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RELATIONSHIP OF GRAIN STOCKS AND FARMER MARKETINGS

BY

TYLER HOLMQUIST

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Economics

South Dakota State University

2016

RELATIONSHIP OF GRAIN STOCKS AND FARMER MARKETINGS

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science in Economics degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidates are necessarily the conclusions of the major department.

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ABSTRACT

RELATIONSHIP OF GRAIN STOCKS AND FARMER MARKETINGS

TYLER HOLMQUIST

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This research explores the relationship between quarterly grain stocks and monthly grain marketings. Reviewing when, how, and why stocks move from on-farm and off-farm inventories, an interpretation of quarterly commodity disappearance and crop marketings is formed. An explanatory model is first developed for farmer marketings, where price expectations are used to assess market signals to change ownership of crops. The model is applied to South Dakota corn, soybeans, and wheat from 1985 through 2015. The subsequent analysis contributes to a model that explains quarterly changes in stocks in terms of supply levels and the expected effect from marketings on disappearance. An expected basis function is developed as an explanatory variable, but market indicators are dominated by strong seasonal patterns in both disappearance and marketings.

A disparity between on-farm and off-farm disappearance is identified, the latter being intractable to quantify. A disparity between marketings and on-farm disappearance suggests a large portion of off-farm stocks are owned by farmers, potentially creating storage constraints at off-farm locations.

CHAPTER 1: INTRODUCTION

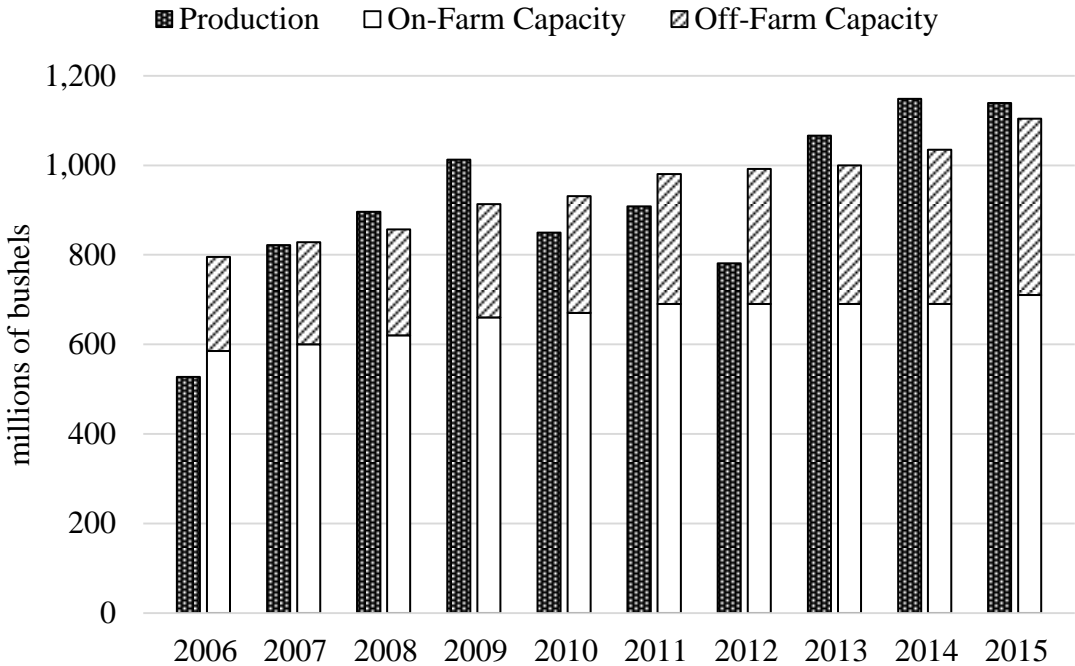
Background

Every year agricultural producers cultivate plants and raise animals for use as food, fiber, or fuel. Though consumption is relatively stable, seasonal production of many agricultural products necessitates temporary storage. Moreover, regional concentration of growers gives rise to transportation networks for distribution. The development of warehousing facilities and shipping infrastructure has increased the availability and diversity of household provisions to people around the world.

Aided by technology and economies of scale, producers continue to yield more output per unit of land. Annually produced commodities, especially grains and oilseeds, represent a one-time return for a year's investment. These crops are often assembled and stored to be distributed in future weeks and months. Storage facilities, then, are an important on-farm investment for providing marketing choices and for avoiding spoilage. Elevators and depots supplement on-farm storage capacity, handling agricultural commodities and brokering transactions between sellers and buyers. This function is especially important to smaller farm operations, which may lack the ability to efficiently market production.

Intertemporal storage is a critical factor in the long-run stability of commodity markets, preempting seasonal shortages with the allocation of harvest surpluses. The integration of agricultural and financial markets prompts the need to understand dynamics of changes in production, demand for storage, and investment in storage capacity. Figure 1 shows the cumulative South Dakota corn, soybeans, and wheat production from 2006 to 2015. Aggregate production is approaching 1.2 billion bushels

for these crops alone. Also shown is total on-farm and off-farm grain storage capacity (Figure 1). Investment in storage infrastructure has coincided with rising annual production. However, production routinely exceeds on-farm capacity, necessitating off-farm storage or accelerated merchandising of production. Also, supply shocks have at times outpaced the ability to smoothly handle and store crops, such as occurred in late 2013 (Agricultural Marketing Service, 2015).

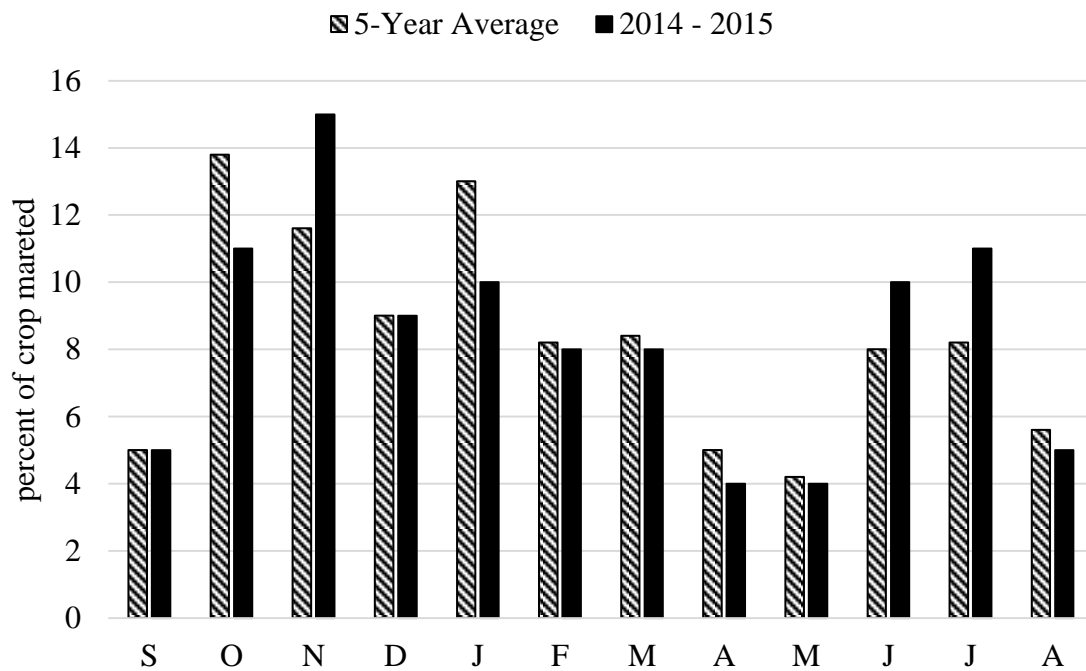


Source: USDA-NASS

Figure 1. South Dakota Production and Storage Capacity

Consideration of state and regional grain inventories is important to many agricultural stakeholders. Reasonable estimates of inventories help market participants optimize production, inform futures prices, and determine the general allocation of resources. With an improved understanding of producer marketing behavior, it may be possible to better explain and forecast stocks and prices.

Marketings measure the proportions of a commodity's quantity sold during a given time period. Total sales at the farm level are surveyed by United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS), and the results are tabulated as the percentage of the year's crop marketed each month. The survey collects a random sample of the total quantity marketed by producers to first buyers, and consists of all grades and qualities. The responses are reported at the state level by NASS in its August (wheat), September (soybeans), and November (corn) *Agricultural Prices* reports (USDA-NASS, 2015). Each percentage value of farm marketings represents a proportional change in ownership of that commodity. This does not necessarily coincide with the physical transfer from on-farm storage to off-farm storage or to an end-user during the same period, but capacity constraints and eventual degradation dissuade long-



Source: USDA-NASS

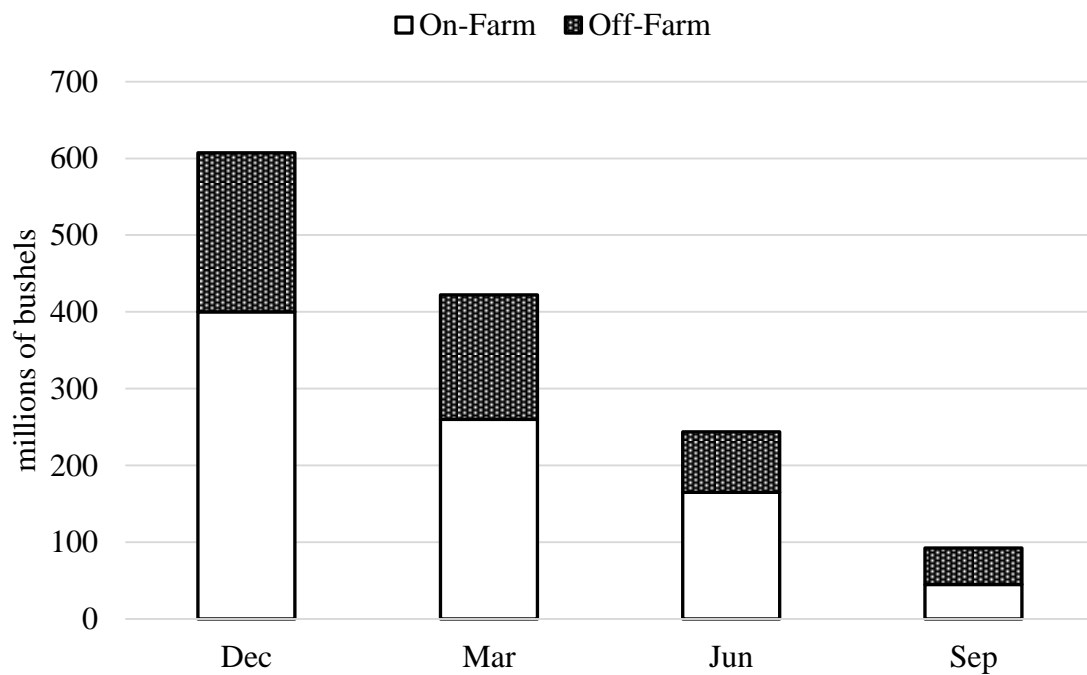
Figure 2. Monthly South Dakota Corn Marketings

term holding of most crops. Led by market signals and production factors, conventional farm-level marketing strategies facilitate regional and national patterns of monthly sales (Cunningham, Brorsen and Anderson, 2007). Figure 2 depicts the percent of corn marketed in South Dakota for each month of the 2014-2015 crop year compared to the monthly five-year average. Thus, sales out of annual production are allocated across the entire year, a result of interim storage after harvest.

Marketing data are useful for establishing past producer behavior and historical trends, but *post hoc* reporting cannot readily address intra-year ambiguity. Sales are surveyed monthly, but statistics are only released at the end of each marketing year – one to five quarters after the last transactions occurred. The marketing year for a commodity is based on typical harvest time. The marketing year varies by crop and by state. For example, the wheat marketing year in South Dakota extends from July to June. Since 2001, corn and soybean producers in South Dakota and most neighboring states have shared the same marketing year, extending from September through August. Unmarketed production must be stored for future sale or use, and is carried over to subsequent inventories.

Grain stocks, or stocks, is the quantity measure of a storable commodity at a given time. The cumulative measure includes inventory located in on-farm and off-farm storage facilities. On-farm stocks comprise all contents of bins, cribs, sheds, and other structures located on farms. Off-farm stocks include the inventories of all elevators, warehouses, terminals, merchant mills, and any other off-farm stores of grains and oilseeds. NASS surveys a random sample of farmers to estimate on-farm stocks, and enumerates all off-farm stocks quarterly as of the first day of March, June, September, and December

(USDA-NASS, 2016). The reported quantities are static inventories determined at fixed intervals, leaving actual inflows and outflows to be assessed separately. Figure 3 shows quarterly stocks of corn in South Dakota during the 2014-2015 crop year. Corn production in 2014 was 787,360,000 bushels. Thus, stocks reflect the annual accumulation of inventory during harvest and subsequent depletion throughout the rest of the year.



Source: USDA-NASS

Figure 3. Quarterly South Dakota Corn Stocks, 2014-2015

A vital distinction to make regarding marketings is that it is a measure of sales, which may or may not coincide with physical consignment of the commodity. A producer may market a crop weeks or months before delivery, or may transfer custody of the grain prior to sale. This disparity between sale and delivery makes reconciliation of marketings and stocks challenging.

Commodity disappearance, the change in stocks from one period to the next, is the implicit representation of all production, consumption, and conversion during that period. Producers, throughout the course of a year, determine how much of a particular good to produce, and decide how much of the final product should be sold at specific intervals. *Ceteris paribus*, a rational individual will market the commodity in the present period unless the expected premium for a delayed sale exceeds the marginal cost of storage. Storage provides opportunities to benefit from higher prices later in the year, and creates a buffer at harvest time when production outpaces short-term utilization.

One can assume that the transfer of stocks is unidirectional – that marketings would not be likely to reenter on-farm stocks. Marketings measure farm-level grain sales, which includes undelivered sales, but excludes deliveries made prior to finalized sales. These transactions, if overlapping during the survey period, may create a clerical discord. This discrepancy is likely not material in an analysis at the aggregate level. On-farm stocks can be expected eventually either to pass through off-farm storage, or to directly transfer to an end-user, with the exception of commodities purchased as feedstuffs. The composition changes of off-farm and total inventories, however, are more ambiguous.

Agricultural marketing contracts are widely-utilized as a tool for managing risk. Contracts allow producers to agree to terms of sale prior to harvest, which often results in a crop being marketed and delivered in different reporting periods. Prevalence of contracts has increased in recent years, particularly between 2001 and 2008. Nationally, 26 percent of corn, 25 percent of soybeans, and 21 percent of wheat produced in 2008 was covered by contracts (MacDonald and Korb, 2011). This may help explain why changes in stocks can lead or lag marketings. Additionally, producers also use futures and

options as risk management tools. Producers are able to secure commodity prices in advance, and hedge against unfavorable market developments. On-farm storage, if available, enables a harvested crop to be marketed after advantageous price changes, or to be sold incrementally in anticipation of other significant market events. Off-farm facilities, including commercial elevators and cooperatives, allow a producer to do the same thing if on-farm storage is not available. Nearly all of these alternatives could result in a disconnection of sale and delivery, perhaps producing an incongruent measurement of stocks.

Basis, the difference between a commodity's cash price and its value in the futures market, is a signal for producers and buyers engaged in marketing contracts. Carry, the difference among futures prices for different contract months, likewise helps coordinate the timing of the arrangement. Both basis and carry are persuasively linked to commodity marketing strategies, and may help explain the relationship between marketings and stocks.

Objectives

The investigation begins with a review of when, how, and why stocks move from on-farm to off-farm storage locations, the extent of correlation between disappearance and the portion of the crop marketed, and the level of on-farm disappearance that can be attributed to on-farm consumption. Preliminary analysis focused on trends in the year-to-year quarterly usage, controlling for differences in price and production.

The objective of this study is to provide a coherent framework for analyzing, quantifying, and understanding marketing levels and quarterly stocks, using data from

South Dakota corn, soybeans, and wheat. It is proposed that monthly NASS marketing levels of corn, soybeans, and wheat be aggregated to quarterly totals and used to explain changes in stocks levels or disappearance. As such, production will be accounted for during harvest quarters. Marketing levels are expected to be a function of expected intertemporal price differences implied by indicators of carry and basis. Carry will be estimated using a difference in deferred and nearby futures prices measured each quarter. For example, in April the nearby corn futures contract month is May and the next deferred month is July. April carry is determined as the price difference between the July and May futures prices. Basis will be estimated using the difference between the quarter's middle-month average cash price for the commodity at the state level and the nearby futures price measured at the end the previous month. Basis for the quarter extending from March through May, for instance, will be the difference between the April average cash price and the nearby (May contract) futures price on the first day of April. A quarterly rate of interest will be used for calculating opportunity costs of intertemporal marketing differences.

Justification

In addition to greater understanding of the relationship between marketing levels and quarterly stocks, the assessment should also allow for insights into the location of stocks. A lingering concern has been the presence of farmer-owned grain in off-farm storage locations. A divergence of marketing levels and stocks may explain disparities between on-farm and off-farm stocks levels. Improved forecasts of quarterly grain stocks, based on variables in the model, may also lead to better price forecasts. Optimal commodity allocation is a product of sufficient expectations and minimized storage and

transportation constraints. Recent logistical concerns have resulted from unanticipated production levels that stressed regional rail lines and tested warehousing capacity (Agricultural Marketing Service, 2015). Unforeseen delivery bottlenecks and inventory overflows may lead to commodity spoilage, excessive storage costs, and diminished marketing performance, which could be detrimental at the market level and disastrous at the farm level. Adequate storage capacity provides a buffer to mitigate such situations, and reliable forecasts enable better market arbitrage for efficient market convergence.

Understanding, to a higher degree, the expected effect that each determinant will have on usage – and the resulting stocks of each commodity – will help market participants plan for the future, and can eliminate stress on market infrastructure during years of high production. These results will help producers, merchandisers, and end-users better manage production stored at a given point in time. The analysis will help explain the timing of sales and transportation needs, and will increase understanding of the regional crop supply chain.

The statewide production of corn, soybeans, and wheat is used for this analysis, and the paper is organized as follows. The next chapter includes a review of related literature. Then, a chapter is used to discuss the development of models to explain changes in farmer marketings and stocks levels. Then, empirical results are reported and implications discussed. A concluding chapter emphasizes the nascent framework of the model and potential ways to extend and improve on the results.

CHAPTER 2: LITERATURE

This section considers literature relevant to commodity storage and allocation. A review of storage theory provides an analytical foundation, while investigation of market incentives, producer behavior, and prior research provides a framework to better explain marketing behavior and commodity disappearance.

Aggregate Storage

The problem of storage and allocation is inherent in agricultural production – particularly in annually produced grains and oilseeds. Seasonally-constrained enterprises are the focus of the theory of price of storage, and of subsequent research by Working (1949) and others. The theoretical tenets explain observed price behavior as a function of inventory size. Using a quarterly model for corn, Westcott, Hull, and Green (1985) discuss the correlation between prices and end-of-quarter stocks inventory. The effect of stocks on prices varies at different times of the year. A given level of stocks will reap lower prices as the crop year elapses. This is caused by anticipation of additions from the new crop. Collateral price determinants such as stocks-to-use ratio, harvest size, acres planted, and weather developments are also considered. Favorable changes in harvest conditions may bolster the intra year differences, while unfavorable news may dampen the effect (Westcott and Hoffman, 1999).

Lowry et al. (1987) consider how storage allocates annual inventories, both within and between crop years. The model uses nation-wide quarterly shift parameters, prior-year harvest levels, and new-crop forecast indicators in conjunction with endogenous consumption, export, and storage variables. The resulting price functions explain

demand, given varying levels of inventory and carryover stocks. Rational price expectations are found to be a function of beginning stocks and new-crop plantings and growing conditions. With reliable data, price variance is insignificant.

When market conditions change, producers may choose to add additional on-farm storage. The Australian domestic wheat market, for example, was deregulated in 1989, authorizing an expansion of on-farm storage to existing state-managed storage capacity. Hunter, Hooper, and Moon (1992) describe this development of on-farm capacity as investment and consider the role that storage plays in grain allocation. Storage facilities are an important on-farm investment for providing marketing choices and for avoiding spoilage.

Both on-farm and off-farm storage are constrained by physical capacity (space), ability to prevent spoilage (time), and availability of transportation (distance). These limitations are typically more binding for on-farm storage. Additionally, these challenges are likely addressed with fewer options and less information. Individual grain producers in a competitive market are assumed to be price takers, and accordingly, adjust quantities sold each month. As buyers and sellers engage in bidding and asking, the resulting price discovery is the principal determinant of how a given measure of a commodity is marketed or stored.

As transportation costs increase with distance, the opportunity costs of storage decline. The dynamic between storage premiums, which have a negative relationship with market proximity, and transportation costs, which have a positive correlation with distance, suggests that an optimization function exists. Benirschka and Binkley (1995)

consider the geographical distribution of grain storage. A strong positive relationship exists between storage capacity and distance from central markets, suggesting that decision makers are employing regional comparative advantage for holding stocks.

Marketings Research

Monthly marketing data have been examined by Tomek and Peterson (2005) using NASS sources, and by Anderson and Brorsen (2005) and Dietz et al. (2009) using elevator sources. Such studies commonly address the assumption that farmers market a significant portion of crops at low price levels. The authors alternately question whether it is practical to expect superior performance from marketing strategies. This skepticism is consistent with the efficient market hypothesis, which asserts that commodity prices reflect all existing information. Consequently, marginal gains from a responsive marketing plan would not exceed the marginal costs of arbitrage. The theory follows that the quantity of a commodity held in storage will settle where the cost of storage is equal to the temporal price spread (basis). If this condition were in disequilibrium, there would be opportunity for profitable arbitrage until restoration of market efficiency (Brennan, 1995; Working, 1949).

Multiple studies investigate state-level marketing patterns. Models evaluate producers' timing and effectiveness (Anderson and Brorsen, 2005; Dietz et al., 2009) and overall marketing style (Cunningham, Brorsen, and Anderson, 2007). The evidence suggests that producers predictably choose a general timeframe to market, but exhibit lags from technical signals in the short run. Regarding marketing style, there seems not to be a practical advantage to be derived from an active marketing style over a mechanical,

persistent style. Anderson and Brorsen (2005) find that the average producer will invariably receive an average price in the long run.

Much of the literature regarding the storage of commodities attempts to reconcile economic theory with empirical results. Peterson and Tomek (2005) address longstanding criticisms of efficient market concepts. It is not uncommon to find instances of storage costs that exceed the resulting basis, which is to say that negative returns are possible. Convenience yield and risk premium are the most popular explanations for this.

Storage Literature

Several studies have assessed the use of various market signals to determine how producers actually make decisions to market or to store. Storage allows producers added flexibility to choose optimal times and quantities to market. One must only determine whether or not the price is expected to rise to a level that would exceed the cost of storage in the future. Fackler and Livingston (2002) applied a simplifying all-or-nothing approach wherein a model explains when a producer either markets an entire inventory or stores it. Backtesting shows that the method is successful in yielding consistent storage premia within a sizable sample of Illinois soybeans. Additionally, the irreversibility concept employed by Fackler and Livingston enables an abridged account of how grain passes through on-farm and off-farm storage. The assumption is driven by the transaction costs that would dissuade speculative repurchases from being conducted at significant scale.

Lai, Myers, and Hanson (2003) construct a model to assess optimal timing of storage throughout the crop year, noting that an all-or-nothing assumption is inconsistent

with observations in practice. Selling multiple times throughout the year is a way to reduce a degree of price risk. It follows that risk-averse farmers may hedge their production using storage strategies. This, of course, is contingent upon other factors, particularly the opportunity cost of holding stocks. The optimal distribution of marketings throughout the year varies by the degree of risk aversion, the market demand for storage, interest rates, and price variance. In their analysis, Lai, Myers, and Hanson (2003) determine that risk-averse farmers will sell a considerable portion of production right after harvest, unless cash prices are low. This reduces overall risk at the expense of expected storage returns. The approach reflects actual performance, as substantial disappearance occurs during the harvest quarter – especially for soybeans and wheat.

Kastens and Dhuyvetter (1999) employ empirical analysis of the effectiveness of various grain storage strategies for multiple commodities, particularly the use of hedging with deferred futures. Using historical data from select Kansas elevators for wheat, soybeans, corn, and milo, a subjunctive review of performance is simulated. The producers in the test group were evaluated using a decision matrix advised by futures and basis levels. If the decision framework had been followed in place of actual results, average profits would have been moderately higher while total losses would have been considerably lower.

Comparing similar market metrics, Siaplay et al. (2012) determine basis to be the most important market signal for a profit-maximizing producer. In an analysis of Oklahoma wheat, basis is more significant and more consistent than either the futures price or a futures price spread in communicating the appropriate times to sell at harvest or store. This approach considered returns to storage, but not risk tolerance.

The variety of production factors cloud the insights offered by economic analysis, as prices are composed of systematic and random components. Tomek and Peterson (2005) survey marketing patterns to illustrate a range of strategies, including immediate cash sale at harvest, storage with deferred marketings, and variations with mixed degrees of hedging and speculation. The results support the principle of market efficiency – that the costs of arbitrage drive market participants toward systematic behavior. Systematic behavior of prices, though, is obscured by random factors that challenge the identification of inter-seasonal and intra-seasonal patterns.

Peterson and Tomek (2005) explore the intra-seasonal price behavior associated with the level of stocks. Price variance and skewness increase with the depletion of inventories and with the advent of new-crop harvests. The evaluation expressly avoids specification of idiosyncratic marketing factors like farmers' individual opportunity costs, risk tolerances, and tax management strategies. By controlling for the release of new information about current and expected supply and demand conditions, the model was able to coherently insulate the effect of such variables.

Contracts are used to manage price risks, along with cash sales, financial hedges, and storage options. MacDonald and Korb (2011) report changes in marketing mechanisms in recent decades. The use of marketing and production contracts have become increasingly popular, covering 26 percent of the value of all corn production in the U.S., 25 percent of soybeans production, and 23 percent of wheat production in 2008. Incidence is closely correlated with farm size, and though many operations do not use any contracting method, while those that do, use them comprehensively. The report notes

that as of 2008, less than 20 percent of corn, wheat, and soybean production is produced on farms that market exclusively in cash markets.

Forward contracts predominately call for delivery at harvest. Thus, marketing and delivery would occur during the harvest quarter. Some contracts assign a post-harvest delivery date, for example, a contract against March corn futures. Such contracts would also imply a consistent marketing and delivery date. Farmers delivering and storing grain at an elevator would be an obvious exception. Delivery would be made to an elevator, but the change in ownership (or marketing) would not occur. The farmer would pay for storage and then market the grain with the price induced from sale. One final type of behavior, with uncertain effects on this system, would be the use of delayed pricing contracts. Such contracts have become prevalent and routinely capture a significant number of bushels harvested in the Northern Plains. How they are perceived by farmers and by NASS is unclear. Baldwin, Thraen, and Larson (1987) develop a model to gauge the impact of delayed price contracts on basis and marketing efficiency.

A comprehensive economic framework must consider that human decision makers are the drivers of market activity. Populations and markets behave somewhat reliably, but individuals are much less predictable. Even under a supposition of efficient markets, some participants may engage in strategies to exploit any attainable asymmetry. Fruitless endeavors, according to efficient market theory, will forgo only transaction costs. Behavioral economics – and actual events – uncovers the possibility of more substantial loss from speculation (Kahneman and Riepe, 1998). This human element provides the underlying concept behind technical analysis and active portfolio management.

Brorsen and Anderson (2001) survey five human tendencies that underpin common psychological biases: anchoring, myopic loss aversion, fallacy of small numbers, overconfidence, and hindsight bias. Anchoring exists as people retain preconceptions in lieu of new information. This is why many people fail to remedy and learn from mistakes and losses. Myopic loss aversion endures because of an inclination to escape feeling regret. By failing to ignore sunk costs in the short run, producers may hold stocks beyond a point of economic rationale. Though problematic to quantify, this is surely a component of crop marketings and price. Such biases may help to understand deviations from expected rational economic behavior.

CHAPTER 3: RESEARCH DESIGN

The previous chapters developed the research problem, proposed objectives, and surveyed prior related research. This chapter discusses sources of applicable data and describes measures significant to this analysis. A model for explaining marketings is specified and discussed, and specification issues are identified. A second model is then devised, using aggregated monthly marketings to explain quarterly changes in on-farm and total stocks.

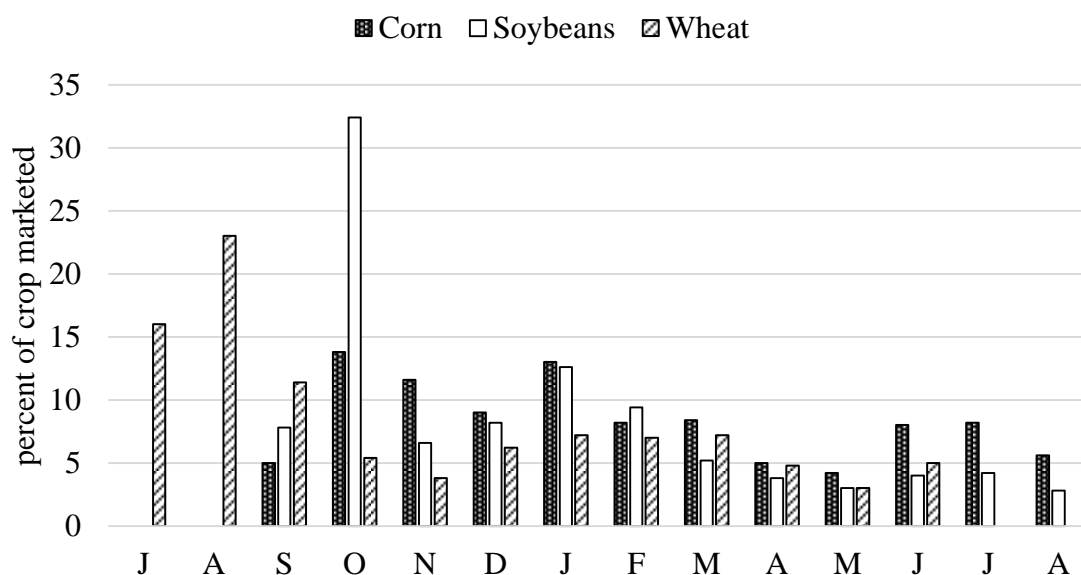
Data

NASS conducts state-specific surveys according to the specific commodities produced in each area. Monthly data compiled from producers include prices received for crops and quantities sold. NASS also surveys elevators and buyers to obtain total quantity purchased and total dollars received.

Surveys are conducted in every state, although not all states survey every commodity (USDA-NASS, 2011). The data are aggregated and published in the *Agricultural Prices* report on or near the last business day of each month.

Marketings and monthly cash price data for this research are derived from this survey, and were collected from the NASS searchable database, QuickStats. NASS maintains average monthly prices of the major commodities from more than a century ago, but state-level marketings are a relatively recent addition to *Agricultural Prices* reports, first appearing as a standard component in the late 1990s. Bulletins published by the South Dakota Department of Agriculture include marketings back to the 1985-1986 marketing year (South Dakota Agricultural Statistics Service, 1987). Figure 4 shows

South Dakota average monthly marketings between 2010 and 2015 for corn, soybeans, and wheat. Certain months exhibit substantial percentages sold. Significant activity occurs in months immediately following harvest, particularly for soybeans and wheat. For this research, marketings are aggregated into quarters. This likely masks some explanatory differences between the months in each quarter, but stocks data are only available quarterly. Disappearance is not attributable to specific months at the state level.



Source: USDA-NASS

Figure 4. South Dakota Average Monthly Marketings, 2010-2015

The monthly Crops/Stocks surveys conducted by NASS obtain detailed estimates of on-farm grain and oilseeds stocks, as well as crop acreage, yields, and production. Surveyed operators provide data on the total acres available, acreage in each commodity of interest and amount produced at harvest. The off-farm figures are obtained through a quarterly enumeration of all identified commercial grain storage facilities. Responses include total stocks of grain and oilseeds stored, itemized by commodity. Surveys are

unique to each state, based on prevalent agricultural production. Survey results are published in the monthly *Crop Production* reports and the quarterly *Grain Stocks* reports, in addition to specific annual updates. On-farm and off-farm stocks levels are collected during the March, June, September, and December surveys, and storage capacity estimates are gathered annually in the December survey. Grain stocks data for this research are derived from this survey, and were collected from QuickStats. NASS maintains on-farm and off-farm stocks nationally from the 1920s, and at the state level beginning in the 1940s. Because state-level marketings data are unavailable before 1985, only data from that point forward are used for this study.

Basis, the difference between a futures price and a cash price for the same commodity, varies between states and within states. Regional and local idiosyncrasies reflect market arbitration that is consequential to national markets. However, farm-level indicators must be aggregated to correspond with broader measures of marketings and disappearance. For this analysis, basis is calculated as the difference between the historical state-wide average monthly cash price and the nearby futures price of the same commodity for the same month. Nearby refers to the futures contract with the most immediate maturity date. Futures data are from the Bloomberg electronic database. To facilitate a quarterly model, observations from the middle month of each quarter are used.

The marketing year for corn for South Dakota switched from October through September to September through August in 2001, thus marketings for September 2001 are included in both the 2001 and 2002 marketing years. The new marketing year for corn and the marketing year for soybeans align with the beginning of a stocks reporting period. The marketing year for wheat, however, begins in July, which means that stocks

data acquired from the June through August period come from two different marketing years. Likewise, corn stocks data from before 2001 overlay two crop years during the September through November period. Reporting period overlaps are mitigated by expressing marketings as a percent of harvest.

Model

Decisions to market or to store are generally advised by expectations of future market conditions, relative to current levels. A profit-maximizing producer will choose to hold stocks if the marginal future benefit exceeds the marginal holding cost. Marketings, then, are expected to increase with a narrow basis and to decrease with a strong carry. On-farm disappearance is expected to increase with a narrow basis and a lack of carry. As the stocks are quarterly, the marketings are accumulated to quarterly totals. Basis and carry, which are observed quarterly, are linked with expectations. Quarterly dummy variables are expected to show the seasonal shifts from harvest, seasonal demand, and a tendency to delay sales until after January 1 for income tax management.

The marketing year for annually-produced commodities is divided into quarters, beginning the first day of December, March, June, and September. These quarters coincide with the reporting periods used by NASS for grain stocks. Marketings are aggregated and expressed as the percent of annual production marketed during a given quarter. Marketings (M_t) are expected to be a function of the expected intra-year price differences $E[PD_t]$, which indicate advantageous conditions to store or to move inventory, and other exogenous variables X_t :

$$M_t = f(E[PD_t], X_t),$$

where:

$$E[PD_t] = [F_t + E(B_t)] - [S_t + (I_t \times S_t)],$$

S_t and F_t are the spot price and deferred futures price, I_t is the Federal Reserve Bank of Minneapolis rate of interest for agricultural operating loans reported quarterly, and $E[B_t]$ is the three-year average basis for a given quarter (B_t). Expectations of basis are formed from historical levels. For example, $E[B_t]$ of a given crop for the quarter extending from June through August 2015 is determined using July basis averaged from 2012-2014. Spot price (S_t) is the statewide average cash price during July 2015, and futures price (F_t) is the nearby futures price (e.g., September corn) observed on the first day of July 2015.

Grain is harvested and added to total inventory during only one quarter, while inventory is used throughout all four quarters. Disappearance (D_t^k) is the measure of stocks that are depleted during period t from k locations. The disappearance functions note differences between on-farm and total inventory levels:

$$D_t^{On-Farm} = g(E[PD_t], M_t, \mathbf{X}_t), \text{ and}$$

$$D_t^{Total} = h(E[PD_t], M_t, \mathbf{X}_t).$$

Crops are grown on farms, thus it is assumed that all inventories originate with on-farm storage, even if a commodity is transported directly from the field to an off-farm location. This assumption simplifies supply chain concepts and allows for persuasive comparisons between on-farm and total levels.

Because cumulative marketings for a given year result from a change in ownership and cumulative disappearance for a given year describes physical changes in a

commodity's location, producer behavior may help to explain disparities between marketings and disappearance. On-farm disappearance in excess of marketings likely reflects the presence of farmer-owned grain in off-farm storage locations, which has complicated state and regional forecasting efforts (Agricultural Marketing Service, 2015). Marketings in excess of disappearance is a possible effect of contracting and of some hedging strategies.

To investigate the influence of expectations on marketings, OLS regression will be employed to estimate the effect. The estimator for each crop is formulated by the following equation:

$$M_t = \beta_0 + \beta_1 E(PD_t) + \beta_2 Q_2 + \beta_3 Q_3 + \beta_4 Q_4 + \varepsilon_t,$$

where the exogenous variables are quarterly dummy variables.

Marketings are treated as a percent of harvested bushels. Thus, there is no need to account for on-farm consumption and feed use. The expected signs on the variables are listed in Table 1. Note that the coefficients for the quarterly dummy variables can rationally be positive or negative, depending on seasonal drivers and persistence of marketing behavior.

Table 1. Expected Signs on Marketings Parameter Coefficients

Variable	Expected Coefficient Sign
Intercept	Positive
$E(PD_t)$	Negative
$D_t^{\text{On-Farm}}$	Positive
Q_2	Unknown
Q_3	Unknown
Q_4	Unknown

For each crop, total disappearance is specified as:

$$D_t^{Total} = \delta_0 + \delta_1 M_t + \delta_2 E(PD_t) + \delta_4 Q_2 + \delta_5 Q_3 + \delta_6 Q_4 + \varepsilon_t,$$

where D_t^{Total} is state-wide total disappearance expressed as a percentage of the year's harvest for quarter t , M_t is the percent of the year's harvest marketed during quarter t , $E(PD_t)$ is the *ex-ante* estimated per-bushel price difference between quarters t and $t+1$. Dummy variables Q_2 , Q_3 , and Q_4 provide a *ceteris paribus* comparison of disappearance between each quarter and the harvest quarter. The base quarter, implied Q_1 , is the period in which a given crop is typically harvested. For wheat, this is from June through August. For corn and soybeans this is from September through November.

For comparison, the same explanatory variables are regressed on on-farm disappearance:

$$D_t^{On-Farm} = \gamma_0 + \gamma_1 M_t + \gamma_2 E(PD_t) + \gamma_4 Q_2 + \gamma_5 Q_3 + \gamma_6 Q_4 + \varepsilon_t.$$

Table 2 lists the expected signs of the independent variable coefficients in the disappearance models. Note that the quarterly dummy variables can be rationally positive or negative. Marketings should exhibit a positive sign, because any amount that is sold would at least be removed from on-farm inventory.

Table 2. Expected Signs on Disappearance Parameter Coefficients

Variable	D_t^{Total}	$D_t^{On-Farm}$
Intercept	Positive	Positive
M_t	Positive	Positive
$E(PD)$	Negative	Negative
Q_2	Unknown	Unknown
Q_3	Unknown	Unknown
Q_4	Unknown	Unknown

Off-Farm Disappearance

Differences in the coefficients in the disappearance models would reveal distinctions in how the variables explain on-farm and total disappearance levels. Alternatively, carryover effects could be documented as a drawdown or build-up of ending stocks by marketing year. The presence or absence of carryover stocks during the final quarter of the marketing year is theoretically and empirically significant, but there is not a simple way to address the impact. Lowry et al. (1987) demonstrate the conditional importance of carryover stocks. However, the data used in this research confine allocation to the marketing year. Marketings expressed as a percentage of the whole conceal parallax overlaps between years.

Figure 5 depicts South Dakota on-farm and total corn disappearance from 1985 to 2015, expressed as percentages of harvest per quarter. Note the cyclical patterns that emerge from each data series. Over time, on-farm and total disappearance percentages have diverged during harvest quarters, as higher percentages leave farms than leave total stocks. A similar pattern is evident in soybeans, shown in Figure 6. Soybeans are marketed more promptly than corn during the harvest quarter, and display a wider range between quarters. On-farm and total disappearance for South Dakota wheat for the same sample period is displayed in Figure 7. Like soybeans, a large portion of harvest leaves farms during the first quarter of the crop year. All crops disappear more smoothly in total than from on-farm inventories. This can perhaps be explained by on-farm retention and in-state processing and allocation.

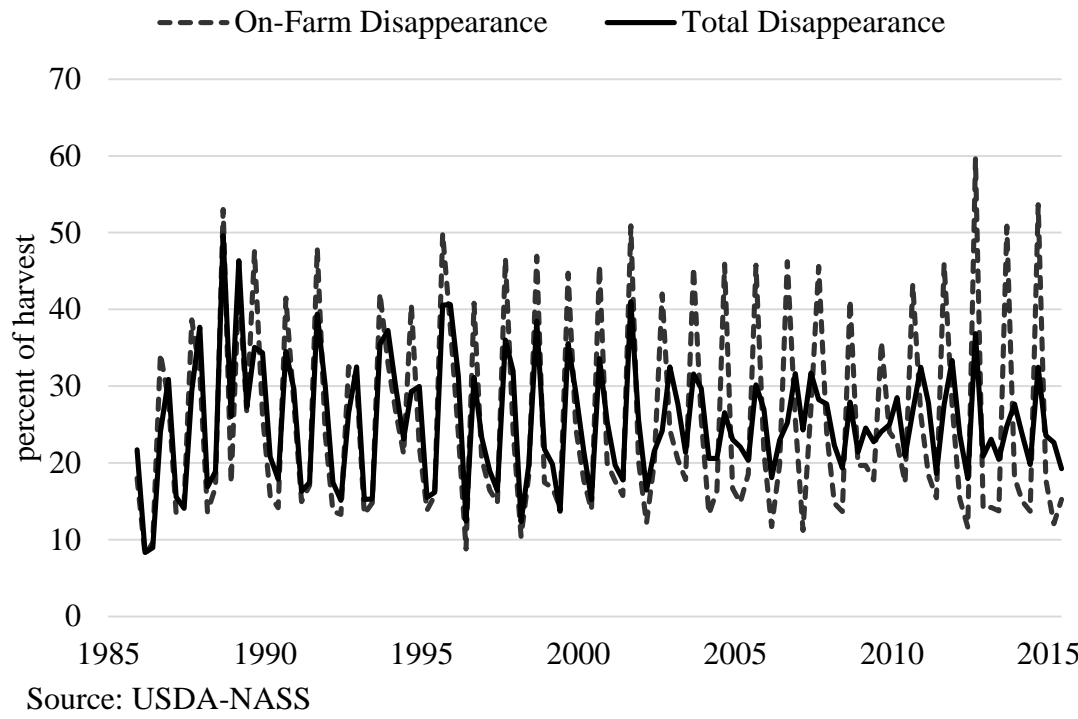


Figure 5. South Dakota Quarterly Corn Disappearance

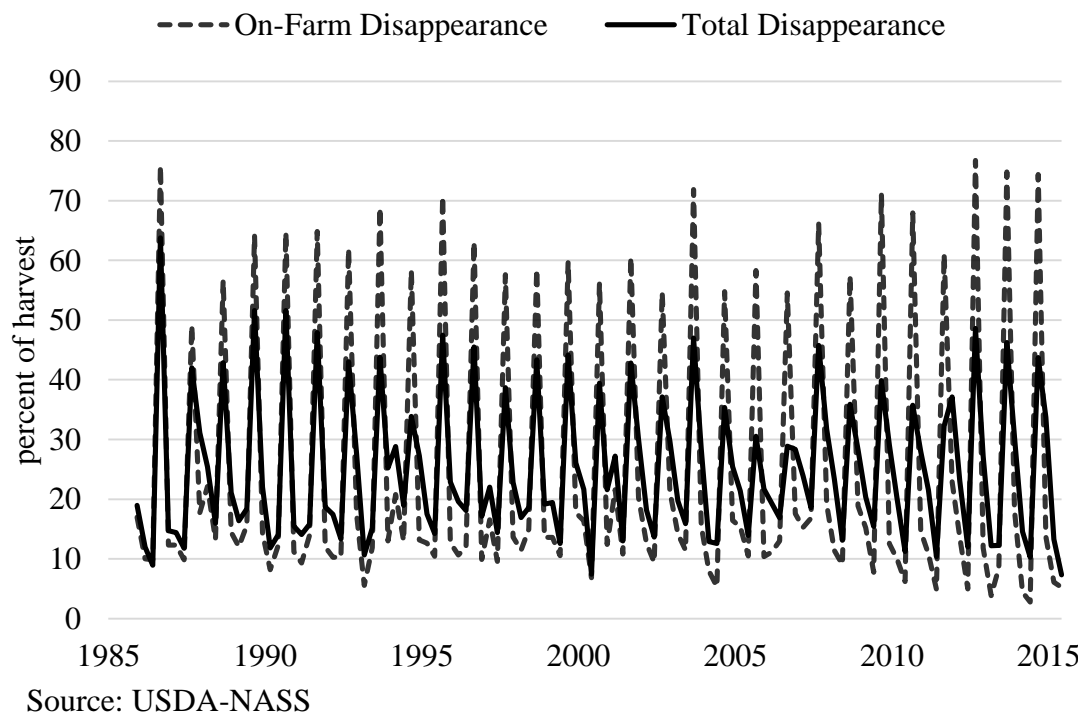


Figure 6. South Dakota Quarterly Soybeans Disappearance

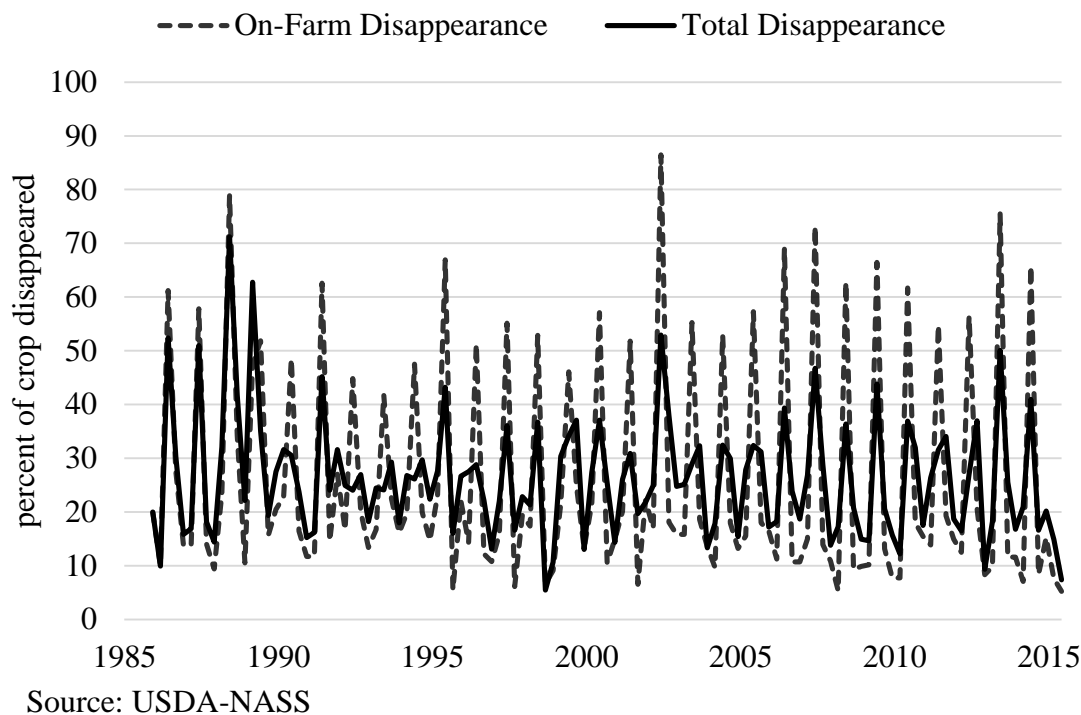


Figure 7. South Dakota Quarterly Wheat Disappearance

On-farm disappearance is the difference in beginning and ending on-farm stocks plus any harvested bushels. Total disappearance is defined similarly as it also accounts for any harvested bushels. There is a range of potential off-farm disappearance totals. A minimum is the change in off-farm stocks for the quarter. A maximum is the change in off-farm stocks for the quarter plus on-farm disappearance for the quarter. This limit could be reached only if the entire beginning on-farm inventory passed through off-farm storage during the same quarter before leaving the state. The lower bound or minimum may also be influenced or modified if cumulative on-farm disappearance exceeds cumulative farmer marketings. Carryover stocks would affect the lower bound.

Consider the potential off-farm disappearance levels for the second quarter (December, January, and February) of the 2014 South Dakota corn crop. During a non-

harvest quarter, the change in on-farm stocks and the change in total stocks are disappearance (Table 3). No inflows to either location would be rational except for during harvest. The range of possible off-farm disappearance depends on the level of inflows from on-farm sources. Should no bushels move to elevators or end-users, then off-farm disappearance would be solely from beginning off-farm stocks. If all bushels move to elevators or end-users, then off-farm disappearance would also include those additional beginning stocks or all on-farm disappearance. Whereas interesting conclusions may be drawn by comparing on-farm and total disappearance, the inability to accurately establish the degree of off-farm disappearance makes it an intractable variable to explain.

Table 3. Possible Disappearance Levels, 2014-2015

	On-Farm	Off-Farm Minimum	Off-Farm Maximum	Total
	Millions of bushels			
Beginning Stocks	400	208	208	608
Inflows	0	0	140	0
Disappearance	140	46	186	186
Ending Stocks	260	162	162	422

Note: South Dakota Corn, Second Quarter Off-Farm Disappearance

CHAPTER 4: EMPIRICAL RESULTS AND ANALYSIS

This chapter presents results and analysis for the corn, soybean, and wheat marketings, on-farm disappearance, and total disappearance models described in Chapter 3. Ordinary least squares (OLS) results are reported for each variation, serial correlation and endogeneity concerns are resolved, and off-farm disappearance issues are revisited.

Models developed in Chapter 3 take the following functional forms:

$$M_t = \beta_0 + \beta_1 E(PD_t) + \beta_2 D_t^{on-farm} + \beta_3 Q_t^2 + \beta_4 Q_t^3 + \beta_5 Q_t^4 + \varepsilon_t \quad (1)$$

$$D_t^{On-Farm} = \gamma_0 + \gamma_1 M_t + \gamma_2 E(PD_t) + \gamma_4 Q_t^2 + \gamma_5 Q_t^3 + \gamma_6 Q_t^4 + \varepsilon_t \quad (2)$$

$$D_t^{Total} = \delta_0 + \delta_1 M_t + \delta_2 E(PD_t) + \delta_4 Q_t^2 + \delta_5 Q_t^3 + \delta_6 Q_t^4 + \varepsilon_t \quad (3)$$

Descriptive statistics of each model are discussed by crop, and implications are considered. Differences in parameter results are then compared to conclusions found in the literature.

Marketings

Parameter estimates are reported in table 4 for three variations of the marketings model – one for each commodity. The dependent variables, quarterly marketings, are regressed on the expected price difference and on dummy variables to denote each subsequent quarter. The regression results indicate that the expected intertemporal price difference is statistically insignificant in predicting marketings. The quarterly variables are each statistically significant, indicating accordance with persistence formulated by Cunningham, Brorsen, and Anderson (2007). The data suggest that substantial inventory

is marketed in the harvest quarter, and smaller amounts are marketed throughout the rest of the year.

Table 4. OLS Parameter Estimates for Quarterly Marketings

Variable	Corn	Soybeans	Wheat
Intercept	27.27* (5.17)	17.31* (7.68)	24.61* (4.61)
E(PD _t)	-1.81 (1.80)	-1.69 (1.02)	0.42 (0.98)
D _t ^{On-Farm}	0.17 (0.11)	0.49* (0.12)	0.25* (0.08)
Q _t ²	-4.88* (2.94)	-2.51 (6.00)	-7.92* (3.66)
Q _t ³	-12.43* (3.61)	-7.93 (6.35)	-6.18* (3.73)
Q _t ⁴	-9.59* (3.63)	-9.13 (6.60)	-11.03* (3.64)
Adjusted R ²	0.50	0.83	0.67

Note: * denotes significance at the 0.05 level.

With an adjusted R² of 0.50, the corn model explains about half of the variation in corn marketings. All else equal, the significant intercept suggests approximately 27 percent of the harvested crop will be marketed during the harvest quarter. The sign of the expected price difference coefficient is consistent with a belief that an incentive to store would be a disincentive to market, but statistically insignificant. Approximately 22 percent, 15 percent, and 18 percent of harvest can be anticipated to be marketed in the remaining quarters, respectively.

The model for soybeans exhibits the best overall fit with an adjusted R^2 of 0.83. The OLS estimation suggests that approximately 17 of the crop can be expected to be marketed during the harvest quarter. All else equal, approximately 15 percent, 9 percent, and 8 percent of harvest can be anticipated to be marketed in remaining quarters, respectively. The sign of the $E(PD_t)$ coefficient is again negative, but statistically insignificant.

With an adjusted R^2 of 0.67, the wheat model explains a significant degree of the variation in marketings. All else equal, approximately 25 percent of the harvested crop will be marketed during the harvest quarter. Approximately 17 percent, 18 percent, and 14 percent of harvest can be anticipated in the remaining quarters, respectively. The sign of the $E(PD_t)$ coefficient is positive, suggesting other factors may be affecting behavior. Recall that the harvest quarter for wheat begins on June 1. Thus, much of the wheat is marketed prior to when the corn and soybean harvest quarter begins.

Disappearance

Parameter estimates for the other models are reported in tables 5, 6, and 7, in which the dependent variables, on-farm disappearance and total disappearance, are regressed on quarterly marketings, the expected price difference, and quarterly dummy variables. The regression results show that, as specified, marketings consistently explain disappearance. The expected price differences are statistically insignificant in explaining disappearance for corn and wheat, and for on-farm soybeans. For each commodity, the parameters are better able to explain on-farm disappearance than total disappearance.

Table 5. OLS Parameter Estimates for Quarterly Disappearance of Corn

Variable	On-Farm	Total
Intercept	40.94* (2.90)	25.13* (2.98)
M_t	0.12 (0.08)	0.20* (0.08)
$E(PD_t)$	0.99 (1.50)	1.99 (1.55)
Q_t^2	-20.38* (1.57)	-1.47 (1.62)
Q_t^3	-26.48* (1.96)	-6.83* (2.02)
Q_t^4	-27.04* (1.82)	-10.21* (1.87)
Adjusted R^2	0.82	0.47

Note: * denotes significance at the 0.05 level.

The model for on-farm corn disappearance exhibits a good overall fit with an adjusted R^2 of 0.82, as well as sizable, significant coefficients for the intercept and dummy variables. The intercept coefficient implies that, all else equal, 41 percent of the crop can be expected to leave on-farm storage during the harvest quarter. Approximately 21 percent, 14 percent, and 14 percent of production will disappear from on-farm stocks in remaining quarters, respectively. The sign of marketings is consistent with expectations (but only a portion of sold inventory leaves on-farm storage during the same quarter). Disappearance is subject to physical limitations of both storage constraints and

transportation capability. The sign of the $E(PD_t)$ coefficient is positive, contrary to expectations, but statistically insignificant.

All else equal, approximately 25 percent of the harvested corn crop will leave total stocks during the harvest quarter. Roughly 24 percent, 18 percent, and 15 percent of harvest can be anticipated in the remaining quarters, respectively. The M_t coefficient is statistically significant, but less than 1.0.

Table 6. OLS Parameter Estimates for Quarterly Disappearance of Soybeans

Variable	On-Farm	Total
Intercept	50.62* (3.23)	24.49* (3.29)
M_t	0.26* (0.06)	0.37* (0.07)
$E(PD_t)$	0.72 (0.75)	1.54* (0.76)
Q_t^2	-41.23* (2.07)	-7.29* (2.11)
Q_t^3	-42.43* (2.44)	-11.44* (2.49)
Q_t^4	-43.99* (2.57)	-15.47* (2.62)
Adjusted R^2	0.96	0.84

Note: * denotes significance at the 0.05 level.

The model for on-farm soybeans disappearance exhibits an exceptional overall fit with an adjusted R^2 of 0.96, as well as sizable, significant coefficients for the intercept and dummy variables. The OLS coefficient for the intercept implies that, all else equal, 51 percent of the crop can be expected to leave on-farm storage during the harvest

quarter. Approximately 9 percent, 8 percent, and 7 percent of production will disappear in the remaining quarters, respectively. The sign for the M_t coefficient is positive as expected, and statistically significant. Disappearance is caused by marketings, which will eventually be resolved. The positive sign of the (PD_t) coefficient was unexpected, but statistically insignificant.

All else equal, approximately 24 percent of the harvested soybeans crop will leave total stocks during the harvest quarter. Disappearance of roughly 17 percent, 13 percent, and 9 percent of harvest can be anticipated in the remaining quarters, respectively. Again, the sign for the M_t coefficient is as expected, though the coefficient is small, and the sign of the $E(PD_t)$ coefficient was unexpected.

Table 7. OLS Parameter Estimates for Quarterly Disappearance of Wheat

Variable	On-Farm	Total
Intercept	44.79* (4.49)	29.89* (5.12)
M_t	0.36* (0.11)	0.21 (0.12)
$E(PD_t)$	0.88 (1.17)	1.27 (1.33)
Q_t^2	-36.54* (2.82)	-8.09* (3.21)
Q_t^3	-38.31* (2.70)	-16.33* (3.08)
Q_t^4	-35.28* (3.06)	-9.84* (3.49)
Adjusted R^2	0.87	0.43

Note: * denotes significance at the 0.05 level.

The model for on-farm wheat disappearance exhibits a good overall fit with an adjusted R^2 of 0.87, as well as sizable, significant coefficients for the intercept and dummy variables. The OLS intercept coefficient implies that, all else equal, 45 percent of the crop can be expected to leave on-farm storage during the harvest quarter. Approximately 8 percent, 6 percent, and 10 percent of production will disappear in subsequent quarters, respectively. The sign of the M_t coefficient is consistent with expectations, but only 36 percent of sold inventory is revealed in on-farm disappearance during the same quarter. The sign of the $E(PD_t)$ coefficient is positive, contrary to expectations.

All else equal, approximately 30 percent of the harvested wheat crop will leave total stocks during the harvest quarter. Approximately 22 percent, 14 percent, and 20 percent of harvest can be anticipated in the remaining quarters. The sign of the M_t coefficient is again positive, but only 21 percent of marketed wheat is revealed in total disappearance during the same quarter. The sign of the $E(PD_t)$ coefficient is positive, contrary to expectations, but statistically insignificant.

For all of the on-farm disappearance models, the intercept coefficients are substantial and statistically significant. The quarterly dummy variables are highly significant, with the exception of Q_t^2 in the total corn disappearance model. The relative uniformity of the coefficients indicates that a persistent portion of a given crop can be expected to leave on-farm storage during each quarter after harvest. Compared with total disappearance, which is less uniform across quarters, on-farm disappearance for a given quarter appears to be more predictable.

The total disappearance models exhibit some idiosyncrasies. The coefficients for the quarterly dummy variables are smaller and less significant than those in the on-farm disappearance models, and are less uniform. This is perhaps a result of off-farm activity.

An objective of this research is to explain marketings and disappearance in order to predict the timing of future sales and prospective transportation needs within the regional supply system. Predicting future stocks levels and disappearance will help market participants plan for the future, and may eliminate stress on market infrastructure during years of high crop production. Using the model developed in the previous chapter, a forecast of on-farm stocks disappearance can be estimated for an upcoming crop year. If marketings are known, they can be a significant factor in explaining disappearance. As discussed in this chapter, market fundamentals alone cannot convincingly explain farmer marketings. Other trend variables are likely too subjective to be valuable. The quarterly model can, however, provide reasonable predictions of crop-year marketings and disappearance. State-level projections of inventories can be made as soon as dependable harvest data are available, and baseline proportions can be used at any juncture. For example, producers, merchandisers, and end-users can expect 50.2 to 51.2 percent of harvested corn to be sold during the harvest quarter, with a 95 percent confidence interval. This would make it simpler to manage production and inventory.

Retained ownership by farmers is prevalent, especially in the harvest quarter. The crop is delivered to an elevator or end-user, but an ownership change or marketing is not reported as occurring. The cause of this may be an absence of on-farm storage capacity; the only way to not market the crop is to move it to off-farm storage. Farmers may also move the crop to off-farm locations to free up space for other crops, avoid difficulties

maintaining the condition of crops, avoid eventual challenges delivering crops because of poor weather or poor road conditions and utilize pricing programs of buyers (e.g., delayed pricing contracts or delivery commitments).

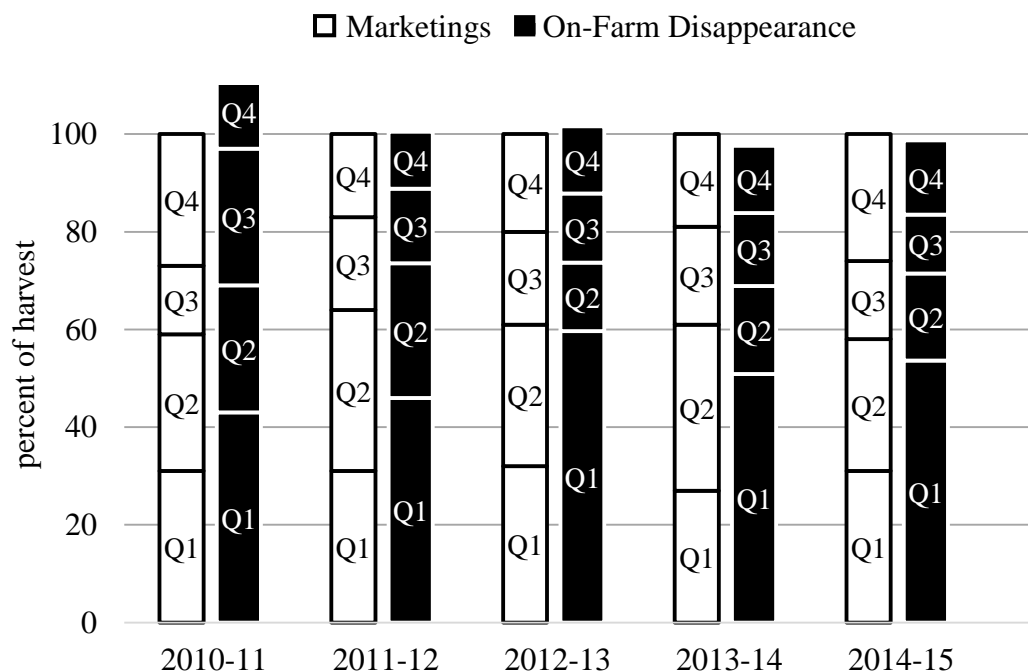
MacDonald and Korb (2011) review the use of marketing strategies used by United States corn, soybean, and wheat producers in 2008. More than half of the producers surveyed used on-farm storage as a marketing strategy. This is constrained by capacity, for without sufficient on-farm capacity, producers may move stocks to off-farm locations.

In South Dakota, the concentration of production in the eastern part of the state reflects important geographical distinctions that shape the state agricultural industry. Eastern South Dakota generally features higher precipitation and better conditions for growing grains and oilseeds than the western part of the state. Such topographical distinctions and production concentration amplify the periodic pressure on storage capacity and transportation infrastructure. MacDonald and Korb (2011) review prevalence of futures and options, and the use of farmer-owned cooperatives for marketing and storage. Nationally, 62 percent of farmers who use contracts also utilize cooperatives, as well as 40 percent of non-contract producers who do. Farmer-owned cooperatives provide an opportunity to employ a variety of marketing methods, some of which lead to disappearance and marketings occurring independently. The degree of correlation between national tendencies and those at the state level is unclear.

Figure 8 compares quarterly percentages of South Dakota corn marketings and on-farm disappearance between 2010 and 2015, while figures 9 and 10 show quarterly marketings

and disappearance for soybeans and wheat. This arrangement is helpful for illustrating differences in cyclical patterns, by crop, and the inter-year and intra-year intricacies developed by Westcott, Hull, and Green (1985). Year-to-year and quarter-to-quarter differences in stocks levels are a function of numerous production and environmental factors, and significantly contribute to price variations throughout the crop year.

Figures 8, 9, 10 show that there are varying degrees of discord between marketings and on-farm disappearance throughout a marketing year. Farmer marketings generally lag same-quarter on-farm disappearance. During some years, more bushels of soybeans and wheat disappear from farm inventories during the harvest quarter than are marketed during the first two quarters of the crop year combined. The prevalence of early



Source: USDA-NASS

Figure 8. South Dakota Corn Marketings and On-Farm Disappearance

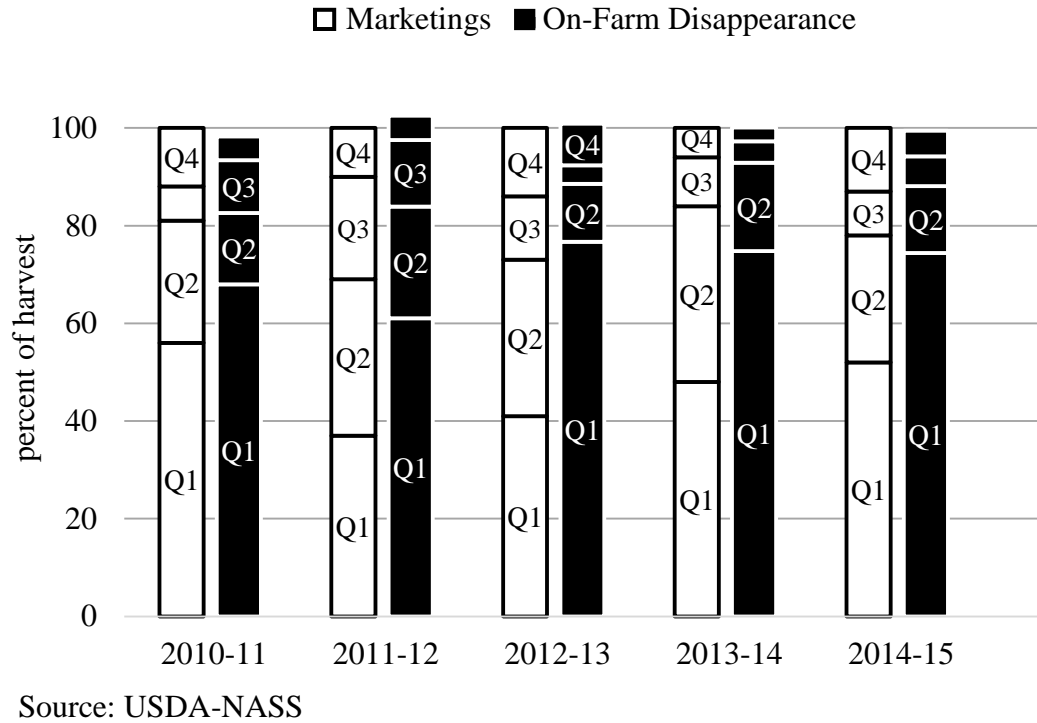


Figure 9. South Dakota Soybean Marketings and On-Farm Disappearance

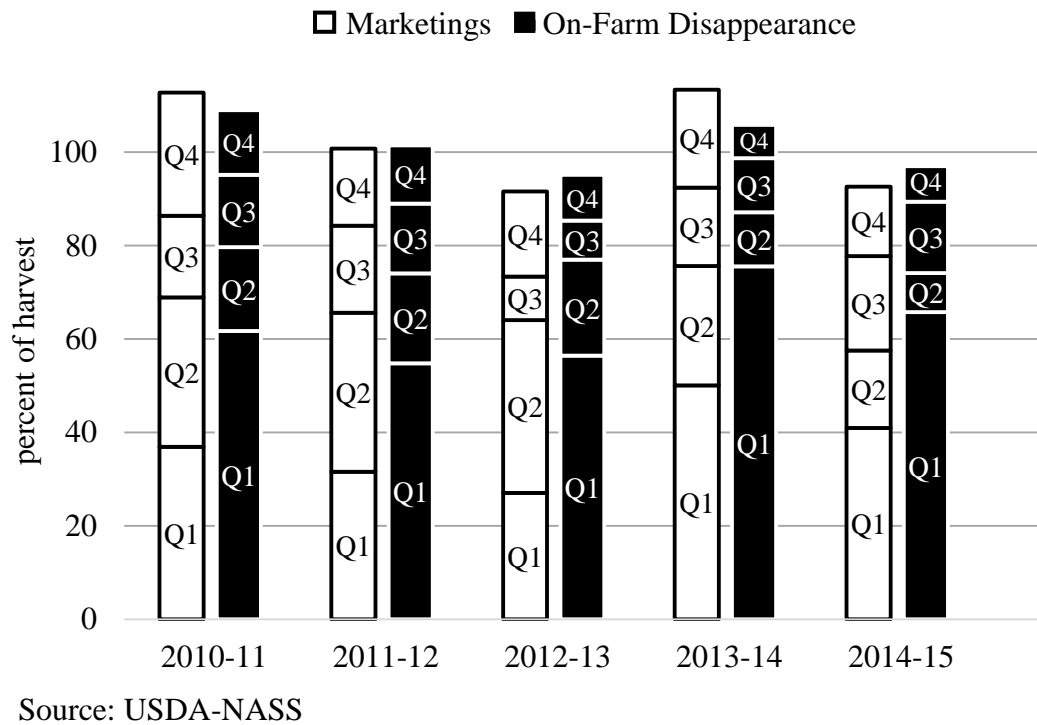


Figure 10. South Dakota Wheat Marketings and On-Farm Disappearance

marketings is consistent with the observations of Lai, Myers, and Hanson (2003) regarding risk averse producers. Marketing at an acceptable price earlier in the year eliminates future downside risk. While residual stocks may be maintained throughout the year for speculative purposes, it is logical that marketed stocks would not be extensively held. It follows that producers with constrained storage capacity would be inclined to consign stocks to be advantageously marketed, and to be relieved of quantities that have already been priced.

As stocks are utilized and contracts are delivered, marketings and disappearance levels converge before the advent of new-crop bushels. Farmer marketings, as reported by NASS, are apportioned entirely within the crop year, so disparities between accrued marketings and disappearance represent stocks carried into the ensuing crop year. Though these disparities are often settled before subsequent harvests, it is not uncommon for stocks to carry forward. Inter-year carryover stocks in figures 8, 9, and 10 are indicated by levels above or below 100 percent within a crop year. On-farm consumption provides an additional explanation. Quantities grown and used by producers would be included in disappearance, but would never be marketed.

Of the three crops in this study, disappearance of corn is the most evenly allocated across quarters (figure 8). This is likely because of the most common uses for the grain. Recent estimations suggest that corn is the commodity with the greatest capacity for in-state utilization, because of ethanol production and livestock feeding. Fed directly, or as a byproduct like dried distillers' grains, much of the crop provides the principal energy component in animal feed (Brown and Diersen, 2015).

The portion of harvest quarter soybean disappearance is noticeably more substantial than for corn (figure 9). This is likely explained by the degree of mechanized processing. Soybeans are a major source of animal protein, but relative to corn are more often commercially processed prior to being used as livestock feed. Expansion of soybean processing in South Dakota could have a substantial impact on these trends.

South Dakota wheat farmers predominantly grow two different varieties of wheat: hard red winter and hard red spring. Both are combined in figure 10. Compared with corn and soybeans, wheat is more likely to maintain carryover inventories. This could be explained by its less frequent use as a feedstuff. Additionally, the specialized varieties of wheat provide opportunities for speculative storage, and may necessitate multiple marketing intervals.

The impact of farmer-owned stocks in off-farm locations has grown in both absolute bushels and as a share of all stocks in off-farm locations. Consider the situation in 2014, the most recent year with complete marketings and stocks data. The corn marketings and on-farm disappearance shares are shown in table 8. In the harvest quarter, 54 percent of the 2014 bushels ultimately leaving on-farm stocks did not remain on the farm as of December 1. In contrast, producers reported marketing a total of 31 percent of the 2014 corn crop during September, October and November. Thus, 23 percent of the crop changed location, but not ownership. The corn harvest was 787 million bushels, implying 181 million bushels were owned by farmers and held in off-farm locations.

Table 8. 2014 Corn On-Farm Disappearance and Marketings by Quarter

Quarter	On-Farm Disappearance (% of Harvest)	Marketed (% of Harvest)	Cumulative Difference
Sep Oct Nov	54	31	+23
Dec Jan Feb	18	27	+14
Mar Apr May	12	16	+10
Jun Jul Aug	15	26	-1

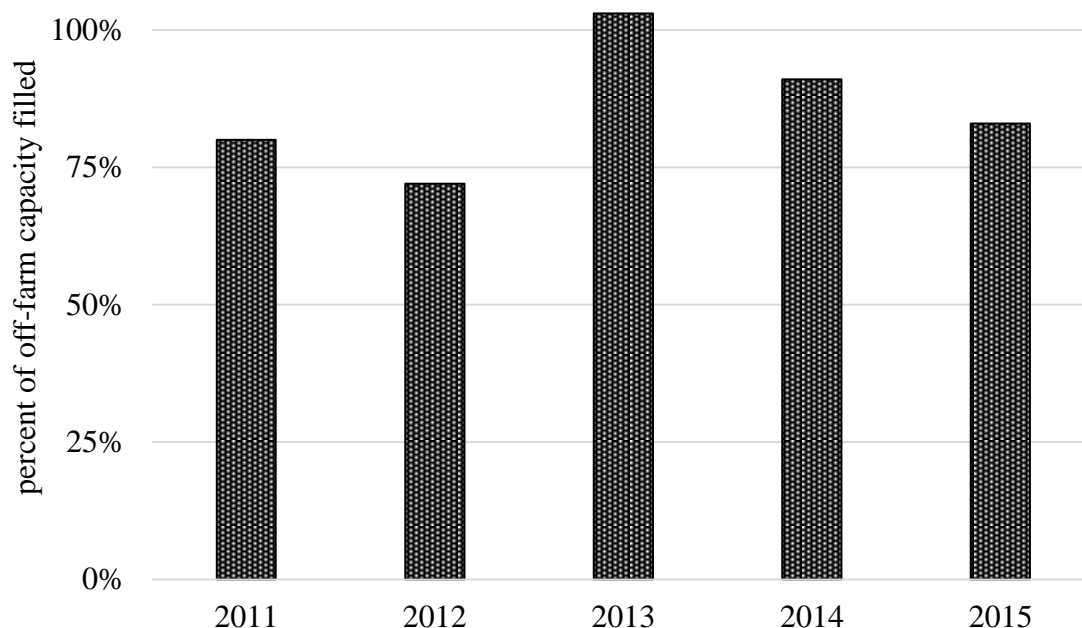
Note: South Dakota 2014 Corn Crop (787 million bushels)

Similarly, the soybeans and wheat owned at off-farm locations totaled 52 and 22 million bushels, respectively. The wheat is the cumulative difference after two quarters. The sum across corn, soybeans, and wheat suggests there were 252 million bushels of farmer-owned off-farm stocks on December 1, 2014. The total reported for all owners of off-farm stocks was 315 million bushels. Total reported off-farm capacity was 345 million bushels.

Figure 11 shows December 1 South Dakota off-farm stocks of corn, soybeans, and wheat, relative to off-farm storage capacity from 2011 to 2015. Statewide, elevators and handlers have often filled most of their capacity, and in 2013 exceeded one-time capacity. This suggests the use of temporary storage methods, perhaps on a shed floor or on the ground, increasing the risk of spoilage. Inventory levels maintained during high- production years are manageable with organized, well-functioning transportation infrastructure. Shipping deficiencies, however, create pervasive challenges for regional and national market participants, many of which are articulated by the Agricultural Marketing Service (2015).

Testing for Serial Correlation

The likelihood of an autocorrelative process reflects a practical consequence of the human coordination within a commodity market. Serial correlation is prevalent in



Source: USDA-NASS

Figure 11. December 1st Off-Farm Stocks of Corn, Soybeans, and Wheat

time-series analysis, as events are often impacted by previous occurrences. The existence of some form of AR(1) would demonstrate that a variable is a function of the preceding iteration, in this case, of marketings or disappearance levels in the prior quarter. The existence of some measure of AR(4) would demonstrate that a variable is a function of the fourth-prior iteration – or the prior year in a quarterly format.

To investigate the reliability of each model, it is important to test that the function adhere to the assumptions that would make it the best linear unbiased estimator (BLUE). A specification exhibiting serial correlation, which fails the BLUE assumption, occurs if an observation can be explained by a previous observation's OLS residuals. Serial correlation would not likely bias the coefficients of an OLS regression, but its presence often causes standard errors to be underestimated. This can be addressed by calculating

Newey-West standard errors, lagged to resolve the correlative process. This is not the only method for correcting serial correlation, but it is appropriate for higher-order forms, as is evident in this instance of AR(4). Tables 9 and 10 present the results of each model estimated with Newey-West standard errors. After transformation, each coefficient remains virtually unchanged. The standard errors, however, more closely reflect the significance with which the variables explain the marketings and disappearance.

Table 9. Marketings Parameters with Newey-West Standard Errors

Variable	Corn		Soybeans		Wheat	
	Original	Corrected	Original	Corrected	Original	Corrected
Intercept	27.27* (5.17)	27.27* (6.01)	17.31* (7.68)	17.31** (11.75)	24.61* (4.61)	24.61* (6.63)
E(PD _t)	-1.81 (1.80)	-1.81* (0.86)	-1.69 (1.02)	-1.69 (1.03)	0.42 (0.98)	0.42 (0.88)
D _t ^{On-Farm}	0.17 (0.11)	0.17 (0.12)	0.49* (0.12)	0.49* (0.18)	0.25* (0.08)	0.25* (0.11)
Q _t ²	-4.88* (2.94)	-4.88 (3.78)	-2.51 (6.00)	-2.51 (9.49)	-7.92* (3.66)	-7.92 (5.56)
Q _t ³	-12.43* (3.61)	-12.43* (4.27)	-7.93 (6.35)	-7.93 (9.90)	-6.18* (3.73)	-6.18 (5.50)
Q _t ⁴	-9.59* (3.63)	-9.59* (4.13)	-9.13 (6.60)	-9.13 (9.98)	-11.03* (3.64)	-11.03* (4.83)

Note: * denotes significance at the 0.05 level. ** denotes significance at the 0.10 level.

The Durban-Watson test was used to test for first-degree autocorrelation AR(1), which in this case is autocorrelation precipitating from the immediate previous quarter. All iterations failed to reject a null hypothesis of no serial correlation. Each model, then, likely exhibits AR(1). Because the data are partitioned into quarters, the Breusch-Godfrey test, specified for AR(4), was conducted to test for year-to-year autocorrelation. Corn

marketings are inconclusive. Soybean marketings, on-farm disappearance, and total disappearance reject the null hypothesis of no serial correlation.

Table 10. Disappearance Parameters with Newey-West Standard Errors

Variable	Corn		Soybeans		Wheat	
	Original	Corrected	Original	Corrected	Original	Corrected
Intercept	40.94* (2.90)	40.94* (3.26)	50.62* (3.23)	50.62* (3.28)	44.79* (4.49)	44.79* (5.97)
$E(PD_t)$	0.99 (1.50)	0.99 (1.46)	0.72 (0.75)	0.72 (1.01)	0.88 (1.17)	0.88 (0.69)
M_t	0.12 (0.08)	0.12 (0.08)	0.26* (0.06)	0.26* (0.07)	0.36* (0.11)	0.36* (0.14)
Q_t^2	-20.38* (1.57)	-20.38* (2.13)	-41.23* (2.07)	-41.23* (2.05)	-36.54* (2.82)	-36.54* (3.44)
Q_t^3	-26.48* (1.96)	-26.48* (2.38)	-42.43* (2.44)	-42.43* (2.36)	-38.31* (2.70)	-38.31* (3.39)
Q_t^4	-27.04* (1.82)	-27.04* (1.95)	-43.99* (2.57)	-43.99* (2.51)	-35.28* (3.06)	-35.28* (4.32)

Note: * denotes significance at the 0.05 level.

CHAPTER 5: CONCLUSIONS

The purpose of this research was to provide a framework for analyzing, quantifying, and understanding marketing levels and quarterly stocks, using data from South Dakota corn, soybeans, and wheat. Marketings reflect a transfer of ownership; disappearance levels reflect a change in location. Using aggregated monthly NASS marketing levels to explain changes in stocks levels and disappearance, production was accounted for during harvest quarters.

Marketing levels were expected to be a function of expected intertemporal price differences implied by indicators of carry, basis, and interest cost. Marketings by farmers and disappearance from on-farm stocks are interrelated across crops. Marketings are strongly explained by seasonal patterns, while not by anticipated market signals. Disappearance levels were not significantly explained by changes in price expectations. Disappearance patterns differ from farms and from the system (on-farm and total).

A strong seasonal effect, assessed with quarterly dummy variables, explains marketings and disappearance. This varies by crop, but the evidence of marketing persistence seen by Cunningham, Brorsen, and Anderson (2007) was substantiated by this analysis. The results from this research support the proclivity of a mechanical marketing style over an active style at the state level for South Dakota.

On-farm disappearance is the difference in beginning and ending on-farm stocks plus any harvested bushels. Total disappearance is defined similarly as it also accounts for any harvested bushels. There is a range of potential off-farm disappearance totals. A minimum is the change in off-farm stocks for the quarter. A maximum is the change in

off-farm stocks for the quarter plus on-farm disappearance for the quarter. The lower bound or minimum may also be influenced or modified if cumulative on-farm disappearance exceeds cumulative farmer marketings. The inability to accurately establish the degree of off-farm disappearance makes it an intractable variable to explain.

Farmer-owned stocks in off-farm locations are observed at a high percent of capacity, which has been a lingering concern prior to this study. Future research is necessary to account for the potential simultaneous nature of price expectations, marketings and on-farm disappearance. For example, the level of delayed pricing may affect the bushels delivered, but not classified as marketed.

The high proportion of marketings and disappearance occurring during the harvest quarter is consistent with the conclusions of Lai, Myers, and Hanson (2003), whose assessment of the timing of storage throughout the crop year observed that risk-averse farmers will sell a considerable portion of production right after harvest, unless cash prices are especially low. Harvest-period disappearance is notably concentrated for soybeans and wheat, while corn's market-year allocation is comparatively more constant.

The evidence of persistent marketing strategies follows the results of Kastens and Dhuyvetter (1999), who observed that producers assess a variety of indicators, subject to time and knowledge constraints and convenience. Many producers are responsible for every aspect of their farm's operation, and do not find it advantageous to exhaust finite time and resources selecting multiple occasions to market annually-produced crops. Risk premiums, as a supplement to storage theory, are another explanation for departure from technical trading.

This research helps to better explain the effect that basis and carry, through differences in expected price, have on farmer marketings and stocks disappearance at various levels. This will help market participants plan for the future and may reduce stress on market infrastructure during years of high production. These results will help producers, merchandisers, and end-users better manage production and old crop stored at any given point in time. The analysis helps explain the timing of sales and transportation needs and will increase understanding of the regional supply system.

There are several ways to extend or amplify this research. This analysis drew from aggregated publicly-available data. While the sources represent reliable, expedient data, there are limitations. More complete implications could be drawn from further information. Data were accumulated across many farms and local markets for three-month observations. It is likely that explanatory power may be concealed by aggregation, but the availability and scope of the parameters and observations are subject to cost effectiveness and confidentiality. The practicality of improved measurement should be weighed against its potential benefits.

The data and analysis in this research are a result of conditions unique to South Dakota production and utilization. It is likely that significant differences could be found in assessing other states, especially in those regions closest to central agricultural markets and export hubs. Other inconsistencies would be expected from differences in storage configuration and proximity to major transportation depots.

Future applications might also consider the evolution of commodity marketing strategies, and the growing use of contracts and deferred pricing mechanisms. Extended

state-level data would better explain the relationship between marketing performance and stocks disappearance. Additional exploration of inter-state stocks movement would improve understanding of temporal and spatial storage needs.

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