The effect of grain elevator market concentration on Saskatchewan farmland prices

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Abstract

In western Canada, grain elevators assume a central role in the Grain Handling and Transportation System (GHTS). Over the decades, the GHTS has undergone important changes. First, the number of grain elevators has declined rapidly, and older elevators have been replaced by larger and more efficient elevators. This resulted in increased average market concentration ratios of grain elevators and increased length of truck haul by farmers. Second, the removal of the single desk seller power of the Canadian Wheat Board in 2012 affected the way GHTS operates. After the removal of the CWB, grain elevator companies were left to handle both marketing and logistics (Çakir and Nolan, 2015). This change resulted in the removal of the CWB as an established participant in the GHTS and it became legal for Canadian grain farmers to sell their grain to whomever they choose.

We examine the effect of grain elevator market concentration on Saskatchewan farmland prices. We present two models of market concentration. Market power is measured by the total number of elevators within a radius of farmland or by the distance between elevators. In order to measure efficiency, we consider the total capacity of elevators within a radius around a farmland or the capacities of the closest grain elevators.

Our specification explains farmland prices based on market power and capacity variables. Overall, consistent with the economic theory, the models suggest that as the local market power measures increase, the farmland prices decrease after 2012. Furthermore, contrary to the general economic theory, the efficiency measures are negatively related to farmland prices. For the most part, the results of both models are consistent.

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1 Introduction

1.1 Motivation

A distinctive characteristic of agricultural production is its spatial dimension. Geographic location selection and pricing policies adopted by agricultural processing firms are key factors in determining the competitiveness and efficiency of agricultural markets (Graubner and Sexton, 2022). As farm products are transported at high costs, spatially distributed firms create natural oligopolies.

Contrary to many other grain producing countries where production is close to exporting tidewater, in the Canadian Grain Handling and Transportation System (GHTS)[1], an average rail haul from inland to the port position is about 1,500km (Quorum, 2015). Vast distances make the GHTS vulnerable to market power issues. Therefore, the Canadian GHTS has been heavily regulated to protect the profits of farmers against the market power of large grain handling and transportation companies.

In western Canada [2], the GHTS has gone through substantial changes over the decades. First, railways have consolidated. In 1995, direct government transportation subsidies were eliminated as a result of fiscal reform and new World Trade Organization rules (Quorum, 2015). As a consequence of the elimination of government subsidies, Class 1 railways cut operating costs and reduced the size of their networks (Quorum, 2015). After the rationalization process of the railways, grain elevators are closed on abandoned rail tracks. Second, combined with the consolidation of railways, grain elevator companies have also consolidated. The number of grain elevators in western Canada changed dramatically from over five thousand to less than four hundred in the last sixty years in Figure 1.1a.

The rapid sharp decline in the number of grain elevators has increased the average length of truck haul to bring grain from the farmers' gates to country elevators. As a consequence, the average trucking cost of

[1] The Canadian GHTS is a complex system with a variety of actors and interconnected infrastructure. The main functions of the GHTS are collection, transportation, cleaning, handling, and storage of the grain. Heavy dependence on rail freight and separation of those grain producers (farmers) from those controlling and marketing the grain (railways and grain elevators) differentiates the GHTS from a typical supply chain (Quorum, 2015).

[2] Western Canada is the Canadian region includes the four western provinces which are British Columbia, Alberta, Saskatchewan and Manitoba.

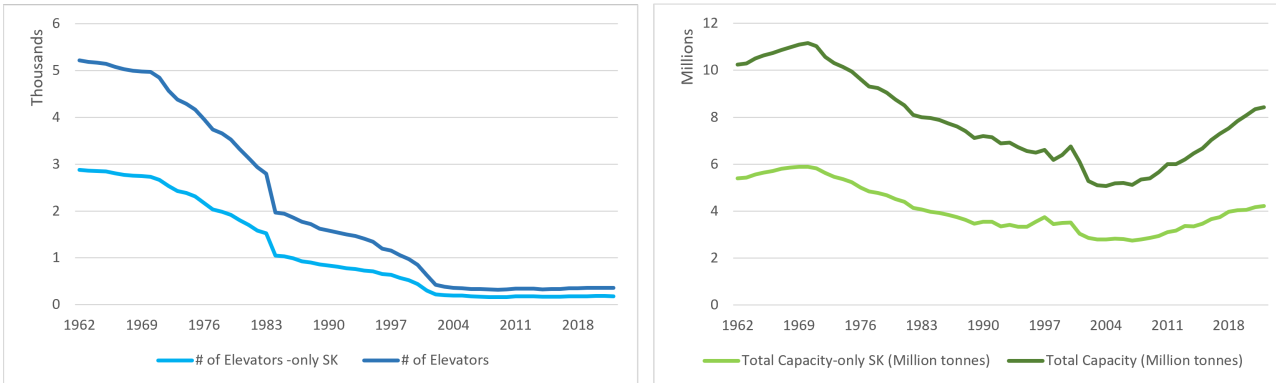

Figure 1.1: On the left side (a), the total number of primary grain elevators in western Canada versus Saskatchewan is shown. On the right side (b), the total capacity of primary grain elevators in western Canada versus Saskatchewan is shown.

a farmer has increased [3]. Figure 1.2a shows that in 1993, the average distance to the closest grain elevator was 11km (in 2020, the average distance to the closest grain elevator increased to 28km). Furthermore, an average farmer had access to three different elevators within 20km of his farmland in 1993. However, in 2020, this distance increased to 45km. Thus, farmers have to truck their grain longer distances for delivery and at the same time, the competition level for grain elevators has dropped as more farmers have limited options over the years.

The third important change in the GHTS was the removal of the single desk selling power of the CWB in 2012. This policy change affected the way the GHTS operated, leaving grain companies to handle both marketing and logistics (Çakir and Nolan, 2015). Furthermore, the CWB was privatized by the federal government and agreed to create a new enterprise, G3 Canada Limited, which is intended to be a highly efficient coast-to-coast Canadian grain elevator company.

The effect of increased elevator concentration on farmland prices is a complex question. Standard economic theory predicts that prices generally rise with concentration (Weiss, 1989). However, with concentration often comes economies of scale and greater cost efficiency. The increase in concentration levels has two contradictory effects. First, increased concentration may reduce competition and lead grain handlers to exercise their market power, thereby reducing the contract prices received by farmers. Second, consolidation might increase the efficiency of the system. These cost savings may be passed on to farmers. Empirical studies have found evidence supporting both of these effects. In some contexts market power leads to deleterious price effects (Hernandez and Torero, 2013; McCorriston, 1993; Shi et al., 2009) in others, the efficiency gains from economies of scale resulting in better prices for farmers (Azzam, 1997; Azzam and Schroeter Jr, 1995;

[3] In Canada, the trucking industry is a commercially autonomous entity and is not required to report commercial terms or rates (Quorum, 2002). This situation has posed challenges to the analysis as without a regulatory body, it is not possible to trace trucking rates and/or trucking subsidies given by grain elevators. For a more comprehensive review of the Canadian trucking industry, see Quorum(2002).

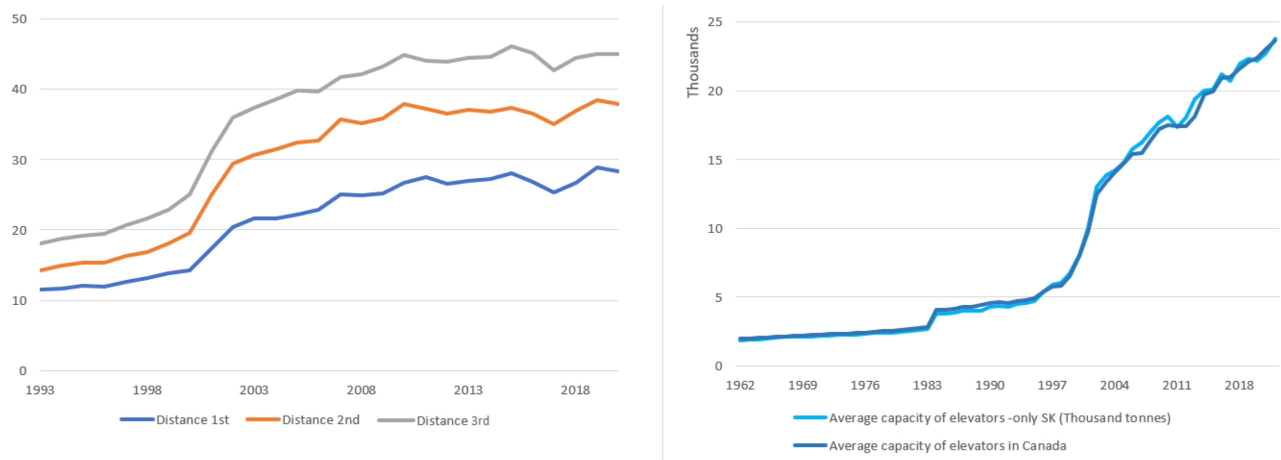

Figure 1.2: On the left side, the average distances from farm gate to the first, second and third closest grain elevators are shown between the years 1993-2020. On the right side, the average capacity of grain elevators in Saskatchewan and Canada is shown between the years 1962 and 2022.

Paul, 2001; Ward, 1982).

Recent years have seen dramatic increases in market concentration in multiple agricultural sectors (Clapp, 2018; Sexton and Xia, 2018). Increases in market concentration have reshaped these agricultural markets and caused concern about growing market power. Over the years, this issue has become an important policy concern. In Canada, the consolidation of agricultural markets and grain-handling companies in conjunction with the consolidation of the country elevator system has left farmers with less choice when selling their grain.

The dramatic decrease in the number of grain elevators and the total capacity of the elevators are illustrated in Figures 1.1a and 1.1b between the years 1962 and 2022. The number of grain elevators rapidly declines and corollary to this, the distances between the grain elevators also increase. As the grain elevators distant themselves apart from each other, they avoid competition and increase their local market shares and market power.

1.2 Problem Statement

In Figure 1.2, the average capacity of the grain elevators in Canada and Saskatchewan are shown. The average capacity of an elevator increases more than 10 fold from less than 2,000 tonnes in 1962 to more than 23,000 tonnes in 2022. Given the reliance of farmers on grain elevators, the spatial competition of elevators can have major impact on prices received by farmers (Bekkerman and Taylor, 2020) and ultimately, affects the farmland prices. In this thesis, we examine the spatial competition of grain elevators and its impact on farmland prices in Saskatchewan between 1993 and 2020.

1.3 Goal and Objectives

The goal of the study is to examine the impact of spatial market concentration on farmland prices in Saskatchewan. We develop a theoretical model of spatial competition. Specifically, we separate the impact of market concentration into market power and capacity variables. Furthermore, we separated the study period into the CWB and the Post-CWB to account the removal of the single desk selling power of the CWB in 2012 as it was a major structural change in the Canadian GHTS. The CWB period represents the farmland sales before the crop year of 2012 and the Post-CWB period represents the farmland sales in the crop year of 2012 and after.

Currently, there are no studies in the Canadian context. Prior studies have not explored the impact of spatial competition of grain elevators on Canadian farmland prices. This thesis adds to the body of work surrounding spatial competition by analyzing farmland in Saskatchewan.

In Table 1.1, we present two models that show the impact of market concentration on land prices through two specifications, a radius based model for the years 1993-2020, and a distance based model for the Post-CWB period. The grain elevator locations before 2012 were not available as exact coordinates. Therefore, we created a radius model which uses radius based variables rather than using exact coordinates. These radius variables are less sensitive to individual elevator impacts.

Both models use market power and efficiency measures as interest variables and controls for the specific features of the farmland such as soil type. Essentially, both models measure the impact of the spatial grain elevator market concentration and grain elevator efficiency impacts on farmland prices using slightly different variables and time ranges.

In the Post-CWB period, the results of the radius model indicate that farmland price is increasing with the number of elevators within a specified radius . The distance based model also predicts a negative relationship between market power and farmland prices. However, the coefficient of market power is not significant. For the capacity variables, the results of both models reveal a significant and negative relationship.

In the CWB period, we use only the radius model. The results of the model suggest that as the distance between grain elevators increases (market power increases), farmland prices decrease. However, these effects are not significant. The capacity variable, on the other hand, seems to be negatively related to farmland prices. As the capacity of an individual grain elevator increases, farmland prices decrease, but the magnitudes of coefficients are smaller relative to the Post-CWB period.

We see our research as making three primary contributions to producer groups, and policymakers:

1. Our research provides valuable information to policymakers as they design competition policies that will regulate the Canadian agricultural industry. In particular, our results can be used to provide information to the Competition Bureau regarding its stance on future mergers and acquisitions in output markets.

Variables	Radius Model	Distance Model
Market power variable	The # of elevators within a radius	The distance between the grain elevators (km)
Capacity variable	The total capacity of elevators within a radius	The capacity of the grain elevator
Data	1993-2020	2012-2020

Table 1.1: Model comparison table.

2. Our research informs the position that SaskWheat and other interested producer groups can take on future consolidation.

3. The research points to areas that need greater competition through regulation and/or price reporting. Such competition could be achieved by encouraging the entry of new players or the development of cooperatives.

1.4 Thesis Overview and Organization

The organization of the thesis follows from Chapter 2 to Chapter 8. Chapter 2 gives the background information necessary to understand the study. Chapter 3 reviews the related literature. Chapter 4 describes data and presents descriptive statistics. Chapter 5 explains the methodology used in this study, Chapter 6 provides empirical models, Chapter 7 provides our results, Chapter 8 concludes the study, and provides policy implications and the limitations of the study.

2 Background

The grain elevators in the Prairies are one of the central pieces of the Canadian GHTS. A farmer's first point of contact with the GHTS is almost always with a grain handling company operating a grain elevator. The main roles of grain elevators are to collect the grain from farmers and prepare the grain for further marketing or processing. In return, grain elevators charge farmers for their services. Thus, they have a direct impact on farmers' income. Furthermore, grain elevators provide access to both domestic and international markets by connecting with rail transportation. There are two major (Class 1) railways in Canada: Canadian National and Canadian Pacific. Almost all of the grain elevators have access to one of the major railroad networks.

The Canadian grain elevators are spatially dispersed over a vast area and local producers have access to only a few elevators to sell their grain. Thus, a local farmer is historically in a disadvantaged position against the market power of grain elevator companies. Therefore, the Canadian GHTS has been regulated by marketing boards to mitigate market power issues.

2.1 Canadian Wheat Board (CWB)

The first Canadian Wheat Board (CWB) was established in 1917 as a temporary wartime measure to centralize the purchasing of grain, and after the war, there were several attempts to reestablish the board as the uncertainty of the war continued. The Canadian Wheat Board Act of 1935 established the CWB as a voluntary marketing board and finally from 1943 until 2012, the CWB was made mandatory single-desk marketing during World War II (Quorum, 2015).

Under the mandatory marketing of the CWB, grain handling companies and grain elevators provided services for grain handling and the price of the CWB grains was determined independently from grain elevator companies by pooling over the crop year. The CWB operated four different price pools: (1) wheat, other than durum wheat; (2) durum wheat; (3) feed barley; and (4) designated barley (almost always malting barley) (Schmitz and Furtan, 2000).

Under the CWB price pooling system, farmers' delivery decisions can have a limited effect on a farmer's contract price as all farmers received the same pooled price for the same quality of the grain independent of the delivery date in a given crop year. However, after the dismantling of the mandatory single desk selling power of the CWB, farmers' delivery decision can change the contract price of an individual farmer during a crop year [1]. Thus, the CWB might have moderated the oligopoly problem until 2012.

One of the greatest challenges of GHTS has been the matching of sales volume to the available GHTS logistics capacity (Quorum, 2015). Historically, the CWB played a significant role in matching this capacity with the sales volume, rationing farmer deliveries to grain elevators through acres based permits and quotas rather than a free market mechanism, directing the Canadian grain to port positions, and allocating the rail cars. A land owner held a CWB permit to deliver his grain to a CWB account and the CWB coordinated the movement of grain through delivery calls to producers who signed delivery contracts with the CWB. Through these instruments, all farmers gained equal access to the GHTS.

After the removal of single desk selling powers in 2012, grain companies were left to handle both marketing and logistics (Çakir and Nolan, 2015). This change enabled grain companies to forward contracts for the delivery of wheat and barley, effective after August 1, 2012 (Quorum, 2015). Under this major market deregulation policy, the hope was to introduce more competition and more choices for the participants of the GHTS (Brewin et al., 2017a). However, after the dismantling of the CWB, the delivery date of the grain became relevant for the farmer to secure a fair price. Thus, one might expect that the removal of a single desk power of CWB might amplify market power issues.

Grain companies compete with each other to buy grain from farmers. When there is enough storage and capacity to move the grain to a port position, the export basis (which is the price difference between the port and grain elevator position) closely reflects grain handling costs (Gray, 2016). As long as the grain companies compete with each other to buy more grain, they keep the export basis at the marginal cost. However, when there is limited storage and capacity to move the grain offered for sale by farmers, grain elevator companies offer lower bids to ensure deliveries do not exceed the system's limited storage and movement capacity. Consequently, producers receive a lower price, and farm revenues are reduced due to the increase in export basis.

2.1.1 The Congestion of 2013 Crop Year

In western Canada, the 2013 crop year saw a record grain harvest. The total production of 97.2 million tonnes, including 28 million tonnes of wheat, exceeded all previous levels (Gray, 2016; Slade and Gray, 2019). The record harvest, combined with the harsh winter of 2013, lead to congestion of the GHTS. Grain export companies reduced cash bids to ration deliveries, which led to an increase in the export basis. In the

[1] As grain elevators have limited storage or capacity to move the grain (especially during congestion periods, see Section 2.1.1), a farmer's early delivery decision can secure him a contract price and at the same time, increases the price risk of other farmer deliveries without a pooling system. Under the CWB price pooling, the CWB rations the grain through delivery quotas and matches the available elevator capacity to farmer deliveries without a market mechanism. Under the CWB, farmers have less incentive to secure themselves a contract price as all farmers receive the same pooled price. Therefore, price pooling prevented the competition between farmers and lowering each others' contract prices.

2012 crop year, the export basis was close to the average posted tariff rate of $72 per tonne when there was sufficient capacity to move the grain. Next year, with a record harvest, the export basis rapidly increased to $250 per tonne (Gray, 2016).

Brewin (2016) studies competition in the Canadian grain supply chain. He suggests that in the empirical literature, departures from Bertrand's competition are minimal in the Canadian GHTS [2]. This suggests that in general, the market structure of the Canadian GHTS is not a major problem in terms of rent distribution. However, if the capacity to move the grain is limited in the GHTS, then grain elevators capture significant rents. Brewin (2016) states that in the 2012 crop year when there was enough capacity to move the grain, a competitive outcome was achieved as the export basis reflected marginal costs. Contrary to that, grain elevators behaved as a cartel might act during the congestion of 2013 (Brewin, 2016). This finding suggests that the capacity constraints of GHTS might exaggerate the problems with the market concentration of the grain elevators.

Canadian farmers have suffered significant losses due to a lack of export capacity in 2013. Gray (2016) estimates the total value of loss to producers in the order of $5 to $6.7 billion dollars. There are several explanations for the persistence of congestion in the GHTS. The first explanation suggests the problem of market power exertion of grain elevators against farmers. Çakir and Nolan (2015) note the increase in the market power exertion by railways and/or grain handling companies would decrease the quantity of grain supplied to the terminal elevators. Similarly, Brewin (2016) argues that the increase in the export basis is consistent with the change in the nature of competition from Bertrand to perfect collusion.

Contrary to the market power problem explanation, Slade and Gray (2019) argue that the bumper crop carrying over from the previous year increased the marginal cost of grain handling which reduced the demand for wheat. Furthermore, large wheat stocks are responsible for severing the cointegration of inland and port prices in Canada during this period.

Serfas et al. (2018) claim that the elevated export basis during the congestion of the 2013 crop year in Canada shows the role CWB played in the GHTS. Under the CWB, there were multiple periods when large crops could not be moved to export positions within the crop year [3]. Still, export basis levels stayed within the posted tariff rates as the CWB restricted farmer deliveries to match available export capacity. However, without the CWB, this rationing occurs on the export basis. As the system's available capacity decreases, the grain companies lower their cash bids until the producer deliveries match the available capacity to move the grain.

Serfas et al. (2018) argue that the removal of the CWB single desk selling powers has changed the pricing,

[2]He cites Zhang et al.(2007) and Fulton et al.(1998) as they suggest a competitive market model for the Canadian GHTS rather than a model with significant market power.

[3]Grain and oilseed production in Canada exceeded the average yields in the previous five years in 2005 and 2008 (Serfas et al., 2018).

logistics, and incentives in the GHTS. After the removal of CWB, competition between the grain elevators especially during the times of congestion seems to be decreased. Therefore, after the removal of CWB, market power issues between the grain elevators and farmers are more likely to occur.

The market power of railways in the GHTS has been a consistent issue (Brewin et al., 2017b; Gleim and Nolan, 2015; Lawrence et al., 2016; Nolan and Peterson, 2015). Çakir and Nolan (2015) study the market power problem in the railway sector versus grain handling companies. They find that market power exercised by the complementary input sector such as the major railways in Canada generates a greater negative welfare impact compared to market power exercised by the downstream sector such as the grain handling companies. However, Canadian rail rates for grain have been regulated by maximum revenue entitlement (MRE) which requires the average price charged per tonne-mile of grain hauled to be less than the 2000 crop year (after adjustments for inflation and average haul length) (Brewin et al., 2017b).

During the congestion of the 2013 crop year, rail car demand was high in Canada. However, as the MRE constrained the maximum average freight rate, grain handling companies were allowed to capture a larger portion of the export basis (Serfas et al., 2018). Contrary to Canada, the rail rates in the U.S. are not subject to a revenue cap. Therefore, the rail rates are consistently higher on the other side of the border, except at locations where railways are subject to intermodal competition (Serfas et al., 2018). For example, the 2013 export basis was smaller in the State of Montana compared to other states in the U.S. as railways are subject to competition from the Snake River barge system. Furthermore, during the 2013 crop year, railways in the U.S. were able to capture part of the increased export basis, whereas, in Canada, the excess rents accrued solely to grain handling companies (Serfas et al., 2018). Therefore, oligopoly problem in grain elevators seem to be more important than railway sector in the Canadian GHTS.

2.2 Grain Elevators

Grain elevators in the Canadian GHTS buy grain from farmers and sell to the grain buyers. Until the removal of the CWB, grain elevators acted as agents of the CWB and over 90% of the wheat grown in the Prairies was bought by these grain elevators acting as agents of the CWB (Hucq, 1998). The CWB operated a variety of pools over the crop year and paid farmers for their grain at various times beginning at the time of the delivery. Grain elevators charge for their services and the price of the CWB grains determined independently from the grain elevators.

Elevator companies compete with each other for potential farmers in a variety of ways. The price received by the farmer is obviously the most important factor to attract more farmer deliveries. Under the CWB, there were limited options for grain elevators to compete and attract more farmer deliveries as the price of the grain pooled by the CWB. The grain elevators could ask different prices for their services but they had virtually no impact on the price of the CWB grains. A more subtle method of competition includes the

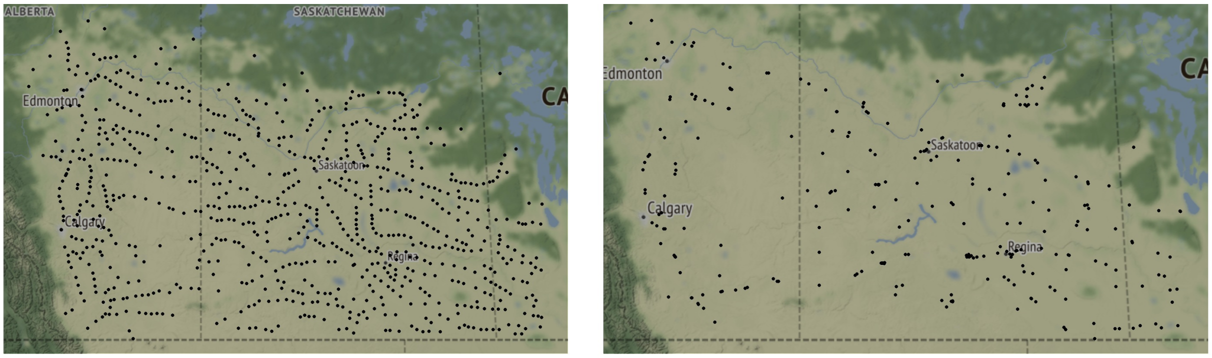

Figure 2.1: The grain elevators included in this study are shown on the maps. On the left side (a), primary grain elevators as of 1993. On the right side (b), primary grain elevators as of 2020.

grades offered for grain and the amount of services offered by the grain elevators (Hucq, 1998). After the dismantling of the CWB in 2012, grain elevators had the option to offer different contract prices not just for their services but for the price of grain. Therefore, after the dismantling of the CWB, the grain elevator market structure could have more impact on the farmers' income.

There are six major grain companies that operate country elevators in Canada: Viterra, Richardson International, Cargill, Paterson Grain, Parrish and Heimbecker, and Louis Dreyfus Canada (Quorum, 2015). Collectively, they own around 75% of the grain elevator capacity (Quorum, 2015). Before 1997, the tariff charged by every company had to be uniform across all elevators owned by that company (Hucq, 1998). However, this has changed and grain elevator companies can now charge different prices at different locations depending on the nature of the competition.

Together with the consolidation of the railway industry, grain elevators have undergone a consolidation process. In 1962, there were over five thousand grain elevators in the Prairies, more than half of them located in Saskatchewan. However, the number of grain elevators declined rapidly until the early 2000s and stayed around less than four hundred, again slightly more than half of them are located in Saskatchewan. Especially after the mid-2000s, as the older and smaller grain elevators exited the market, newer and larger grain elevators entered the market. As a result of newer and larger grain elevator entries, the total capacity of the GHTS increased by 66% between 2004 and 2022 even though the total number of elevators remained the same. (Figure 1.1) This suggests that the average market power has been increasing due to the increasing average local market shares of these larger capacity, efficient grain elevators.

In Figure 2.1, the primary grain elevators included in this study are shown. We include grain elevators from neighboring provinces as the farmers located close to the Saskatchewan border may choose to deliver their grain to these grain elevators and/or the pricing of the other grain elevators can be affected. The dramatic decline of the grain elevators is clearly visible in Figure 2.1.

3 Literature Review

To contextualize our work, we will refer to four different literature; the first examines the competition in agricultural markets, the second is the competition level and distribution of rents in the different GHTS, the third is the grain elevator studies, and lastly, farmland prices in Canada.

3.1 Competition in Agricultural Markets

Global agricultural markets are undergoing a significant change. Large processing, trading, and retailing corporations are expanding, while conventional auction or spot markets vanish from the scene (Sexton, 2013). The increasing consolidation in the agricultural industry has made the market power of firms an issue and an important policy concern over the years.

On the other hand, concentration levels might be associated with higher efficiency. There is substantial literature on efficiency and price-cost margins. However, a few studies have separated market power from cost efficiency. This new approach, so-called the new empirical industrial organization (NEIO) framework, has focused on estimating structural models of single industries hypothesized to be characterized by market power (Sexton and Lavoie, 2001).

The NEIO approach has been frequently used in agricultural markets (Azzam and Schroeter Jr, 1995; Bhuyan and Lopez, 1997; Lopez et al., 2002; Schroeter and Azzam, 1990; Schroeter, 1988; Wann and Richard J, 1992). As opposed to previous studies, one advantage of NEIO type of studies is to rely on prices and quantities rather than cost or profit markups which are difficult to obtain.

Appelbaum (1982) provides a non-parametric econometric framework for testing monopolistic behavior and measuring the degree of market power. He applies his framework to the U.S. rubber, textile, electrical machinery, and tobacco industries. He finds that the first two industries are characterized by competitive behavior and the last two industries are characterized by significant oligopolistic behavior.

Following Appelbaum (1982)'s approach, Schroeter (1988) and Azzam (1997) study the oligopoly power in the U.S. beef packing industry. Schroeter (1988) estimates the measurement of monopsony power and finds that there exists a small but significant price distortion in the slaughter cattle and wholesale beef markets in the U.S. Despite a current increasing market concentration trend, he finds no evidence against a less competitive market. Azzam (1997) accounts for the concentration explicitly. He separates the market power effect of concentration from its cost efficiency effect and measures their relative strength associated with higher concentration for the U.S. beef packing industry between the years 1970 and 1992. His findings support oligopsonistic market power and slaughter-cost efficiency in the industry and conclude that the cost efficiency effect outweighs the market power effect. The separation of the effects of market concentration is not only important for academic interests but is especially important for public policy.

Using an analog model to Azzam (1997), Lopez et al. (2002) study the impact of concentration in 32 U.S. food-processing industries. They find that in about one-third of food-processing industries, concentration increases cost efficiency, while in the rest, oligopolist power effects either dominate cost efficiency or reinforce inefficiency.

Similar to Lopez et al. (2002) many other studies also find statistically significant estimates of market power using input demand functions derived from profit maximization of firms such as Azzam and Schroeter Jr (1995), Schroeter (1988), Schroeter and Azzam (1990), and Bhuyan and Lopez (1997). However, some other NEIO studies do not find evidence for market power such as Azzam (1997), Schroeter et al. (2000), and Saitone et al. (2017). Despite the prevalence of high concentration in the industry, many NEIO studies found that there are only small departures from competitive pricing (Myers et al., 2010).

The above literature constructs structural model and detects if these industries are competitive or monopolistic based on the industries' ability to set market prices higher than their marginal cost. They use industry-level aggregated data such as input prices and output prices rather than individual firm prices. Relying on industry level data is one of the empirical advantages of NEIO, as firm level data is harder to find compared to industry level data.

3.2 Competition Level and Distribution of Rents in the GHTS

The market power of buyers of grain has been a concern for farmers since the early years. That is why the Canadian GHTS has been heavily regulated and transitioned to balance the market competition over the decades.

Brewin (2016) studies competition in the Canadian grain supply chain. He points out that in the empirical literature, departures from Bertrand's assumption are minimal in agricultural markets. Thus, it would be appropriate to use models with Bertrand's competition to model agricultural markets.

In the GHTS, the level of competition and regulations have an impact on the distribution of rents between the three main participants: farmers, grain handling companies, and railroad companies. Thus, the competition level and the distribution of the rents in GHTS have been a consistent subject of economic research (Brewin, 2016; Çakir and Nolan, 2015; Carter et al., 1998; Gray, 1995; Park and Koo, 2001; Schmitz et al., 1997; Serfas et al., 2018).

One strand of literature relies on a comparison between different GHTS to reveal the differences. Park and Koo (2001) and Serfas et al. (2018) compare the U.S. GHTS to the Canadian GHTS. Even though these two countries share a long border and similar growing conditions for wheat, they developed completely different systems over the years. The U.S. GHTS has been deregulated since the 1980s. On the other hand, the Canadian GHTS has been regulated by the CWB until the 2012 crop year. As a result, the U.S. GHTS experienced an earlier transition and rationalization which has brought substantial increases in volume and a decrease in railway freight rates in the U.S. GHTS (Park and Koo, 2001).

The differences in regulations in both countries affected the distribution of rent over the years. Serfas et al. (2018) analyze the distribution of rents between farmers, grain handling companies, and railways in the Post-CWB wheat market both in the U.S. and Canada. They note that the grain handling margins are significantly higher in Canada than in the United States. Park and Koo (2001) suggest that the smaller capacity of the grain elevators in Canada leads to higher grain handling costs as investments in capacity enhance the ability to market grain. Carter et al. (1998) attribute higher grain handling margins in Canada to the CWB's involvement in grain marketing and supplying excess marketing services to farmers. On the other hand, contrary to Carter et al. (1998), Serfas et al. (2018) find that the grain handling margins stay higher after the removal of the CWB in 2012.

In the Canadian GHTS, an average rail haul from inland to a terminal port position is about 1,500km and 95% of the grain at the terminal port is transported by rail (Quorum, 2015). The Canadian GHTS heavily relies on dependable rail service to compete in international markets. There is no close substitute for railway transportation in Canada, unlike any other grain exporting country. For example, in Australia's GHTS, half of the grain is transported to the port position by trucking as the distance to haul grain is between 100 to 400km (White et al., 2015). Also, in the US, railways compete with trucking companies and barge transportation as these are a substitute for rail freight (Park and Koo, 2001).

Çakir and Nolan (2015) examine the effect of market power in the Canadian grain transportation industry using a theoretical model. They find that the negative effects of market power are stronger when exercised by railways rather than grain companies. This result suggests the need for a railway regulation such as the maximum revenue entitlement (MRE). Furthermore, they note that if grain companies have market power, then these companies capture the rents of railways, not farmers.

Contrary to grain handling margins, Serfas et al. (2018) find that rail rates are significantly higher in the U.S. relative to Canada as the rail rates are regulated by MRE in Canada. MRE puts a limit on the average rail rate that can be charged by railways. Consistent with Çakir and Nolan (2015), they find that MRE regulation redistributes rents away from railways and toward grain companies and producers.

3.3 Grain Elevator Studies

The applied research on spatial price competition in local and regional agricultural markets is scarce except for a few outdated studies (Grashuis, 2019). Fortenbery et al. (1993) estimate the impact of grain elevator concentration on producer prices between 1980 and 1992, just after major railway deregulation that led to cost savings in 1980 in the U.S. GHTS. Fortenbery et al. (1993) state that these cost saving benefits do not appear to be shared by farmers in states with historically high elevator concentration rates.

Using corn cash price offers from Iowa grain merchants as an example, Grashuis (2019) examines spatial competition in the agricultural input procurement sector. He finds that rail and river access, size, and ethanol production have a positive impact on cash prices, on the other hand, the impact of ownership structure as corporate or cooperative is complex.

Bekkerman and Taylor (2020) provide the evidence that pass-through rate due to improved efficiency is higher in a more competitive market. Bekkerman and Taylor (2020) model the pass-through of cost savings behavior of grain elevators in the US. They use pooled cross-sectional local wheat prices of grain elevators in Montana and Kansas between 2004 and 2013. Their results indicate that the pass-through rate is higher in the more competitive grain market of Kansas relative to Montana. Furthermore, their results show that more local competition leads to pressure on grain elevators that do not have the cost saving technology to increase their cash prices.

Jiang et al. (2022) develop a model of exit decisions by Canadian grain elevators using the data between 1999 and 2016. They explain the exit decisions based on traditional variables, such as capacity, vintage, and multiple plant ownership as well as spatial and vertical linkages to industry variables to account for demand, supply, and competition levels. There exists a limited amount of research related to vertical connections in a firm's exit decision. The car loading capacity of an elevator is used as a measure of vertical linkage between grain elevators and railways. Their findings are consistent with prior literature and support the notion that exit decisions are affected by the size, vertical linkages, local supply, demand, and spatial competition. The measure of vertical linkages has a strong negative impact on exit decisions by elevators. Unlike the existing literature, they find mixed evidence that multiple plant ownership has a significant impact on decisions.

3.4 Farmland Prices in Canada

In 2021, farmland comprised 81.5% of the total value of farm capital in Saskatchewan and remains the major input in the production of agricultural products (Canada, 2021).

David Ricardo's formulation of an economic theory of rent in 1817 was a cornerstone in the basic model of land values (Nickerson and Zhang, 2014). His key insight was that land generates rent as it is limited in supply and differs in quality (Nickerson and Zhang, 2014). Under a competitive market, the price of farmland is expected to be a function of its future discounted values of profits. Thus, the capitalization model is flexible as it accounts for expected returns and opportunity cost of capital, and for the same reason, it has been used frequently in the literature.

In terms of studies examining Canadian farmland prices, there is a relative lack of literature. Deaton and Lawley (2022) provide a recent survey of literature examining farmland prices focusing on Canadian farmland and assessing key determinants of farmland prices. Overall, important factors such as agricultural zoning, government subsidies that influence farmland prices were identified as having varying effects. The capitalization model has been used widely in the literature. However, the model's ability to explain rapid appreciation and subsequent declines in farmland prices is limited during boom and bust periods[1] (Deaton and Lawley, 2022).

Veeman et al. (1993) implement a simple dynamic model to explain farmland prices in Canada. Based on their capitalization model simulation, they find that the removal of all net subsidies paid directly to farmers would reduce the short run farmland prices by 5% and long run farmland prices by 19%. Furthermore, the changes in farmland prices vary by region. Goodwin and Ortalo-Magné (1992) find a strong relationship between agricultural support policies in Canada and farmland values using data from 1979 to 1989. Clark et al. (1993) study the capitalization of subsidies into land values in Saskatchewan. They find that income by itself cannot provide evidence for secular growth in farmland prices. However, their results indicate that income plus subsidies are mildly cointegrated with farmland values. The evidence in these studies suggests that direct government payments to agriculture have had a significant impact on the value of Canadian farmland.

Painter (2000) analyses the investment performance of farmland in Saskatchewan. In terms of investment features, farmland offers negatively correlated returns with other equity markets. Thus, when added to a portfolio, the risk of the portfolio can be reduced while maintaining the same rate of return. He suggests that a Saskatchewan farmland mutual fund would alleviate the problems concerning farmland ownership such as low liquidity, poor marketability, and asset lumpiness.

Sheng et al. (2018) evaluate the benefits to farmland from access to transport infrastructure using a hedonic regression which is frequently used to examine the relationship between the price of farmland and unpriced characteristics. They use Australian farmland data between 2009 and 2011. Their results show that a one percent reduction in the cost of transportation between farms and ports leads to 0.33 percent increase in farmland prices. Furthermore, benefits generated by transport infrastructure vary between industries and farm sizes suggesting multiple channels through which public infrastructure influences production.

[1] During a land boom, people buy land because they expect a value increase rather than profiting through operations.

4 Data

In this study, we use two major data sets: grain elevator data from the Canadian Grain Commission and Saskatchewan farmland sales data from the Farmland Security Board. The grain elevator data includes capacity, location, and the type of elevator. The exact coordinates of the grain elevators are available after the year 2012. Before August 1, 2012, the railway station names provided by CGC are used as the approximate location of the grain elevators. We use only primary elevators[1] in this study.

The farmland sales data contains sales of quarter sections of Saskatchewan farmland between 1993 and 2020. A quarter section usually includes 160 acres of farmland. This data includes the property sales price as well as the number of acres, sales date, legal land description, soil classification, names of the seller and buyer, and code for sale type as arm's length or family transaction.

In this study, we include farmland sales with more than 10 acres, real prices (2019, CAD) less than $3000 per acre and more than $100 per acre, and sales with arm's length code to make sure all farmland sales included in the study represent the market value of the farmland devoted to farming. We omit farmland sales with real prices higher than $3000 per acre and less than 10 acres, as these farmland tend to be closer to urban areas. Therefore, it's less likely that these farmland are used strictly for agricultural production (Lawley, 2018)[2].

Furthermore, we omit the farmland sales if there is a suspicion that the sale does not reflect the market price of the farmland [3]. After the data cleaning, there are 230,384 farmland transactions between 1993 and 2020. After the year 2012, there are 61,805 transactions. In Figure 4.1, the average farmland real prices are shown.

The farmland sales and grain elevators data are matched based on the crop years. For each farmland transaction, the distances to all grain elevators for that crop year are calculated and ordered from closest to furthest grain elevators. Based on the models, the number of grain elevators and the total capacity of the grain elevators within specific radius distances are calculated. The capacity variables are divided by the

[1] The Canadian Grain Commission licenses three types of grain elevator. Primary elevators receive, blend, and store grain. In addition to providing the same services as primary elevators, process elevators also process grain. Terminal elevators are located at port positions. (Quorum, 2015).

[2] Lawley (2018) cites Brorsen et al. (2015) as they present the evidence that the "small parcel size premium puzzle" is related to the fact that small farmland likely to be closer to urban areas.

[3] For example, we omit the sales between the people with the same surname, the same company name and buyer/seller surname (ex: sales between "John Fink" and "Fink Corp."), and Hutterian colonies. Also, we removed any sales if the buyer/seller is the Majesty or a crown company.

average capacity of the grain elevator for ease of interpretation[4].

Variable	Description	Mean	St. Dev.
Price	Real price (2019) per acre	684.874	516.964
Acres	Acres in Quarter Section	158.634	3.228
D_i^1	Distance to the closest elevator	21.327	15.946
D_i^2	Distance to the second closest elevator	29.440	19.165
D_i^3	Distance to the third closest elevator	35.813	20.946
$D_i^{1\to2}$	Distance from first to second closest elevator	25.312	24.839
$D_i^{2\to3}$	Distance from second to third closest elevator	29.548	29.686
C_i^1	Capacity of the closest elevator	1.192631	1.470124
C_i^2	Capacity of second the closest elevator	1.388969	1.572858
N_i^{40km}	Total number of elevators within 40km of farmland	5.350	4.648
N_i^{80km}	Total number of elevators within 80km of farmland	20.475	15.226
C_i^{40km}	Total capacity of elevators within 40km of farmland	5.6976	5.6781
C_i^{80km}	Total capacity of elevators within 80km of farmland	22.0524	11.25332

Table 4.1: Summary statistics of selected variables.

[4]For all farmland sales between 1993 and 2020, the average capacity of an elevator within 40, 80, 160, 240km are 10,645, 10,793, 10,688 and 10,570 tonnes. We assume that the average capacity of an elevator is 10,000 tonnes and divide the capacity variables by 10,000.

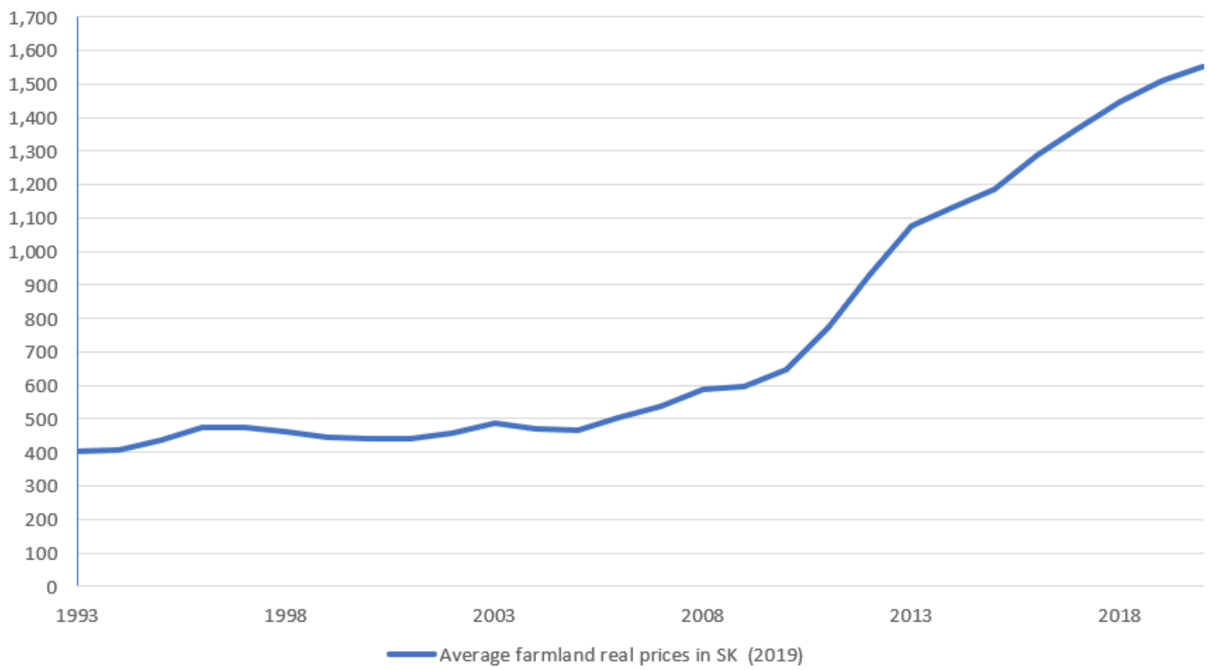

Figure 4.1: The average farmland real (2019, CAD) prices in Saskatchewan are shown.

5 Theoretical Model

In this chapter, we present a theoretical model of competition and derive our hypotheses. We use a Hotelling model to analyze the impact of grain elevator spatial competition on farmland prices.

5.1 Model

Let us assume a Hotelling model with two grain elevators located along a single line with endpoints 0 and α. The elevators are located at the endpoints. Farmers are distributed uniformly along with the market, produce one unit of crop, and sell the crop to the highest contract price adjusted for trucking cost to the chosen elevator. As all farmers receive the same contract price at the elevator position, it is assumed that grain elevators cannot price discriminate.

The marginal cost of grain handling and the capacity of the ith grain elevator are represented by $mc(z_i)$ and z_i, respectively. Based on the scale economics, it is assumed that as the capacity of the ith elevator increases, the marginal cost of grain handling decreases, $\frac{\partial mc(z_i)}{\partial z_i} < 0$. The elevators maximize their profit based on Equations 5.1 and 5.2,

$$\pi_1 = (p_{port} - p_1 - mc(z_1))Q_1 \tag{5.1}$$

$$\pi_2 = (p_{port} - p_2 - mc(z_2))Q_2. \tag{5.2}$$

The price at the port position is p_{port} and all elevators are price takers when selling. The contract price offered to the farmers, marginal cost of grain handling, and demand for the first grain elevator are represented by p_1, $mc(z_1)$, and Q_1, respectively.

Assume that the market is covered, such that all farmers receive a contract price higher than the expected cost of production. In this case, there would be an indifferent farmer between the first and the second elevator if the condition in Equation 5.3 holds,

$$P_1 - tx = P_2 - t(\alpha - x). \tag{5.3}$$

In Figure 5.1, a diagram of the Hotelling model is shown. The indifferent farmer in Equation 5.3 is shown on point x between these two grain elevators. Based on the Hotelling model, farmers located between [0,x)

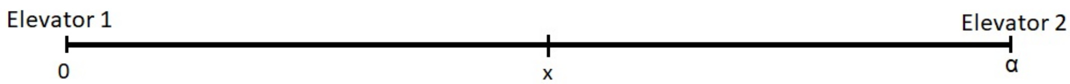

Figure 5.1: The diagram of the Hotelling model. The elevators are located at the endpoints.

deliver to the Elevator 1 and farmers located between $(x,\alpha]$ deliver to the Elevator 2.

The marginal cost of trucking is t. The position of the indifferent farmer is x and all farmers between these grain elevators are represented by α. If we isolate x in Equation 5.3, we get the quantity equation for the first elevator in Equation 5.4,

$$Q_1 = \frac{p_1 - p_2 + t\alpha}{2t}. \tag{5.4}$$

In Equation 5.5, the demand function from Equation 5.4 is plugged into the profit function in Equation 5.1,

$$\pi_1 = (p_{port} - p_1 - mc(z_1))\frac{p_1 - p_2 + t\alpha}{2t}. \tag{5.5}$$

Rearranging Equation 5.5,

$$\pi_1 = \frac{p_{port}p_1 - p_{port}p_2 + p_{port}t\alpha - p_1^2 + p_1p_2 - p_1t\alpha - mc(z_1)p_1 - mc(z_1)p_2 - mc(z_1)t\alpha}{2t}. \tag{5.6}$$

Take derivative with respect to p_1,

$$\frac{\partial\pi_1}{p_1} = \frac{p_{port} - 2p_1 + p_2 - t\alpha - mc(z_1)}{2t} = 0. \tag{5.7}$$

Rearrange to solve for p_1 yields,

$$p_1^* = \frac{p_{port} + p_2 - t\alpha - mc(z_1)}{2}. \tag{5.8}$$

By symmetry the optimum price for firm 2 is,

$$p_2^* = \frac{p_{port} + p_1 - t\alpha - mc(z_2)}{2}. \tag{5.9}$$

Rearranging Equation 5.8,

$$p_1 = \frac{p_{port} - t\alpha - mc(z_1)}{2} + \frac{p_2}{2}. \tag{5.10}$$

Plugging Equation 5.9 into Equation 5.10,

$$p_1 = \frac{p_{port} - t\alpha - mc(z_1)}{2} + \frac{p_{port} + p_1 - t\alpha - mc(z_2)}{4}. \tag{5.11}$$

Solve for p_1,

$$p_1 = p_{port} - t\alpha - \frac{2}{3}mc(z_1) - \frac{1}{3}mc(z_2). \tag{5.12}$$

Farmers maximize profit function in Equation 5.13,

$$\Pi = max([p_1 - tx] - c^f, [p_2 - t(\alpha - x)] - c^f). \tag{5.13}$$

A farmer will produce one unit of output, y, and sell to a grain elevator that maximizes the contract price adjusted for trucking cost. The closest grain elevator's contract price and the second closest grain elevator's contract price for one unit of grain production are represented by p_1 and p_2, respectively. The cost of production of farmer is represented by c^f.

Land price is the discounted sum of future profits of the farmer from this particular land as it is assumed that farmland are only used for agricultural production. The discount rate in the market is represented by δ. Equation 5.14 shows the farmland price as the summation of the discounted profits of the farmer,

$$L = \sum_{t=1}^{\infty} \frac{\prod_t}{(1+\delta)^t}. \tag{5.14}$$

5.2 Hypothesis

H1: *As the distance to the closest grain elevator increases, farmland prices will decrease.*

The distance to the closest grain elevator (D_i^1) represents the minimum distance that a farmer has to haul his grain for delivery. As the distance to the closest grain elevator increases by k km, this farmland's minimum cost of transportation in a crop year increases by k times the marginal cost of trucking per km.

It may be expected that an increase in transportation costs will reduce the farmland price as much as the discounted sum of future transportation costs will increase. Even if we assume that farmers do not always sell to the closest grain elevator, still, one might expect the coefficient of the D_i^1 variable to be negatively related to farmland prices as it is correlated with the minimum cost of trucking.

In the Hotelling model, farmers always choose the closest grain elevator given that there are two identical grain elevators offering the same contract price. In reality, farmers are more likely to choose the closest grain elevator more frequently than any other distant grain elevator because the closest grain elevator has a price advantage as much as the difference in cost of transportation to the distant grain elevator.

From Equation 5.13, we have Equation 5.15,

$$\frac{\partial \Pi}{\partial x} = -t. \tag{5.15}$$

The derivative of land price with respect to the closest grain elevator is,

$$\frac{\partial L}{\partial x} = \sum \frac{1}{(1+\delta^t)} \frac{\partial \Pi}{\partial x} = \sum \frac{1}{(1+\delta^t)}(-t)y < 0. \tag{5.16}$$

H2: ***As the market power of grain elevators increases, farmland prices will decrease***

The market power variables are calculated for each farmland transaction in the data set. Based on the Hotelling model, as the distance between the elevators increases (market power increases), farmland prices will decrease. Keeping the distance to the closest grain elevator constant, as the distance between the grain elevators increases, the market power of the closest grain elevator increases. This increases the likelihood of exercising market power by the closest grain elevator. Thus, reduces the contract prices received by farmers. In the Hotelling model, the distance between the 1st and the 2nd elevator is α. From Equation 5.12, we have Equation 5.17,

$$\frac{\partial p_1}{\partial \alpha} = -t. \tag{5.17}$$

The derivative of land price with respect to the distance between the elevators is,

$$\frac{\partial L}{\partial \alpha} = \sum \frac{1}{(1+\delta^t)} \frac{\partial \Pi}{\partial \alpha} = \sum \frac{1}{(1+\delta^t)} \frac{\partial p_1}{\partial \alpha} y = \sum \frac{1}{(1+\delta^t)}(-t)y < 0. \tag{5.18}$$

As the distance between the elevators increases, market power increases. In this case, a farmer who delivers to the first elevator will realize a farmland price decrease of as much as the discounted sum of the marginal cost of trucking.

H3: *As the efficiency of grain elevators increases, farmland prices will increase*

An elevator's efficiency is highly dependent on its size and age (Hucq, 1998).[1] It is assumed that as the capacity of an elevator increases, the marginal cost of grain handling decreases, and the grain elevator becomes more efficient due to economies of scale ($\frac{\partial mc(z_i)}{\partial z_i} < 0$). Based on the Hotelling model, as grain elevators become more efficient, they reflect the cost efficiency on their contract prices.

There are certain advantages of high capacity grain elevators. A high capacity grain elevator can get discounted rail rates for shipping larger grain volumes at a single time, segregate and blend grain more efficiently and handle surges in supply. One might expect that cost savings through increased capacity can be passed on to farmers and ultimately, increase farmland prices. The capacities of the closest and second closest grain elevators are z_1 and z_2, respectively. From Equation 5.12, we have Equation 5.19 and 5.20,

$$\frac{\partial p_1}{\partial z_1} = -\frac{2}{3} mc'(z_1) \tag{5.19}$$

$$\frac{\partial p_1}{\partial z_2} = -\frac{1}{3} mc'(z_2). \tag{5.20}$$

In Equation 5.21, the price impact of the increased efficiency of the closest grain elevator is shown,

$$\frac{\partial L}{\partial z_1} = \sum \frac{1}{(1+\delta^t)} \frac{\partial \Pi}{\partial z_1} = \sum \frac{1}{(1+\delta^t)} \frac{\partial p_1}{\partial z_1} y = \sum \frac{1}{(1+\delta^t)} \frac{-2}{3} mc'(z_1) y > 0. \tag{5.21}$$

The price impact of the increased efficiency of the second closest grain elevator is,

$$\frac{\partial L}{\partial z_2} = \sum \frac{1}{(1+\delta^t)} \frac{\partial \Pi}{\partial z_2} = \sum \frac{1}{(1+\delta^t)} \frac{\partial p_1}{\partial z_2} y = \sum \frac{1}{(1+\delta^t)} \frac{-1}{3} mc'(z_2) y > 0. \tag{5.22}$$

The overall change is expected to be positive as $\frac{\partial mc(z_1)}{\partial z_1} < 0$ and $\frac{\partial mc(z_2)}{\partial z_2} < 0$.

[1] Hucq (1998) presents a theoretical cost structure of an elevator. The smaller elevator has a lower fixed cost but the variable cost of operation is higher compared to a larger elevator. Thus, larger capacity grain elevators are more efficient than the smaller capacity grain elevators given that the elevators operate at high throughput levels.

6 Empirical Models

We model the effect of spatial market concentration of grain elevators on farmland prices in Saskatchewan. Specifically, we use two different models to capture the variation in per acre farmland prices for market concentration and capacity variables.

The first model is a *radius* model which is used for the years between 1993 and 2020. For the *radius* model, we created circles for each farmland sale with varying radiuses and measure the number of grain elevators within these circles to compute the market power variables and the total capacity of grain elevators for capacity variables. For the *radius* model, we measure market power as the total number of grain elevators within a circle around the farmland. The reason behind this approach is the lower accuracy of the elevator locations before 2012. The Canadian Grain Commission provides only approximate locations before 2012. By using radius measures, we avoid using direct distances of individual grain elevators.

After the removal of the single desk selling powers of the CWB in 2012, the market structure has evolved. This had an impact on all market participants as producers must manage all of their marketing relationships with grain elevators which are in full control of the marketing of grains (Quorum, 2015). Thus, we use CWB dummy variables for the radius models.

The second model is a *distance* model which is used for the years between 2012 and 2020. For this model, we use the distances between grain elevators as market power variables and the capacity of individual elevators as capacity variables. We use the exact locations of grain elevators as we have the exact coordinates of all the grain elevators between the years 2012 and 2020.

6.1 Fixed Effects

We use fixed effects to account for unobserved time-invariant effects that might be correlated with the independent variables. For example, the number of grain elevators within an area can be correlated with proximity to a large city. Using fixed effects accounts for this correlated omitted variable even though we do not include the omitted variable in the regression. The underlying assumption is that unobservable factors that affect both the right hand and left hand sides of the regression are time invariant. These time invariant qualities do not change across time and assumed to have the same impact across time such as proximity to an urban area or proximity to urban areas. Since these fixed effects are not observable most of the time, they cannot be controlled directly. Using fixed effects eliminates these unobservable time-invariant effects by demeaning the variables.

There is no certain way of determining the level of fixed effects. However, there is a tradeoff between bias and variance: the researcher forgoes explaining between-unit differences in outcomes in favor of (hopefully) bias-free estimates of within-unit treatment effects (Mummolo and Peterson, 2018). For instance, unit fixed effects in panel data discard all variation between units (Mummolo and Peterson, 2018). Furthermore, there are not sufficient annual farmland sales for each quarter section in farmland sales data. Therefore, we did not use quarter section fixed effects. We use section level and crop year fixed effects assuming that group variation within section is enough to capture the price impact of market power and capacity variables.

6.2 Radius Model

The first model is the *radius* model which depends on variables that are created based on specific radiuses in Equation 6.1 and 6.2,

$$Ln(P_{i,t}) = \beta_1 \ D^1_{i,t} + \beta_2 \ C^{80km}_{i,t} + \beta_3 \ N^{80km}_{i,t} \ + \ \gamma_t \ + \delta_i \ + \ X_i + \ \epsilon_{i,t} \tag{6.1}$$

$$\begin{aligned} Ln(P_{i,t}) = \beta_1 \ D^1_{i,t} + \beta_2 \ C^{40km}_{i,t} + \beta_3 \ N^{40km}_{i,t} \ + \beta_4 \ C^{40km \to 80km}_{i,t} \ + \beta_5 \ N^{40km \to 80km}_{i,t} \\ + \beta_6 \ C^{80km \to 120km}_{i,t} \ + \beta_7 \ N^{80km \to 120km}_{i,t} \ + \ \gamma_t \ + \delta_i \ + \ X_i \ + \ \epsilon_{i,t}. \end{aligned} \tag{6.2}$$

where:

$Ln(P_{i,t})$	= real logarithmic farmland price
$D^1_{i,t}$	= distance to the closest grain elevator
$C^{\#km}_{i,t}$	= total capacity of grain elevators within # km of farmland
$N^{\#km}_{i,t}$	= number of grain elevators within # km of farmland
$C^{\#km \to \#' km}_{i,t}$	= total capacity of grain elevators from # km to up to #′ km from the farmland
$N^{\#km \to \#' km}_{i,t}$	= number of grain elevators from # km to up to #′ km from the farmland
γ_t	= crop year fixed effect
δ_i	= section level fixed effect
X_i	= soil type control
$\epsilon_{i,t}$	= error term

The logarithmic per acre farmland real price is $Ln(P_{i,t})$, the section and crop year fixed effects are represented by δ_i and γ_t, respectively. The control variables such as soil type are represented by X_i. We divide the capacity variables by the average capacity of a grain elevator for ease of interpretation. Thus, the capacity variables such as $C_{i,t}^{40km}, C_{i,t}^{80km}, C_{i,t}^{40km \rightarrow 80km}, C_{i,t}^{80km \rightarrow 120km}$ represents the change in the price of farmland if we increase the capacity variable by 10,000 tonnes.

We use the number of grain elevators within a specified radius as the market power variable. As the number of grain elevators increases within a specific radius, the average distance between the grain elevators decreases, and the local market power decreases as the degree of elevator competition increases.

For the capacity variable, we use the total capacity of the grain elevators within a specified radius. As the total capacity of the grain elevators increases within a specific radius, one should expect the efficiency of local grain elevators increases. The capacity variable is positively related to the total capacity of grain elevators within a specified radius.

The distance to the closest grain elevator variable in km is $D_{i,t}^{1}$. Based on the first hypothesis (H1), β_1 is expected to be negative. The total capacity of grain elevators within 80km of the farmland is $C_{i,t}^{80km}$ and it represents the capacity variable. As the total capacity of the grain elevators increases within a radius, the average capacities of the individual grain elevators increase. Thus, based on hypothesis three (H3), we expect that β_2 is positively related to farmland prices. The total number of grain elevators within 80km of the farmland is $N_{i,t}^{80km}$. This variable represents the market power variable and as the number of grain elevators increases within a specified radius, the average market share of grain elevators decreases. Thus, the market power decreases. We expect the coefficient of β_3 to be positive based on hypothesis two (H2).

We use two specification of the radius model. The first specification uses a single radius which captures the grain elevators within 80km of the farmland in Equation 6.1. The second specification in Equation 6.2 uses three interwoven circles with varying radiuses. The first market power and capacity variables are based on the 40km circle. The second market power and capacity variables are based on the area (annulus) difference between 80km radius circle and 40km radius circle. Similarly, the third market power and capacity variables are based on the area (annulus) difference between 120km radius circle and 80km radius circle.

We kept the range of the radiuses within a farmer's possible grain hauling range [1]. For both radius model specifications, we had consistent results with different radius lengths. We determined the length of the radiuses comparing the model fit. The absolute value of the magnitude of coefficients usually decreases as the length of the radius increases. For the second radius model specification with three different radiuses, the absolute value of the magnitude of the coefficients usually gets smaller as we move from the center circle to the outer circle.

[1] In Figure 1.2, the average distances to the closest grain elevators are shown. An average farmer has access to three different grain elevators within 50km of his farmland. We assumed that a farmer would prefer a grain elevator up to 120km from his farmland. Thus, we include radiuses up to 120km.

6.3 Distance Model

The second model is the *distance* model which depends on accurate distances between the grain elevators and farmland in Equation 6.3,

$$Ln(P_{i,t}) = \beta_1 \ D^1_{i,t} \ + \beta_2 \ C^1_{i,t} \ + \beta_3 \ C^2_{i,t} \ + \beta_4 \ D^{1\to 2}_{i,t} + \gamma_t \ + \delta_i \ + \ X_i \ + \ \epsilon_{i,t} \tag{6.3}$$

where:

$Ln(P_{i,t})$ = real logarithmic farmland price
$D^1_{i,t}$ = distance to the closest grain elevator
$C^1_{i,t}$ = capacity of the closest grain elevator from the farmland
$C^2_{i,t}$ = capacity of the second closest grain elevator from the farmland
$D^{1\to 2}_{i,t}$ = distance from closest to the second closest grain elevator
γ_t = crop year fixed effect
δ_i = section level fixed effect
X_i = soil type control
$\epsilon_{i,t}$ = error term

For the market power variable, we use the distance between the closest and the second closest grain elevator to farmland. Market power is positively related to this variable. Based on the Hotelling model, market power is at the lowest level for two grain elevators when they are located side by side. Furthermore, if these elevators are identical, the model predicts that these grain elevators share the market between them. Market power is at its highest when the second closest grain elevator is far enough that its contracts cannot alter the pricing of the closest grain elevator. In this case, the closest grain elevator is a monopsonist.

For the capacity variable, we use the individual capacities of the grain elevators such as the capacity of the closest grain elevator and the capacity of the second closest grain elevator. The capacity variable is positively related to the capacity.

The logarithmic per acre farmland real price is $Ln(P_{i,t})$, the section and crop year fixed effects are represented by δ_i and γ_t, respectively. The control variable for soil type is represented by X_i. The distance to the closest grain elevator variable in km is $D^1_{i,t}$. Based on the first hypothesis (H1), β_1 is expected to be negative. The individual capacities of the closest and second closest grain elevators to farmland are $C^1_{i,t}$ and $C^2_{i,t}$. Based on hypothesis three (H3), we expect that β_2 and β_3 are positively related to farmland prices. The distance from the closest to the second closest grain elevator is $D^{1\to 2}_{i,t}$ and represents the market power variable. We expect the coefficient of β_4 to be negatively related to farmland prices.

7 Results

Table 7.1 and Table 7.2 present the results from the radius models and Table 7.3 presents the result from the distance model.

7.1 Radius Model

Table 7.1 and Table 7.2 present the results of two specifications of the radius models. These two specifications differ in the variables and their sensitivity. Table 7.1 shows the first radius model specification which uses a single 80km radius to derive the efficiency and market power variables. Table 7.2 shows the second model specification which uses three interwoven circles with different radiuses to derive the efficiency and market power variables.

7.1.1 Radius Model - 80km

Table 7.1 presents the results of the first radius model which uses an 80km radius. We use CWB dummy variables. CWB dummy takes the value 0 if the farmland transaction occurred after the removal of CWB on August 1st, 2012, otherwise it is set to 1.

In Table 7.1 Post-CWB period, D_i^1 variable is -0.0005, negative and significant at 0.01 level. The market power variable, N_i^{80km}, is 0.0128 and significant at 0.01 level. The market power variable predicts that if a grain elevator enters the market within 80km of the farmland, then a 1.28% increase in farmland values is expected. The capacity variable, C_i^{80km}, is -0.0051. This suggests that if the total capacity within 80km of the farmland increases by one average capacity of an elevator, then a 5.1% decrease in farmland prices is expected. If a new grain elevator with a capacity greater than 25,098 tonnes enters the market within 80km of the farmland, the farmland price will decrease.

In Table 7.1 CWB period, D_i^1 variable is 0.0005, positive and significant at 0.01 level. The market power variable, N_i^{80km}, is -0.000005, negative and it is not significant. The capacity variable, C_i^{80km}, is -0.0005 and it is not significant.

The radius model with 80 km specification explains 84% of the overall and 0.27% of the within section price variation in farmland between the years 1993 and 2020.

Table 7.1: Estimates of the radius model - 80km

Dependent Variable:	$Ln(P_{i,t})$
Model:	(Radius model - 80km)
Variables	
CWB	
D_i^1	0.0005^{***}
	(0.0001)
N_i^{80km}	-0.000005
	(0.0003)
C_i^{80km}	-0.0005
	(0.0005)
Post-CWB	
D_i^1	-0.0005^{***}
	(0.0001)
N_i^{80km}	0.0128^{***}
	(0.0008)
C_i^{80km}	-0.0051^{***}
	(0.0003)
Fixed-effects	
soil	Yes
section	Yes
year	Yes
Fit statistics	
Observations	241,464
R^2	0.83851
Within R^2	0.00269

IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

7.1.2 Radius Model -40-80-120km

Table 7.2 shows the second model specification which uses three interwoven circles with different radiuses to derive the efficiency and market power variables. The first radius is 40km in length, the second radius is from 40km to 80km, which is based on the difference between the area of circles with 40km and 80km, and the last radius is from 80km to 120km, which is based on the differences between the area of circles. We use CWB dummy variables to differentiate the two distinct periods.

In Table 7.2 Post-CWB period, D_i^1 variable is -0.0003, negative and significant at 0.05 level. The first market power variable, N_i^{40km}, is 0.0194 and significant at 0.01 level. The first market power variable predicts that if a grain elevator enters the market within 40km of the farmland, then a 1.94% increase in farmland values is expected. The second market power variable, $N_i^{40km \to 80km}$, is 0.0103 and significant at 0.01 level. The second market power variable predicts that if a grain elevator enters the market within 40-80km of the farmland, then a 1.03% increase in farmland values is expected. The third market power variable, $N_i^{80km \to 120km}$, is 0.005. and significant at 0.01 level. The third market power variable predicts that if a grain elevator enters the market within 80-120km of the farmland, then a 0.5% increase in farmland values is expected. All the market power variables are jointly significant at 0.05 level.

The first capacity variable, C_i^{40km}, is -0.0078 and significant at 0.01 level. This suggests that if the total capacity within 40km of the farmland increases by one average capacity of an elevator, then a 0.78% decrease in farmland prices is expected. The second capacity variable, $C_i^{40km \to 80km}$, is -0.0049 and significant at 0.01 level. This suggests that if the total capacity within 40-80km of the farmland increases by one average capacity of an elevator, then a 0.49% decrease in farmland prices is expected. The third capacity variable, $C_i^{80km \to 120km}$, is -0.0033 and significant at 0.01 level. This suggests that if the total capacity within 80-120km of the farmland increases by one average capacity of an elevator, then a 0.33% decrease in farmland prices is expected. All the capacity variables are jointly significant at 0.05 level. In Table 7.2 Post-CWB period, If a new grain elevator with a capacity greater than 24,864, 21,004, and 15,115 tonnes enters the market within 0 to 40km, 40 to 80km and 80 to 120km of the farmland, the farmland price will decrease.

In Table 7.2 CWB period, D_i^1 variable is 0.0004, positive and significant at 0.01 level. The first market power variable, N_i^{40km}, is -0.0015 and significant at 0.05 level. The first market power variable predicts that if a grain elevator enters the market within 40km of the farmland, then a 0.15% decrease in farmland values is expected. The second market power variable, $N_i^{40km \to 80km}$, is -0.00046 and significant at 0.01 level. The second market power variable predicts that if a grain elevator enters the market within 40-80km of the farmland, then a 0.046% decrease in farmland values is expected. The third market power variable, $N_i^{80km \to 120km}$, is 0.0019 and significant at 0.01 level. The third market power variable predicts that if a grain elevator enters the market within 80-120km of the farmland, then a 0.19% increase in farmland values is expected. All the market power variables are jointly significant at 0.05 level.

The first capacity variable, C_i^{40km}, is -0.000003 and it is not significant. This suggests that if the total capacity within 40km of the farmland increases by one average capacity of an elevator, then a 0.0003% decrease in farmland prices is expected. The second capacity variable, $C_i^{40km \rightarrow 80km}$, is -0.0014 and significant at 0.01 level. This suggests that if the total capacity within 40-80km of the farmland increases by one average capacity of an elevator, then a 0.14% decrease in farmland prices is expected. The third capacity variable, $C_i^{80km \rightarrow 120km}$, is -0.0029 and significant at 0.01 level. This suggests that if the total capacity within 80-120km of the farmland increases by one average capacity of an elevator, then a 0.29% decrease in farmland prices is expected. All the capacity variables are jointly significant at 0.05 level. In Table 7.2 CWB period, If a new grain elevator with a capacity greater than 6,341 tonnes enters the market within 80 to 120km of the farmland, the farmland price will decrease.

The radius model with 40-80-120 km specification explains 84% of the overall and 0.4% of the within section price variation in farmland between the years 1993 and 2020.

Table 7.2: Estimates of the radius model - 40-80-120km

Dependent Variable:	$Ln(P_{i,t})$
Model:	(Radius model - 40-80-120km)
Variables	
CWB	
D_i^1	0.0004**
	(0.0001)
N_i^{40km}	-0.0015*
	(0.0007)
C_i^{40km}	-0.000003
	(0.0006)
$N_i^{40km \to 80km}$	-0.00046
	(0.0004)
$C_i^{40km \to 80km}$	-0.0014***
	(0.0004)
$N_i^{80km \to 120km}$	0.0019***
	(0.0002)
$C_i^{80km \to 120km}$	-0.0029***
	(0.0003)
Post-CWB	
D_i^1	-0.0003*
	(0.0002)
N_i^{40km}	0.0194***
	(0.0018)
C_i^{40km}	-0.0078***
	(0.0006)
$N_i^{40km \to 80km}$	0.0103***
	(0.0010)
$C_i^{40km \to 80km}$	-0.0049***
	(0.0004)
$N_i^{80km \to 120km}$	0.0050***
	(0.0007)
$C_i^{80km \to 120km}$	-0.0033 ***
	(0.0003)
Fixed-effects	
year	Yes
section	Yes
soil	Yes
Fit statistics	
Observations	241,464
R^2	0.83872
Within R^2	0.00398

IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

7.2 Distance Model

Table 7.3 presents the results of the distance-based model. Based on the accurate distances between the farmland and the grain elevators, this model does not require the selection of radiuses before estimation. This model relates the market power and efficiency of the closest and second closest grain elevators to farmland using data after 2012.

In Table 7.3, D_i^1 variable is positive and insignificant. The market power variable, $D_i^{1\to 2}$, is -0.0005 and significant at 0.01 level. The market power variable predict that if the distance between the closest and second closest grain elevators increases by one km, then we expect a 0.05% farmland price decrease.

The capacity variables, C_i^1 and C_i^2, are at -0.0079 and -0.0117, respectively. This suggests that if the capacity of the closest grain elevator increases by one average capacity of an elevator, then we expect a 0.79 % farmland price decrease. Lastly, if the capacity of the second closest grain elevator increases by one average capacity of an elevator, then we expect a 1.17% farmland price decrease.

The distance model explains 88% of the overall and 0.162% of the within section price variation in farmland between the years 2012 and 2020.

Table 7.3: Estimates of the distance model

Dependent Variable:	$Ln(P_{i,t})$
Model:	(Distance model)
Variables	
D_i^1	0.0003
	(0.0004)
C_i^1	-0.0079***
	(0.0023)
C_i^2	-0.0117***
	(0.001769)
$D_i^{1\to 2}$	-0.0005**
	(0.0002)
Fixed-effects	
year	Yes
section	Yes
soil	Yes
Fit statistics	
Observations	69,190
R^2	0.88489
Within R^2	0.00162

IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

7.3 Empirical Results for Testing Hypotheses

7.3.1 Empirical Results for Testing Hypothesis 1 : Distance to the closest elevator

The distance to the closest elevator hypothesis (H1) suggests that there is a negative relationship between the distance to the closest grain elevator and farmland price. This hypothesis is rejected for all periods.

All the models and their specifications suggest that the distance to the closest grain elevator is not negatively and significantly related to farmland prices except the radius models in the Post-CWB period. Even though this coefficient is significant at 0.05 level, the result from the distance model does not confirm the negative relationship.

7.3.2 Empirical Results for Testing Hypothesis 2 : Market power variable

The market power hypothesis (H2) states that there is a negative relationship between local market power measures and farmland prices. This hypothesis is rejected for the CWB period. In the Post-CWB period, local market power measures can significantly predict the farmland prices for both distance and radius models.

For the Post-CWB period, the radius model with 80km specification suggests a negative relationship with the market power and estimates 1.28% price increase in case of a new grain elevator entry within 80km of farmland. The second radius model with 40-80-120km specification estimates 1.94%, 1.03, and 0.5% price changes in case of a new grain elevator enters the market within 40km, 40 to 80km, and 80 to 120km of the farmland, respectively.

For the CWB period, the radius model with 80km specification estimates a negative but insignificant relationship with the market power variable. The second radius model with 40-80-120km specification estimates a significant and negative relationship with the market power variable within 40km and 40 to 80km of farmland. The magnitudes of the coefficients are small. This model estimates 0.15% and 0.046% price decrease if a grain elevator enters the market within 40km and 40 to 80km of farmland, respectively. However, the model estimates a 0.19% price increase if there is an entry within 80 to 120km of farmland.

7.3.3 Empirical Results for Testing Hypothesis 3 : Capacity variable

The capacity hypothesis (H3) suggests that there is a positive relationship between the local grain elevator capacity and the farmland price. The efficiency hypothesis is consistently rejected by all models. This is the most surprising and important result as the signs of the coefficients are unexpected for all the models and their specifications. The negative relationship is significant for all models except the radius model with

80km specification in the CWB period.

For the Post-CWB period, the first radius model with 80km specification estimates -0.0051. The second radius model with 40-80-120km specification estimates -0.0078, -0.0049, and -0.0033 for 40km, 40 to 80km, and 80 to 120km radiuses, respectively. The absolute value of the magnitude of the coefficients decreases as the distance to farmland increases. This suggests that the negative impact of additional capacity decreases as the radius length increases. The distance model predicts a negative relationship between the capacity of the first and second closest grain elevators. The coefficient of the capacity of the closest grain elevator is -0.0079 and the coefficient of the second closest grain elevator is -0.0117. The magnitude of the coefficients suggests that the negative impact of increased capacity is higher when the second closest elevator increases its capacity rather than the closest grain elevator.

For the CWB period, the first radius model with 80km specification estimates the capacity variable as -0.0005. However, the coefficient is not significant. The second radius model estimates -0.000003, -0.0014, and -0.0029 for 40km, 40 to 80km, and 80 to 120km radiuses, respectively. The absolute value of the magnitude of the coefficients are increasing as the distance to farmland increases.

8 Discussion and Conclusion

8.1 Thesis Summary

The thesis' findings explain the Saskatchewan farmland prices through market power and capacity variables over the years 1993 and 2020. The results of the thesis can be summarized as: first, the market power of grain elevators has a negative price impact on nearby farmland prices in the Post-CWB period. Second, the capacity variable has a negative price impact on nearby farmland prices. This negative price impact is greater in magnitude in the Post-CWB period.

8.2 Discussion and Conclusion

The market power of grain elevators seems to have a negative price impact on nearby farmland after the dismantling of the CWB. The negative price impact of increased market power of grain elevators is consistent with the Hotelling model and the economics theory. Before the dismantling of the CWB, market power does not seem to be a problem. Furthermore, there is some evidence that the market power is positively affecting the farmland prices. The difference between these periods is likely to be caused by the structural change in the GHTS as the CWB was dismantled in 2012.

The additional capacity of grain elevators is likely to have a negative price impact on nearby farmland. The Hotelling model expects a positive relationship between additional grain elevator capacity and farmland prices as the additional capacity decreases the marginal cost of grain handling. One possible explanation for the negative capacity impact is the market power of larger capacity grain elevators. Larger grain elevators can make positive profits by charging farmers above marginal cost prices. In addition, they can punish the smaller grain elevators in case the smaller elevators compete with the larger grain elevators. Thus, in case of a large grain elevator entry to a local grain market, contract prices received by farmers drop as the larger grain elevator offers lower contract prices and pushes other grain elevators out of the market.

8.3 Policy Implications

According to the results of this thesis, farmers can benefit from policies that regulate the market power of grain elevators and prevent them from exercising their power. There are two types of policy that can be applied. The first approach is to increase competition between grain elevators by directly targeting average market power measures. As part of these policies, new grain elevators may be encouraged with financial incentives such as government subsidies, and/or careful consideration of grain elevator mergers by the Competition Bureau[1] to prevent mergers that will substantially increase individual grain elevator market share.

Second, policies that aim to reduce the negative consequences of market power measures without directly impacting them. These policies may include price regulations that prevents the grain elevators to exercise their market power. Currently, the Canadian Grain Commission requires all licensed grain companies to file a schedule of charges. However, it does not set or approve any changes. Elevator charge summaries can be modified in a restrictive manner to prevent the grain elevators exercise their market power. For example, the Canadian Grain Commission may prevent grain elevators from making changes to charges throughout the crop year to take advantage of the congestion of the GHTS or may require grain elevators to equally charge any farmer delivery to prevent grain elevators from price discriminating farmers.

Another policy option is price pooling. The objective of price pooling is to average the market value of a crop over a course of time and a location. Thus, price pooling spreads the price risk of a farmer. In the CWB period, the market power of the grain elevators seem not to be a problem for farmers. One possible explanation is the price pooling mechanism under the CWB that ensures all farmers receive the same price for their grain. A form of price pooling mechanism can mitigate market power issues. As a policy, the government can assist and encourage farmer cooperatives to market grain under a cooperative price pooling plan. Price regulations can prevent large grain elevators from exercising their market power however, implementing these policies can have unintentional and unpredictable impacts in the market as price regulations can have extremely complex results.

Farmers can also benefit from the smaller capacity of grain elevators. Policies that lowers the additional and/or the average capacity of grain elevators would increase the farmland prices. For example, in the Post-CWB period, policies leading to introduction of approximately 25,000 tonnes or less capacity grain elevators can increase the farmland prices upto 80km, and introduction of 15,000 tonnes or less capacity grain elevators can increase the farmland prices upto 120km. Thus, the government can give financial incentives for the construction of small capacity grain elevators and/or incentives for de-mergers of large grain elevators to

[1]Under the Competition Act, the Competition Bureau has a mandate to review mergers to determine whether the merger is likely to cause prevention of competition.

create separate grain elevators. Furthermore, the privatization of the CWB and introduction of high throughput G3 grain elevators might have a negative price impact on Saskatchewan farmland prices as this policy introduced high capacity grain elevators with high local market shares and increased the additional capacity of the GHTS.

8.4 Limitations of Research and Further Research

The impact of additional grain elevator capacity, as shown in the models, reduces farmland prices. Under the current model, the explanation for the negative impact of additional grain elevator capacity is not clear. For future research, the model can be updated for its limitations to explain the negative impact of capacity. This would be a challenging endeavor as the model's complexity increases.

In this study, we did not account for the farmer concentration and the monopsony power of large farmers against the smaller and inefficient farmers. We assume identical farmers produce a unit of output and grain elevators do not price discriminate based on the quantity of grain supplied by a farmer. Thus, all the farmers receive the same contract price independent from its quantity of production. This assumption ensures that the farmland sales data represent all the farmers in Saskatchewan.

The assumption of no price discrimination by grain elevators based on the quantity of grain supplied might be violated in the real world. This violation might result in consistently higher contract prices for large farmers. As large farmers receive higher contract prices and make positive profits, they value farmland higher than small farmers. Thus, they do not sell but only buy farmland. As a result, farmland prices may not reflect the sum of the discounted future returns of an average farmer but rather reflect the valuation of a small farmer. For future research, the assumptions of no price discrimination by grain elevators and no farmer concentration can be relaxed.

Another limitation of the study is the different throughput of grain elevators did not account for. We use the capacity of a grain elevator as the sole representative of the efficiency of the grain elevator as throughput of the grain elevators is unknown. In the real world, some grain elevators can achieve higher throughput rates during a crop year. Thus, they can utilize their capacity more than other grain elevators. For future research, the capacity variable can be updated to represent the efficiency of the grain elevators better. For example, car loading capacity of a grain elevators can be included with the throughput levels of grain elevators.

Appendix A

Farmland Prices in Canada

Every five years, Statistics Canada collects information about the price of farmland and buildings for the Census of Agriculture. Furthermore, based on assessment information provided by Farm Credit Canada (FCC), Statistics Canada updates annual values between these years. Figure A.1 provides the average farmland prices (Deaton and Lawley, 2022)

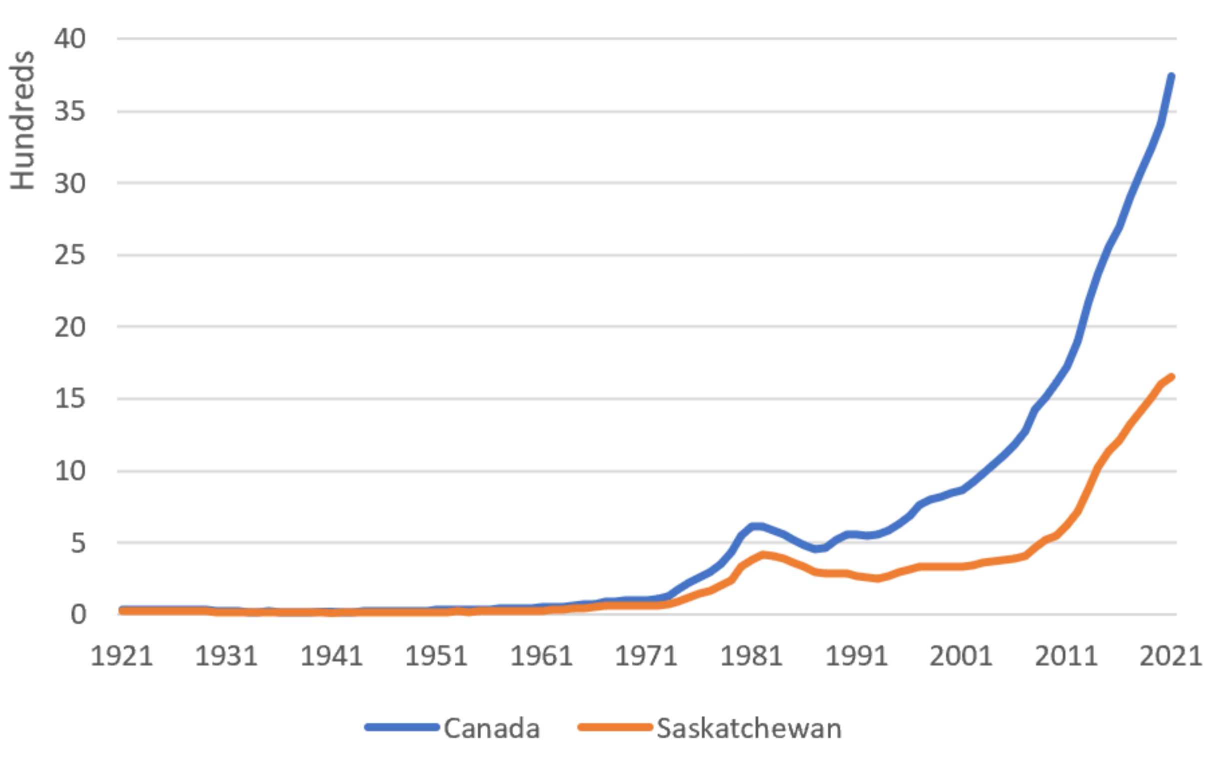

Figure A.1: The average prices of farmland in Canada and Saskatchewan are shown between the years 1921-2021.

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