Effects of Soil Quality on Farmland Prices in Manitoba

by

Yanlin Dan

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF SCIENCE

Department of Agribusiness and Agricultural Economics

University of Manitoba

Winnipeg

ABSTRACT

This paper illustrates farmland values in the ten Rural Municipalities (RMs) of southern Manitoba. Farmland price is measured using a Hedonic pricing model based on farmland's inherent characteristics (e.g. soil quality, farmland location and land size) and market variables (e.g. interest rate, agriculture incomes and price index). This paper aims to quantify the effect of soil fertility on land value. Based on transaction-level data and Manitoba soil reports, the results agree with the hypothesis in previous literature. The significance of soil quality in farmland price determination has been highlighted in this paper as well.

TABLE OF CONTENT

Chapter 1. Problem Statement and Objectives

1.1 Purpose and Contribution

Farmland pricing is a sustained topic that interests operators, economists and politicians. Since farmland is not only the major operation input in agriculture activity, but also a good investment piece in high urbanization potential area, farmland is a steady commodity to hedge against inflation. Furthermore, farmland price is sensitive to both farmland's characteristics and external financial factors.

By looking at the Canadian farmland values in the past five years, we can note that the increasing rate of farmland value slows down countrywide, with one exception being British Columbia. While most Canadian farmland markets are friendly to farm expansion, the farmland market in British Columbia faces severe pressures from urbanization issues (Farm Credit Canada 2017). Moreover, due to the regional disparity in geography, politics, economics and agriculture, studies focused on one location are not likely applicable to another. According to the results from the FCC (2017), out of the 51 regions that are reported there are no two equal regions. Even in a same province, the change in farmland value is responds differently to similar factors. For example, the farmland price in southwestern Saskatchewan is as high as 16.6% in 2016; but the farmland price remains the same in southeastern Saskatchewan.

Farmland is usually the most valuable asset in a farm. According to data from Statistic Canada (2011), the value of farmland and the attached building accounts for more than 75% of farm capital in 2010. The value of farmland with buildings per acre in Manitoba in 2010 more than doubled compared to prices in 1981 (Statistic Canada 2011). For those farmers who rent the land, rental cost is a substantial expenditure on the farm operation as well. Not only the farmers themselves, but governments also pay attention to land conservation and sustainability in the farmland market in order to maintain famers' wealth. For example, in the late 1930s, the Manitoba Government of Agriculture joined with the University of Manitoba and started soil surveys for insurance and taxation purposes (Manitoba Government 2017). Additionally, the investors wanted to capture benefits from farmland price swings. With all the attention from different aspects: the farm owners, the leaseholders, the governments and the speculators, it is important for researchers to understand farmers' requirements for their land purchases, and how those requirements impact the farmland price.

In Manitoba, one of the major farmland price determinants is soil productivity. Since the urbanization problem is not prominent, farmland is usually purchased for agriculture purposes in Manitoba. Moreover, crop production occupies more than 90% of the total farm capital. 11.6 million acres out of 19.1 million acres of total Manitoba farmland is cropland (Statistic Canada 2011). In this case, farm yield becomes especially important to the purchasers. Whereas, farm yield is mainly decided by soil quality. Thus, the farmland with high quality land is preferred in the market.

There are massive research efforts that are devoted to farmland price investigation, and it is widely agreed that soil quality is one of the most important determinants in farmland pricing. However, research can be constrained by aggregated data and fail to measure the importance of soil quality in farmland purchasing quantitatively.

The unique feature of this paper is that both farmland price data and soil quality data are in transaction-level. This allows researchers to analyse farmland price based on the soil quality information. The less aggregated data associated with the hedonic price model (HPM) provides a tool for farmland price investigation. The location information of each farm is also included in the dataset, which provides the sources to analyse the effect of regional distinction on farmland price. Furthermore, increases in farm income increase the price of farmland. The increasing farm-operation profits stimulate the demand of farmland, which pushes the price up gradually. Financial factors such as price inflation and interest rate, contribute to farmland price determination as well.

Overall, the major purpose of this paper is to determine the factors that may affect the farmland price in Manitoba with transaction-level data. Among all the farmland price determinants, the soil quality factor is the main concern of this study.

1.2 Overview

This thesis contains seven chapters: introduction, background, literature review, theory, data, empirical model and the results, and summary and conclusion. The first chapter provides a brief introduction of the topic and states the importance of soil quality in farmland price determination. Chapter 2 is divided into two parts: the history of Manitoba farmland market, and information about soil quality leveling system in Manitoba. Chapter 3 provides related literature reviews. Chapter 4 introduces the hedonic pricing model and explains the reason why this model is appropriate for this study. Chapter 5 describes the dataset and shows how the data is modified in order to fit into the theory. Chapter 6 analyzes the results and interprets the estimators. Chapter 7 summarizes the entire thesis, indicates the limitation of this research, and proposes some suggestions on the future studies.

Chapter 2. Background

2.1 History of Manitoba Farmland:

For the purpose of attracting immigration from Europe, America, and eastern Canada, some significant changes in Canada have been made; changes such as a new transcontinental railroad, and new policies on land ownership. The Canadian Dominion Land Act was designed to gear up the local economy and the population size (Gagnon N.D.).

The Canadian Homestead Act (1872) allowed the government to distribute 160 acres of land to a male applicant for free with only a 10 dollar fee for administration. Since the soil in the southern Palliser's Triangle area is relatively arid, the Canadian Homestead Act also allowed the male farmers to put an additional 10 dollars down to claim another 160 acres of neighboring land. Farmers were able to obtain 320 acres of farmland in total using this policy option (Homestead Congress 2010). A 320 acres of farmland is large enough for farmers to generate profits from, even though the soil quality was not ideal for cultivation. To prevent speculators from benefitting by this act, government required the applicants to cultivate at least one quarters of the distributed land within three years, and to build a permanent residence in the same time frame. Furthermore, when it was initially passed in 1872, this Act stipulated that the land should be at least 20 miles away from the railway (Gagnon N.D.). The original intention of this condition was to discourage the speculators. However, it also kept farmers from benefiting from this policy as well, because when the farmland is far away from the transportation centers, the transportation cost is too high to make a profit. As a result, the Canadian Homestead Act failed to achieve its goal in the beginning. Several adjustments were made to shrink the exclusion zone to popularize the Canadian Homestead Act. Finally, the exclusion zone was totally wiped off in 1882.

Since then, the Canadian Homestead Act brought massive population increases to the three prairie provinces: Manitoba, Saskatchewan and Alberta. The rural population data of Manitoba is available from 1871; whereas this data is not available until 1901 for Saskatchewan and Alberta. As shown in Figure 2.1, the rural population in all the three Prairie Provinces was expanded when this Act was enacted, and faced a small population decrease when the Canadian Homestead Act was ended in 1930. In beginning of the 1930s, the Canadian Homestead Act was limitedly effective in the Northwest area.

Canadian agriculture production boomed because of the international market, and dry farming techniques (Dick, 1980). For example, when we consider wheat production we see the export income tripled every ten years from 1890 to 1920 (Figure 2.2). Strong wheat prices were one of pillars supporting the increase in export incomes. According to the data from the United States Department of Agriculture (1941) (Figure 2.3), wheat prices doubled within two years. Wheat prices swung around the high price point for three years, but crashed in 1920 and reached the trough in 1921. The drought in 1930 accelerated the soil degradation in the prairie provinces, which directly lead to crop failure.

Apart from agricultural production and commodity prices, interest rate is another determinant of the agriculture market. Figure 2.4, 2.5 and 2.6 indicate that interest rate, farm debt by Chartered banks, and the farmland value per acre all reached their peaks in 1980. As the inflation rate rose in the 1970s, many farmers chose to bring additional funds from banks for farmland purchasing. Unfortunately, farm equity was broken by the climbing interest rates in the early 1980’s, and some farmers were forced to sell their land to reduce the leverage rate. Some of them even declared bankruptcy due to the financial market fluctuation.

After suffering from economic downturns for over a decade, farmland markets eventually recovered. From 1992, Manitoba farmland value increased every year up to 2016. Farmland value grew to over four times the price in 1992 (Figure 2.7). The farmland value appreciated partially from the development of agriculture technology. With the assistance of agricultural machinery, cost-efficient cultivation and advanced crop/livestock breeding, less manpower was needed and yields increased. According to Figure 2.8, from 1950 to 2011, 35% of rural population moved to urban areas. In this case, farms had to expand their scale to increase profit. However, the Manitoba total farmland area remains relatively stable. As shown in Figure 2.9, the total Manitoba farmland acreage in 2011 was the same as sixty years ago. The only way for farms to expand, is to merge with neighbor farms, effectively reducing the total number of farms and enlarging the average farm area. The number of Manitoba farms and its area data are illustrated in Figure 2.10 (a) and 2.10 (b). The average area per farm tripled from 1951 to 2011, and the number of farms is one third of what it was six decades ago. As a result, the total Manitoba farm's gross receipts increased from $4.07 billion to $5.29 billion, from 2006 to 2011 (Government of Manitoba 2011). The number of high gross receipts' farms increased in percentage as well: only 20% of farms received (gross) more than 250000 dollars in 2006; however, this number has increased to 29% in 2011 (Figure 2.11).

2.2 Soil quality

As early as the 1960s, Franklin J. Reiss was aware of the importance of soil productivity to farmland market. In 1965 he published "Farm tenancy arrangements in the USA" to illustrate the correlation between soil qualities and rent level (1984). He indicated that rent levels and soil fertility are closely connected. For example, the typical share rent for a piece of high quality land is one-half; however, the share rent for a low productivity farm can be as low as a quarter. Barry et al. (2000) also emphasized that crop yield increases as soil quality increases. Compared with barren land, the yield can be doubled in high quality land. Since the soil productivity divergence generates a huge yield difference, the soil fertility becomes very important to farmland pricing. Miranowski and Hammes (1984) pointed out that aggregated data averaged out the price differences of farms with distinguished soil quality levels. Thus, they chose to use the transaction-level data to check into the implication behind the soil characteristics for farmland value. Without a comprehensive soil leveling system, Miranowski and Hammes collected the soil using the following three aspects: the topsoil depth, the pH level, and the potential erosivity. The coefficients suggest that all three variables have the expected sign, and are significant to the farmland value determination. Meanwhile, Miranowski and Hammes' work also provided guidelines for making policy and the creation of soil level systems.

The ideal soil for cultivation should be black, well-drained with medium-texture, and have deep top soil. Among all those factors that influence soil productivity, soil moisture appears to be especially crucial in the case of Manitoba agriculture due to its special geographic features. Manitoba was called "Wet prairie" by Bower (2011), which is a joint name for differnt kinds of wet landscapes. Basing on anthropocentric perceptions, "Wet prairie" was defined as an area that has too much surface water to be developed as an agricultural land (Bower 2011). One of the reasons that results in surface water surplus is the unique physical geography of Manitoba. With almost the same acreage as Denmark, though Manitoba was described as a large flat area (Krenz and Leitch 1993), the higher elevation on both sides of Manitoba makes the province a large basin (University of Manitoba 2015). From west to east, based on the height above sea level, Manitoba can be divided into three regions: south west uplands, Manitoba lowlands, and Precambrian shield. According to Krenz and Leitch (1993), the majority of Manitoba is gripped by two higher elevation regions. Manitoba terrain leads to water pooling when it rains or when the snow melts. With this topography feature, the drainage ability of soil for agriculture becomes particularly important for Manitoba's agricultural land.

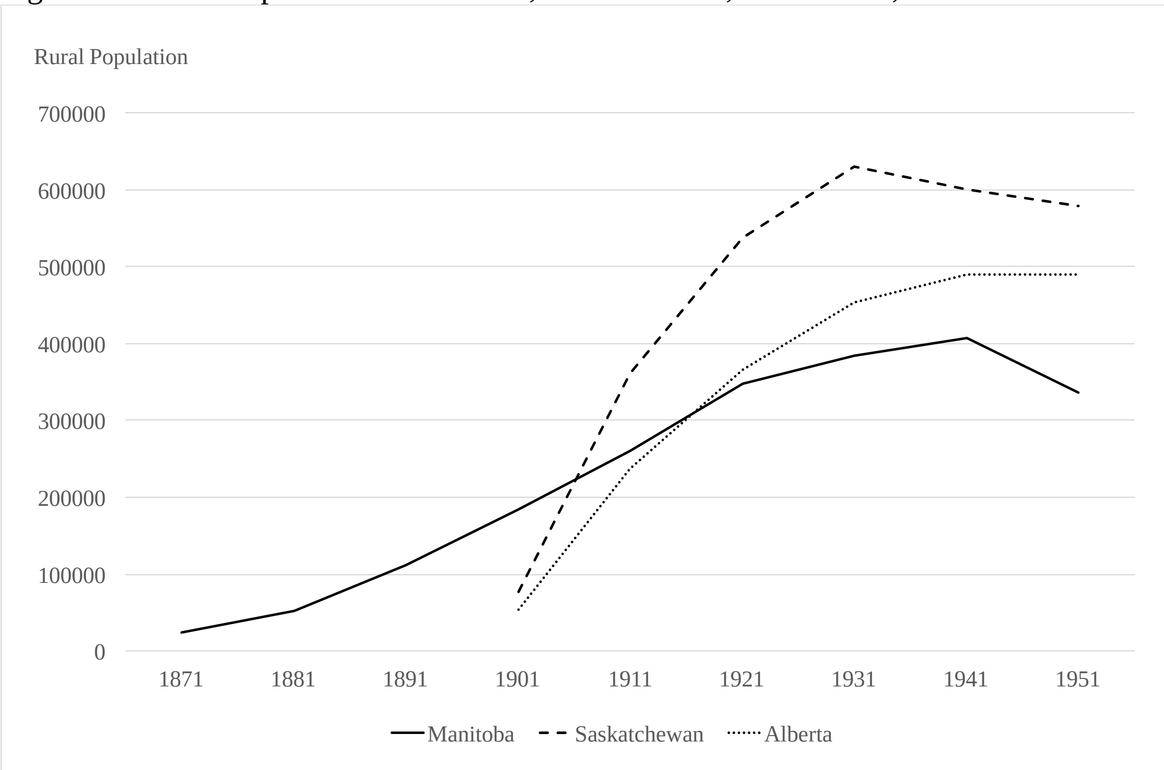
In the 1930s, in cooperation with the Department of Soil Science at the University of Manitoba, Manitoba Agriculture started a Manitoba soil survey to classify Manitoba soil systematically. Most areas in Manitoba have been studied and classified into over seven-hundred soil series' by their morphological features. At the start, these reports were used directly for engineering, recreation planning, and agriculture purposes. For example, based on these soil reports, in 1960 the Manitoba Crop Insurance Corporation (MCIC) started to provide insurance to farmers. However, the farmers complained about the insurance system. The premium rate and the insurance coverage were mismatched because the soil reports do not include the farm's actual potential soil productivity information. Thus, the MCIC found that the ideal insurance system should link with the yield level of land. Finally, the MCIC created a new soil classification system, called Soil Productivity Index (SPI), which can reflect lands' potential productivity (Government of Manitoba 2010).

Theoretically, the soils can be ranked through only yield history data if the yield history data is available across the entire Manitoba agriculture area. However, the yield history data is only available in a small portion of Manitoba. In this case, the SPI system was generated based on both the yield history the soil reports through two steps. Firstly, the soils with yield history are ranked from A to J (high yield to low yield). By using the information from the soil reports, the characteristics of each soil level were summarised. Then, ten benchmark soils were defined with both potential yields and morphological features. The second step is to compare the remaining soils (without the yield history) with each benchmark soil. As a result, each quarter section of the land was assigned with an SPI, which is same as its most similar benchmark soil. (Ridley et al. 1966).

Other than the potential yield, climatic factors were also considered by the MCIC when the insurance system was established. The climate is influenced by temperature and moisture. The temperature related climatic factors are: length of growing season, frost hazards, and heat units. The moisture related factors are precipitation rate and evapotranspiration rate. All of these factors were covered in the rating system. The actual yield of soil is decided by both climate and its potential yields. Thus, MCIC divided Manitoba into sixteen risk areas to differentiate the yield risks. The soils with the same SPI in different risk areas may have different premium payments due to the climate differences. However, in this thesis, the targeted ten rural municipalities (the gray area in Figure 2.12) are contiguous with each other, so the climate variation is not a significant variable.

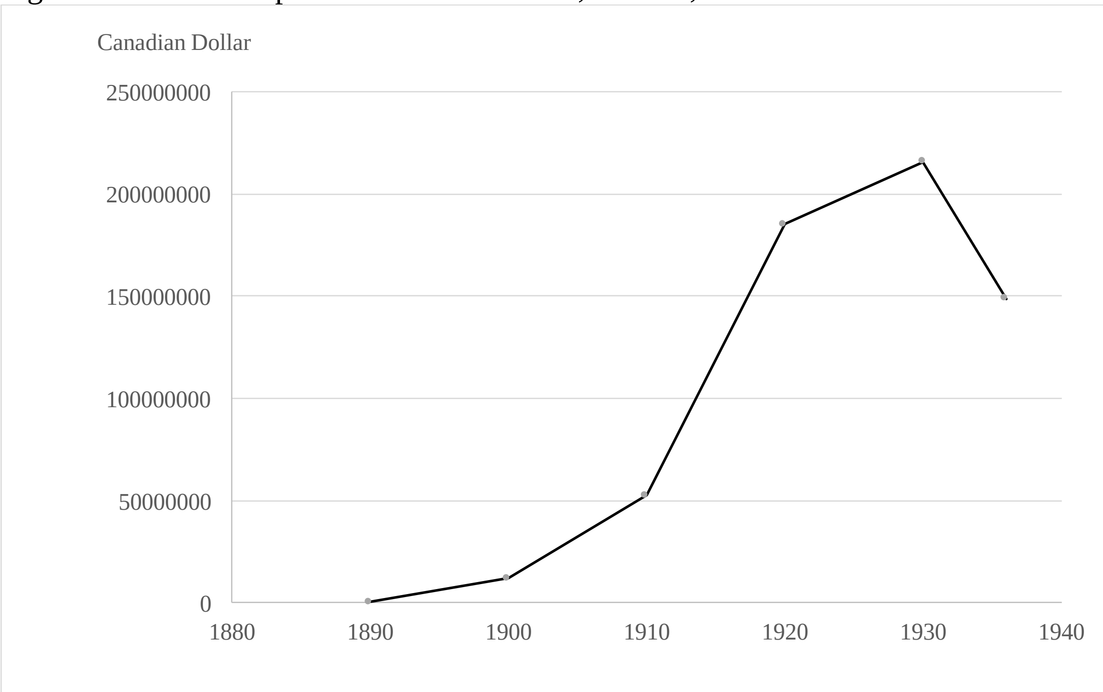
2.3 Figures

Figure 2.1. Rural Population in Manitoba, Saskatchewan, and Alberta, 1871-1951



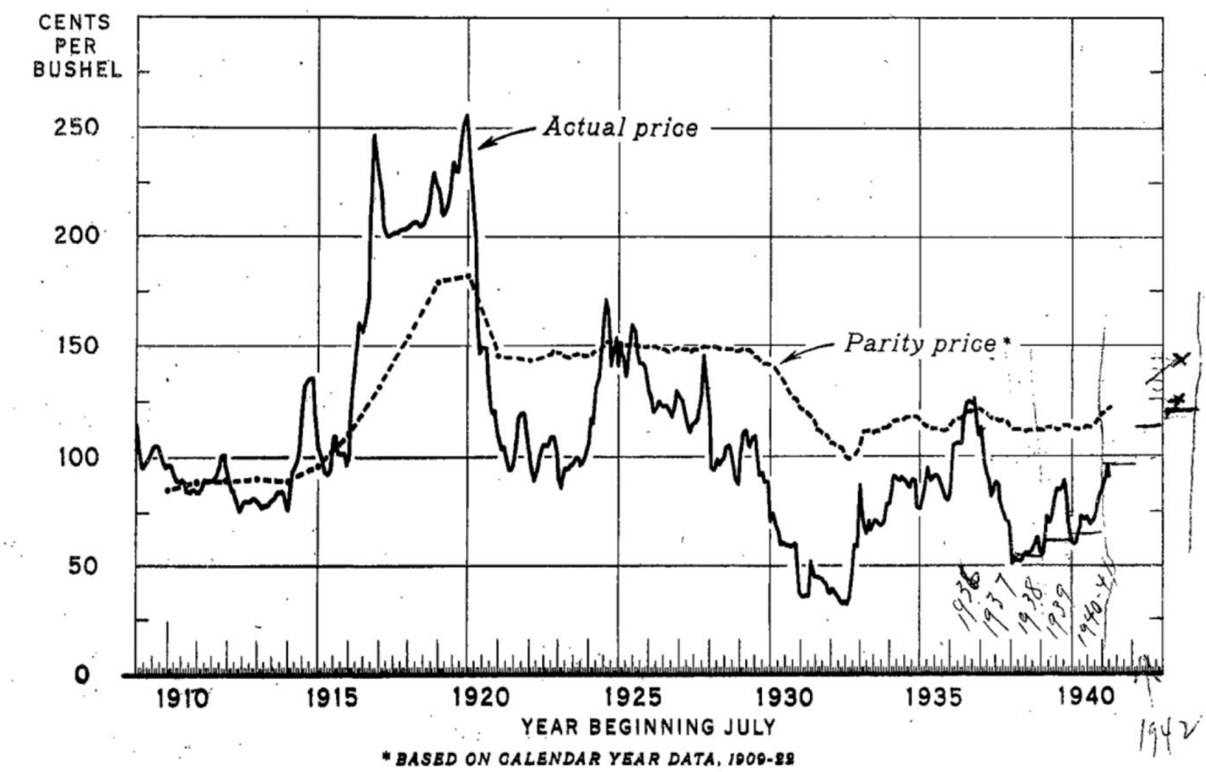
(Statistics Canada 2011)

Figure 2.2. Wheat Export in Canadian Dollar, Canada, 1890-1936



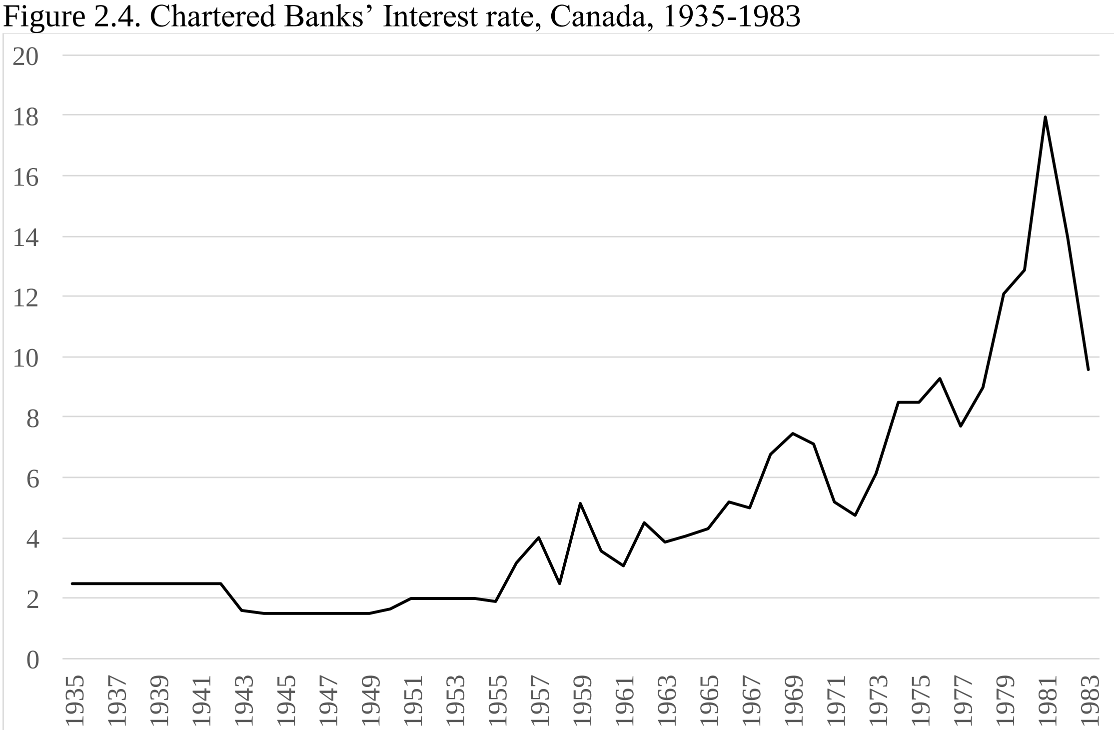
(Statistics Canada 2009)

Figure 2.3. Wheat Price in US Dollar, United States, 1909-1941



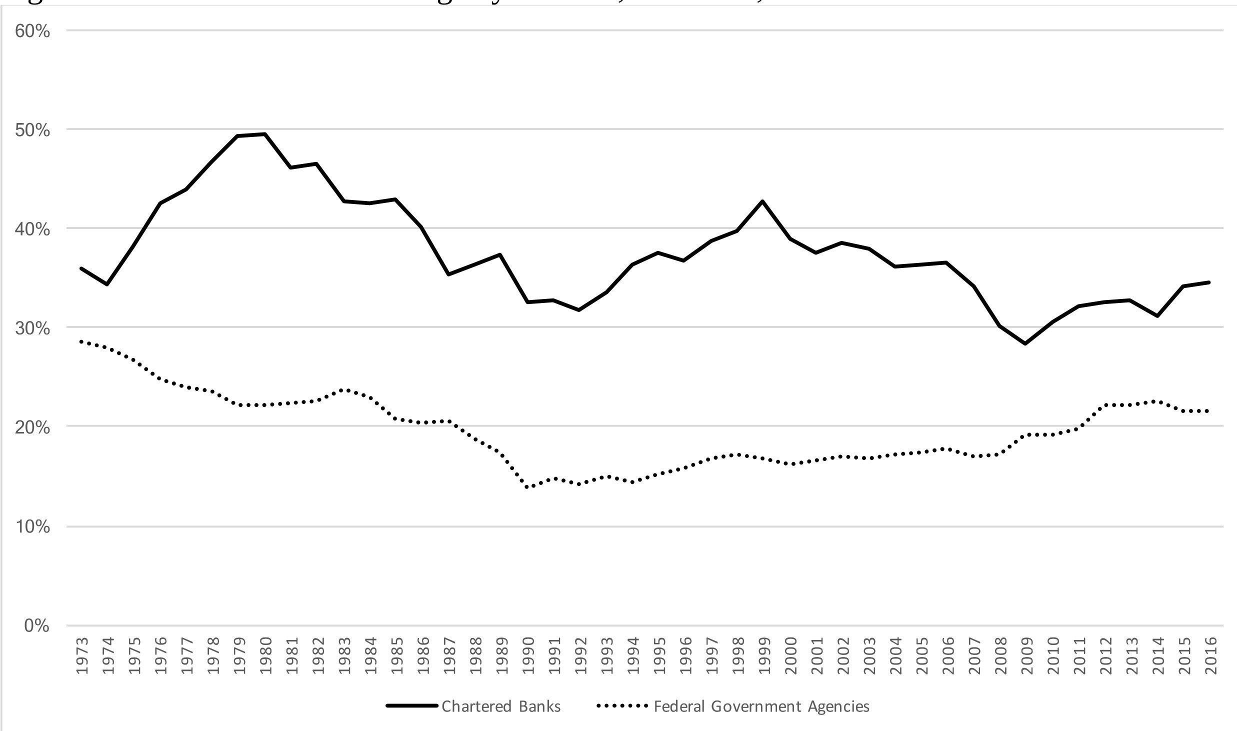
(United States Department of Agriculture 1941)

Figure 2.4. Chartered Banks' Interest rate, Canada, 1935-1983



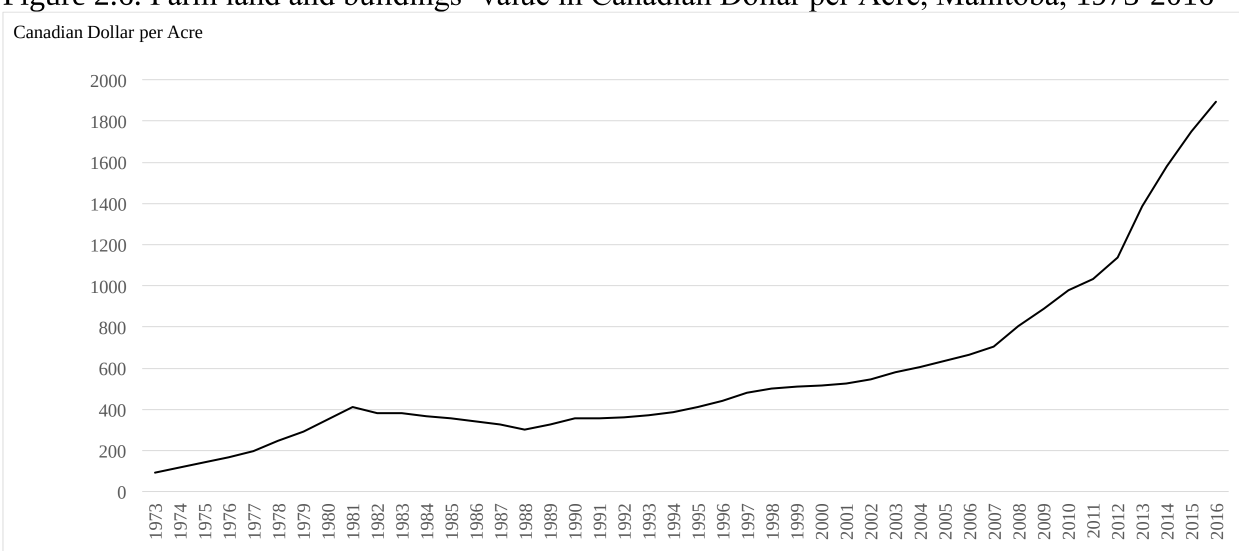
(Statistics Canada 2012)

Figure 2.5. Farm Debt in Percentage by Lenders, Manitoba, 1973-2016



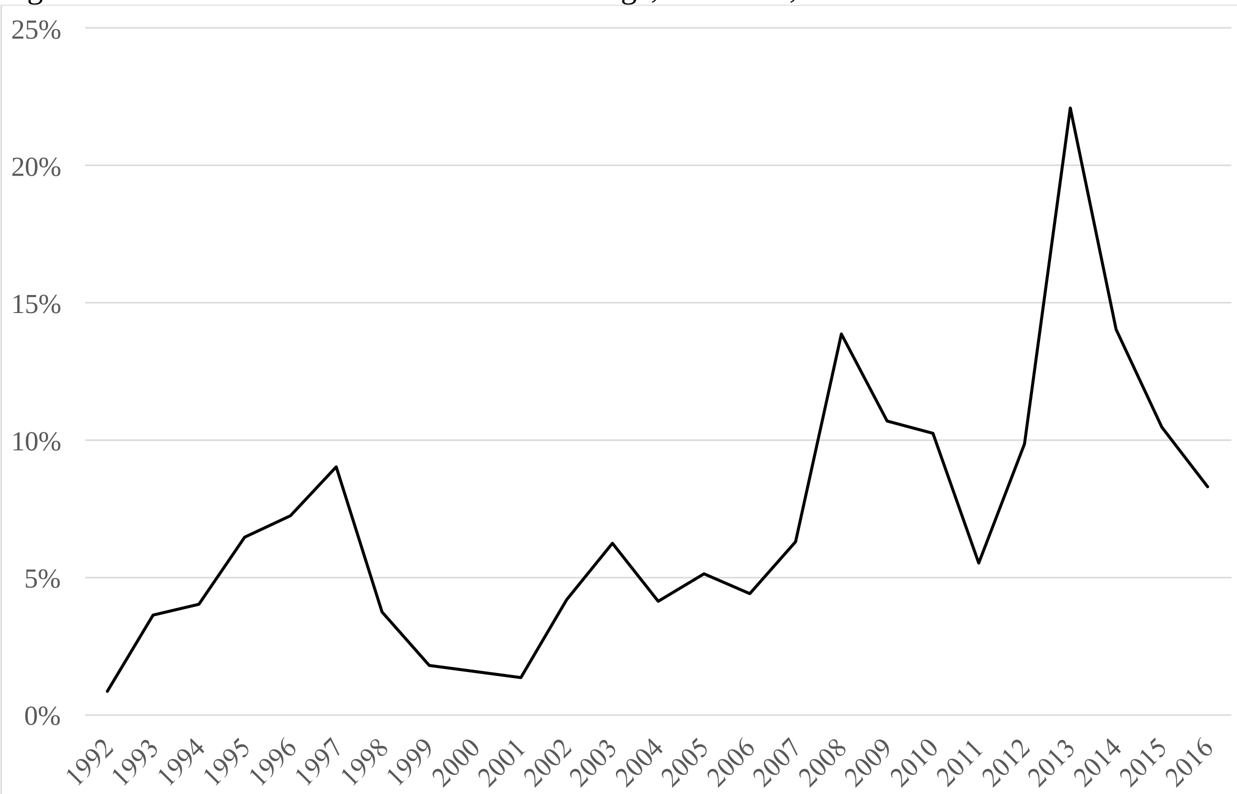
(Statistic Canada 2017)

Figure 2.6. Farm land and buildings' value in Canadian Dollar per Acre, Manitoba, 1973-2016



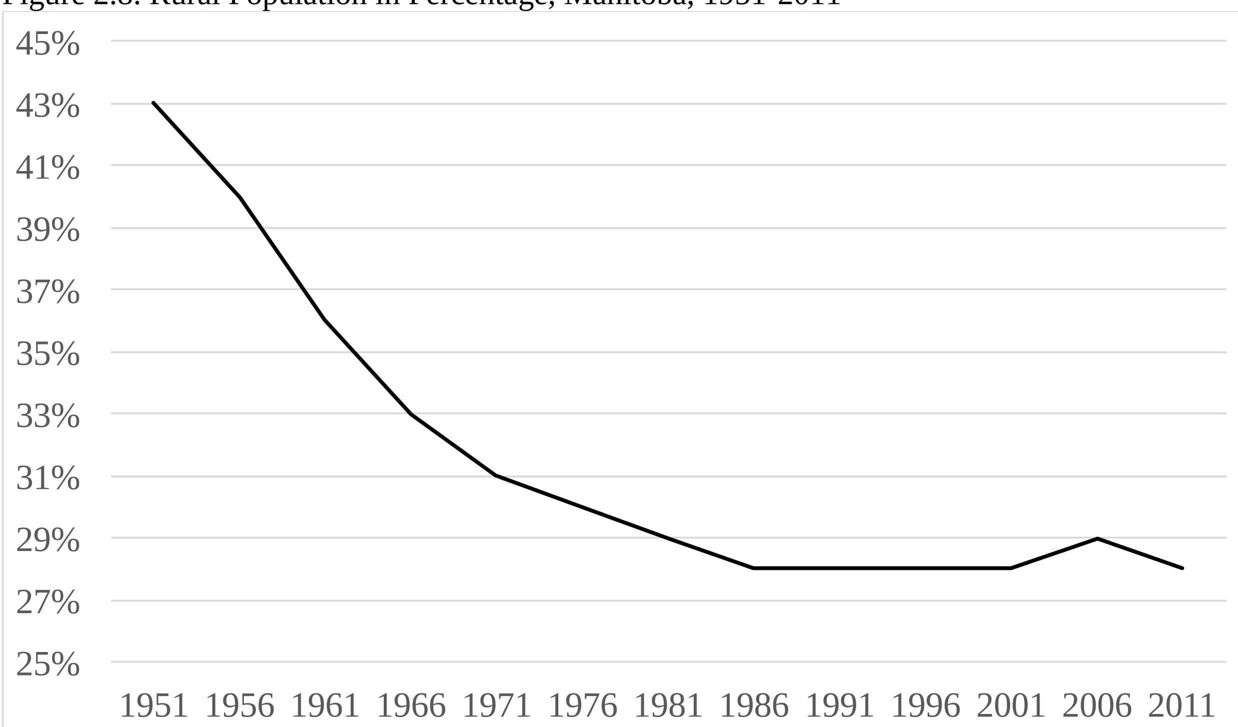
(Statistic Canada 2017)

Figure 2.7. Farmland Value Increase in Percentage, Manitoba, 1992-2016



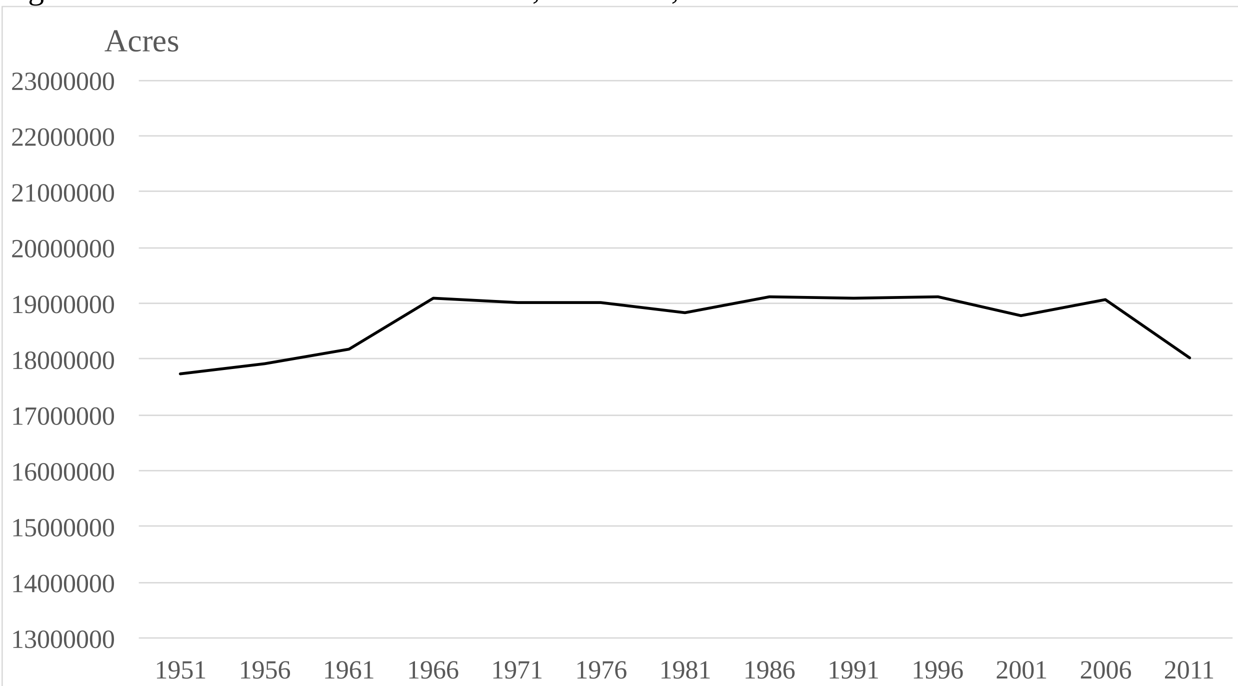
(Statistic Canada 2017)

Figure 2.8. Rural Population in Percentage, Manitoba, 1951-2011



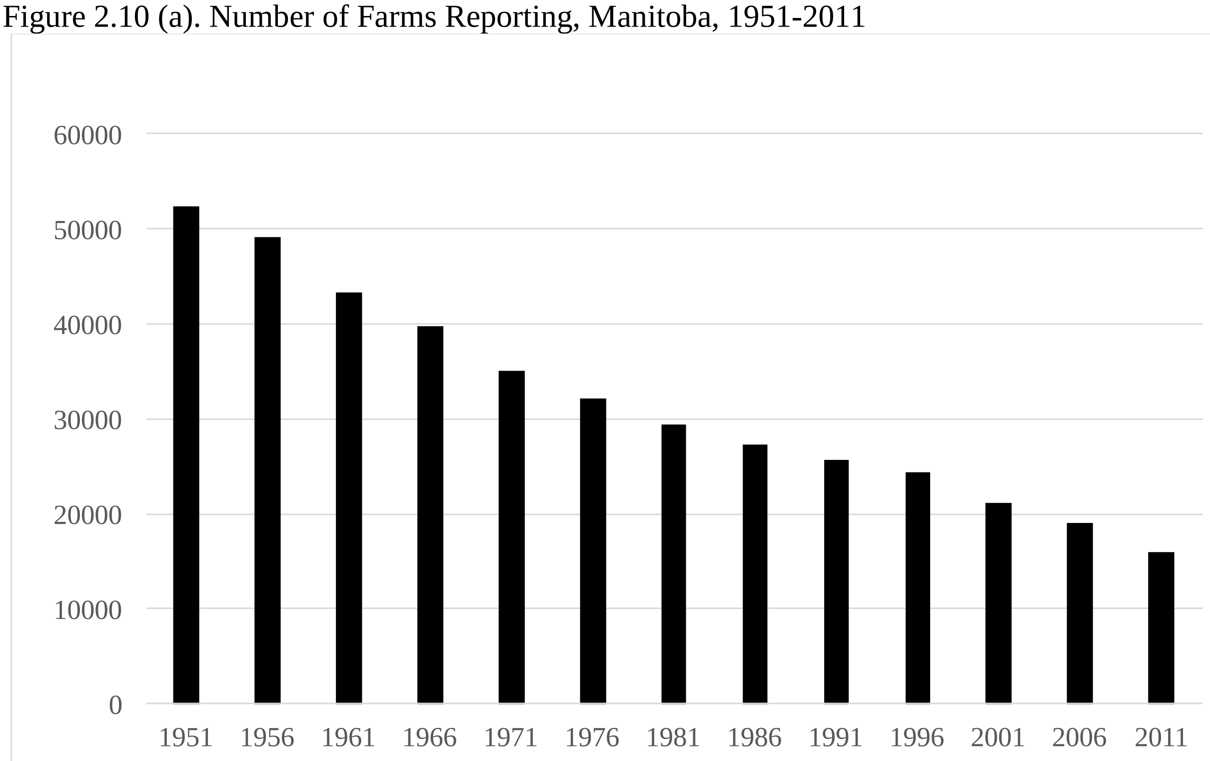
(Statistics Canada 2011)

Figure 2.9. Total Farmland Area in Acres, Manitoba, 1951-2011



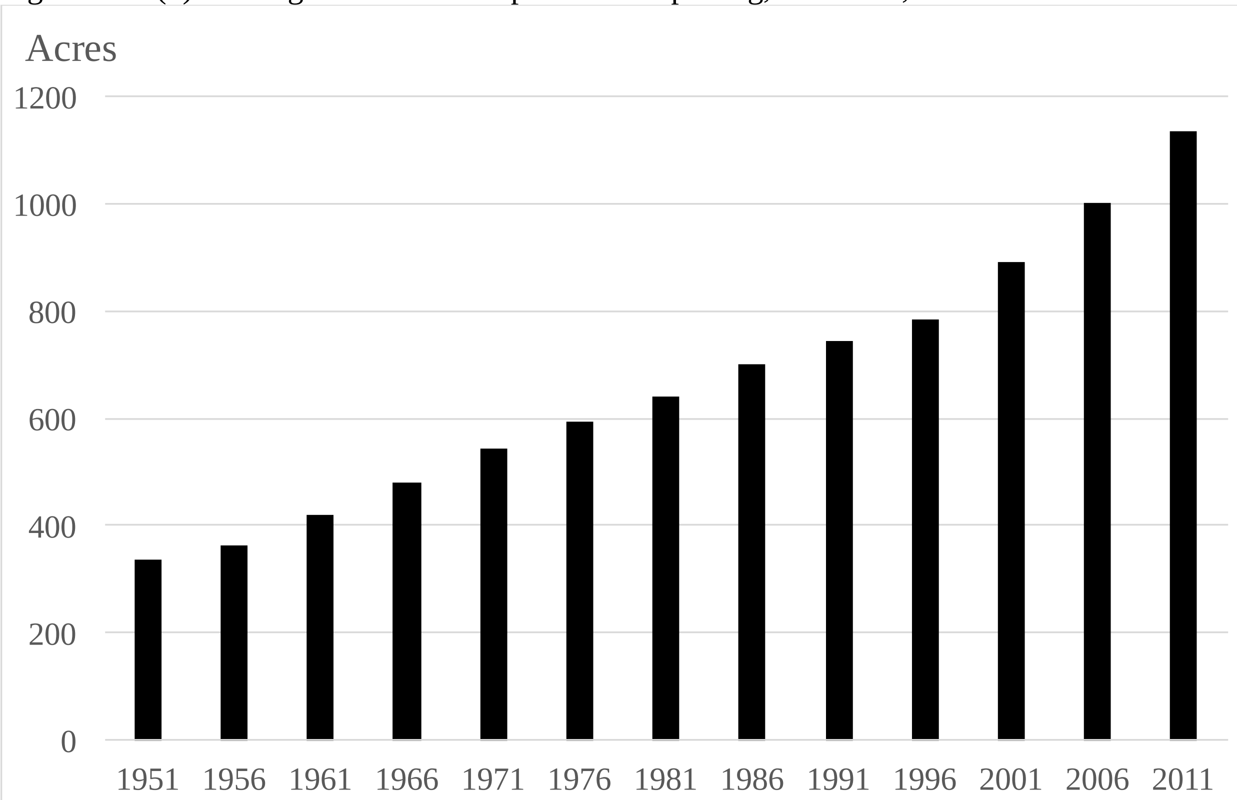
(Statistic Canada 2012)

Figure 2.10 (a). Number of Farms Reporting, Manitoba, 1951-2011



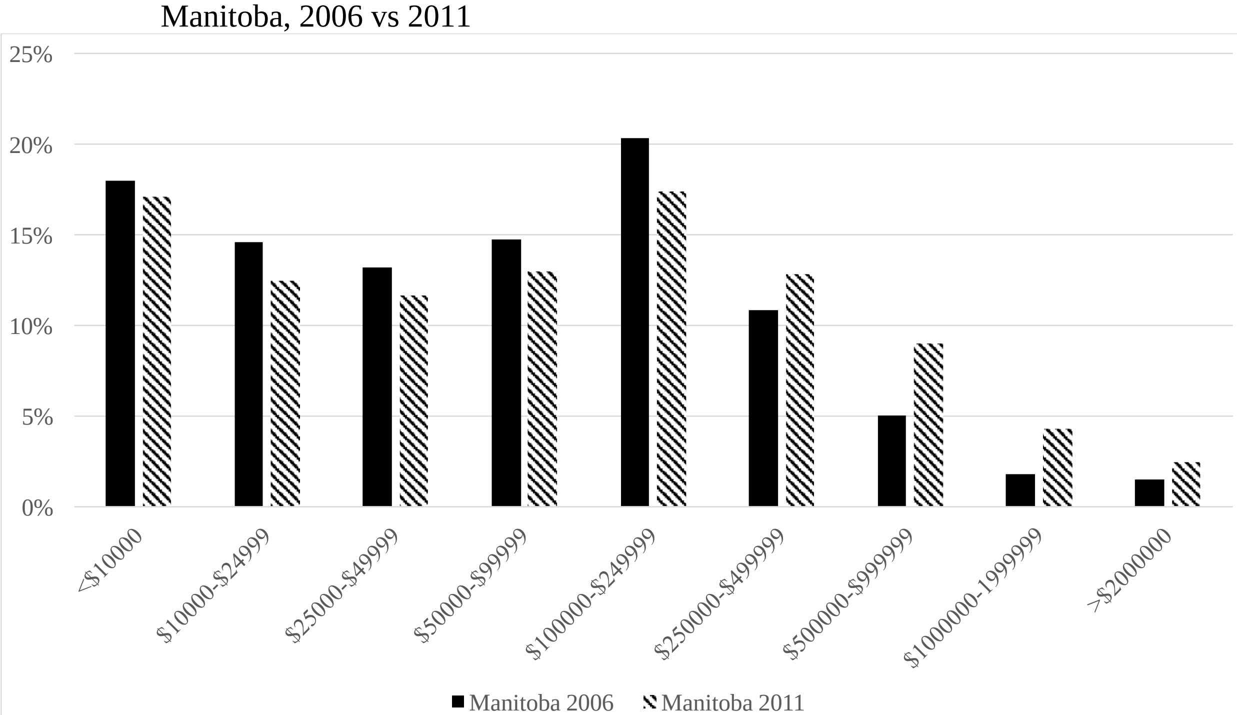
(Statistic Canada 2012)

Figure 2.10 (b). Average Area in Acres per Farm Reporting, Manitoba, 1951-2011



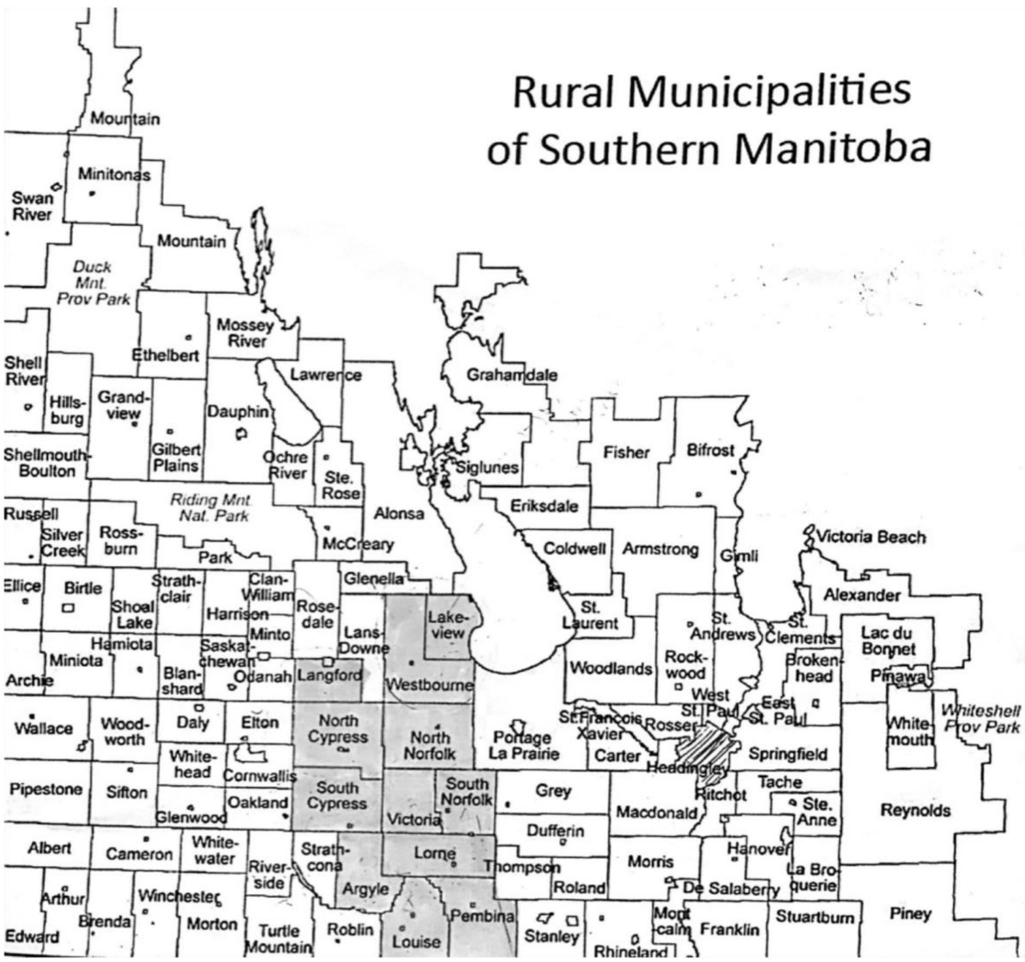
(Statistic Canada 2012)

Figure 2.11. Number of Farms Reporting in Percentage Classified by Gross Farm Receipts, Manitoba, 2006 vs 2011



(Manitoba Government 2011)

Figure 2.12. Location of the Ten Rural Municipalities, Rural Municipalities of Southern Manitoba



Chapter 3. Literature review

As one of the most important components on a farm's balance sheet, farmland determines farmers' total capital level directly. At least 75% of total agricultural assets come from farm real estate values (Gulcan et al 2018). A considerable volume of research has been carried out on farmland pricing from various aspects.

3.1 Econometric and Farmland trading facts

Farmland is such a special product that is unmovable from its location with predetermined quality. The uniqueness of farmland makes it not only an agriculture producing fundamental, but also to be a financial tool to hedging against inflation (Just and Miranowski, 1993). Moreover, the quality and location of farmland that a farmer already owned influence farmers' purchasing choices of an extra piece of land (Ziemer and White, 1981). Thus, farmland pricing should be based on both features of farmland market and econometric models.

Just and Miranowski (1993) indicated that the econometric model tends to make misspecifications, and the results are usually biased if the independent variables are highly related with each other. To complement these shortcomings, Just and Miranowski choose to use not only econometric model, but also economic theories to figure out the reasons of the large farmland price changes in the USA during the 1970s and 1980s. Their paper focused on a macroeconomic perspective, and organized the relationship among the independent variables based on several factors, such as the wealth accumulation, debt-reducing, effect of inflation on savings, and the tax law before applying econometric models. The paper mentioned that the return to farm is the only main price driver in the 1970s. However, as early as 1973, the farm returns started to decrease. With increasing farmland prices, the gap between return and price reached the highest point in 1981. Since the capital theory indicates that the price of the property should follow its returns, the gap between return and price creates the arbitrage potential.

Ziemer and White (1981) took the farmers' motivations on purchasing farmland into consideration through the Tobit model. A farm's total production is determined by both yield and commodities' price. In addition, the land size and the quality of the soils decide the total yields that the farmer can get. Moreover, as a part of the inputs, the expenses on purchasing farmland is also considered as part of the operation cost. Farmers' demands on farmland are determined by their production expectations and budgets. Thus, once the farmer's Hedonic price curve tangents with the Bid curve at a different equilibrium point, which leads to a higher land demand, the farmer starts to expand the farm. This indicates that the amount of farmland that the farmers hold will affect the demand of extra farmland. As a result, ignoring the processes and the reasons for farmers to expand their property would lead to biased results. The observations in Ziemer and White's research are confined into 89 individuals who fulfill all the three requirements: (i) own farmland since 1960, (ii) still own the land in 1977, and (iii) purchased the land between 1970 to 1978. The data contained information about the land size, market price, the owner's age, off-farm income, and historical land ownership. Because the observations were not sampled randomly, the Tobit model was raised to eliminate the bias. According to the results, all variables have expected sign and are statistically significantly different from zero. Also, following the life cycle, the land demand by young and old individuals are higher than the middle age buyers; the lowest demand group is at age forty-seven.

3.2 Agricultural Policies

In order to preserve the benefit of farmers, protect soil quality and water resources, and prevent urbanization, governments have introduced various programs and policies. Since farmland is such an important part of agriculture, these programs and policies are formulated based on farmland pricing models. Lence and Mishra (2003) emphasized the strong relationship between the government programs and the farmland rental market. Taiwan passed the minimum lot size (MLS) policy in 2000. It prescribes that farmland must be larger than a certain size in order to be traded. Chang and Lin (2016) try to explain how the MLS program influenced farmland price quantitatively through pricing models. Weersink et al. (1999) focused on finding out how the agricultural policy attributes to enhanced farmland price and how much it affects it.

3.3 Farmland Pricing Models

3.3.1 The Net Present value model

The present value model assumes that the farmland price is determined by the future returning of the land purchasing investment. The present value formulation of farmland can be expressed as

$$V=\sum_{t=0}^{\infty} \frac{R_t}{(1+r_t)^t}$$

i.e. V is the present value of a piece of farmland, R_t is the income that generated by the farm in the time period “t”, and r_t is the discount rate of the period “t”.

Through a nonlinear functional form present value model, Miller and Plantinga (1999) expressed the farmland price by rental ratio, distance to city, population changes, interest rates, and transformation cost. The distance factor in this research is the travel time from farmland to city instead of air-line distance. In addition, spatial interactions are taken into account by cross section data. This research also indicates that it is important to assume the model as a non-linear function, since the coefficients of most squared terms and interaction terms are significantly different from zero. Though it is expected that the government interventions are important, the results show that taxation has no significant effects on the farmland price.

Robison et al. (1992) argued that since both urban factors and government subsidies make farmland market value higher than its agriculture value, the revenue of agriculture production is not the only faction contributing to the farmland value fluctuation. In addition, speculator's overestimation on future farmland market causes market bubbles, which further increases the differences between the farmland's agriculture value and the market value. Since governments always devote themselves to protecting the agricultural land, distinguishing the farmland's agriculture value and its market value is important from a policy development perspective. The data that the authors used to estimate the farmland agricultural incomes and the farmland market value is from the USDA. Different from traditional present value model, the paper separates the agriculture income from the non-agriculture income, rather than using an aggregated farmland income data. The results show that the proportion of agriculture value in farmland market value varies in different Stats. As a result, the study concluded that it is inappropriate to ignore non-agriculture incomes when modeling farmland value through the present value approach.

Basing on the traditional present value model, Moss (1997) indicated that though the farmland prices across US change in a same way, some areas are more sensitive to some specific factors, while others are less sensitive. The paper emphasises the importance of farmland income, interest rates, and inflation of farmland pricing. For instance, for those regions with high government payments, the farmland price is more vulnerable to the asset returns.

3.3.2 Hedonic pricing model

The hedonic pricing model was established by Rosen in 1974, it assumed the farmland as a heterogeneous product which can be divided into several characteristics. With this assumption, the farmland is treated as a bundle of products, amd these products are unable to be traded individually. The only way to obtain any one of the characteristics is to purchase the characteristic bundle as a whole. The typical farmland value determinates include non-agriculture factors, agriculture factors, and financial factors.

Several researchers who focused on urbanization agree that buyers pay more attention to non-agricultural components compared to agricultural factors in specific areas. The farmland could possibly be absorbed into a city if it is located near an urban area. Speculators are willing to pay a premium on this kind of farmland for the urbanization value. The speculation opportunities transfer farmlands to non-agricultural land. This potential value depends on population, people's incomes, and the rate of a cities' expansion (Livanis et al 2006). According to Tan et al. (2009), the loss of farmland is very common worldwide, especially in high population density areas such as China. A massive price gap exists between obtaining converted lands from the Chinese government, and trading them in second market. This indicates a large profit potential from the lands' non-agricultural values. Guiling et al. (2009) found that as the distance from the farm to the main cities decreases. the farmland price increases significantly in Oklahoma, which indicates the existence of a strong urban influence. City expansion, and total agricultural land decrease, are also common issues in the Calgary-Edmonton corridor of Alberta (Martellozzo et al. 2015). Through the satellite imagery, Martellozzo et al. (2015) found out that farms are moving away from the city core, and give up high quality soil due to city construction and expansion.

However, agriculture factors play a dominant role if the farmland is far away from high population density cities. The situation of purchasing the farmland for property investment other than agriculture use is rare in inland agriculture provinces like Manitoba. From 2006 to 2011, Manitoba only lost about 1% agriculture land (Heminthavong and Lavoie 2015), which indicates that most cities in Manitoba are slow to expand. Moreover, the targeted ten rural municipalities are at least 100 kilometers away from Winnipeg, so the farmland price in the area is unlikely to be influenced by urbanization. With low non-agriculture effects, agriculture characteristics of farmland become the main determinants of land prices.

To farmers, especially crop producers, land is not only a place where they cultivate, or a piece of land where the investment settles in, but also the foundation of high yield and incomes. In this case, high quality soil becomes the most desirable feature for farmers. King and Sinden (1988) indicated that farmers should realize the value to protect soil productivity, since the poor soil quality decreases both the value of farmland and the land's potential yields. With the data from the Soil Conservation Service of New South Wales, King and Sinden (1988) found that premiums are paid for land with productive soil and buyers avoid purchasing low quality soil farmland. Unfortunately, soil productivity data is not always available to researchers. The results from the poor data are usually less than satisfactory.

Miranowski and Hammes (1984) intended to emphasize the value of soil productivity for a farmland. However, their results do not correspond with the expectation, since the data in the study is county level soil data. Some bias may be raised because of aggregated and non-random sample data. According to the results, the farmland market fails to reflect the value of soil productivity completely. Huang, Miller and Sherrick (2006) had the same problem as well. They established their work through a Hedonic Pricing Model (HPM) with the following factors: farmland size, attached building value, soil productivity, distances to cities, measurement of ruralness, consumer price index, population, annual income level, swine farm density, and swine farm scale. However, the data of main factors such as soil productivity rating data, they hold, is in county level. Even though they had the transaction-level farmland price data, they still had to average the price data by years and counties in order to match it with the soil productivity data. Compared to these works, the main advance this thesis makes is that soil productivity data within this thesis comes with each farmland transaction. This less aggregated dataset allows a deeper understanding of price.

Nevertheless, with the advent of the era of Big Data, less aggregated soil quality datasets are finally available to researchers. The main perspective of Samarasinghe and Greenhalgh's (2013) paper is to investigate the relationship between the soil quality and the farmland price. Their data includes soil characteristics, farm size, climate, topography, geography, and location factors of farms. Each farm is assigned with soil productivity indicators based on the soil gravel class (easiness for rooting), the soil drainage class (oxygen supply and water drainage abilities), the potential rooting depth (easiness for root to extent), and the water supply (ability to store water for crops). Supported by Big Data, their results show that all the variables are significant to farmland value. Finally, they quantified the importance of high quality soil to farmland price.

Last but not the least, as a type of real estate, the price of farmland is susceptible to financial factors such as interest rate and inflation rate. The interest rate decides the cost of the mortgage. The total amount of interest cost plus the farmland value is the actual farmland price that the buyer pays in the end. With a higher interest rate, less money is available for farmland purchasing (Moss 1997). Moreover, the farmland market tends to overreact to the changes in both interest and inflation rates. As the financial rates fluctuate, the distribution of the real farmland prices becomes wider (Moss 1997, Lach and Tsiddon 1992).

Chapter 4. Theory

One of the popular models for farmland price analysis, is the present value model. Falk (1991) assumed that farmland price is determined by the sum of the present value of the potential future rentals. However, the rental rate is less sensitive than the farmland price in reflecting market changes. The results obtained from the study minimize the actual changes of land prices (Tegene and Kuchler 1993). Furthermore, the HPM focuses on all the possible factors that may affect the land prices, such as interest rate and commodity prices. In this case, these two models can be incorporated with each other to improve the finalized model. Another theory, the supply and demand model, is abandoned because it assumes products to be homogeneous, which is unrealistic in the empirical world. Due to the facts described above, a combination of HPM and present value model are used for price explanation.

4.1 The Hedonic Price Model

Under the HPM, the value of farmland depends upon its characteristics. The principle of the HPM was studied, organized, and published by Rosen in 1974. Since Rosen's theory only focuses on the situation when the buyers are purchasing for household use, the model is derived from the utility maximization theory. However, the farmland purchasing purpose is always for future income. Thus, Rosen's hedonic pricing model should be modified for farmland price analysis. The modified hedonic pricing model was not studied in detail until Palmquist published his research about the implication of hedonic model on farmland pricing in 1989. Palmquist's model assumed that buyers purchase the land as an input of their production, and therefore, the model was started with a profit maximization problem. By segmenting farmland into different characteristics, one piece of farmland Z is denoted as a set of vectors:

$$Z = Z\ (z_1, z_2, \dots, z_n)$$

Where z_i (i=1, 2, …, n) measure the characteristics of farmland, either in quantitative or in categorical formats. Since farmland is a heterogenous product, it is priced according to the quality of each characteristic. That is, the unit price of farmland inheriting the properties of Z and it can be written as:

$$P(Z) = P(z_1, z_2, \dots, z_n),$$

which is called the hedonic price function by Rosen (1974). The market price of farmland is $a \cdot P(Z)$, where a is the size of farmland. As figure 4.1 indicates, with all other features being fixed and z_i being the only variable, the marginal price of each characteristic is always positive (because HPM assumes that farmers prefer more than less). However, the marginal price may increase, decrease or even be constant as the i^{th} feature increases. For example, the marginal price of farmland per acre is expected to decrease as farmland size increases; but in the diamond market, the price of a diamond with twice the carats would have its price more than doubled.

Assume the initial capital for investing in a farm is Y. This total budget is allocated into to two parts: the farmland related costs Y_Z and the costs on non-farmland related inputs x with unit price (in another words, the quantity and budget distribution on x are numerically the same). Thus, the farmland related budget is

$$Y_Z = Y - x \tag{1}$$

where the farmland related costs are decided by the properties of farmland Z. In this case, the farmland related budget can also be written as

$$Y_Z = Y_Z(Z) = a \cdot P(Z),$$

Accordingly, the profit function of farmland demander is $\pi = w \cdot f(x, Z) - Y_Z(Z) - x$, where $f(x, Z)$ is the production function of the farm and w is the unit prices of products. The optimal solutions can be solved by maximizing profit with subjecting to the budget constrain:

$$\max_{z} \pi = w \cdot f(x, Z) - Y_Z(Z) - x$$

subject to $Y = Y_Z + x$, and

$$\pi \geq 0 \tag{2}$$

As a result, the optimal results should satisfy

$$\frac{dY_Z(Z)}{dz_i} = \frac{\partial f(x,Z)}{\partial z_i} / \frac{\partial f(x,Z)}{\partial x} \tag{3}$$

The partial derivative on the left side of the equation (3) shows how much the marginal farmland related budget would change as the i^{th} farmland feature changes. The right side of equation (3), $\frac{\partial f(x,Z)}{\partial z_i} / \frac{\partial f(x,Z)}{\partial x}$, is the Marginal Rate of Technical Substitution (MRTS), which describes how many units of x that can be replaced by an extra unit of z_i with constant output. This allows an indifference output curve between x and z_i to be drawn Figure 4.2 (a). By using equation (1), the indifference output curve can be converted to a relationship between the farmland related budget $Y_Z(z_i; z_{-i}, Y, f^*)$ and quantity of $z_i$the total budget, production level, and all other characteristics of farmland unchanged. The curve in Figure 4.2 (b) which is derived from the indifference curve was called the "bid curve" by Rosen (1974).

By combining the curves in Figure 4.1 and Figure 4.2 (b) into one graph (Figure 4.3 (a) and (b)), if the two curves are tangent to each other, which states that the market prices match with the farmers' willingness to pay, then the tangent point would satisfy the equation (3). Farmers may finalize into different tangent points according to their bid curves. For example, consider two farmers with the same budget that have different expected production levels f_1 and f_3. The farmer with higher expected production level, f_1, distributes more budget into farmland purchase to get a higher level of z_i (Figure 4.3 (a)). A buyer who fails to match his or her willingness to pay (the bid curve) with the hedonic price curve would either fail to buy a farmland. Or decrease their expected production level.

Different from the demand side, the supply side of farmland can adopt the theory from Rosen's HPM. The landlords' willingness to sell relates to the land value and is decided by their expected profit and costs:

$$\phi(Z,r,\pi^s) = \pi^s + c(Z,r)$$

(4)

where $\phi(\cdot)$ is called the offer function by Rosen, $\phi(\cdot) = P(Z)$ at equilibrium point; r represents the elements other than Z that affect the landlords' costs on the farmland, such as the landlords' management ability. The expected profit $\pi^s$is defined by the owner's profit function, and $c(\cdot)$ indicates the costs on holding the land. Similar to the bid curve, the offer curve has to tangent with the hedonic price function in order to finish the trade. It reaches equilibrium if the offer curve, hedonic price function and the bid curve tangent at the same point (Figure 4.4). Since the observations in this study are from successfully completed transactions, it is reasonable to assume that each observation represents the one matched optimal point. (Rosen 1974).

The HPM lacks some constraints of other models and makes several additional assumptions, which make it a good match for the farmland market in Manitoba. The most important improvement of the HPM is that this model no longer assumes the products to be homogeneous. Each piece of land would be unique with different soil types, locations, and sizes. Moreover, non-agricultural investing in farmland is rare, which makes the land purchasing purpose to be unitary in Manitoba (only purchase for agriculture purposes). As a result, the elements that affect farmland price, and how those elements affect the price, become unified. Secondly, the HPM treats a product as a bundle of characteristics, each characteristic inside the bundle is unable to be traded individually in the market. This feature is passed down to a product's price, which can be expressed by a sum-product of the prices with the amount of attributes in a simple linear model. This is applicable in the case of farmland market because neither soil fertility or location features can be separated from farmland. Also, no substitution exists to compete with the farmers' budget for farmland if the land is purchased for agriculture purchasing purpose. This means that farmland cannot be replaced by other products, which makes the land an indispensable element for agricultural activities.

Thirdly, the factors that determine farmland prices may vary among markets. Observations are required to be in the same market as well. Whereas, it is common practise to treat a state or a province as a single market (Miranowski and Hammes 1984; Huang et al. 2006; Hanson 2013), the dataset in this thesis satisfies this requirement. Another point that the HPM fits into farmland price discovery, is that in the model if a buyer's willingness to pay fails to match with the market price, the buyer would have to change his or her expectation from the land. Since farmland is a predetermined product instead of being produced, demand must cater to supply.

Another important assumption that the HPM makes is to normalize the joint price of x as unity. This normalization allows the HPM to ignore the direct effects on p_i due to the price changes in x. It seems to be a harsh condition to constraint the model, but the separation theorems can help clarify the implication behind it. According to the separation theorems (Aubin 2007), buyers' consumption bundles can be divided into several weekly related subgroups, such as shelter, food, and entertainment. Same as farmland purchasing, the demanding bundle of a farmer is classified in to two independent categories: farmland related and non-farmland related. There are two steps involved in the budget allocation processes: firstly, the farmers' total budget is distributed into the two subgroups; secondly, each good or element gets a partial budget. The goods or elements from two different subgroups are only connected through the redistribution of the subgroups' budgets. Back to the HPM, even though the price of x is a fixed number, the HPM can still capture the budget re-distribution effects, since x is not assumed to be a fixed number. The flow chart of budget distribution process is presented in Figure 4.5. As a result, this assumption simplifies the model and stays close to the empirical farmland market at the same time.

To sum up, this model allows researchers to consider the factors that affect farmland price from both supply and demand perspectives jointly. By losing the constraints that are made by the traditional price analysis models, the HPM provides a better understanding of farmland markets. Additionally, the assumptions that the HPM made fit the actual situation of the Manitoba farmland market. Following this theory, the price of a piece of the land can be attributed to several characteristics, z_i (i=1 ,2 ,…n) and by figuring out the price weight of each z_i, the significance of each features can be captured for farmland price discovery.

4.2 Figures

Figure 4.1. Hedonic Price Curve

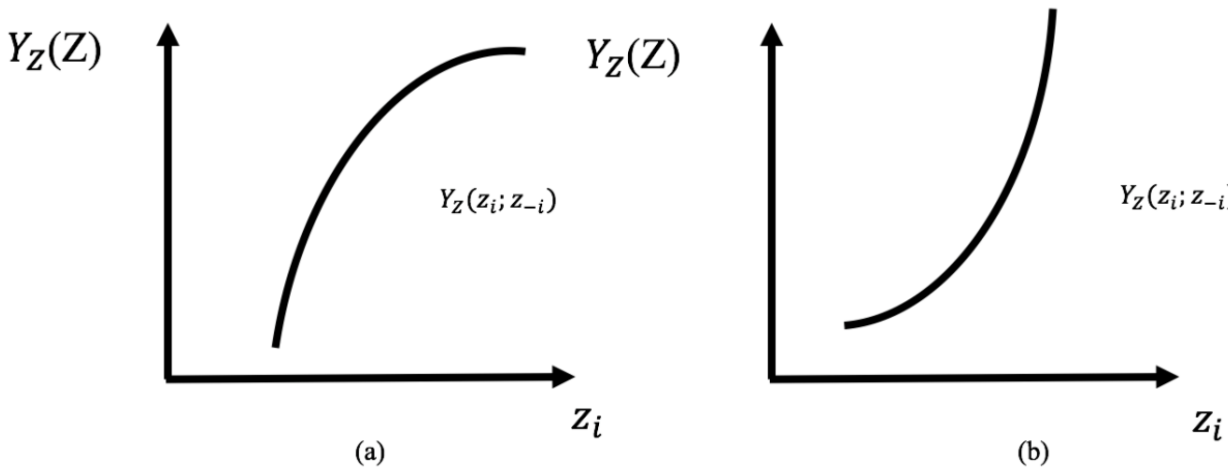


Figure 4.2 (a). Indifference Output Curve

Figure 4.2 (b). Bid Curve

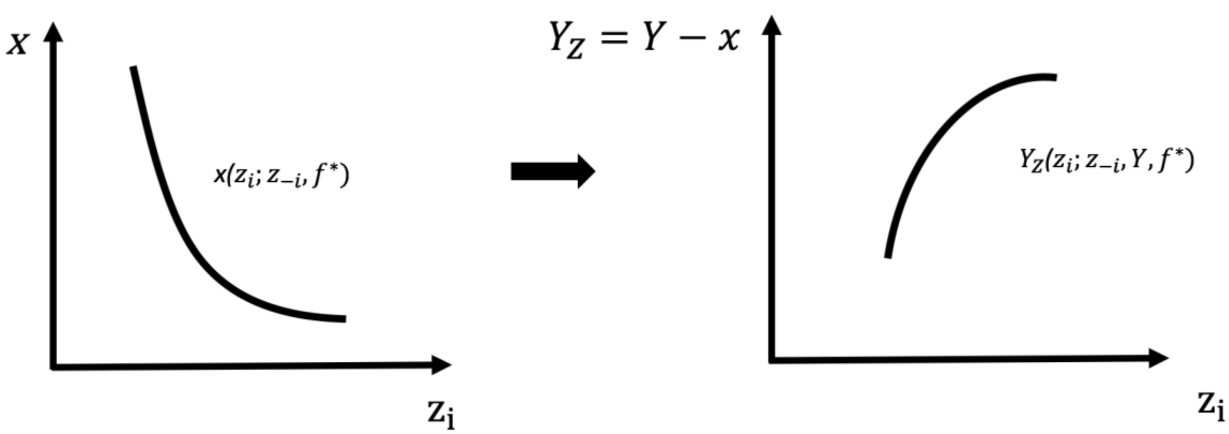


Figure 4.3. Market Price and Farmer's Choices

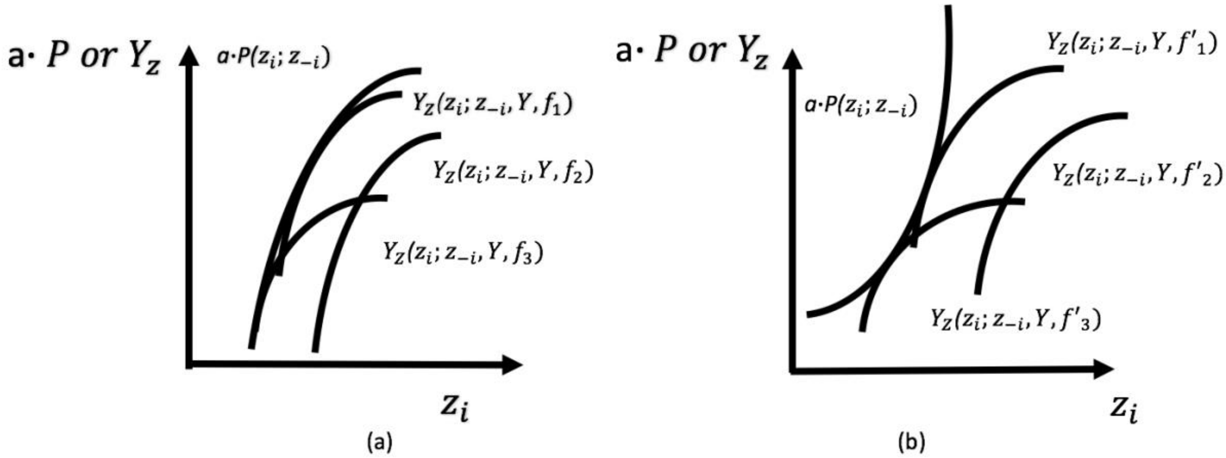


Figure 4.4 the Farmland Market equilibrium

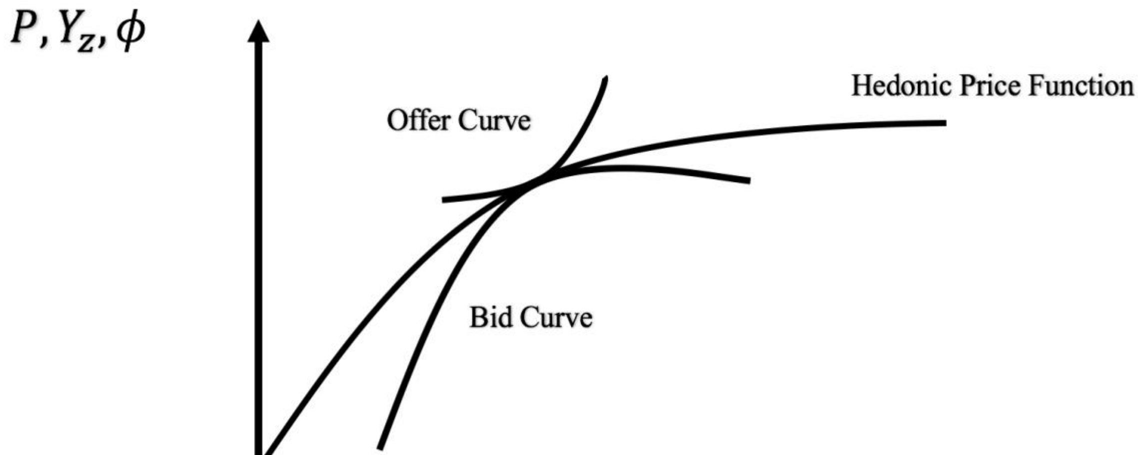
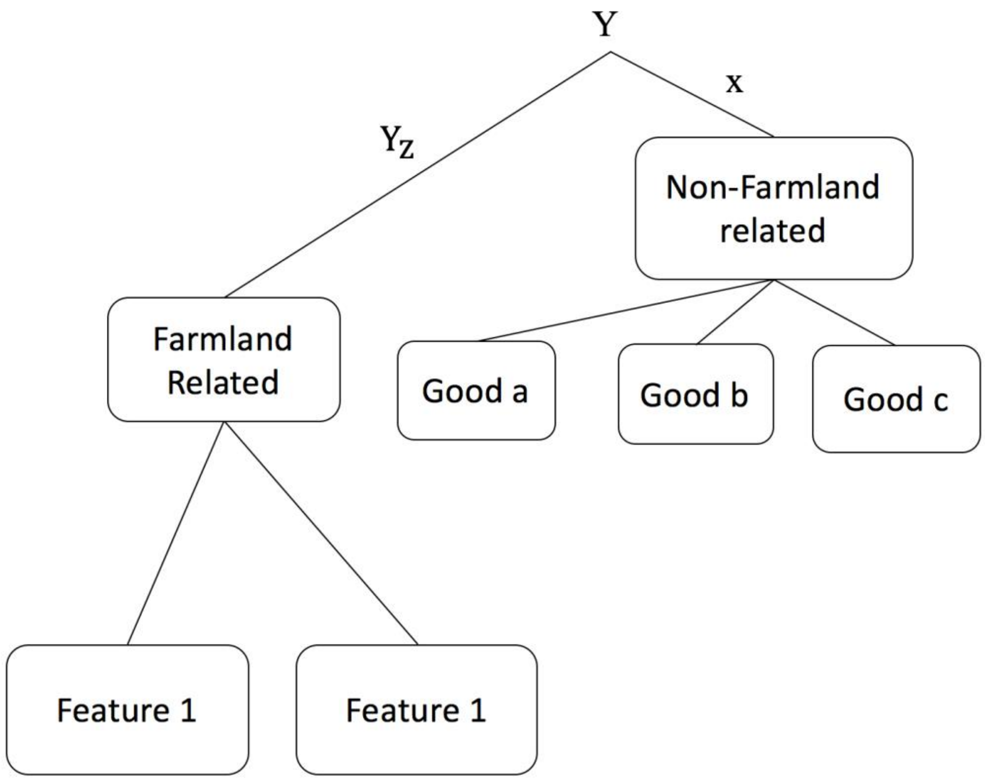


Figure 4.5. Budget Distribution Tree



Chapter 5. Data

This chapter introduces the sources of the datasets, ways to modify the original data, and the reasons for selecting the data. This chapter is divided in two parts; the first part presents the institution and method of collecting the dataset. This part also describes the treatments done on the raw data. The second part lists and discusses the dependent variable and the independent variables. The data for each variable is presented in separate figures.

5.1 Dataset

The data in this study contains three parts: (i) the farmland transaction record; (ii) the soil quality map; and (iii) the financial rates.

(i) Farmland Transaction Record:

This part of data was collected by the Manitoba Municipal Government (2014). It contains the farm price, the attached building price, the farm location, and the farmland size for each farmland transaction from 1987 to 2013 in the ten rural municipalities (Figure 2.12) of south-central Manitoba. This dataset includes all the farm transactions in the time range, which are completed through the three ownership-changing methods: real estate agent; auction; or independent sale. In the first method, the seller turns over a certain level of power on controlling the properties to the real estate agent by signing a listing agreement. The agreement gives clear indication of the services' charging standards: the commission fee is either a certain amount of money or a percentage-based fee. Through the real estate agent, the farm properties can be advertised widely by listing on several different kinds of listing services. Selling properties through auction is another method, which also requires commissions. Comparing with real estate agent, auction can strike a deal within a shorted period of time and avoid the negotiation process. The auction sale "will be sold subject to the owner's approval" or "will be sold subject to confirmation from owner" (Manitoba Government 2017). Sellers can also sell the land by themselves, and by doing this they avoid commission costs. However, an independent sale also means that the owners must advertise and promote their properties by themselves. Another shortcoming of the independent sale method is that the sellers are on their own when negotiating with potential buyers. This method may take a longer time to complete the transaction as information is not as transparent as it would be with the real estate agent or through auction (Manitoba government 2017).

An agreement is signed when the deal is made, which is called the farm Agreement of Purchase and Sale. Issued by the Manitoba Farm Lands Ownership Act, this agreement is required to state land purchasing price, the amount of property and assets, and the geographical coordinates of the farm. In addition, the new owner is also required to report the prices of farmland and the attached buildings separately for income taxation purposes. Though the allocation of price is self-reported, it is determined after consultation of a lawyer or an accountant. Canada Revenue Agency may verify the appropriateness of the allocation as well, and they have the power to adjust any improper price allocation. As a result, the Manitoba Municipal Government not only preserves the data about farm total transaction value, but also records relatively accurate bare land price (Manitoba government, 2017). The separately reported prices help to illustrate the value of soil productivity factors.

To make the dataset applicable to this research, several conditions are applied on the dataset to filter the raw data. Firstly, since the farm is not traded only through the real estate agent and auction, but also by private sale, there is a possibility that the buyers and sellers are not acting independently. The final sale prices that are reached by two related groups may fail to reflect the true market value of the farmland. So only arms-length transactions are included. Also, incomplete recordings and the entries with obvious mistakes are deleted from the dataset. In the end, there were 4748 observations in total.

Between 1987 to 2013, the trading volume was highest at the end of the 1980s, and gradually decreased in the 1990s. One of the possible reasons behind this could be the high interest rate and economic downturns that occurred in the 1980s. Farmers were eager to sell off their properties. As a result, a lot of farmland was made available at market for good prices. Furthermore, since the dataset does not cover all the transactions in the year 2013, there is a sudden drop in the trading volume that year.

(ii) Soil Quality Map:

From 1972 to 2002, the detailed soil survey reports were published successively for each RM on the government's websites. By overlapping the farm location with the soil level maps, the soil quality level information is attached to each farm. The soil quality map was generated for crop insurance purposes, and was provided by the Manitoba Agricultural Services Corporation (MASC). Soil productivity is the most important element in farmland pricing, but most farmland price studies are not able to capture the land quality data for each farm. Though some studies can get transaction-level data of farmland prices, the corresponding soil productivity data are highly aggregated and are reported based on each administrative region. As a result, though it is available to match these two datasets by aggregating, the aggregated data loses the information of individual transactions through aggregating processes such as averaging. One of the breakthroughs that this study makes is that similar to the farmland price, the soil productivity information is also attached to with each observation.

(iii) Financial Rates.

As a type of an immovable property and one of the most valuable assets that the farmers hold, the farmland price is also affected by multiple financial rates such as interest rate, inflation rate and the price index. The monthly prime business interest rate from the chartered bank is considered to represent the loan costs. This interest rate is the typical rate for a big business loan that is larger than $200,000 (Bank of Canada, Department of Monetary and Financial Analysis 2018). The annual realized net income (RNI) of the Manitoba farm is chosen to indicate the farm income. The RNI equals to the farms' total cash receipts plus the income in kind, minus the depreciation charges, and minus the operating expenses after rebates. The income in kind is the value of the commodities that are produced and consumed within the farms (Statistics Canada 2017). This means that the RNI contains the total value of produced commodities and the total government subsidies in Manitoba. The interest rate and the RNI are retrieved from the Canadian Socio-economic Information and Management System (CANSIM II), which is produced by Statistics Canada.

Another important element that affects the farmland price is the inflation factor. Among all the variables of the model, the farmland price and the farm income variables are nominal prices; however, the soil quality and the farm location data do not change with inflation. Since not all of the variables are subject to inflation swings, it is necessary to deflate the prices' data by the indexes. Also, Moss (1997) concluded that the inflation rates and the returns to agricultural assets were the two most important price promotors to Florida's land value between 1960 to 1994. Combined with the fact that real estate is a good resource to hedge the inflation risk, it is reasonable to consider the inflation rate into the model. In general, there are two ways to include inflation into the model: the first way is to deflate all nominal prices with the price index, and the second way is to treat the price index as one of the variables. According to Lach and Tsiddon

(1992), the price dispersion becomes wider as the price index increases. Moreover, comparing to the unexpected inflation, the effects from expected inflation rate on the farmland prices are stronger. These indicate that people often overreact to inflation, and the difference between the expected and the unexpected inflation reflect the level of market's overreaction. As a result, it is possible that the inflation rates not only amplify the prices in magnitude but also intensify the trends of the real price. So, the two approaches are combined to discover the effect of inflation effects on nominal prices and real prices. Due to this reason, both real prices and price index should be included in the practical model. The annual total farm product price index (FPPI) for Manitoba plays the role of inflation rate here for calculating the real prices. However, most of the information that is contained by the FPPI is also covered by the RNI dataset, so the role of FPPI as an independent variable in the model can be replaced by the RNI.

The FPPI is published by Statistics Canada to measure the price changes of farm-made commodities across Canada. The objective behind this index is to measure the price changes based on the market weight average of each commodity. Similar to the RNI, the additional value that is added by after-farm products processing is not included in the FPPI. Statistics Canada also offers different FPPI data for different agriculture sectors such as cereals and cattle (Statistics Canada 2016). Since the available transaction-level farmland price data is not limited to crop or animal farm, the overall FPPI for Canada, with the year 2007 as the baseline, is chosen to be the inflation rate data.

5.2 Variables

5.2.1 Dependent variable

The dependent variable in this research comes from the farmland price variables, which are calculated as "(sell price - building price)/ (farmland acreage*FPPI)". As a result, the regressand in the hedonic model is the price index adjusted bare-land price per acreage. The unit price allows the price comparisons to be made between two farmlands with different land sizes. Figure 5.2 displays the differences between the nominal unit price and real unit price of the 10 RMs of Manitoba farmland. Figure 5.3 compares the farmland real unit price of Manitoba with the price in the 10 RMs of southern Manitoba. The dataset of land price for the entire province of Manitoba is retrieved from the Census of Agriculture and was originally collected by Farm Credit Canada (FCC). According to the historic farmland values report that is announced by FCC, the farmland values in the report are retrieved from the same data resource as in this thesis (2017). As shown in Figure 5.3, these two datasets match each other. The major difference is that the price changes in the entire Manitoba area is smoother than the 10RMs of southern Manitoba due to a broader geographic coverage. Table 5.1 shows the average bare land price per acre by soil quality by location.

5.2.2 Independent variables

The explanatory variables in this thesis can be classified into two groups: the inherent characteristics and the external characteristics. The inherent characteristics describe the overall quality of the farm, which include soil productivity index, location of farmland, and size of the farmland. The value of farmland also connects tightly with outer systems through financial rates, commercial prices, and agricultural income level. Since the datasets come from 10 adjacent RMs of Manitoba, the observations in the datasets are assumed to be in one farmland market and share the same market factors.

Soil quality:

Among all the different kinds of price determinants, the agricultural productivity factors attract the most attention. As early as 1970, Blevins and his partners started their study about sustainable soil health. In order to compare non-tillage and conventional tillage, they tracked the soil properties' alternation for 10 years (Blevins et al. 1983). Since then, researchers and farmers have recognized the problem with traditional agriculture.

The main problems of traditional agriculture are intensive tillage, monoculture and row crops. Poor soil management causes SOM defection, unbalanced PH level, and the deficiency of soil physical properties (Ketcheson 1980). The soil degradation will eventually lead to yield loss. In addition, crop yield depends on favorable climate. For example, Thailand is the world's largest rice exporter, but three fourths of rice area in the country is classified as having poor soil quality. Furthermore, due to extreme weather such as drought and flooding, Thailand's rice production increases very slowly. Whereas in places where climate and soil are both in favorable condition, such as northwest/central Europe and North America, the yields of maize and wheat are at high levels (Cassman, 1999). In order to satisfy the world crop demand and insure food safety, a consistent crop production increase is required. As a result, the sustainable health of soil becomes especially important. Due to this reason, soil scientists published a series of papers about the methods for maintaining soil productivity. One of the main principles of soil management is to maintain the SOM content, the common treatments are minimum tillage, covering land surface with cover crops or mulching, and applying agroforestry ecosystem (White et al. 2012).

Researchers and farmers put their efforts on maintaining soil productivity not only for desirable crop yields, but also for farmland value appreciation. By analysing the data for farmland price and farm profit from 1940 to 1979, Phipps (1984) identified a positive relationship between these two factors, which became the main support for net present value model. The net present value model is one of the most popular farmland price determination theories, the principle behind it is that the farmland value is determined by the total future profit and discount rate. Meanwhile, one of the methods to boost farm profit is to increase yield, which requires the support of a healthy soil. According to Barry et al. (2000), the unit crop production cost is relatively stable; however, the soil quality variety makes a big difference to total farm revenue. As shown in Figure 5.1, the farm profit increases significantly when the soil quality is improved. The benefit of high soil quality is not only captured by farm operators, but also by the landlords who rent out their properties. The negotiation on rent between the landlord and renter is based on the farm quality, and one of the most important features is soil productivity.

Soil quality is defined by a series of characteristics. The factors that determine soil productivity can be classified into three categories: physical attributes, chemical properties, and biological factors. The physical attributes refer to the factors that describe soil structure such as pore size and soil texture. The chemical properties include SOM content, availability of minerals, and composition. Despite the physical and chemical characteristics, the microorganisms that live in the soil such as microbial biomass and fungi, determine the biological features of soil. Influenced by the local climate, these soil quality factors interact with each other, which makes the classification of soil quality to be extremely complex and broadly defined (Carter 2002). Soil scientists classify soil into a set of categories according to the physical, chemical and biological characteristics. Since soil characteristics are not only dependent on its inherent characters but also on climatic factors, the soil classification system is quite localized. For example, even though Canada and the US are both in North America, these two countries classify soil in different ways. Detailed soil reports are usually published for each state or province.

Soil surveys in Manitoba were started in the 1930's, classifying soil into groups by morphological features. However, the classification in Manitoba soil survey is too technological for the agriculture insurance system. To establish a fair agriculture insurance system, constitutors needed to link the soil classification system with potential crop yield. The SPI system was constructed by MCIC for insurance purposes. The SPI system classifies soils into ten soil level from A to J, as yield potential decreases. The soil level data is summarised in Figure 5.4, the total number of level B soil and level J soil is not even ten percent of the 4748 observations, the remaining lands are classified relatively evenly between level C and level I.

Location variable:

As mentioned above, the dataset covers 10 RMs of southern Manitoba. They are: North Cypress-Langford, Lorne, Victoria, South Norfolk, North Norfork, Glenboro-South Cypress, Pembina, Louise. These 10 RMs are adjacent to each other, and are located in the southern area of Manitoba. Westlake-Gladstone, and Argyle. The trade volume for each RM is summarised in Figure 5.5. The farmland markets in Norfolk Treherne and Westlake-Gladstone are the two most active market among the 10 RMs; the trade volume is quadruple the trade volume in Glenboro-South Cypress and Victoria. As mentioned in chapter two, the coefficients of spatial variables are usually treated as indicators of the level of urbanization. However, because these 10 RMs are close to each other and are all far away from the provincial capital, Winnipeg, the differences in terms of urbanization is considered low. So, different from other studies which consider urbanization factors, the main purpose of including RMs in the model is the taxation variation among the 10 RMs. There are price gaps among the annual averaged bare-land price per acreage of this 10 RMs. The prices in different RMs follow the same trend. This evidence suggests that it is reasonable to predict that the coefficients of the location variables are significantly different from zero.

According to The Public Schools Act by the Government of Manitoba (2017), municipal governments are responsible for the collection of school taxes. The total property tax is divided into four parts: Municipal Taxes, Provincial Education Taxes, School Division Taxes, and Local Improvements. The Municipal Taxes are decided by the annual civic budget and the assessment value of properties together. The Provincial Education Levy is set according to the property type. Only the commercial and industrial property owners are required to pay the Provincial Education Levy; this part of the tax is not applied on residential and farm properties. Provincial Education Taxes are collected by provincial governments. However, the School Division Taxes are usually collected by municipal governments because they rely on local school district divisions. Each school district is assigned with a corresponding rate. Though the municipal government is responsible for determining and collecting the School Division Taxes, it is still under the umbrella of the provincial stipulation about the "Special Levy". The local Improvements Levy is the only property tax portion which is not related to the value of properties' portioned assessment. The local Improvements Levy is not charged in every tax term; it is only generated if there are recent improvements around the property. In summary, the levy rate is different for different property types, school divisions, and municipals. Also, the rate is decided by provincial and municipal governments together. The calculation of the property tax is expressed in Figure 5.6 (Winnipeg Assessment 2017). In the case of farmland, the property tax only contains Municipal taxes, School Division Taxes and Local Improvements.

Farmland Size:

In the 4748 observations, the farmland size ranges from 40 acreages to 2887 acreages. The trade volume for each year and different farmland size ranges are summarized in Table 5.2. The most frequently traded farmland is in the 150 to 199.99 Acres' range, which accounts for almost half of the total trade volume for each year. By adding up the trade volume data from 1987 to 2013, it is found that the farms with land sizes larger than 700 Acres are rarely traded by the owners (Figure 5.7 (a)). One of the reasons is that the farmers are eager to expand their properties to decrease operation costs and increase net income. Small farms merge into large ones. As mentioned in Chapter 1, because of the high interest rate at the end of 1980s, a lot of small farms were not able to pay for their interest costs. Therefore, a large number of farmlands were released to the market, and taken in by profitable large farms in the period (Figure 5.7 (b)). In addition, the trade volume of farmland kept decreasing from 2008, and reached a new historical low in the year 2012. One of the possible reasons behind this was that the speed of farmland expansion slowed down and tended to reach to a balanced condition. The data from 2013 is ignored here because the records of farmland transfer do not cover the entire year of 2013, but only cover up to the date when the data was collected.

Interest rate:

The monthly interest rate data in this thesis is captured from the Chartered Bank, which is used in prime business. The monthly interest rate from January 1987 to October 2016 is shown in Figure 5.8. The interest rate decides the cost of purchasing a farm with a mortgage loan. It also shrinks the actual budget for farm purchasing. Furthermore, the interest rate data acts as a standard for other types of debt in farm operation. Though costs on borrowing money from different sources are significantly distinct, the Chartered bank determined interest rates are usually important references to lenders and investors. Interest rates reached the highest point in 1988, as seen in Figure 5.8. Farms with thin profits were unable to support their debt. However, the Manitoba farm market didn’t crash because of the interest rate, the high farmland demand caused by farm expansion held the farm price constant under the crucial financial environment.

In 2009, another big change of interest rates occurred. The Chartered bank adjusted the interest rate to a historically low point after the financial crisis in 2008. The low interest rate encouraged people to withdraw money from the bank and put it into the market flow, which helped the market prosper, and stimulated investment activities. As a result, the interest rate factor is usually a major consideration when constructing farmland pricing systems.

Realized Net Income:

Statistic Canada records three different kinds of incomes: net cash income, realized net income, and total net income. Realized net income is chosen as the income indicator because it represents total commodity sales, both in cash and non-cash, regardless of the total production in that year. In this way, the realized net income is the most appropriate data to describe the actual income of the year. As a major part of farm assets, the value of farmland is decided by the amount of wealth that can be generated by the farm. When the agricultural incomes are higher than the non-agricultural incomes, people put more efforts on agricultural operations, and vice versa. The attraction of higher agricultural incomes can be reflected by the increasing of farmland demand and the growth in farm value and rental. The annual Manitoba RNI from 1987 to 2015 is shown in Figure 5.9. According to the present value model: farmland price equals to the total present value of future incomes. Therefore, the farmland price of the current year is decided by the farm income in future years. For example, the value of farmland in 1990 relates closely with farm incomes in 1991, 1992, etc. Therefore, it is rational to say that increasing farm incomes are favorable for farmland owners.

Farm Product Price Index:

Since real estate is usually the major resource to hedge against inflation, the price index of farm production prices is considered a factor for determining farmland price. The FPPI data from 1987 to 2013 is expressed in Figure 5.10. The base year of this dataset is 2007. For example, the farm production prices in 2010 is 1.056 times of the prices in the base year, 2007 (Figure 5.10). One of the major impacts of price index on farmland price is to magnify the real price. Another reason for introducing FPPI into the model is that people usually over react to inflation, so the price index not only magnifies the real price, but also magnifies amplitude of the changes in the real price. However, since the farm production price information is already covered by RNI, to avoid autocorrelation problems, it is unnecessary to add FPPI into the model as a variable.

5.3 Tables and Figures

Table 5.1. Bare Land Price per Acre by Soil Quality by Location, in the ten RMs of Manitoba, from 1987- 2013

	B	C	D	E	F	G	H	I	J
Lorne	N/A	900.43	648.24	623.23	490.85	481.57	291.70	N/A	N/A
Ncypress-Langford	1291.46	645.74	764.64	808.66	654.20	626.58	629.38	533.64	378.64
North-Norfolk	1795.99	768.37	505.64	571.29	441.34	465.34	351.00	279.26	195.85
Norfolk-Treherne	1210.37	975.49	911.33	594.86	569.38	654.45	299.05	212.27	245.39
Victoria	1556.77	963.88	1023.07	661.15	677.25	401.27	251.40	278.48	232.44
Glenboro-Scypress	N/A	940.20	606.49	424.21	405.89	531.55	388.59	277.79	393.84
Louise	N/A	609.59	523.87	408.84	410.62	379.95	179.51	545.33	417.40
Argyle	N/A	553.00	410.96	435.30	345.38	302.52	235.85	344.90	322.83
Pembina	N/A	735.04	558.59	486.51	388.18	360.51	215.35	N/A	N/A
WestLake-GladStore	N/A	576.78	597.82	520.92	428.05	290.93	215.82	136.57	112.13

Figure 5.1. Farm Profit vs Soil Quality

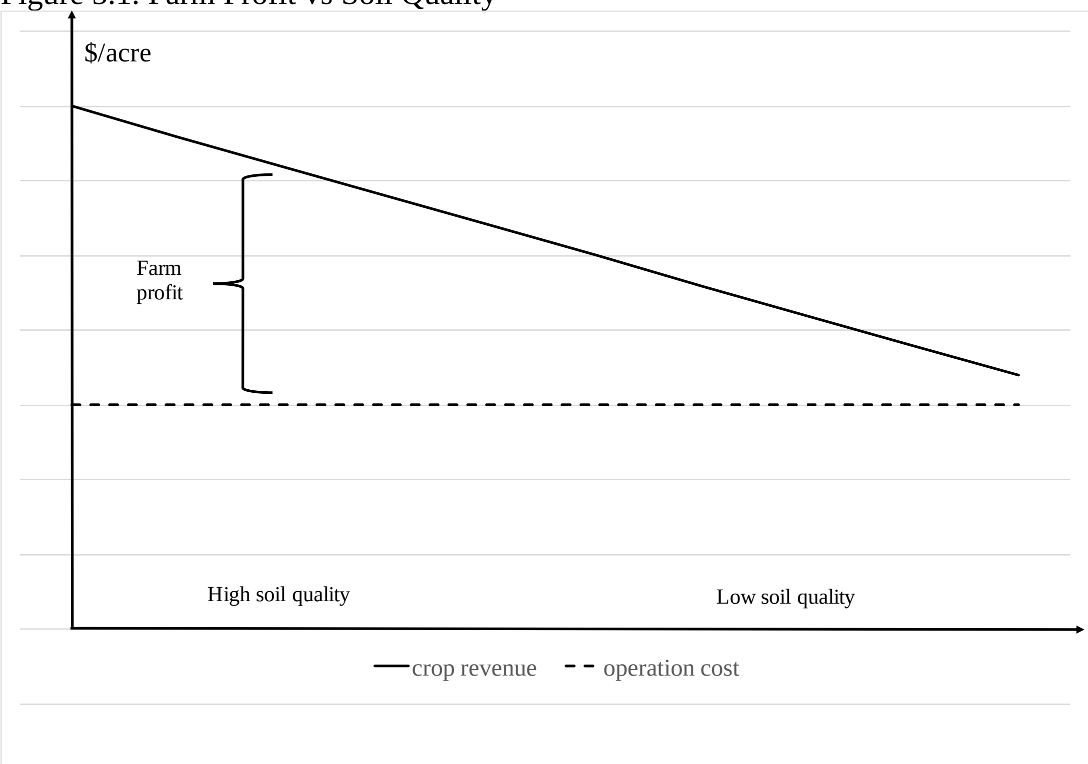


Figure 5.2 Nominal vs Real Price of Farmland in Canadian Dollar, in the ten RMs of Manitoba, from 1987- 2013

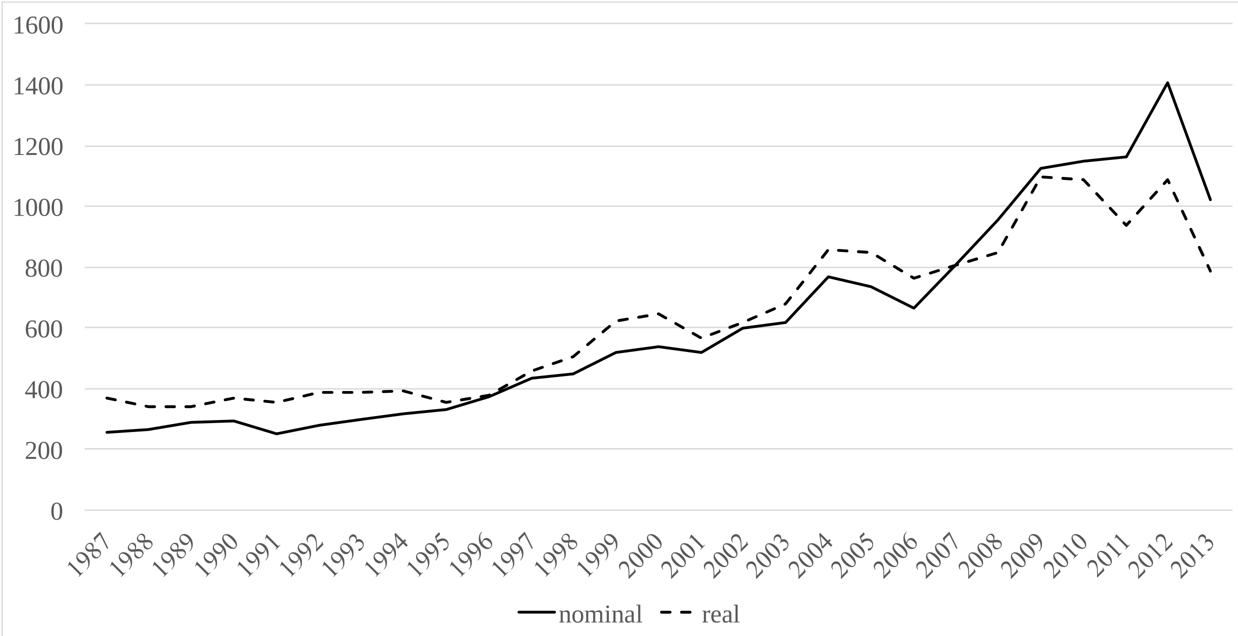


Figure 5.3 Real Bare-Land Price per Acreage of Manitoba and the 10 RMs of Manitoba, 1987-2013

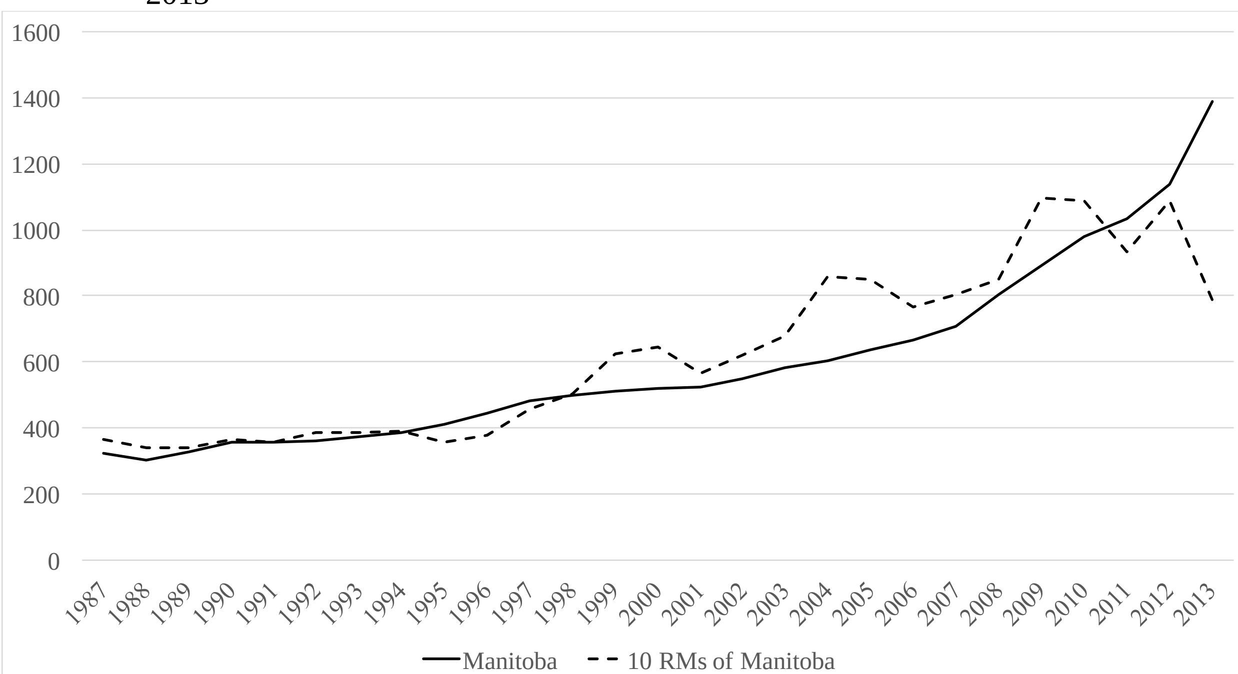


Figure 5.4 Percentage Share of Each Soil Product Index Level, Manitoba, 1987-2013

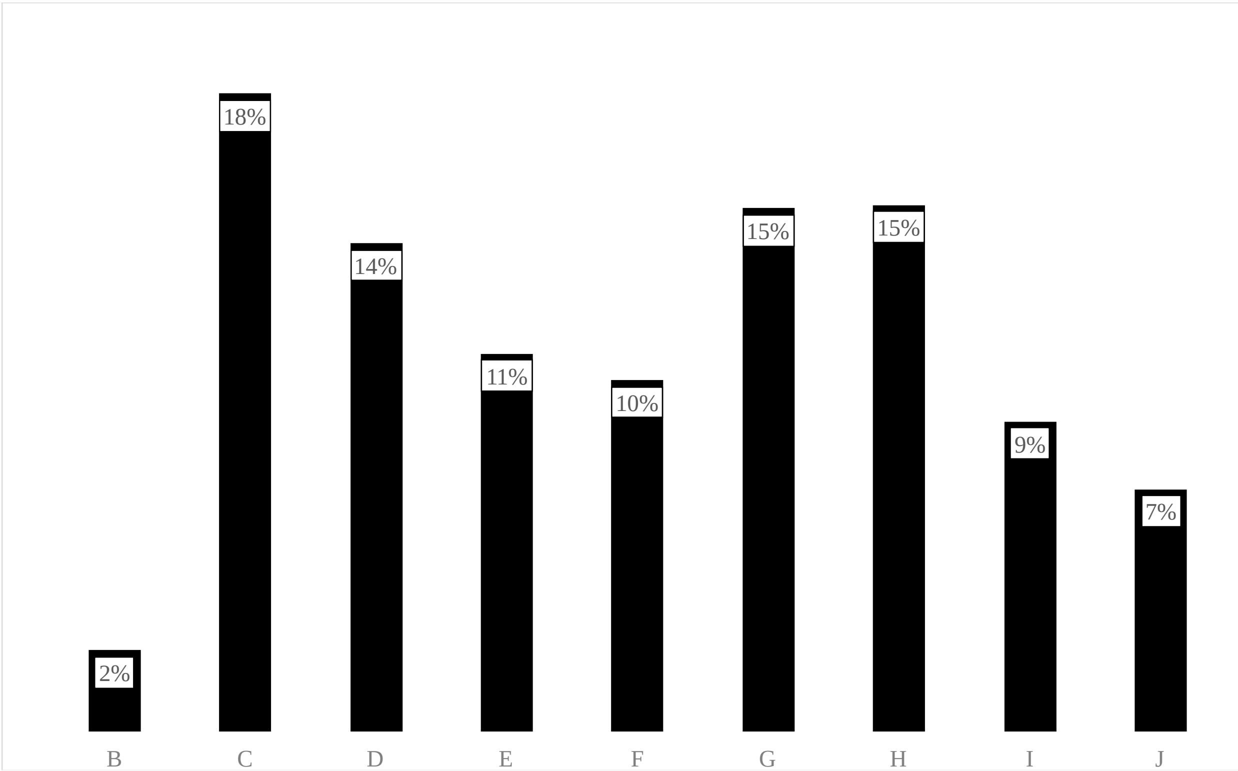


Figure 5.5 Trade Volume by Rural Municipalities, Manitoba, 1987-2013

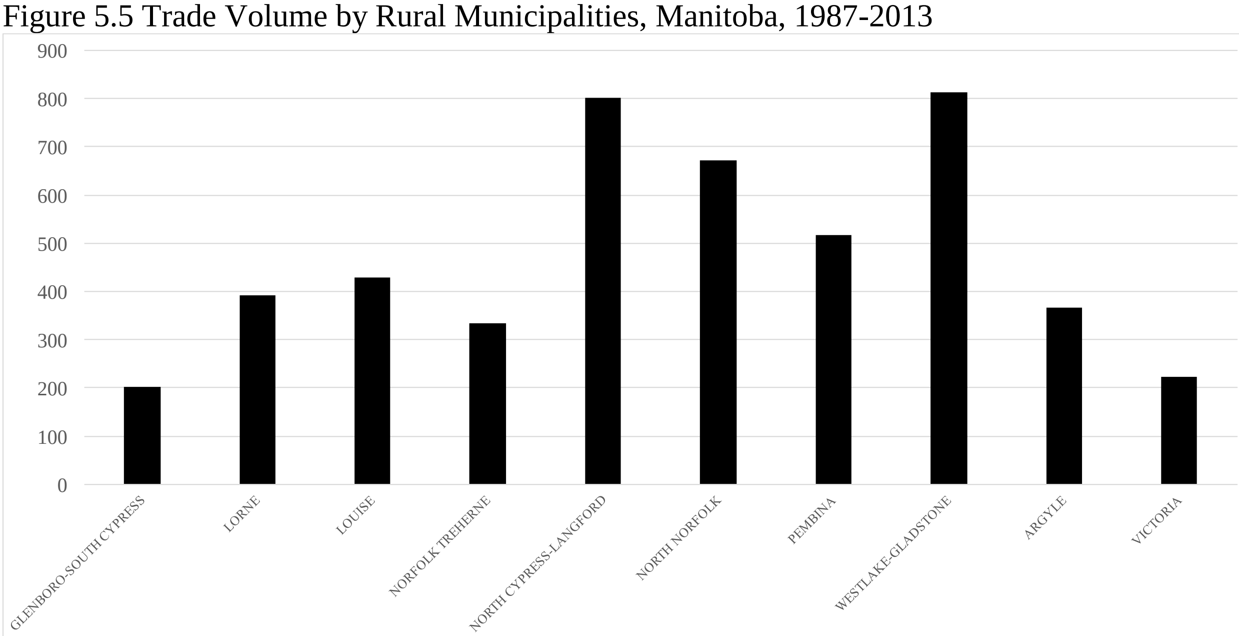


Figure 5.6 Calculation of the property tax in Winnipeg

$$\text{Portioned Assessment} \times \frac{\text{Municipal Mill Rate}}{1000} = \text{Municipal Taxes}$$

+

$$\text{Portioned Assessment} \times \frac{\text{Provincial Education Mill Rate}}{1000} = \text{Provincial Education Taxes}$$

+

$$\text{Portioned Assessment} \times \frac{\text{School Division Mill Rate}}{1000} = \text{School Division Taxes}$$

+

Local Improvements

=

Total Current Taxes (Gross)

(Winnipeg Assessment 2017)

Table 5.2. Annual Farmland Trade Volume by Land Size, Manitoba, 1987-2013

						Acres				
Year	Total trade volume of the year	40-99.99	100-149.99	150-199.99	200-299.99	300-399.99	400-499.99	500-699.99	700-899.99	900+
1987	120	10	11	51	7	29	6	5	1	0
1988	188	17	12	102	6	38	9	3	0	1
1989	363	37	13	167	27	82	17	11	4	5
1990	405	47	25	203	18	77	17	8	3	7
1991	259	18	14	128	17	57	14	4	3	4
1992	295	22	17	152	14	62	17	7	3	1
1993	312	32	17	139	21	69	13	17	3	1
1994	226	25	17	100	12	48	5	12	2	5
1995	174	20	11	77	16	28	6	9	0	7
1996	160	18	13	71	12	27	8	6	2	3
1997	177	29	12	69	10	45	6	2	3	1
1998	172	24	12	80	8	33	5	7	3	0
1999	154	17	12	80	7	18	10	4	0	6
2000	108	16	9	56	5	12	2	4	3	1
2001	129	19	7	54	6	25	7	8	3	0
2002	152	20	13	69	8	26	12	2	0	2
2003	129	34	6	40	7	29	8	2	2	1
2004	98	9	6	45	7	17	6	3	0	5
2005	143	14	15	58	8	23	11	4	4	6
2006	127	23	3	58	4	28	3	3	3	2
2007	166	21	10	53	18	37	12	9	2	4
2008	185	23	12	72	12	42	12	5	2	5
2009	170	21	16	71	11	34	5	5	1	6
2010	140	19	11	55	3	34	7	7	3	1
2011	132	19	11	60	3	19	7	6	1	6
2012	63	9	5	19	4	15	5	2	3	1
2013	1	0	1	0	0	0	0	0	0	0

Figure 5.7(a) Trade Volume in Percentage by Farmland Size, Manitoba, 1987-2013

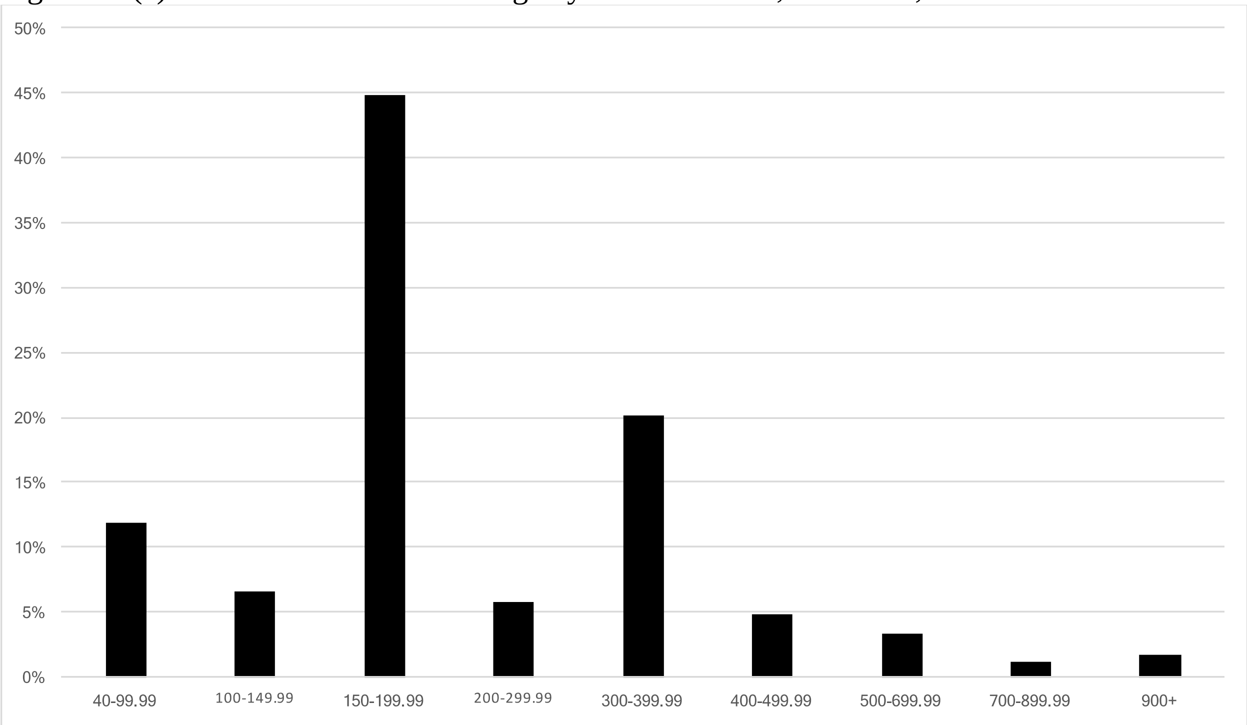


Figure 5.7(b) Total Trade Volume for Each Year, Manitoba, 1987-2013

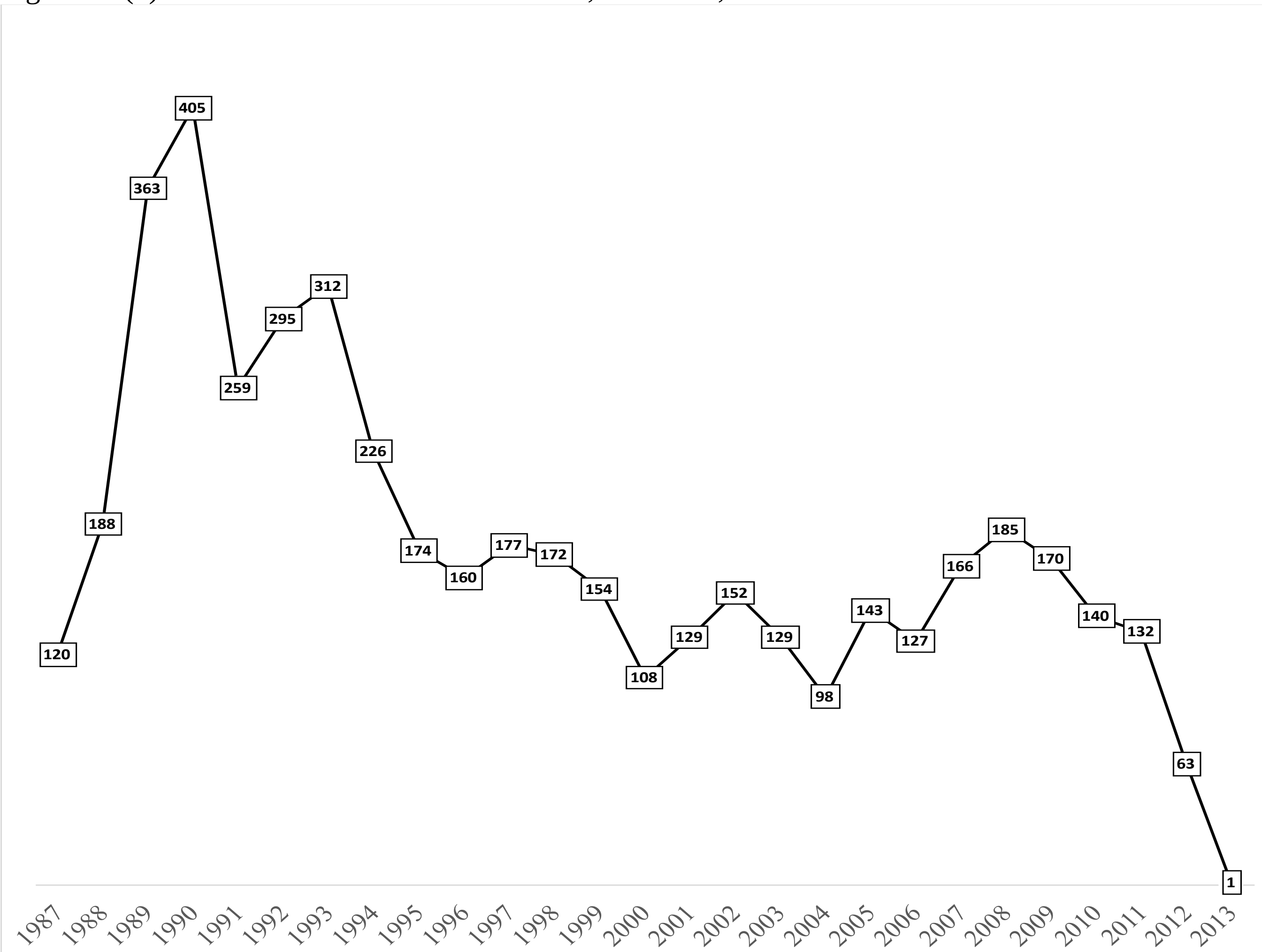
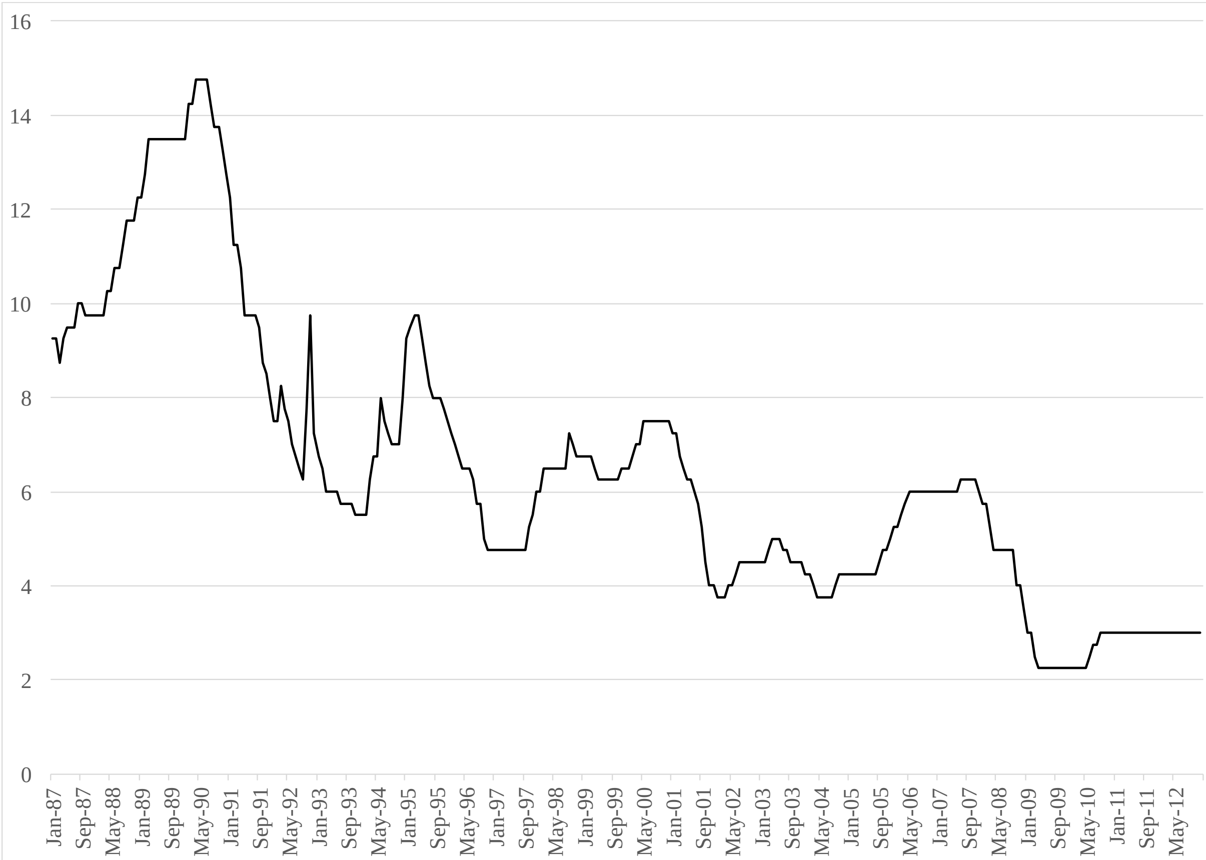
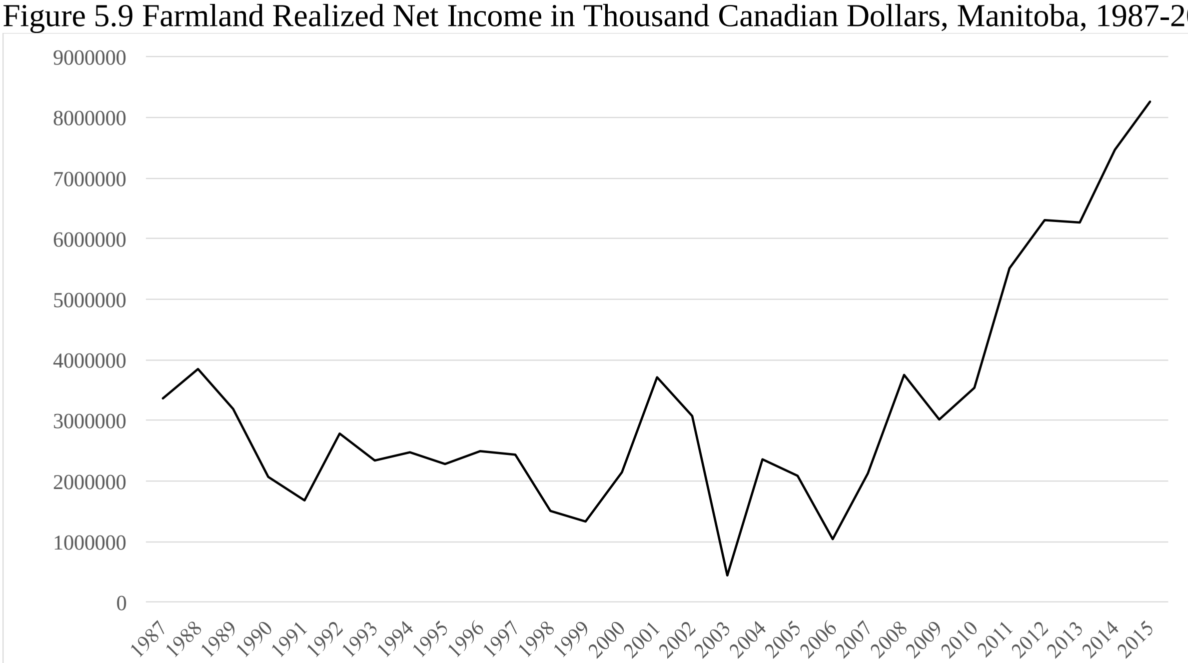


Figure 5.8 Chartered Bank Administered Interest Rates-Prime Business in Percentage, Canada, Jan 1987 - Oct 2016



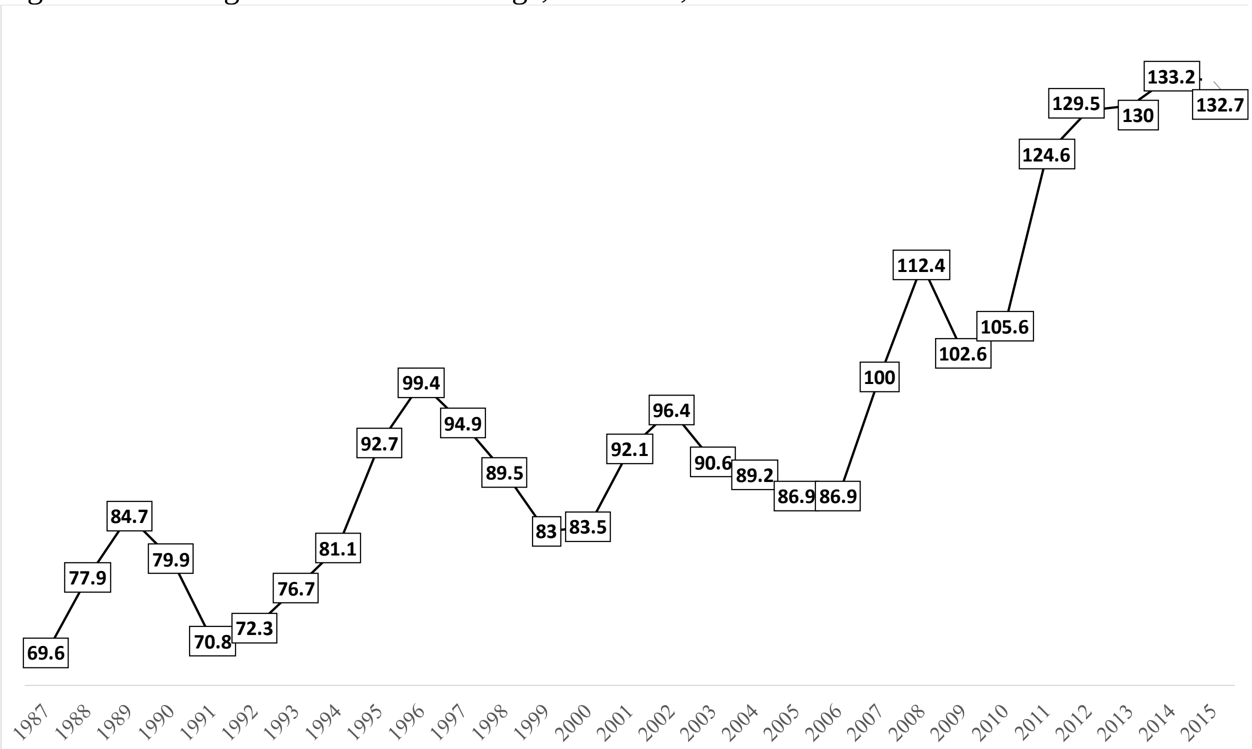
(Bank of Canada, Department of Monetary and Financial Analysis 2018)

Figure 5.9 Farmland Realized Net Income in Thousand Canadian Dollars, Manitoba, 1987-2013



(Statistics Canada 2017)

Figure 5.10 Change of FPPI in Percentage, Manitoba, 1987-2013



(Statistics Canada 2016)

Chapter 6. Empirical Model and Results

This section illustrates the regression results of the hedonic farmland price model and checks the robustness of the empirical model. The final model is specified as following:

$$ln(rP_i) = \beta_1 + \sum \beta_s SQ_{si} + \sum \beta_n RM_{mi} + \beta_2 ln(R_{ti}) + \beta_3 ln(Acg_i) + \beta_4 ln(RNI) + \beta_5 ln(RNI_1) + \beta_6 ln(RNI_2) + \beta_7 ln(RNI_3) + \mu_i \quad (1),$$

Where

$\boldsymbol{rP_i}$ is real (FPPI adjusted) farmland price;

$\boldsymbol{SQ_i}$ is soil quality of the i^{th} parcel, which is the focal point of this thesis;

$\boldsymbol{RM_{mi}}$ is a dummy variable for Rural Municipality;

$\boldsymbol{R_{ti}}$ is the interest rate in time period *t*;

$\boldsymbol{Acg_i}$ is the size of the parcel in acres (larger parcels are expected to be worth less per acre);

$\boldsymbol{RNI}$ is the Manitoba Realized Net Income (higher farm income should lead to higher farmland price. Note the RNI is lagged for three periods to account for persistence in the effect of sustained high or low farm income trends.)

Maximum Likelihood Estimation (MLE) is chosen as the method for estimating the coefficients because of the large sample size in this paper. MLE can provide minimum variance unbiased estimators as the sample size increases. The preliminary MLE results are shown in Table 6.1. All variables are statistically different from zero and possess the expected signs, except the current period Realized Net Income. For soil quality factors, using the lowest-quality J land as a baseline, all soil levels have positive coefficients as expected, with the magnitude of coefficients increasing as soil quality improves from I to B. The magnitudes of coefficients of the soil quality variables are much higher than other variables; this suggests that soil quality plays the most important role in determining Manitoba farmland price based on the datasets.

The dummy variable for each Rural Municipality is statistically significantly different from zero using the Municipality of Westlake-Gladstone as a baseline. This demonstrates that the RM in which a sale occurs has a statistically significantly effect upon price; possibly as a result of different tax rates, etc., within the municipality. Interest rate exerts a negative effect upon farmland price, for two reasons. First, higher borrowing costs decrease farmland prices by requiring a larger portion of the land payment to be comprised of interest, and less therefore of principal. Second, according to the present value formula, total future returns of a farm are discounted into current dollars for valuation purposes, and the interest rate forms the largest part of the discount rate (other factors such as time preference for money and risk also are incorporated into the discount rate). Parcel size is also an important determinant of farmland price; as predicted by theory, the unit prices of larger parcels tend to be less than smaller ones. One reason for this is that, in Manitoba, smaller parcels often have residential or development purpose associated with them; these uses are valued higher than farming, and buyers acquiring land for these purposes can pay more.

The last group of regressors are income factor variables. The net present value (NPV) or the income capitalization model predicts that farmland price is determined by discounted total future returns; accordingly, the relationship between farm income and farmland prices should be positive. This is confirmed by the results reported in Table 6.1. Note that farm income of the purchasing year is not statistically significant; this is congruent with prior expectations as well given farmers' keen interest in future income. The statistical significance of future years' incomes is tested using different lag periods; three years of lagged RNIs are included into the model with each one having the expected positive effect upon farmland prices. To test joint significance of the RNI variables, an F-test is constructed and the result is shown in Table 6.2. The result rejects that null hypothesis, so the RNI variables should be included in the model jointly.

Though FPPI itself is not contained in the final model as one of the variables, it is still an important determinant on farmland price due to the following two reasons. First, as the price index, FPPI enlarges the magnitude of nominal farmland price. For example, if both FPPI and nominal farmland price is doubled, the real farmland price stays the same. Second, market participants tend to over-react to the price index, so FPPI is an important variable to explain the deflated farmland price as well. Nevertheless, given that most information contained in FPPI is also contained within RNI, the former is not included in the final model.

6.1 Specification tests

To estimate a set of reliable coefficients through regression analysis models, the main precondition is to check the validation of the assumptions with respect to each model. The results are only valuable if there is no significant violation against the assumptions of MLE. The fundamental behind MLE is assuming that data distribute in a known probability distribution. This thesis assumes residuals, which come from the Ordinary Least Square (OLS), follow normal distribution. Therefore, the results shown in Table 6.1 are generated by MLE with OLS as a foundation. In this case, the results are subjected to the assumptions made from both MLE and OLS. Results from OLS are considered to be the best linear unbiased estimators (BLUE) under the following four assumptions: linearity, strict erogeneity, full rank, and spherical errors.

Combined with additional assumption made by MLE, five assumptions should be satisfied in total. With the log-log functional form as shown in the equation (1), the first assumption is assured beyond doubt. The second assumption requires regressors to be independent with the error terms. Any violation on this assumption leads to an endogeneity problem. In addition, the correlation among regressors are preferred to be as low as possible for full rank. If not, the high linear related independent variables causes multicollinearity issues. The fourth assumption is utilized to describe error terms: the errors are with constant variance, and their expectation value is zero; moreover, the covariance between any two errors is expected to be zero. The phenomenon of inconstant variance and non-zero covariance of errors is called heteroscedasticity and autocorrelation. Last but not the least, since the fifth assumption is partially overlapped with the fourth one, the coefficients from MLE should be same as the ones from OLS. The differences between OLS and MLE reflect on the standard errors of the coefficients, because the residuals of the OLS model have normality problem (Table 6.3).

The consequences of violating the different assumptions can be classified into two categories: estimator inconsistency and insufficient estimating. The following discussion will focus on tests for multicollinearity, heteroscedasticity and autocorrelation.

The independent variables in this model can be classified into two categories: farmland's inherent characteristics, such as soil quality level and farmland location; and external characteristics, such as Manitoba RNI and interest rate. It is clear that inherent characteristics are not likely to be affected by external characteristics, but it is reasonable to suspect that there are linear relationships within the external characteristics. For example, an increasing interest rate decreases farmers' incomes. Furthermore, farm product price enlarges a farm's total revenues. As a result, it is necessary to check if multicollinearity exists or not in this model. There are two common ways to diagnose multicollinearity: correlation matrix and variance inflation factor (Alin 2010). Table 6.4 is the correlation matrix, the signs of covariances correspond with the expectations. However, the absolute values of the covariances are neutral, and it is hard to tell if the correlations will cause the multicollinearity. In this case, variance inflation factors (VIFs) are needed for a further determination. VIF indicates the relationship of one independent variable with all the other independent variables. It can be expressed as 1/(1-R^2). R is correlation coefficient, which comes from the regression of one independent variable on all the other independent variables. Accordingly, as multicollinearity gets severe, the VIF increases. The results from Table 6.5 show that all the VIFs are less than 10, so the effect from multicollinearity is negligible in this research. The Breusch-Pagan/Cook-Weisberg test is used for diagnosing heteroscedasticity. The results (Table 6.6) reject the null hypothesis, a constant variance of residuals at 10% of significant level. White's estimators are used to adjust the variance. The results are shown in Table 6.7, which are resistence to the adjustment.

Since the data in this research crosses over two decades, and covers ten RMs, another intuitive entry point to think about violation of the assumptions is autocorrelation problems. However, in order to keep transaction-level soil quality dataset in the research, adjusting the model according to temporal or spatial autocorrelation is not the best approach. To explain the reason, a comparison between this thesis and a previous work from Huang et al. (2006) is provided in the following paragraph.

Huang et al. (2006) established their works through a hedonic model with transaction-level farmland price data. However, no additional calculation is needed for each year's soil quality because it is unlikely to have changed over time, also the soil quality data they hold is at county-level. As a result, even though their raw farmland price data was in transaction-level, they still averaged the price to get the farmland value in each county per year. In this way, the modified farmland price data is matched with the soil quality data, and allows researchers to take time series and spatial lag into consideration.

The difference between this study and Huang et al.'s work is at the data level. The soil quality data in this study comes with each transaction. Though it is possible to average the numerical price data for land price per year, it is impossible to average dummy variable data such as soil quality to match with the aggregated farmland price. Furthermore, the soil quality effect is a priority concern in this paper. It is improper to drop the soil quality data in favor of temporal and spatial correlation analysis. Therefore, traditional autocorrelation tests such as Durbin-Watson and Breusch-Godfrey cannot be applied in this case.

However, adding the sale date into the model as one of the independent variables can help us see how farmland price changes over time. The coefficient on 'sale date' from Table 6.8 shows that as time goes by farmland price does increase, but the magnitude of the coefficient is too small to make a significant difference on the farmland price. With this fact, it is predictable that time series' can be ignored.

To summarize, multicollinearity is not a concern in this particular study, heteroskedasticity problems exist in this model, and it is not clear whether autocorrelation causes estimation failure or not. However, by taking the data, the regression results and the main purpose of this paper into account, adjustments are not neccesary due to the following two reasons. Firstly, since the data size is very large and represents the total population of the ten RMs, both T-test and ANOVA are robust to the violation of the assumptions. As a result, even though not all of the assumptions are perfectly satisfied, it does not significantly affect the coefficients and the p-values. Secondly, both heteroskedasticity and autocorrelation lead to inefficient, unbiased and consistent estimaters. Thus, these two problems do not affect the coefficient estimators. The standard deviations and the P-values would be smaller if there are less assumption violations. However, the P-values in the existing results are already close to zero, which means the coefficients are significant enough, and the estimators are immune to heteroskedasticity and autocorrelation. As a result, no adjustment is needed to contrapose the heteroskedasticity and the potential autocorrelation problems in this research.

6.2 Implication of Results

Since the functional form of this empirical model is “log-log”, the interpretations of coefficients are distinct from a linear model. There are two types of variables in this model: the dummy variables, which include soil quality and farm location, and the non-binary normal variables which include interest rate, farm income, and farmland size.

In order to interpret the coefficients of dummy variables, anti-logging both sides of empirical model are required. Suppose the dummy variables are $X_1, X_2 \dots X_n$ with coefficients $\beta_1, \beta_2 \dots \beta_n$, and the baseline variable is arbitrarily chosen, whose coefficient is assumed to be zero. The price of land with $X_i$is $e^{\beta_i - \beta_j}$ times of the price of land with X_j (where i, j=1,2,…n) (Hardy 1993). The interpretation of the binary normal variables’ coefficients is summarized in table 6.9 (a) and (b). As shown in table 6.9 (a), keeping all other factors as the same, the land prices with level B, C, D, E, F, G, H, I soil are 4.18, 3.22, 2.76, 2.47, 2.02, 1.71, 1.34, 1.13 times of the land prices with level J soil, respectively. With only one level higher of the soil productivity index, the farmland price is increased at least 12% to as high as 30%. The implication of soil quality to livestock farms and crop farms are different. For livestock farming, the soil quality factors are less important, so it is not necessary to pay premium on good soils if a farmer is purchasing the land for grazing. Whereas, soil quality is one of the essential elements for crop farmer in both land purchasing and farm operations. Thus, by understanding the value of soil, farmers can make wiser decisions on managing the farm.

Moreover, with the farmland price in Westlake-Gladstone as a baseline, the coefficients of all the location variables are positive, so it costs more to purchase lands in the nine RMs than in Westlake-Gladstone. The farmland price in the RM of Lorne is the most expensive, which is 1.8 times of the farmland price in the baseline area. The second most expensive RM is Ncypress-Langford and it costs 60% more to purchase a same piece of land in the RM of Westlake-Gladstone. Then following by the RM of North-Norfolk, Norfolk-Treherne, Victoria, and Glenboro-Scypress, the farmland prices in these four RMs are close to each other, which are around 40% more expensive than Westlake-Gladstone. The farmland price in Louise and Pembina are 1.26, and 1.30 times of the price in Westlake-Gladstone. Also, the RM of Argyle is the least expensive area in the nine RMs, which is only 1.15 time of the price in Westlake-Gladstone. If a farmer already has a piece of land, he tends to purchase land close to his existing property. The farmer will purchase a new piece of land in the same area as the owned land, regardless of price differences among RMs. Thus, the implications of location variables are more important to the new farmland purchasers and those who are willing to reallocate. By considering taxation costs, location, and price gaps among the RMs, farmers can narrow down their selections.

The coefficients for the non-binary normal variables are elasticity coefficients representing the percentage changes in bare farmland price per acre given a one percent change in an independent variable. The coefficients of non-binary normal variables and implications of the coefficients are shown in Table 6.10. The results suggest that a 1% increase in interest rate results in a 0.617% decrease in bare farmland price per acre. This point is particularly important when farmers are making their decisions on whether lease or own land, or the amount of money to put into down payments if they decide to purchase one. Since the rental rate is less sensitive to the interest rate, the fixed costs are less in leasing than buying when the interest rate suddenly increases. However, risks are attached with farmland leasing as well. Many land owners prefer short term leases, so farmers lose the opportunity to gain profits in long term. The interest rate decides the cost of lending, if the farmer purchase his own land. Overall, farmers should consider the total budget, liquidity, and amortization length.

The implication of the current year RNI coefficient is not available because this variable is not significant enough to affect farmland price. Each percentage increase in the RNI of the next year, the next second year and the next third year, boost up farmland price by 0.137%, 0.161% and 0.176% respectively. The coefficients of RNI variables increase as the operational term gets longer. This indicates that farming is a long-term investment and future incomes are the main considerations. Another implication is that any event that boosts up agriculture incomes (e.g. technology improvement) may increase farmland price. One of the example is that the farmland price fluctuates as the agriculture income to non-agriculture income ratio changes. Last but not the least, the farmland price decreases 0.046% with an 1% larger in land size. This result demonstrates that the unit price decreasing as the land size increasing. Also, the total price increases as the land size increases. Thus, farmers should decide the size of land they want to purchase according to their budget and farm production expectation.

6.3 Tables

Table 6.1. Maximum Likelihood Estimation Results,
Manitoba Hedonic Farmland Pricing Model, 1987-2013

	Coefficient	Std.Err.	P>|t|
B-land	1.430	0.058	0
C-land	1.168	0.037	0
D-land	1.017	0.037	0
E-land	0.905	0.038	0
F-land	0.705	0.039	0
G-land	0.535	0.036	0
H-land	0.292	0.036	0
I-land	0.124	0.039	0.001
Lorne	0.595	0.034	0
Ncypress-Langford	0.469	0.028	0
North-Norfolk	0.375	0.027	0
Norfolk-Treherne	0.354	0.034	0
Victoria	0.370	0.040	0
Glenboro-Scypress	0.320	0.041	0
Louise	0.230	0.035	0
Argyle	0.137	0.033	0
Pembina	0.260	0.033	0
lnR	-0.617	0.018	0
lnrRNI	-0.008	0.015	0.580
lnrRNI1	0.137	0.014	0
lnrRNI2	0.161	0.014	0
lnrRNI3	0.176	0.014	0
lnAcreage	-0.046	0.012	0
cons	-1.780	0.299	0
Wald chi2(23)			5968.99
Number of Observations			4748

Table 6.2. F-test for joint significance of the RNI variables.

Ho:	Coefficients of RNI variables all equal to zero
F(4,4724)	72.94
Prob>F	0

Table 6.3. Test on residuals from MLS by Skewness/ Kurtosis normality test, 1987-2013

				-------	joint -----
Variable	**Observation**	**Pr(Skewness)**	**Pr(Kurtosis)**	**adj chi2(2)**	**Prob>chi2**
Residuals	4748	0.0016	0.0000	69.58	0.0000

Table 6.4. Variance covariance matrix, 1987-2013

	RNI	**R**
RNI	1	
R	-0.5058	1

Table 6.5. Variance inflation factor, 1987-2013

Variable	**VIF**	**1/VIF**
C-land	3.78	0.264859
H-land	3.08	0.324269
G-land	3.04	0.329193
D-land	3.03	0.33004
E-land	2.54	0.393126
F-land	2.47	0.405479
I-land	2.17	0.46012
Pembina	1.98	0.505157
Ncypress-Langford	1.98	0.505329
Louise	1.8	0.555051
North-Norfolk	1.65	0.606971
Lorne	1.63	0.614702
lnrRNI	1.4	0.715671
Argyle	1.39	0.721224
Norfolk-Treherne	1.37	0.72869
lnR	1.34	0.747351
B-land	1.32	0.757335
Victoria	1.31	0.76504
lnrRNI1	1.3	0.766808
lnrRNI2	1.26	0.792643
Glenboro-Scypress	1.24	0.804655
lnrRNI3	1.24	0.806654
lnAcreage	1.03	0.971018
Mean VIF	1.88	

Table 6.6. Breusch-Pagan/Cook-Weisberg heteroscedasticity test, 1987-2013

Ho:	Constant Variance
Variables:	Fitted values of lnrP
Chi2(1)=	5.05
Prob>Chi2=	0.0246

Table 6.7 Variance adjusted results, 1978-2013

	Coefficient	**Std.Err.**	**P > I t I**
B-land	1.430	0.061	0
C-land	1.168	0.043	0
D-land	1.017	0.042	0
C-land	0.905	0.044	0
E-land	0.706	0.044	0
F-land	0.535	0.042	0
H-land	0.292	0.042	0
I-land	0.124	0.046	0.007
Lorne	0.595	0.031	0
Ncypress-Langford	0.469	0.033	0
North-Norfolk	0.375	0.026	0
Norfolk-Treherne	0.354	0.032	0
Victoria	0.370	0.041	0
Glenboro-Scypress	0.320	0.043	0
Louise	0.231	0.031	0
Argyle	0.137	0.033	0
Pembina	0.260	0.032	0
lnR	-0.617	0.018	0
lnrRNI	-0.008	0.015	0.580
lnrRNI1	0.137	0.015	0
lnrRNI2	0.161	0.014	0
lnrRNI3	0.176	0.014	0
lnAcreage	-0.046	0.013	0
cons	-1.780	0.291	0
R-squared			0.557
Adj R-squared			0.5548
Number of Observations			4748

Table 6.8. Ordinary least squares result with sale data variable, Manitoba Hedonic Farmland Pricing Model, 1987-2013

	Coefficient	**Std.Err.**	**P>|t|**
B-land	1.4271	0.0557	0
C-land	1.1853	0.0362	0
D-land	1.0320	0.0361	0
E-land	0.9001	0.0370	0
F-land	0.7132	0.0376	0
G-land	0.5511	0.0352	0
H-land	0.3079	0.0353	0
I-land	0.1351	0.0374	0
Lorne	0.5876	0.0332	0
Ncypress-Langford	0.4695	0.0269	0
North-Norfolk	0.3800	0.0264	0
Norfolk-Treherne	0.3600	0.0329	0
Victoria	0.3649	0.0388	0
Glenboro-Scypress	0.3182	0.0396	0
Louise	0.2349	0.0336	0
Argyle	0.1585	0.0316	0
Pembina	0.2554	0.0323	0
lnR	-0.0138	0.0355	0.698
lnrRNI	0.0332	0.0142	0.019
lnrRNI1	0.0370	0.0143	0.01
lnrRNI2	0.0224	0.0153	0.143
lnrRNI3	0.0126	0.0155	0.418
lnAcreage	-0.0494	0.0120	0
SaleDate	0.0001	0.0000	0
cons	-2.0215	0.2893	0
R-squared			0.5895
Adj R-squared			0.5874
Number of Observations			4748

Table 6.9. Coefficients of the binary normal variables and the interpretations

(a). Soil quality variables with J-land as a baseline

	Coefficient	Times of the farmland price with J-land
B-land	1.430	4.18
C-land	1.168	3.22
D-land	1.017	2.76
E-land	0.905	2.47
F-land	0.705	2.02
G-land	0.535	1.71
H-land	0.292	1.34
I-land	0.124	1.13
	Baseline:	J-land

(b). Farmland location variables with Westlake-Gladstone as a baseline

	Coefficient	Times of the farmland price in Westlake-Gladstone
Lorne	0.595	1.81
Ncypress-Langford	0.469	1.60
North-Norfolk	0.375	1.45
Norfolk-Treherne	0.354	1.42
Victoria	0.370	1.45
Glenboro-Scypress	0.320	1.38
Louise	0.230	1.26
Argyle	0.137	1.15
Pembina	0.260	1.30
	Baseline	Westlake-Gladstone

Table 6.10. Coefficients of the non-binary normal variables and the interpretations

	Coefficient	Farmland price change with 1% change of the variable
lnR	-0.617	-0.617%
lnrRNI	-0.008	N/A
lnrRNI1	0.137	0.137%
lnrRNI2	0.161	0.161%
lnrRNI3	0.176	0.176%
lnAcreage	-0.046	-0.046%

Chapter 7. Summary and Conclusions

This thesis analyzes farmland transaction data from 1987 to 2013 that was collected by Manitoba Municipal Government (2014). The dataset covers the 10 RMs of Southern Manitoba which are indicated by the gray area as shown in Figure 2.12. Integrating with the Hedonic pricing model and Manitoba soil reports, the main contribution of this research is finding out how soil quality factors influence farmland prices. Since the total farmland area in Manitoba remains the same over the past six decades, the urban expansion rate is at a minimum level in Manitoba. In this situation, non-agricultural factors are negligible in the farmland pricing of Manitoba. Thus, the importance of soil quality factor in Manitoba farmland pricing is magnified, and the farmland trades in Manitoba are mainly for agriculture purposes.

Farmers would pay a premium for land with high quality soil because of its high potential yield. However, due to the difficulty in collecting soil quality data, researchers were unable to quantify the significance of soil quality factors on farmland price determination. The breakthrough of this thesis is on dataset. The soil quality data in this paper is linked directly to the transaction-level farmland price. The soil quality data is generated through the SPI system. This system ranks each quarter section of the studied land into A to J levels from high yield potential to low yield potential. As a result, the empirical results satisfy the following two points. Firstly, the farmland with level B soil (there is no level A soil reported in the dataset) is the most expensive one among all the levels. Additionally, farmland prices decrease gradually as the SPI changes from B to J. The empirical results completely anastomose with the expectations. In this case, it can be stated with confidence that this thesis quantifies the effects of soil quality on Manitoba farmland prices through a hedonic pricing model and dis-aggregated dataset.

In addition, the remaining empirical results correspond with expectations. Following soil quality factor, the interest rate is the next most important farmland price determinant. Since the interest rate not only increases the purchasing costs of the farmland, but also discounts the future value of farmland. Farmland prices decrease as the interest rate increases. Moreover, the location of farmland is another concern in farm purchasing. The farmlands located in different RMs are priced differently, which is caused by possible tax variation across rural municipalities. Furthermore, the results show that the farmland price is boosted up by the future farm incomes. On the contrary, the farmland price is unlikely to be affected by the farm income in the current year. Last but not the least, the results also verified that as the size of a farmland increases, the unit farmland price decreases.

The results in this paper are only based on the available dataset, they may not implicate a general fact, so limitations exist in this paper. Firstly, the farmland transaction data is limited to only 10 RMs out of 116 rural municipalities in Manitoba. The results would be more general if the farmland transaction data was collected for the entire province of Manitoba. Secondly, this thesis finds out the significant farmland price gaps among different RMs, but does not provide the reasons of this price gaps. A detailed analysis can be established if further RM factors are added into the dataset.

Considering the focus point of this paper and the limitations that are mentioned above, future farmland pricing studies can put emphasis on several different aspects. Above all, the raw data of the remaining 106 RMs could be gathered from the Manitoba Municipal Government and Manitoba soil reports. Furthermore, since part of the farm income comes from government subsidies, one of the entry points of farmland pricing is through agricultural policies and insurances. Another possible main point of farmland price modeling is to indicate and quantify the factors that cause the significant price differences among RMs.

Overall, it is possible to capture valuable empirical results, which agree with the statement that the soil quality factor is the most important determinants for farmland prices in the 10 RMs of Manitoba based on the transaction-level datasets and the Hedonic pricing model. In addition, the statement is also supported by the significant coefficients with expected signs. By understanding the value of soil quality, the farmers are able to manage their agricultural operation and soil conservation. The implications of the results about farmland location could also help with site selection for new farmers. Moreover, the information in this thesis could contribute to the agricultural program design in Manitoba. In summary, the content and results from this thesis provide useful information for farm management, purchasing decisions, policy making and future studies.

References

Alin, A. 2010. Multicollinearity. *Wiley Interdisciplinary Reviews: Computational Statistics* 2 (3): 370-374.

Aubin, J. P. 2007. *Mathematical methods of game and economic theory*. Mineola, NY: Dover Publication, INC.

Bank of Canada, Department of Monetary and Financial Analysis. 2018. Chartered Bank Administered Interest Rates: Prime Business 1935-2018 (Percent). http://www.stats.gov.nl.ca/Statistics/trade/PDF/Interest_Rate_Prime_Business.pdf (accessed January 9, 2018).

Barry, P., L. Moss, N. Sotomayor and C. Escalante. 2000. Lease Pricing for Farm Real Estate. *Review of Agricultural Economics,* 22(1), 2-16.

Blevins, R. L., G. W. Thomas, M. S. Smith, W. W. Frye and P. L. Cornelius. 1983. Changes in soil properties after 10 years continuous non-tilled and conventionally tilled corn. *Soil & Tillage Research* 3 (2): 135-146.

Bower, S. S. 2011. *Wet prairie: people, land, and water in agricultural Manitoba*. Vancouver, BC: UBC Press.

Carter, M. 2002. Soil quality for sustainable land management: Organic matter and aggregation interactions that maintain soil functions. *Agronomy Journal* 94(1), 38-47.

Cassman, K. G. 1999. Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture. *Proceedings of the National Academy of Sciences of the United States* 96 (11): 5952-5959.

Dick, T. 1980. Productivity Change and Grain Farm Practice on the Canadian Prairie, 1900-1930. *Journal of Economic History* 40 (1): 105-110.

Falk, B. 1991. Formally testing the present value model of farmland prices. *American Journal of Agricultural Economics* 73 (1):1-10.

Farm Credit Canada. 2017. 2016 farmland values in Canada: 3 things you should know https://www.fcc-fac.ca/en/ag-knowledge/ag-economist/2016-farmland-values-in-canada-three-things-you-should-know.html (accessed October 6, 2017).

Farm Credit Canada. 2017. Historic FCC Farmland Value Report. https://www.fcc-fac.ca/content/dam/fcc/about-fcc/reports/farmland-values-historic-2016.pdf (accessed on October 17, 2017).

Gagnon, E. N.D. Settling the West: Immigration to the Prairies from 1867 to 1914. https://www.pier21.ca/research/immigration-history/settling-the-west-immigration-to-the-prairies-from-1867-to-1914#footnote-4. (accessed September 17, 2017).

Goodwin, B. K., A. K. Mishra and F. N. Ortalo-Magné. 2003. What's wrong with our models of agricultural land values? *American Journal of Agricultural Economics* 85 (3): 744-752.

Government of Manitoba. 2010. Agriculture, Food and Rural Initiatives Interpretive Maps. http://www.gov.mb.ca/agriculture/land/soil-survey/print,interpretive-maps.html#soil (accessed March 24, 2017).

Government of Manitoba. 2011. Manitoba crop highlights – 2011 census of agriculture. https://www.gov.mb.ca/agriculture/market-prices-and-statistics/crop-statistics/pubs/crop_highlights_census.pdf (accessed March 27, 2017).

Government of Manitoba. 2017. The Public Schools Act. http://web2.gov.mb.ca/laws/statutes/ccsm/p250e.php (accessed on October 28, 2017).

Guiling, P., B. W. Brorsen and D. Doye. 2009. Effect of urban proximity on agricultural land values. *Land Economics* 85 (2): 252-264.

Hanson, E. D. 2013. Determinants of Illinois farmland prices. Master Thesis. Urbana: University of Illinois.

Hardy, M. A. 1993. *Regression with dummy variables.* Thousand Oaks, CA: Sage Publications.

Heminthavong, K. and A. Lavoie. 2015. *Farmland Grabbing in Canada*. Ottawa, ON: Library of Parliament and Canadian Electronic Library.

Homestead Progress. 2017. Canadian Homestead Act. http://homesteadcongress.blogspot.ca/2010/12/canadian-homestead-act.html (accessed on March 17, 2018)

Huang, H., G. Y. Miller, B. J. Sherrick and M. I. Gomez. 2006. Factors influencing Illinois farmland values. *American journal of agricultural economics* 88 (2): 458-470.

Just, R. E. and J. A. Miranowski. 1993. Understanding farmland price changes. *American Journal of Agricultural Economics* 75 (1): 156-168.

Ketcheson, J.W. 1980. Long-range effects of intensive cultivation and monoculture on the quality of southern Ontario soils. *Canadian Journal of Soil Science* 60 (3):403–410.

King, D. A. and J. A. Sinden. 1988. Influence of soil conservation on farm land values. *Land Economics* 64 (3): 242-255.

Krenz, G. and J. Leitch. 1993. *A river runs north: managing an international river*. Winnipeg, MB: Red River Water Resources Council.

Lach, S. and D. Tsiddon. 1992. The behavior of prices and inflation: An empirical analysis of disaggregate price data. *Journal of political economy* 100 (2): 349-389.

Lence, S. H. and A. K. Mishra. 2003. The impacts of different farm programs on cash rents. *American Journal of Agricultural Economics* 85 (3): 753-761.

Livanis, G., C.B. Moss, V.E. Breneman and R.F. Nehring. 2006. Urban Sprawl and Farmland Prices. *American Journal of Agricultural Economics* 88 (4): 915-929**.**

Maart-Noelck, S. C., O. Musshoff and M. Maack. 2013. The impact of price floors on farmland investments: a real options based experimental analysis. *Applied Economics* 45 (35): 4872-4882.

Manitoba Municipal Government. 2014. "Farmland Transactions Prices 1987-2012" *Province of Manitoba.*

Manitoba Government. 2017. A guide to Farmland Ownership in Manitoba http://www.gov.mb.ca/agriculture/business-and-economics/business-management/pubs/farmland-ownership.pdf. (accessed on October 17, 2017).

Martellozzo, F., N. Ramankutty, R. J. Hall, D. T. Price, B. Purdy and M. A. Friedl. 2015. Urbanization and the loss of prime farmland: a case study in the Calgary–Edmonton corridor of Alberta. *Regional Environmental Change* 15 (5): 881-893.

Miller, D. J. and A. J. Plantinga. 1999. Modeling land use decisions with aggregate data. *American Journal of Agricultural Economics* 81(1): 180-194.

Miranowski, J. A. and B. D. Hammes. 1984. Implicit prices of soil characteristics for farmland in Iowa. *American Journal of Agricultural Economics* 66(5): 745-749.

Moss, C. B. 1997. Returns, interest rates, and inflation: how they explain changes in farmland values. *American Journal of Agricultural Economics* 79 (4): 1311-1318.

Onel, G,, J. Kropp and C.B. Moss. 2017. Asset concentration in the US agricultural balance sheet: a relative information approach. Agricultural Finance Review.

Palmquist, R.B. 1989. Land as a differentiated factor of production: A hedonic model and its implications for welfare measurement. *Land Economics* 65 (1): 23-28.

Phipps, T.T. 1984. Land prices and farm-based returns. *American Journal of Agricultural Economics* 66 (4): 422-429.

Pope, R. D., R. A. Kramer. R. D. Green and B. D. Gardner. 1979. An evaluation of econometric models of US farmland prices. *Western Journal of Agricultural Economics* 04 (01): 107-119.

Reiss, F. J. 1965. What is a fair crop-share lease? Circular 918, Cooperative Extension Service, College of Agriculture, University of Illinois, Urbana, Illinois.

Reiss, F. J. 1984. Farm Tenancy Arrangements in the USA. *Agricultural Administration* 19 (4): 245-262.

Ridley, A., J. Friesen and R. E. Smith. 1966. *Preliminary soil productivity index report*. Winnipeg, MB: Manitoba Department of Agriculture and Department of Soil Science, University of Manitoba.

Robison, L. J., S. R. Koenig and S. D. Hanson. 1992. Market value versus agricultural use value of farmland. Working paper #91-12, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

Rosen, S. 1974. Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of political economy* 82 (1): 34-55.

Samarasinghe, O. and S. Greenhalgh. 2013. Valuing the soil natural capital: a New Zealand case study. *Soil Research* 51(4): 278-287.

Statistics Canada. 2009. Canada's leading domestic exports, fiscal years 1890, 1900, 1910,1920, 1930, and 1936. https://www65.statcan.gc.ca/acyb02/1937/acyb02_19370518000x-eng.htm (accessed September 17, 2017).

Statistics Canada. 2011. Value of Farm Capital. http://www.statcan.gc.ca/pub/21-013-x/21-013-x2011002-eng.htm ((accessed October 6, 2017).

Statistics Canada. 2011. 2011 Census of Population Program. http://www12.statcan.gc.ca/census-recensement/2011/index-eng.cfm. (accessed September 17, 2017).

Statistics Canada. 2012. Interest rates and exchange rates. http://www.statcan.gc.ca/pub/11-210-x/2010000/t098-eng.htm (accessed September 18, 2017).

Statistics Canada. 2012. Census of Agriculture, total area of farms and use of farm land, Canada and provinces every 5 years. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0040002&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid= (accessed September 19, 2017).

Statistics Canada. 2016. Farm product price index (FPPI). http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=20069 (accessed October 7, 2016).

Statistics Canada. 2017. Table 002-0008 Farm debt outstanding, classified by lender. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0020008&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid= (accessed September 19, 2017).

Statistics Canada. 2017. Net farm income, by province (Manitoba). https://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/agri02g-eng.htm (accessed November 30, 2017).

Statistics Canada. 2017. Table 002-0003 Value per acre of farm land and buildings, at July 1 annual (dollars). http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=20003 (accessed September 19, 2017).

Tan, R., V. Beckmann, L. V. D. Berg and F. Qu. 2009. Governing farmland conversion: Comparing China with the Netherlands and Germany. *Land Use Policy* 26 (4): 961-974.

Tegene, A. and F. Kuchler. 1993. A regression test of the present value model of US farmland prices. *Journal of Agricultural Economics* 44 (1): 135-143.

United States Department of Agricultures. 1941. the Wheat Situation. http://usda.mannlib.cornell.edu/usda/ers/WHS//1940s/1941/WHS-11-14-1941.pdf (accessed September 17, 2017).

University of Manitoba. 2015. Sustainable living, local geography. http://www.arch.umanitoba.ca/greenmap/pages/PM_RoomtoGrow/pages/1.htm (accessed March 24, 2017).

Weersink, A., S. Clark, C. G. Turvey and R. Sarker. 1999. The effect of agricultural policy on farmland values. *Land Economics* 75 (3): 425-439.

White, P., J. Crawford, M. Díaz Álvarez and R. García Moreno. 2012. Soil Management for Sustainable Agriculture. *Applied and Environmental Soil Science* 2012 (3): 1-3

Winnipeg Assessment. 2017. How are Taxes Calculated - Tax Rates. http://www.winnipegassessment.com/AsmtTax/English/Property/TaxRates.stm (accessed on October 28, 2017).

Ziemer, R. F. and F. C. White. 1981. A Tobit model of the demand for farmland. *Southern Journal of Agricultural Economics* 13 (02): 105-109.