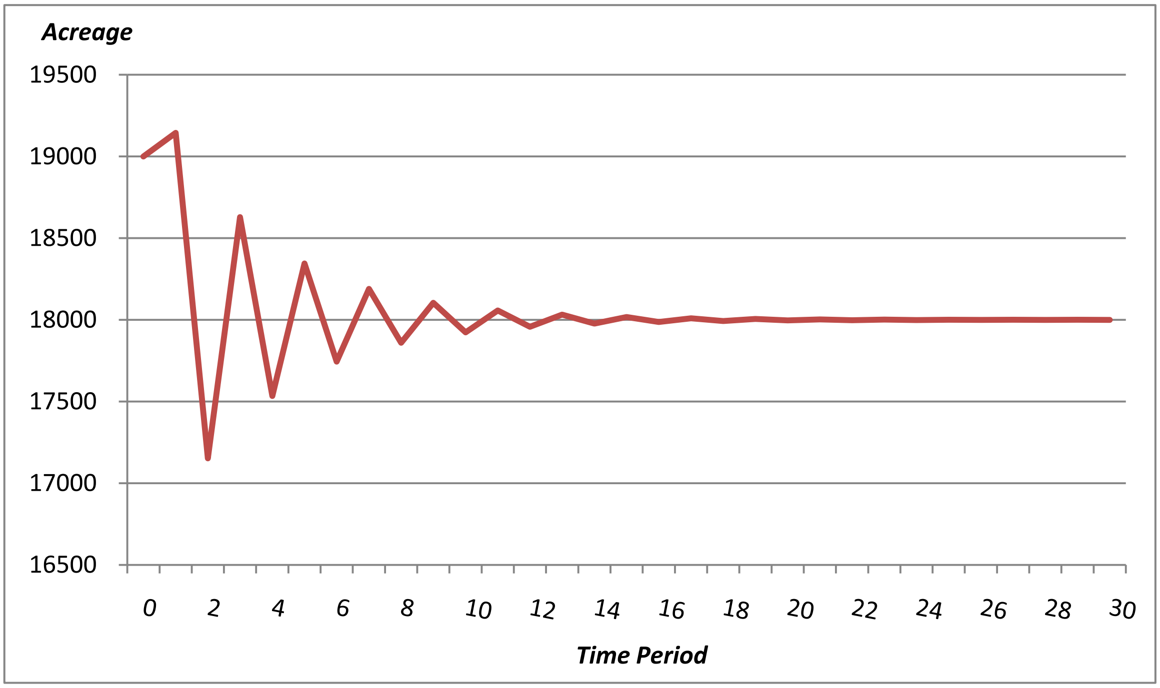
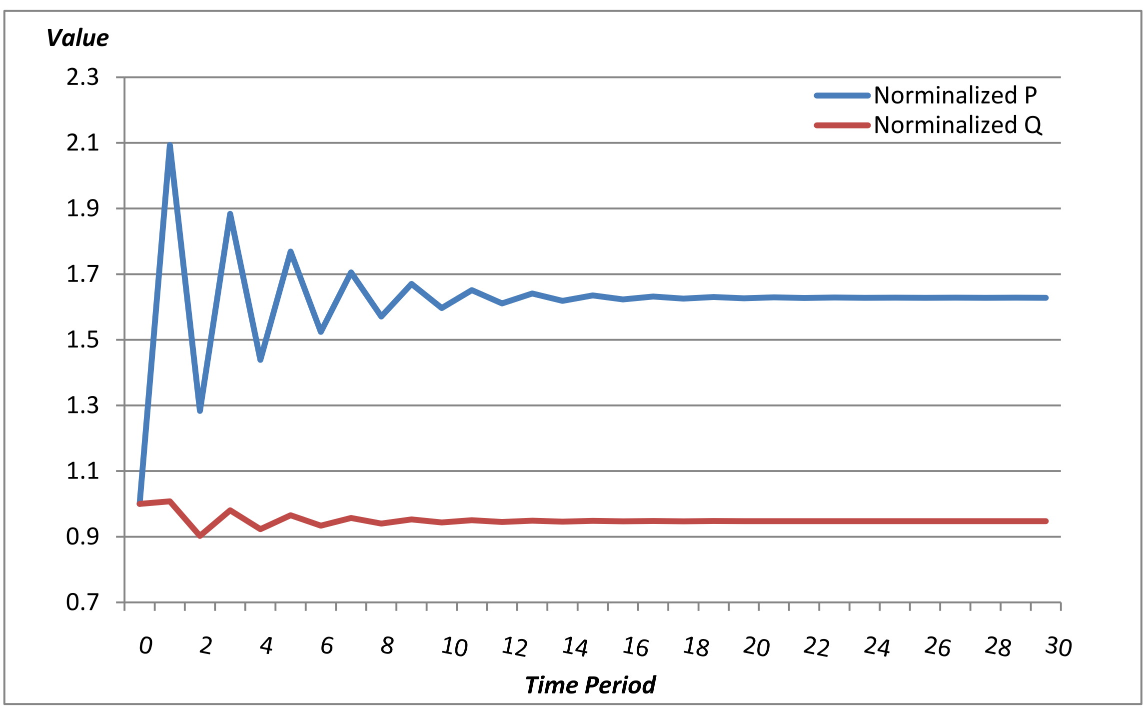


Figure 10: Cobweb Model Simulation for Normalized P and Q



In order to capture the correlation between the price and acreage, both blueberry's price and acreage are normalized. As figure 10 shows, the acreage fluctuates along with the price cycles. However, the oscillations of the acreage are smaller than the ones in blueberry prices due to the inelastic price elasticity of blueberry supply.

Now, with the elastic demand elasticity, as seen in figures 11 and 12, both the price and acreage of blueberries converge to the equilibrium much faster than the inelastic demand scenario. Specifically, it takes only 3 periods for the price and the acreage to converge to a steady stage. This implies that the more elastic the demand curve is, the faster the price and acreage converge to the equilibrium.

Figure 11: Cobweb Model Simulation for Pricing B.C. Blueberries - Elastic Demand Scenario

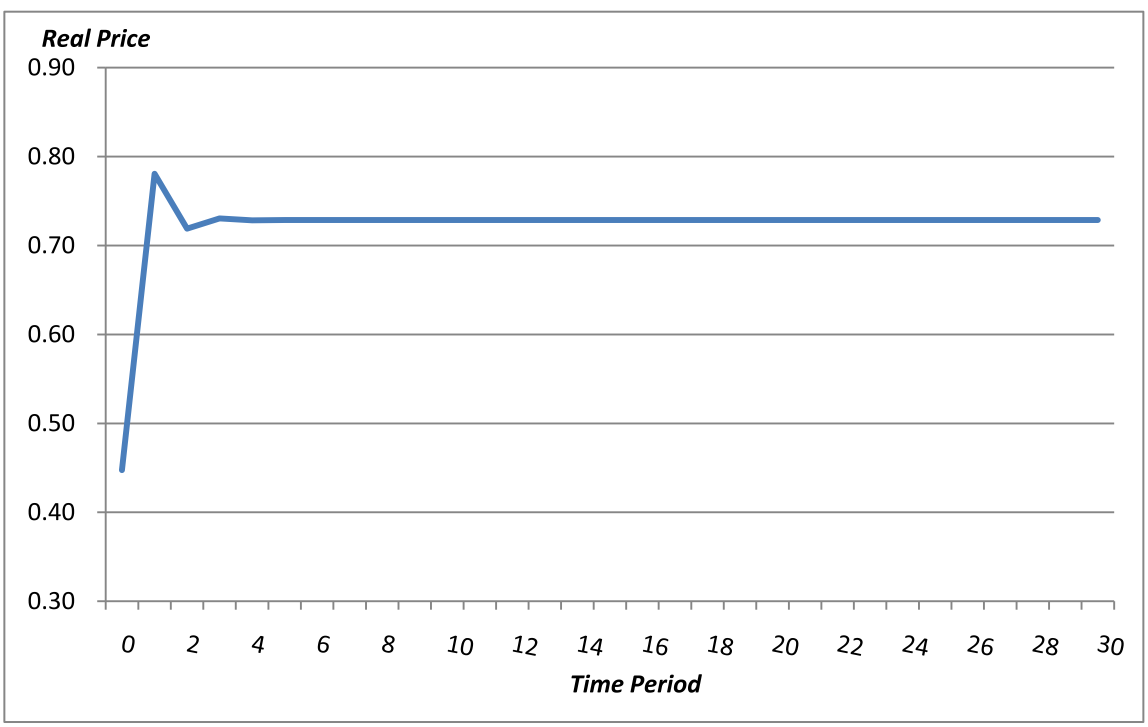
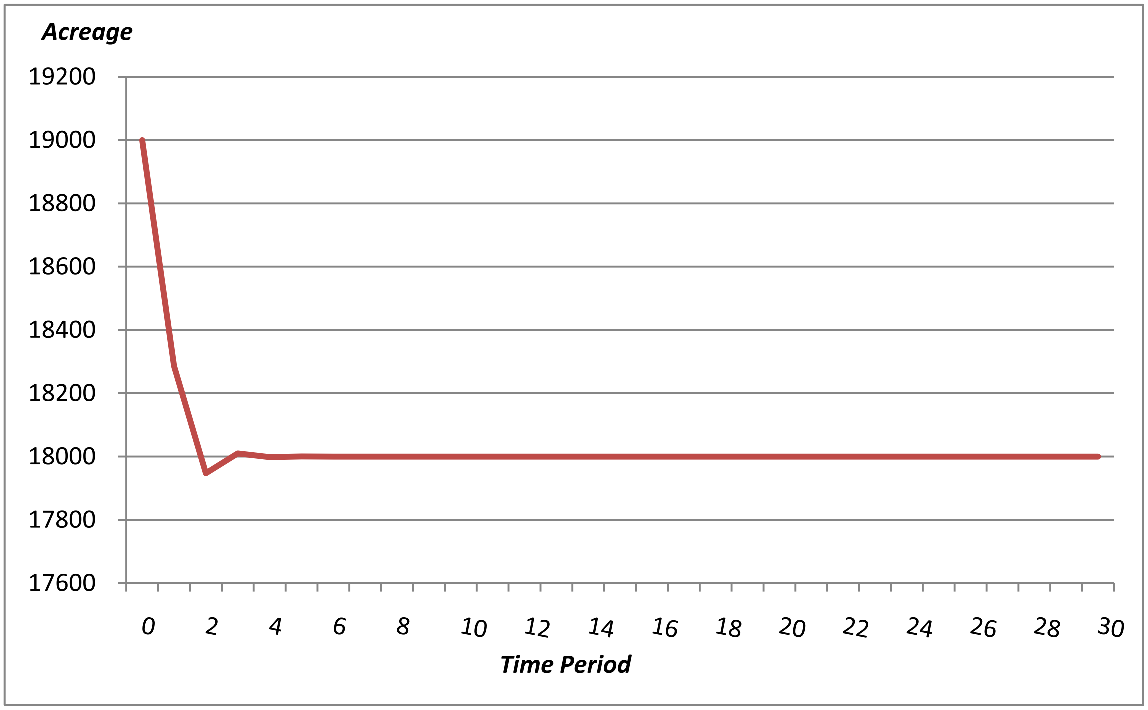


Figure 12: Cobweb Model Simulation for Acreage of B.C. Blueberries-Elastic Demand Scenario



In this chapter, we have examined the boom-and-bust cycles by simulating changes in the price and acreage of blueberries. By doing so, it is clearer to observe the dynamic nature of boom-and-bust cycles graphically. The results show that both price and acreage of blueberries converge to the market equilibrium resulting from the supply and demand function. The sensitivity analysis of convergence to demand elasticities indicates that the speed of convergence of the price and acreage increases as the demand curve becomes more elastic. As discussed earlier (page 54), the blueberry demand elasticity is most likely to be elastic and thereby we expect the boom-and-bust cycles of blueberry prices to converge in a short period.

Chapter 6: Summary and Conclusion

6.1 Summary and Conclusion

The purpose of this thesis was to investigate reasons for boom-and-bust cycles with B.C. blueberries as a case study. Blueberries were introduced to B.C. in 1920's. The growth of blueberry acreage was fairly steady until 1999 when scientists discovered substantial health benefits in blueberries. As a result of this discovery, the acreage of blueberries skyrocketed, which led to the blueberry boom. However, the blueberry price crashed in 2009 due to over production and the blueberry industry fell into the bust.

In order to fully understand and explain the boom-and-bust cycle of B.C. blueberry industry, we constructed three models: the spreadsheet model for analyzing the profitability of blueberry investment in B.C., the supply response model for B.C. blueberry farmers and the cobweb mode for simulating boom-and-bust cycles in the price and acreage of blueberries. First, the spreadsheet model studied the profitability of blueberry farming over a life cycle of 40 years with high prices during the boom period and low prices during the bust period. The results of financial analysis demonstrate that farmers earn considerable returns on investment with high prices during the blueberry boom. By contrast, as expected, farmers only break even, if not any worse, during the bust period in blueberry market. Given the current low prices in blueberries, however, most B.C. blueberry farmers still keep in production due to their commitment to the high land cost and large capital investment in their operations. Moreover, since blueberry is a long term investment, it would be difficult for farmers to switch to production to a more profitable crop within a short time. Many farmers expect the price to rise in the near future based on their past observations that blueberry's prices have been fluctuating over time. Consequently, they would keep staying in production. However, if the price of blueberries fall further down, it is believed that many farmers would have to leave the blueberry industry because they are not able to cover their production costs.

Second, a supply response model was developed for B.C. blueberry producers in order to derive the price elasticity of blueberry supply. The literature review was conducted in order to determine an appropriate supply function for B.C. blueberries. Recently, agriculture is considered as a multi-input and multi-output industry, thus supply response of agricultural products can be estimated through the profit function (Ball et al, 2003). However, we are not able to estimate the profit function due to the data unavailability of inputs required in blueberry production. The Nerlovian supply response model is commonly used in most econometric studies of agricultural products. The model describes desired acreage of crops as a function of expected prices and planted area. This feature enables the Nerlovian model to capture famer's reactions to changes in price expectations and thus it is suitable for estimating the price elasticity of blueberry supply. Although there are some improvements for the Nerlove's model pointed out by Wickens and Greenfield (1973), the data available for blueberries are only price, quantity and planted acreage which are not sufficient to estimate an investment function. Therefore, the Nerlovian model was used to develop the supply function for B.C. blueberries. The price index of other crops is included in the supply function in order to capture the substitution effect on the blueberry acreage. This is one way of our supply model differs from the Nerlovian model. Furthermore, the traditional Nerlove's model does not allow forward thinking, but clearly farmers would look ahead in the market. In order to solve this problem, a dummy on the intercept and the time trend starting in 2003 are respectively included in order to allow forward thinking in response to farmer's merging realization of greater demand for blueberries in the future. Four supply response models were developed with and without the dummy on the intercept and the time trend. The regression results show that B.C. farmers were inelastic to blueberry's price changes in the short run, while they were highly elastic to price changes in the long run.

Third, the average of short-run price elasticities of the four supply functions was used to develop the cobweb model for the simulation. Due to the lack of data on consumption of blueberries in B.C., the demand elasticity of blueberries had to be assumed in order to construct the cobweb model. There are three types of cobweb models determining by the ratios of supply and demand elasticities. The demand elasticity of blueberries is expected to be elastic since blueberries have many other competitive crops such as strawberries, raspberries and other fresh fruits. Moreover, it is evident that agricultural farming is marginally profitable in B.C. and thereby in the long run prices of agricultural products often come to a steady stage where the profits are break-even. Therefore, we adopted the convergent type of cobweb for blueberries. We assumed the absolute value of demand elasticity is greater than the supply elasticity. In order to show how simulations respond to different range of demand elasticities, however, a sensitivity analysis of cobweb simulations to the scenarios of elastic and inelastic demand elasticities was discussed. The imposed equilibrium price, in fact, is approximately the total production cost of blueberries in B.C. before the current bust. In the inelastic demand elasticity scenario, the results of simulation show that both the price and acreage of blueberries fluctuate significantly at the beginning periods however they gradually converge to a steady state where it is the equilibrium price and acreage solving from the supply and demand functions. In the elastic demand elasticity scenario, the convergences of both the price and acreage are much quicker than the ones in the inelastic demand elasticity scenario. Therefore, this finding implies that the speed of convergence of blueberry's price and acreage increases as the demand elasticity becomes more elastic.

The major conclusion of this dissertation is that B.C. blueberry producers were very inelastic in their response to price incentives in the short run but highly elastic in the long run. The estimation of model 3 shows that after the scientific discovery of blueberry's health values the supply curve shifted upward because farmers desired more acreage due to the expectation of larger demand for blueberries in the future. This means that farmers do look ahead and respond to the announcement and media publications. And this is also observed with the significantly higher rate of expansion in the blueberry's planted acreage from the statistical data.

The scientific discovery of substantial health benefits in blueberries led to the boom in the B.C. blueberry industry. The financial analysis from the spreadsheet model demonstrates that blueberry production is lucrative with high prices of blueberries during the boom period. However, due to oversupply, the blueberry boom was followed by the bust in the current blueberry market. According to the nature of boom-and-bust cycles, another blueberry boom might come after the current bust. This can be occurred when a large number of blueberry farmers go out of business or choose to leave the industry because of the low profitability during the bust period. As result of this, the blueberry price would start to increase due to a lower market supply, which may lead to another boom in the blueberry industry. Alternatively, another blueberry boom can be caused by a greater increase of demand for blueberries. It is believed that consumer's demand for blueberries would keep expanding as their realization of health benefits in blueberries further grows. Nevertheless, the simulation shows that in the long run blueberry's price and acreage will converge to a steady stage. The more elastic the demand is, the quicker the convergence is.

6.2 Restrictions and Recommendations

The lack of data required to estimate a demand function for B.C. blueberries is one of the major restrictions in this thesis. However, the results of simulation are as predicted in theory and a sensitivity analysis of demand elasticities is discussed. Another restriction is the derived Nerlovian supply response model is not appropriate for perennial crop such as blueberries. However, with the current availability of data, we are not able to develop the supply response model through the investment function or the profit function. Thus, implementing or extending the results of this current study to a more general case should be developed in further research.

Although there are restrictions of estimating a more accurate supply or demand function for B.C. blueberries, this thesis has fully examined the boom-and-bust problems with the current available data and methodology. It is obvious that this study will be beneficial for B.C.

blueberry producers or young farmers who are considering entering the blueberry industry. Since this dissertation is the first one to estimate the price elasticity for B.C. blueberries, it can also be beneficial for provincial agents such as B.C. Blueberry Council regarding performing econometric studies of blueberries. Moreover, the same approach and methodology adopted in this thesis can also be applied to other agricultural commodities or other industrial sectors.

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