FACTORS AFFECTING THE ANNUAL UNIT SALES VOLUME OF COMBINES IN THE UNITED STATES

by

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ABSTRACT

In the United States, accurately predicting the agricultural industry's future demand for new farm machinery is a complicated, challenging and ever-changing issue. To compound the matter; as the size of large farm machinery continues to increase, the annualized sales volume is decreasing over time. This thesis also finds that recent mandates applicable to the Environmental Protection Agency (EPA) diesel engine emission compliance and the Internal Revenue Service (IRS) Section 179 tax code may help with forecasting the demand for farm machinery on an annual basis.

This thesis evaluates factors that affect the annual unit demand of combines in the United States. Due to the lack of published literature on this specific topic, a survey of John Deere dealership sales professionals who have had recent experience selling new combines to farmers was used. This perspective brings to light factors that impact industry demand for new combines. This study results in an empirical regression model with independent variables based on the survey results. A thorough understanding of the independent variables can aid in predicting the future demand for combines.

This work indicates that forty years of historical data proves to provide enough variability such that statistically significant variables are identified to accurately predict future sales. Statistically significant factors that affect the annual unit sales volume of combines in the United States include: Interest Rate, Net Cash Income, IRS Section 179 Tax Code, Planted Acres and Combine Capacity. Future industry demand is predicted by applying forecasted estimates to the model's applicable independent variables.

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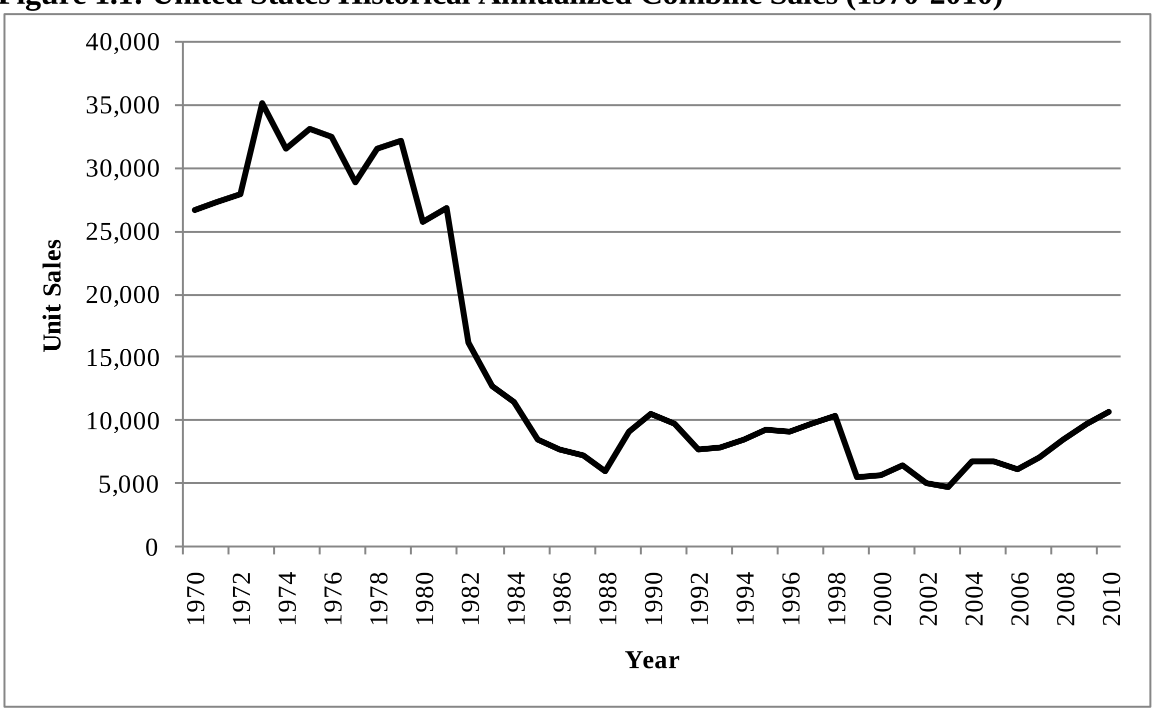
CHAPTER I: INTRODUCTION

The intent of this thesis is to explain the factors affecting the unit sales volume of combines in the United States on an annual basis. Mechanized grain harvesting began in the United States around the early 1930s with pull-type harvesters towed behind tractors. By the late 1930s, self-propelled grain harvesters were developed and their popularity significantly grew after World War II. Since 1970, the annual United States industry combine sales volume has been tracked by the Agriculture Equipment Manufacturers (AEM) organization. Interestingly, Combine sales are cyclic with a downward trend, resulting in fewer combines being sold over time. Figure 1.1 is a graphical representation of the United States historical annualized industry combine sales from the Agriculture Equipment Manufacturers organization.

Figure 1.1: United States Historical Annualized Combine Sales (1970-2010)



Source: AEM

1.1 Thesis Objective

Given the drastic reduction in annual combine sales over time (post-1980s) in the United States, an understanding of how combine sales are expected to trend in the future is of significant importance from an agriculture equipment manufacturer's perspective. Consequently, the objective of this thesis is to formulate a regression model that is able to estimate future annual industry sales of combines. An explanation of the factors that affect combine sales on an annual basis will ultimately lead to the applicable independent variables of a valid model. Finally, a predicted estimate of combine sales in future years will be outlined based off historical data. The justification for this thesis topic stems from the fact that machinery manufacturers strive to accurately and consistently estimate the industry combine sales with a high degree of confidence. Any manufacturer that underestimates industry volume risks losing market share if production constraints (material requirements, supplier lead times, production workforce, etc.) cannot react quickly enough to marketplace dynamics.

1.2 Thesis Organization

Within the content of this thesis, a literature review will highlight previous and documented information that may help to explain the factors that contribute to farm machinery sales in the United States. To bring a current perspective into the discussion of this thesis topic, a survey methodology was developed. The survey was used as a determinant to aid in defining the independent variables for the regression model. Once a thorough explanation of the independent variables is complete, regression model will be estimated and explained. A final summary will include predicting future industry demand.

CHAPTER II: LITERATURE REVIEW

There is little recent published literature to support the theory, economics or factors related to creating a regression model to forecast aggregate farm machinery sales in the United States. For this thesis specifically, there was no literature discovered to support forecasting of combine sales in the United States. In the mid to late 1990s, the United States Department of Agriculture (USDA) Economic Research Service (ERS) published information related to farm machinery sales. While the publication is roughly fifteen years old, ERS' fundamental economic theory may still apply in today's terms. The USDA noted that tractor and combine sales are indicators of the general machinery economy (USDA, Agricultural Handbook No. 712 (AH712) July 1997).

USDA ERS outlined fourteen factors affecting demand for farm machinery: Agriculture Exports, Cash Receipts, Debt-Asset Ratio, Equity, Farm Business Debt, Farm Machinery Loan Rate, Idled Acres, Interest Expenses, Net Cash Income, Net Farm Income, Non-real Estate Assets, Real Estate Assets, Real Prime Rate and Total Production Expenses (USDA, Agriculture Handbook No. 705 (AH705) December 1994). Interestingly, of those fourteen factors noted, Cash Receipts and Net Farm Income were identified as the only two factors with "high" correlation to machinery purchases. Cash Receipts correlate closely with purchases of farm machinery. Net Farm Income (gross cash income, non-money income, and inventory adjustments minus total production expenses) has a high correlation with machinery purchases when purchases are lagged several months. Although the USDA information sheds some light on this thesis topic, the detailed statistics from the USDA regression models were not available for further analysis. Due to the limited availability of information related to this specific thesis topic, other more recent factors contributing to the annual demand for combine sales in the United States will be discussed in this thesis.

CHAPTER III: THEORY

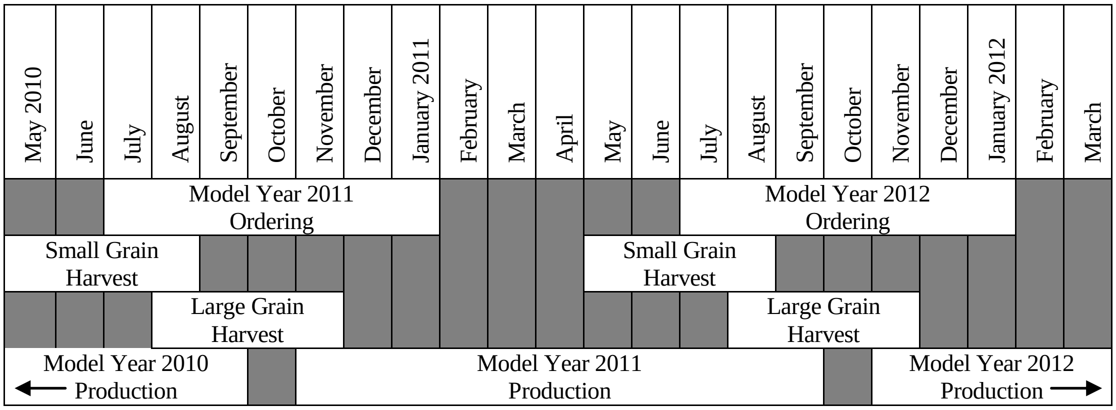
3.1 United States Harvest Overview

In the United States, crops that are destined to be harvested with a combine typically are harvested across seven of the twelve calendar months. Harvest starts in south Texas beginning in May with the harvesting of small grains. The small grains harvest (wheat, barley, oats, etc.) transitions north through the Northern Plains ending around late August. Large grains harvest (rice, corn, soybeans, etc.) typically starts in south Texas in early August and transitions north through the Red River Valley and Corn Belt, traditionally ending around late November.

Due to the seasonality of the harvest windows, combine manufacturers must align their production schedules to meet farmer demand. As a result, the customer ordering period for new combines is similar among manufacturers. A farmer ordering a new combine expects that the machine will be available before the next season's harvest. Consequently, the ordering of combines typically begins in early July and ends in late January.

Combine production typically begins in November during the later stage of the combine ordering period. A simplified, graphical timeline provides further clarification related to combine ordering versus harvesting versus production (Figure 3.1). It is important to note that ordering starts two months before the small grain harvest ends and ordering ends two months after large grain harvest ends. This ordering strategy ensures that producers in all harvest regions of the United States have time to make a combine purchase decision, after their harvest activities are more or less complete.

Figure 3.1: Timeline: Combine Ordering vs. Harvest vs. Production



3.2 Historical Overview of Combine Sales

Historical sales of combines in the United States are quite cyclical, but the question remains; "What factors are driving these cyclical sales, which are also trending downward overtime?" That question is the crux of this thesis. The objective is to create a regression model that helps answer this fundamental question. Combine manufacturers continue to improve combine harvesting efficiency. Precision farming and GPS aided auto-steering technology is becoming mainstreamed by many farmers. Given ideal harvest conditions, a high capacity combine, right-sized grain handling equipment and a high yielding crop field; it is not uncommon for one combine to deliver more than 5,000 bushels of harvested grain per hour. The size and capacity of new combines continues to increase, resulting in fewer overall sales over time. Further complicating this topic is that at the macro level in the United States, farms continue to consolidate which results in fewer producers buying fewer machines. This phenomenon or trend suggests that larger machines and improved grain handling will be needed to meet the traditional harvesting windows, assuming that minimal acres will be incrementally lost or added to the overall United States farm production output.

Little published information was found identifying the contributing factors that drive producers to purchase combines in a given year. As discussed above, the USDA article indicated that Cash Receipts and Net Farm Income correlate closely with purchases of farm machinery. To further examine the contributing factors affecting demand for farm machinery, a survey was created and distributed to John Deere sales professionals. The survey details are outlined in the methods section of this thesis. Survey results were compiled to help determine the current factors affecting the cyclic nature of combine sales with a downward trend.

Personal experience would suggest that United States annualized combine sales are determined as follows: $\textit{Combine Sales} = f\,(\beta_{EPA},\ \beta_{INT},\ \beta_{INC},\ \beta_{TECH},\ \beta_{IRS},\ \beta_{CASH},\ \beta_{ACRE},\ \beta_{TRD},\ \beta_{FUT},\ \beta_{INF},\ \beta_{ROLL},\ \beta_{WEAR}).$ (1)

Table 3.1 further outlines this theoretical model.

Table 3.1: Theoretical Combine Sales Model Coefficients

Coefficient	Description	Expected Sign
$\boldsymbol{\beta}_{\mathbf{EPA}}$	EPA Emissions	Positive
$\boldsymbol{\beta}_{\mathbf{INT}}$	Interest Rate	Negative
$\boldsymbol{\beta}_{\mathbf{INC}}$	Incentives	Positive
$\boldsymbol{\beta}_{\mathbf{TECH}}$	Technology / Capacity Index	Negative
$\boldsymbol{\beta}_{\mathbf{IRS}}$	IRS Section 179 Tax Code Availability	Positive
$\boldsymbol{\beta}_{\mathbf{CASH}}$	Cash Receipts	Positive
$\boldsymbol{\beta}_{\mathbf{ACRE}}$	Harvestable Planted Acres	Positive
$\boldsymbol{\beta}_{\mathbf{TRD}}$	Machinery Trade-In Availability	Positive
$\boldsymbol{\beta}_{\mathbf{FUT}}$	Futures Commodity Pricing	Positive
$\boldsymbol{\beta}_{\mathbf{INF}}$	Inflation / Price Increase	Positive
$\boldsymbol{\beta}_{\mathbf{ROLL}}$	Roll Pattern	Positive
$\boldsymbol{\beta}_{\mathbf{WEAR}}$	Combine Wear	Positive

EPA Emissions: Beginning January 1, 1996 the United States Environmental Protection Agency (EPA) implemented a mandate applicable to all off-road compression ignition (diesel) engines within all horsepower ranges (United States Environmental Protection Agency 1996). Over time, the mandate has progressively become more stringent, reducing the amount of emissions from diesel engines (Table 3.2). While these mandates have reduced diesel engine emissions over time, they typically end up adding more complexity and cost to the overall equipment purchase for the end-user (i.e. farmer). Experience would suggest that combine sales are increased when customers want to purchase current engine technology before it is no longer available as opposed to a new mandate requiring more expensive engine technology. Table 3.2 provides a summary of the EPA engine emission mandates and the resulting reduction in emission standards (tiers) over time.

Table 3.2: EPA Emission Standards Overview

Engine Power	Tier	Mandate Year	Nitrogen Oxide (g/kW-hr)	Hydrocarbon (g/kW-hr)	Nitrogen Oxide + Hydrocarbon (g/kW-hr)	Carbon Monoxide (g/kW-hr)	Particulate Matter (g/kW-hr)
$225 \leq kW \leq 450$ ($300 \leq HP \leq 600$)	1	1996	9.20	1.30	-	11.40	0.54
	2	2001	-	-	6.40	3.50	0.20
	3	2006	-	-	4.00	3.50	0.20
	4 (Interim)	2011	2.00	0.19	-	3.50	0.02
	4 (Final)	2014	0.40	0.19	-	3.50	0.02

Source: EPA 1996

Interest Rates: New combines are expensive assets (>$250,000 list price) and are used only on a seasonal basis to harvest crops. Experience would suggest that sales are higher when customers have access to attractive (lower) interest rates.

Incentives: Different from interest rates, incentives include use-season waivers or retail bonus discounts in lieu of financing. Multi-unit discounts (MUDs) are offered by most agricultural equipment manufacturers as a means to provide customers with larger discounts when they purchase several pieces of new farm machinery at one time. Increased sales occur when customers have access to financial incentives.

Technology / Capacity Index: Customers expect more from new combines. This is sometimes referred to as customers wanting the "latest and greatest technology." When new, updated combines are introduced into the marketplace, they typically feature improved capacity, better efficiency, better uptime and lower operating costs. Experience would suggest decreased combine sales occur when new technology or greater capacity is increased. This often is not continuous in that new model introductions over time often integrate further advancements in technology.

IRS Section 179: The United States Internal Revenue Service (IRS) implemented the Section 179 tax code in 2002 that allowed businesses (i.e. farm operations) to deduct all or a portion of the full purchase price of qualifying assets (i.e. new combine) purchased or financed during the tax year (United State Internal Revenue Service 2011). Experience would suggest increased combine sales occur for the years when the Section 179 maximum allowable tax deduction is higher.

Cash Receipts: When farmers generate higher net cash income, experience suggests an increase in new combine sales result. The crop is more valuable; therefore, more productive and efficient combines result in faster harvest with less yield loss. This creates more value in a new, higher-capacity harvester.

Acres: Experience suggests that an increase in new combine sales occur when there is an increase in harvestable planted acres occurs. The United States farm production acreage mix changes every year. One example could be a reduction in planted cotton acres resulting in a subsequent increase in planted corn or soybean acres. Because cotton is not harvested with a combine and corn or soybeans are harvested with a combine, additional combines would be needed to support this increase in harvestable planted acres.

Trade-In: Experience suggests new combine sales occur when customers are allowed the availability to trade-in a used combine at an agricultural equipment dealership. Used, late-model combines are quite expensive assets and while customers would want fair market value for their used combine, many farmers typically allow an agricultural equipment dealer to take the used combine at an agreed upon trade price. The customer is able to offload the financial carrying cost of the used asset (i.e. combine) by letting the dealer take in the trade and manage the used equipment marketing.

Futures Commodity Pricing: Farmers have the option to market their commodities in various ways. One way that farmers can market commodities is by contracting or locking-in an agreed upon amount of crop (i.e. bushels) at an agreed upon future price. The future price allows customers to purchase a new combine, knowing that a portion of their to-be-harvested crop is guaranteed at a fixed price. In addition, when futures prices are higher than current cash prices, there is an expectation of higher future profitability. This factor assumes that the crop is delivered and meets the futures contract obligation.

Price Increase / Inflation: Agricultural equipment manufacturers tend to increase the sales price of their equipment overtime. These price increases can occur annually at the start of a new model year and/or on an interim basis during a given model year of production. A manufacturer's price increase justification could range from inflationary reasoning, to a direct input material cost increase (i.e. steel or rubber), or due to new combine value such as technology or capacity enhancements resulting from a new model year introduction. It is plausible to suggest that an increase in new combine sales would be expected when customers try to hedge against the timing of a manufacturer's price increase. This customer behavior would result in them saving money on the purchase of a new combine.

Roll Pattern: Some customers are "conditioned into a roll pattern" with new equipment purchases. The frequency of the roll pattern can vary not only by customer, but by quantities of equipment. For example, if a farmer in year one purchases a new tractor. In year two, the same farmer purchases a new self-propelled sprayer and in year three that same farmer purchases a new combine. In year four, the farmer trades-in his three-year old used tractor and updates to a new tractor. In year five, the farmer trades-in his used three-year old sprayer and updates to a new sprayer. In year six, the farmer trades-in his used three-year old combine and updates to a new combine. It must be understood that the complexity of roll patterns (frequency and quantities of equipment) can be different for each farmer. To further complicate this concept, some agricultural equipment manufacturers offer multi-unit discounts (MUDs) to entice customers to purchase more than one piece of new farm machinery. MUDs and new equipment availability can also play into the frequency and/or number of pieces of equipment that a customer may roll in any given year; regardless of historical roll pattern. Experience would suggest that an increase in new combine sales would occur when a customer purchases and rolls new equipment on a more frequent basis.

High Combine Wear: Some customers use combines more intensively than others. This factor includes high engine/separator hours, or harvesting a high amount of bushels of crop on an annual basis. Experience would suggest an increase in new combine sales would occur when farmers would rather trade-in used combines with high wear, as opposed to keeping and reconditioning used machines.

CHAPTER IV: METHODS

4.1 Objective

The objective of this thesis is to create an empirical regression model to determine what factors are statistically significant in predicting the annual industry unit sales volume of combines in the United States. The output of the regression model could be used as an input into the overall combine demand estimate process at John Deere Company, which defines the production planning activities at the combine factory.

4.2 Survey

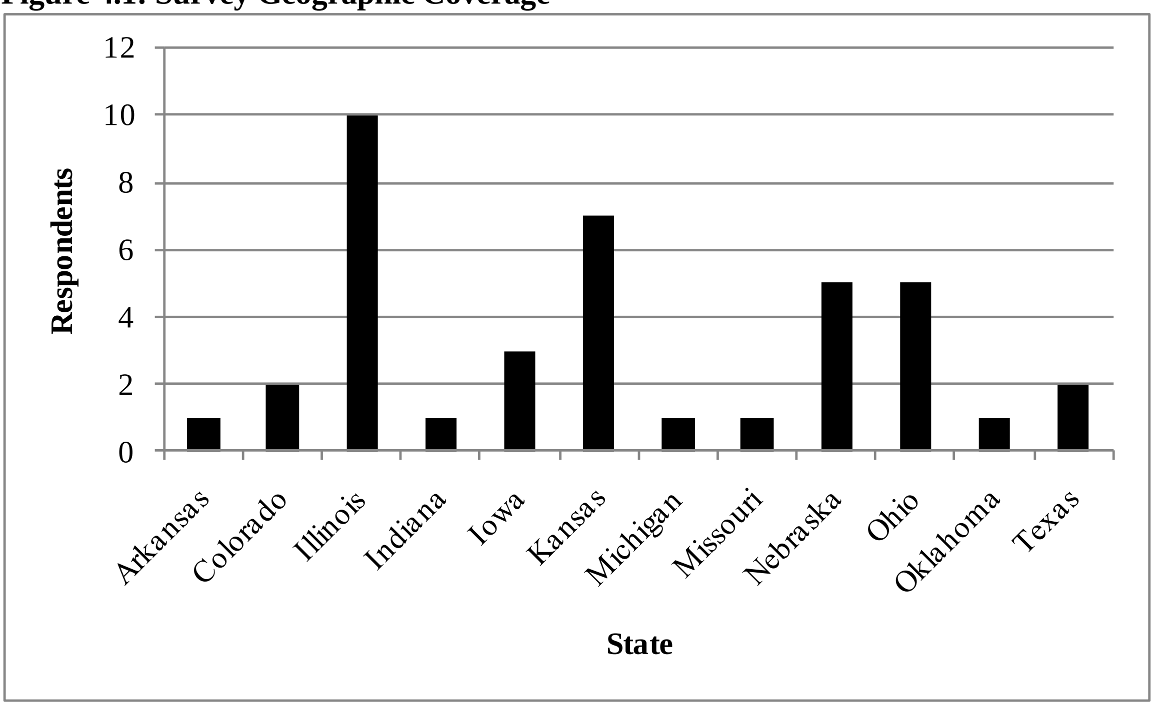
No recent literature was discovered to help baseline the analysis of determining what factors or independent variables could be applied to generate a credible regression model. A survey was developed to gain a better perspective on what variables to consider.

The target audience for this survey was John Deere agriculture dealership sales professionals who have proven experience selling new combines to farmers. Because dealership sales professionals typically tend to have relationships with their customers who purchase combines, it was determined that their perspective would be important to identify the factors that they felt influence their customers decisions to purchase new combines. John Deere Company Territory Managers, who support dealers in the Midwest and Corn Belt regions, were identified to solicit survey responses from sales professionals whom they felt were appropriate and willing to complete the task. From December 22, 2010 to January 15, 2011, a five-question survey was completed by 33 sales professionals. The purpose of the survey was to identify where salesmen were selling new combines, understand their years of experience, capture how many new combines they sell on an annual basis, prioritize five key factors they felt most affect customer demand and allow them an opportunity to comment on any excluded factors affecting the sales of new combines.

4.2.1 Survey Geographic Coverage

The first question asked: *"Select which state(s) that you typically advise customers on the purchase of a NEW combine(s)."* The intent of the first question in the survey was to gain a general understanding of the geographical makeup of the respondents. The survey allowed respondents to identify more than one state where they advise customers on the purchase of new combines. The geographic coverage of the survey (Figure 4.1) resulted in a good mix of small grains harvesting regions (Texas, Kansas, Colorado, etc.) and large grain harvesting regions (Nebraska, Iowa, Illinois, etc.). The survey results for question number one can be found in the Appendix (A.3, A.4).

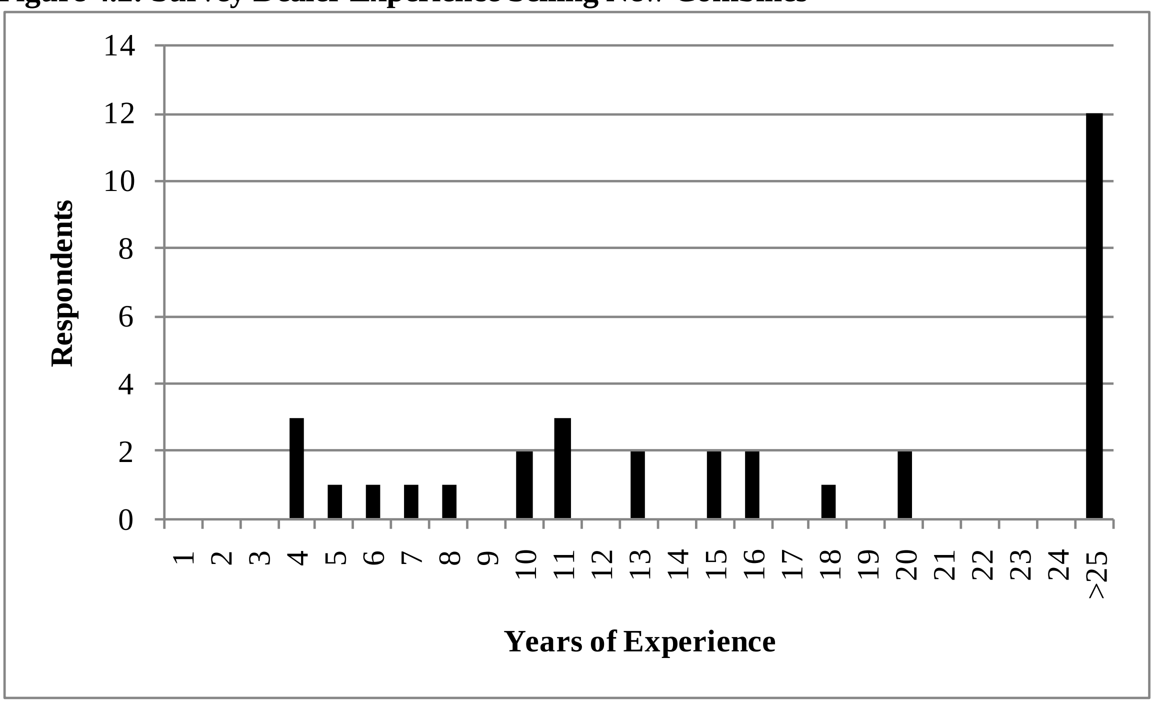
Figure 4.1: Survey Geographic Coverage



4.2.2 Survey Dealer Experience Selling New Combines

The second question asked: *"How many years have you been involved with the sales and marketing of NEW combines to end-user producer customers?"* The intent of the second question in the survey was to gain a general understanding of the respondents' sales experience (years) selling new combines to farmers. The mean experience level was 16.27 years with a standard deviation of 7.85 (Figure 4.2). In general, there was a credible amount of experience selling new combines to farmers. The survey results for question number two can be found in the Appendix (A.5).

Figure 4.2: Survey Dealer Experience Selling New Combines

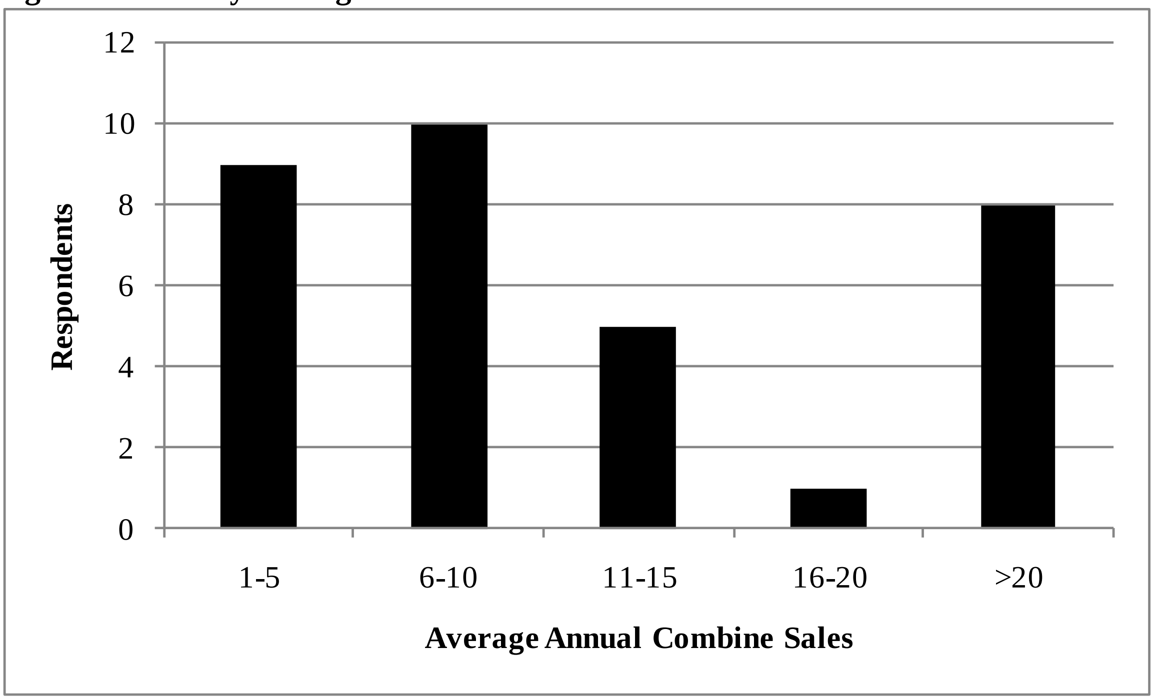


4.2.3 Survey Average Annual Combine Sales

The third question asked: *"On average, what quantity of NEW combines do you typically sell in a given calendar year?"* The intent of the third question in the survey was to gain an understanding of the respondents' average annual sales volume (units) of new combines. Fifty-eight percent of the respondents sell an average of 1-10 new combines per year

(Figure 4.3). Eighteen percent of the respondents sell 11-20 new combines on average per year. Twenty-four percent of the respondents sell more than 20 new combines on average per year. In general, there was a credible amount of new combines sold on an average, annual basis to farmers. The survey results for question number three can be found in the Appendix (A.6, A.7).

Figure 4.3: Survey Average Annual Combine Sales



4.2.4 Survey Factors Affecting Farmer Purchases

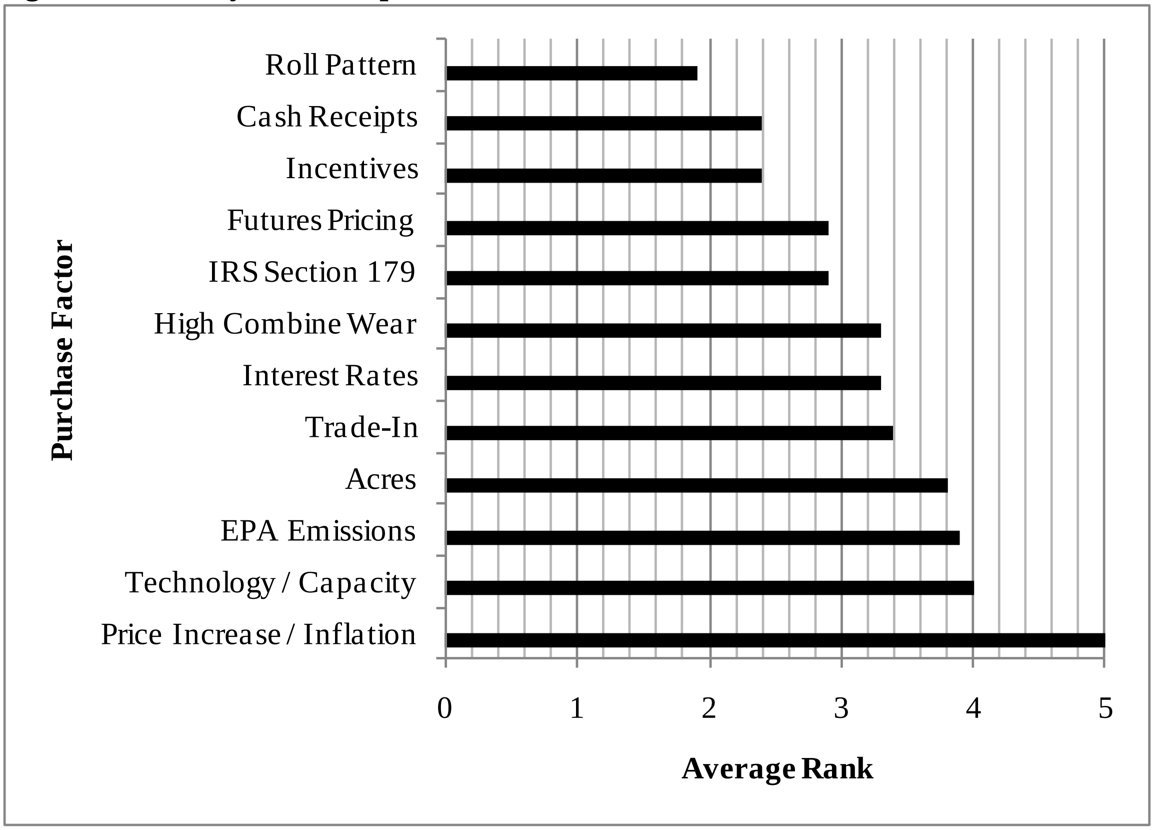
The dealers were asked in question four to rate the most likely factors affecting farmer purchases (Table 4.1): *"Please read through the entire list of options and rank the Top 5 factors that you feel most affects customer demand for NEW combine sales in a given year. When ranking your Top 5 selections; 1 would be the highest or most likely factor within your Top 5 rankings."* The intent of the fourth question in the survey was to gain an understanding of what factors the respondents felt contributed to the overall sales of new industry combines. Based purely on the respondents rankings; Roll Pattern, Cash Receipts, Incentives, Futures Pricing and IRS Section 179 tax code were identified as the Top 5 ranked factors (Figure 4.4). The survey results for question number four can be found in the Appendix (A.8, A.9).

Table 4.1: Survey Factors Affecting Farmer Purchases

Rank (1-5)	**Purchase Decision Factors**
-	Customer desires to buy a new combine with current production engine emission technology (i.e. Tier 3 engine emissions), prior to an upcoming **EPA engine emission** technology update (i.e. Interim Tier 4 engine emissions).
-	Customer has access to attractive **interest rates**.
-	Customer has access to **incentive** options (use-season waiver or cash discount in lieu of financing).
-	Customer desires the "latest and greatest **technology / capacity**" and wants to purchase a new combine that is introduced into the marketplace which is more productive, more efficient and has lower operating costs over the current production combines.
-	Customer can utilize the **IRS Section 179** Tax Deduction (United States tax code that allows businesses to deduct all or a portion of the full purchase price of qualifying equipment that is purchased or financed during the tax year).
-	Customer has "cash in his pocket" otherwise known as **cash receipts**, less expenses (the sales of all crop and livestock commodities, less operating expenses; this would factor in yield and cash price received for commodities).
-	Planted **acres** (an increase in a customer's planted acres, results in an increase in acres required to harvest, triggering the purchase of a new combine).

-	Customer can **trade-in** a used combine (selling dealer is willing to take a customer's used combine into inventory on trade; a new combine sale consequently results).
-	Customer's ability to lock-in commodity **futures pricing** (if a customer is able to lock-in a desirable commodity price, the producer is more likely to purchase a new combine).
-	The producer is concerned with **price increase / inflation** on a new combine (triggers a producer to step-up and purchase a new combine as opposed to delaying a purchase).
-	A customer's "**roll pattern**" or "roll cycle" dictates a new combine purchase (customer is conditioned to a traditional roll pattern, or roll cycle with his equipment fleet and strives to take advantage of a Multi-Unit Discounts or "MUDs").
-	High yields, **high combine wear** or high annual usage (a producer would rather trade into a new combine as opposed to re-condition his current late model combine).

Figure 4.4: Survey Initial Top 5 Ranked Factors



4.2.5 Survey Excluded Factors

The fifth question probed for factors that may have been deemed excluded from the ranking activity: *"If you felt as though an important factor was excluded in the ranking order of Question #4, please feel free to provide another factor. Please state approximately where the excluded factor would rank in your Top 5 selections."* The intent of this survey question was to allow respondents an opportunity to comment on what other factors or variables may have been unintentionally excluded from the options of purchase decision factors (Table 4.2). For future consideration and based off the feedback from the survey comments, a factor could be included that identifies a customer purchasing a new combine related to keeping the machine in warranty to reduce the amount of downtime and/or repair expenses. Another consideration would be including a factor that compensates for new combine sales based off customers trying to manage their combine operating expenses at a threshold within reason (i.e. defined cost per year basis).

Table 4.2: Survey Excluded Factors Comments

I think pure economic conditions spur combine sales in our region. Farming has been quite profitable over the last several years. Lack of custom cutters to do both wheat harvest and fall harvest. When cropping practices in Western Kansas were primarily wheat, many customers did not own combines. Now that our crop rotations include as many fall acres and summer acres, customers are forced to own their own machines.
Customers roll combines to keep machines under warranty and minimize down time at harvest. With new combines, customers know what their operating costs are up front. A three year old combine does not guarantee a customer minimized down time.
Some of our customers will trade based on ego! Their neighbor traded for a new combine so they think they need a new combine. I would say this would rank #6, but could be #5 in any given year! I based this on an average as I would have put current engine emissions as a Top 5 but did not think that would be figuring in the average given year!
I have a few customers on a 5 year, 10 year, etc. trade cycle to keep everything current. Also, a depreciation schedule is a key factor.
Customer wishes to always have his combine in factory warranty; Rank #3.
I feel the #1 ranking should be a customer trades his combine annually to avoid high costly repairs. If the customer would buy a new combine every year, all of his repairs would be performed while the machine is under warranty thus eliminating the costly up keep expense.
It’s cheap per acre cost and no repair expense. No down time is also a factor.
As I indicated above, the most important reason for a new purchase is timing. Most customers keep a machine a set number of years or hours. The other factors can alter that purchase (size of machine, cash or finance, amount of technology options, etc.) but rarely stop it from happening.
Most customers purchasing new combines know there is a “cost per year” of owning a machine.

We work with each of them to keep them current on their equipment fleet and trade at the point when it is a good value for them and for us as a dealership to offer them the best trade figure on their machine.
Stability of used equipment prices lead to new combine sales as customers can trade annually for a similar number locking in the cost/acres. This might be an additional explanation to customer can trade-in used combine.

4.3 Survey Results Analysis

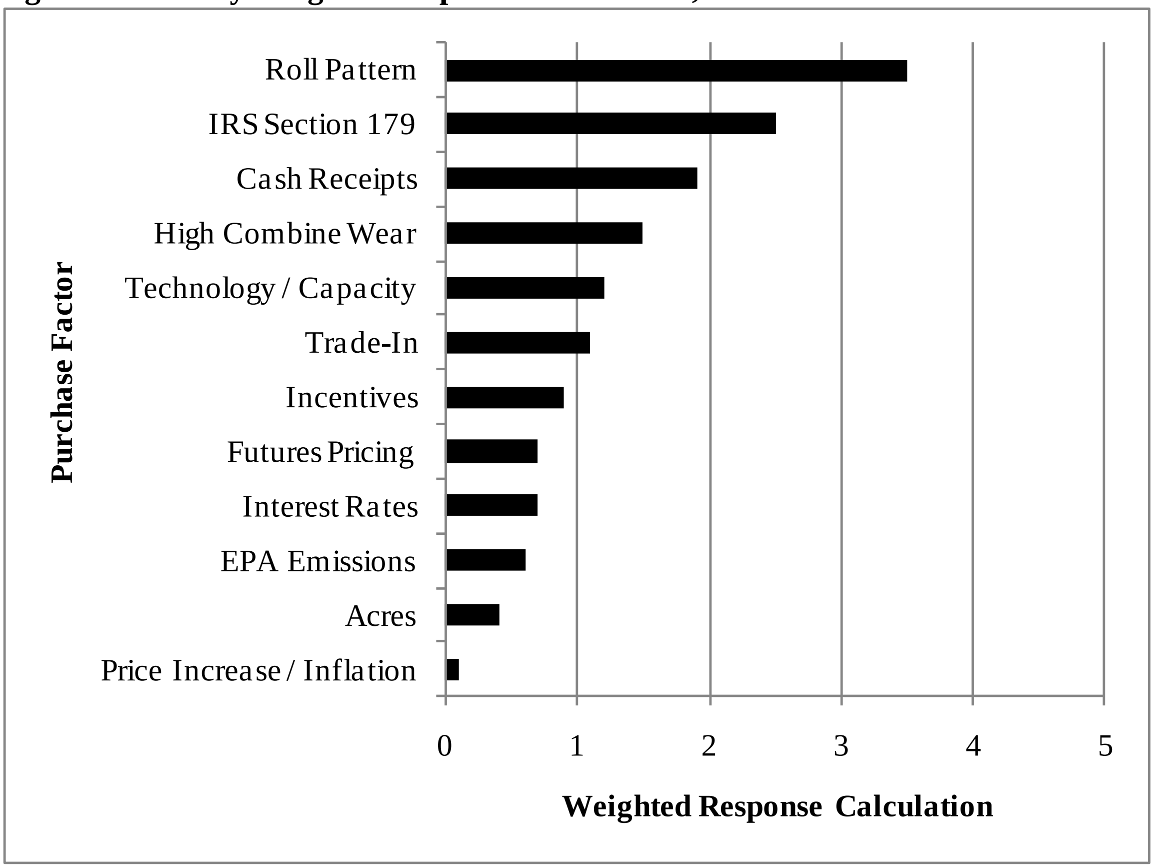
The critical information that was extracted from the survey relates to the ranking of factors outlined in question four. While respondents were asked to prioritize their Top 5 factors (1 being the highest), a methodology to factor-in the ***number of responses per factor*** was needed to bring additional clarity to the data collected. The methodology used to prioritize the responses is as follows:

> First, the respondent rankings were reversed. Each respondent's initial rankings of 1 to 5, 1 being the highest priority; were flipped so that 5 was the highest priority and 1 was the lowest priority. Secondly, the reversed average rank for each factor was calculated. Lastly, for each purchase decision factor in survey question number four, a weighted response was calculated as follows: $Weighted\ Response\ Calculation = Reversed\ Average\ Rank \times \left(\frac{Count\ of\ Responses\ per\ Factor}{Total\ Survey\ Respondants}\right).$ (2)

A graphical representation of the weighted responses, sorted from high to low can be found in Figure 4.5. The calculations for each survey participant are in the Appendix (A.10, A.11).

Perhaps the most intriguing result from the survey is that roll pattern was identified as the most highly ranked (weighted) factor in new combine purchase decisions. This is intriguing because it also is the most complex and difficult variable to measure due to the complexity of roll patterns (frequency and quantities of equipment) and how roll patterns can be different for each farmer. Furthermore, roll patterns can vary overtime based off new equipment availability and incentives.

Figure 4.5: Survey Weighted Response Calculations, Sorted



Once the weighted response was calculated for each purchase decision factor, a determination was made as to whether the factor could be reliably measured. For a factor to be considered reliably measureable, the data needed to be credibly or consistently available from 1970-2010. Additionally, the data needed to be available for all AEM reported United

States industry combine sales. The earliest year identified in the overall analysis was 1970, since it was the earliest sales data point tracked by AEM. If the factor was deemed measureable, it was used in the regression model as an independent variable. A summary table is provided that ranks the weighted responses for all of the purchase decision factors and indicates whether or not the purchase decision factor was deemed reliably measurable (Table 4.3).

Table 4.3: Survey Measurable Reverse Ranked Factors

Purchase Decision Factor	Weighted Response	Reliably Measureable
Roll Pattern	3.5	No
IRS Section 179	2.5	Yes
Net Cash Income	1.9	Yes
High Combine Wear	1.5	No
Technology / Capacity Index	1.2	Yes
Trade-In	1.1	No
Incentives	0.9	No
Interest Rate	0.7	Yes
Futures Pricing	0.7	No
EPA Emissions	0.6	Yes
Acres	0.4	Yes
Price Increase / Inflation	0.1	No

4.4 Regression Model Variables

Upon completion of the survey analysis, the following variables were used in the regression modeling: IRS Section 179 Tax Code, Net Cash Income, Technology / Capacity Index, Interest Rate, EPA Emissions and Acres. Furthermore, it was determined that the regression model performed best using 1970 through 2010 data (n=41) because all independent variable coefficient signs responded as expected, with five out of the six variables indicating statistical significance. Additional regression modeling was estimated for the sub-period 1970 through 1986 (n=17) and for the sub-period 1987 through 2010 (n=24). These two sub-periods factor in or factor out the general United States agriculture economy depression that ended around 1986.

4.5 Dependent Variable

4.5.1 Combines Sales

Historical industry combine sales were collected from the Association of Equipment Manufacturers (AEM). John Deere Company, along with other major combine manufacturing competitors in the United States voluntarily report combine sales to a third party; AEM. Manufacturers who report sales to AEM, gain access or visibility to reported industry sales. "Total industry sales" are defined only by those manufacturers choosing to report sales (Table 4.4). Manufacturers not reporting sales to AEM were not captured in the historical industry sales data.

Table 4.4: AEM Companies Reporting Combine Sales in United States

AGCO Corporation
Case IH
Deere & Company
New Holland

Source: AEM

Historical combine sales data were extracted from the following AEM database (Table 4.5):

Table 4.5: AEM Sales History Database

Geography:	United States
Report Type:	Model Summary x Year (Units)
Product:	Long-Term History Products
Product Subset:	Combines
Time Period:	1970 – 2010 (Calendar Year)

4.6 Measurement of Independent Variables

4.6.1 IRS Section 179 Tax Code

Since 2002, the United States Internal Revenue Service (IRS) Section 179 Tax Code Deduction has been available for farmers to use in their business operations (Section179.org 2011). This tax deduction dollar amount has continued to increase overtime, since its inception (Table 4.6). A qualifying taxpayer can choose to treat the cost of certain property (i.e. purchase of a new combine) as an expense and deduct it in the year the property is placed into service; up to the maximum allowable amount. This tax code expands the traditional farm machinery depreciation schedule. Experience would suggest that farmers would rather spend their income on farm assets (i.e. new combines) as opposed to paying tax on their income. For that reason, it is expected that the years when the Section 179 Tax Code is higher for farmers, a positive correlation would exist for new combine sales.

Table 4.6: Historical IRS Section 179 Tax Code Deductions

Tax Year	IRS Section 179 Maximum Federal Allowable Deduction
2002	$24,000
2003	$100,000
2004	$102,000
2005	$105,000
2006	$108,000
2007	$125,000
2008	$250,000
2009	$250,000
2010	$500,000

Source: IRS 2011

4.6.2 Net Cash Income

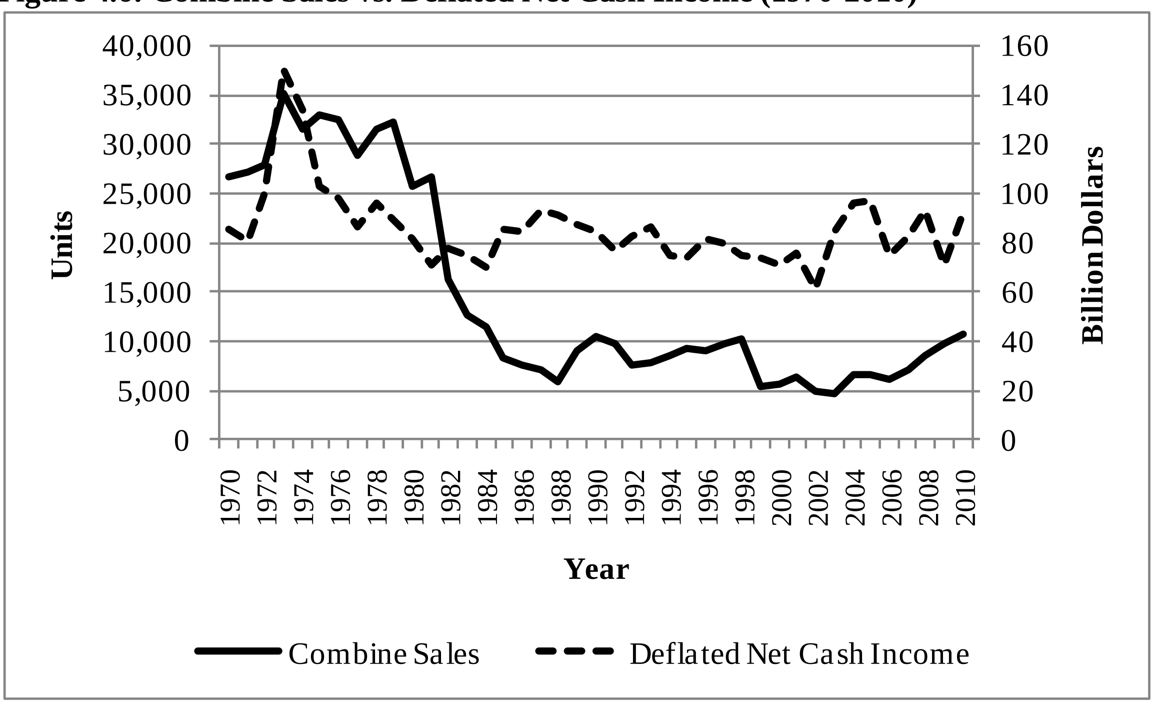
Data pertaining to net cash income were collected from the United States Department of Agriculture (USDA) for the time period 1970-2010 (USDA, Farm Income Data Files 2011). Net cash income is believed to be positively correlated to the purchase of agricultural equipment. If farmers have an increase in net cash income, an increase in the amount of industry combine sales would be expected.

To compensate for inflation overtime, the USDA net cash income figures were deflated using the Personal Consumption Expenditures (PCE) Index with 2010 used as the base year:

$$\textit{Deflated USDA Net Cash Income} = \left(\frac{\textit{Current Year USDA Net Cash Income}}{\textit{Current Year PCE Index}}\right) \times \textit{Year 2010 PCE.} \quad (3)$$

Data for the calculated deflated USDA net cash income can be found in the Appendix (A.12). Figure 4.6 graphs U.S. combine sales (left axis) versus annual deflated net cash income (right axis). Generally, they move in the same direction.

Figure 4.6: Combine Sales vs. Deflated Net Cash Income (1970-2010)



4.6.3 Technology / Capacity Index

The technology or capacity index data were collected from the Association of Equipment Manufacturers (AEM) database. Not only does AEM track the industry sales by year, but they capture and track the sales history by size of combines sold. The sales history was tracked and analyzed across six size segments - kilowatt (kW) (Table 4.7).

Once the annual sales history (1970 – 2010) was collected for the six corresponding segment sizes, the proportional sales mix distribution was calculated for each year.

An aggregated technology or capacity index was created for each year. Each class size (kW) was categorized using the midpoint within each of the six size segment ranges (Table 4.7).

A capacity index (CI) was calculated on an annual basis as follows:

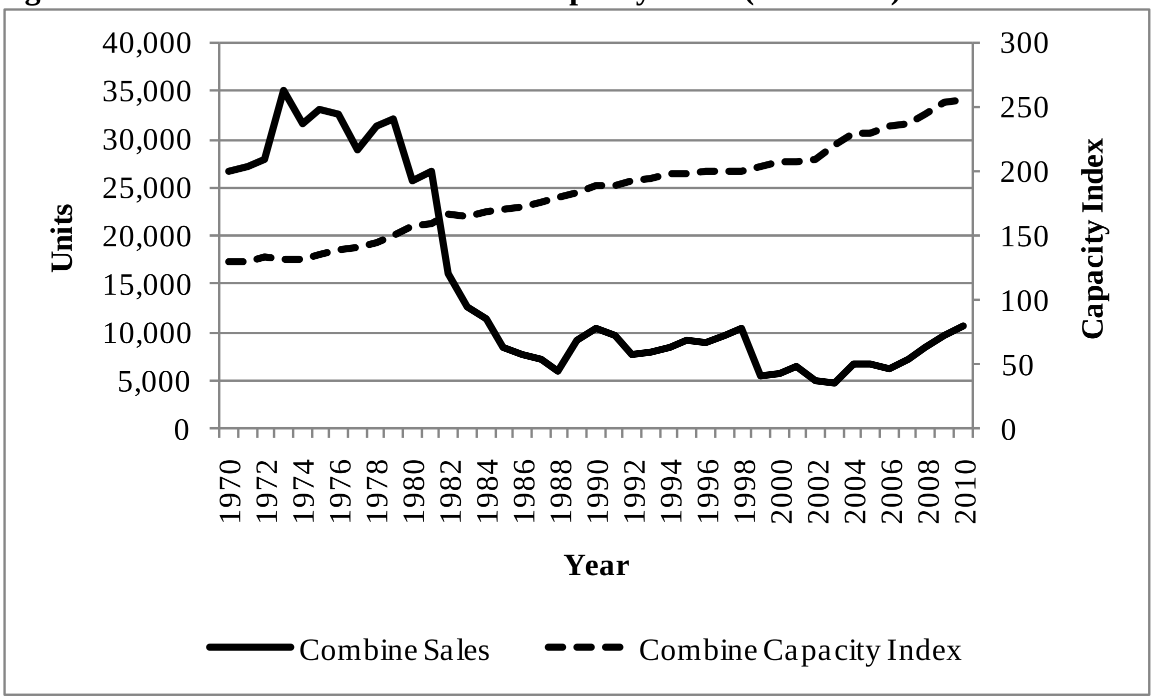
$$\text{CI} = (\text{kW Class Size}_1 \times \%\ \text{Proportional Sales}) + (\text{kW Class Size}_2 \times \%\ \text{Proportional Sales}) + \ldots \quad (4)$$

The capacity index represents the weighted average (kW) of units sold, using the class size midpoint segments. The index ranges from 130 in 1970 to 256 in 2010 (Figure 4.7). When combine capacity (kW) increases over time, a resulting decrease in combine sales would be expected.

Table 4.7: AEM Combine Size Segments

Size Segment kilowatt (kW)	Size Segment horsepower (HP) equivalent	Size Segment Midpoint kilowatt (kW)	Size Segment Midpoint horsepower (HP) equivalent
< 120	< 161	100	134
120 < 160	161 < 215	140	188
160 < 200	215 < 268	180	241
200 < 240	268 < 322	220	295
240 < 280	322 < 375	260	349
> 280	> 375	300	402

Figure 4.7: Combine Sales vs. Combine Capacity Index (1970-2010)



4.6.4 Interest

The historical data for this variable were collected utilizing the annual Federal Reserve Bank prime loan rate from 1970-2010 (FederalReserve 2011).

For each year of interest, inflation was calculated as follows:

$$Inflation = \left(\frac{Current\ Year\ Personal\ Consumption\ Expenditure\ Index}{Prior\ Year\ Personal\ Consumption\ Expenditure\ Index}\right) - 1. \qquad (5)$$

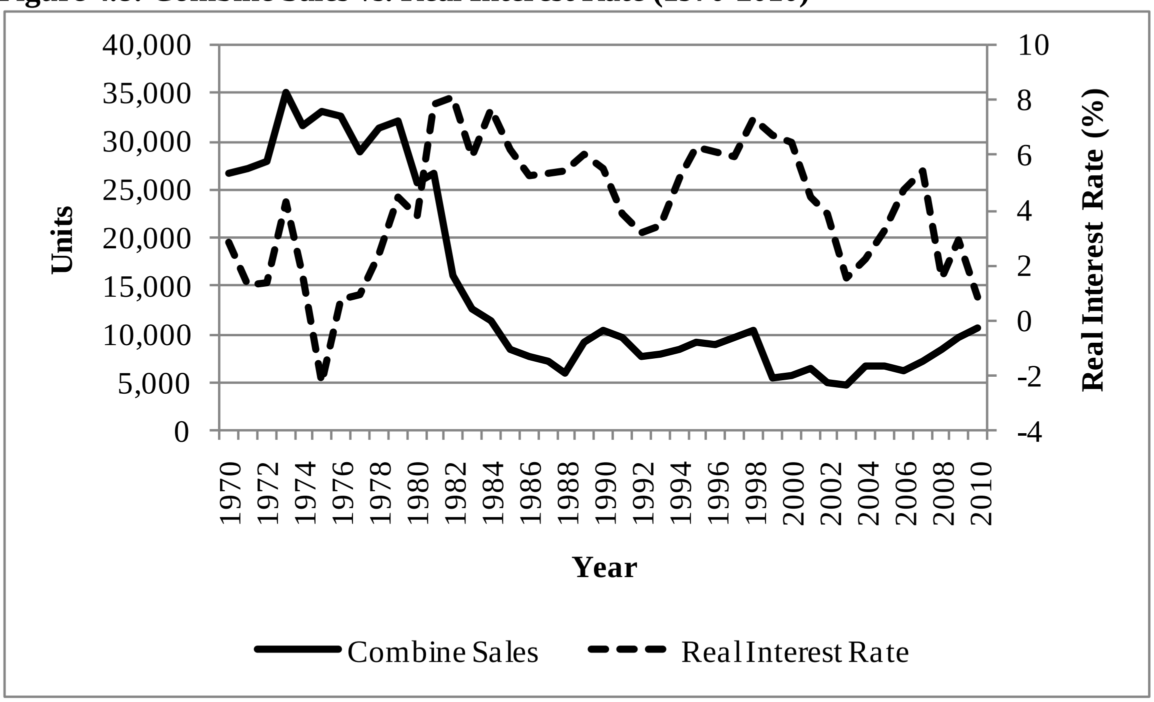
For each year, a resulting real interest rate was calculated as follows:

$$Real\ Interest\ Rate = \left(\frac{1 + Current\ Year\ Federal\ Reserve\ Interest\ Rate}{1 + Current\ Year\ Inflation}\right) - 1. \quad (6)$$

Data for the calculated real interest rate can be found in the Appendix (A.13).

Since new combines are expensive assets (>$250,000 list price), of new combine sales are often financed on an interest bearing note. The estimated coefficient for the interest variable is expected to be negative because when interest rates increase, fewer sales would be expected (Figure 4.8).

Figure 4.8: Combine Sales vs. Real Interest Rate (1970-2010)



4.6.5 EPA Emissions

Since 1996, the EPA has mandated more stringent engine emission improvements. In the agricultural equipment industry, it is believed that a portion of customers purchasing new combines would rather not wait to purchase the new mandated engine technology, but instead purchase a new combine in the year prior to the EPA mandate. This is due to customers not wanting to hassle or deal with new and potentially problematic technology, along with paying a higher price for the new emissions technology.

Within the data set (1970-2010), a dummy variable lagged by one year was used to identify the "sales pull ahead" years (1995, 2000, 2005 and 2010) that would be expected prior to the EPA emission mandate years (Table 4.9). The coefficient on this variable is expected to be positive and would suggest that in the years prior to EPA mandates; an increase in combine sales ("sales pull ahead") would be expected.

Table 4.8: Lagged EPA Engine Emission

Engine Tier Emission Level	EPA Mandate Year	Lagged EPA Emission Dummy Variable
1	1996	1995
2	2001	2000
3	2006	2005
4 (Interim)	2011	2010

Source: (United States Environmental Protection Agency 1996)

4.6.6 Acres

The United States Department of Agriculture (USDA) tracks acreage, both planted and harvested, for a multitude of crops (Agriculture 2011). For this model, the sum of acres of crops harvested by a combine from 1970-2010 was used. The individual crop types included in the aggregate harvestable planted acreage data are found in Table 4.9.

Table 4.9: USDA Planted Acres

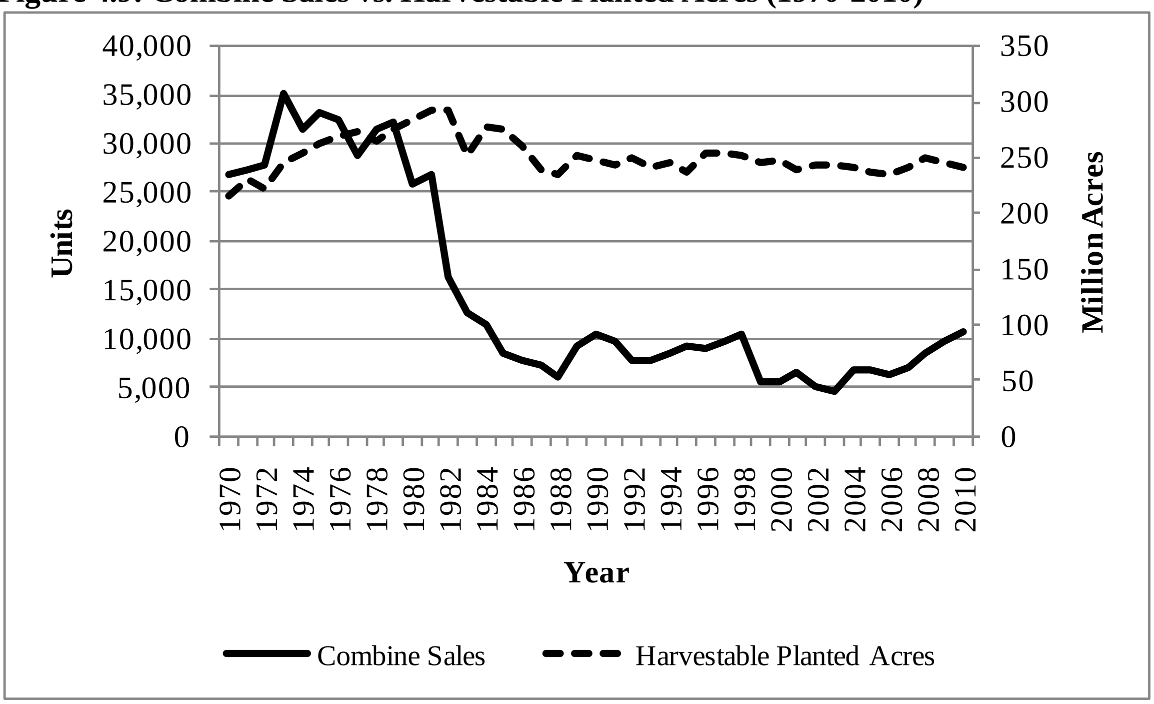
Harvestable Crop Types
All Wheat
Barley
Canola
Corn
Dry Edible Beans
Oats
Rice
Rye
Sorghum
Soybeans
Sunflowers

Source: (USDA, Farm Income Data Files 2011)

Data for the calculated USDA harvestable planted acres can be found in the Appendix (A.14).

The coefficient on this variable is expected to be positive. When harvestable acreage increases, an increase in combine sales would be expected (Figure 4.9).

Figure 4.9: Combine Sales vs. Harvestable Planted Acres (1970-2010)



CHAPTER V: RESULTS

5.1 Regression Model (1970-2010)

Once the data were compiled, the regression models were estimated using Minitab software. Three time periods were analyzed with regression modeling; 1970-2010, 1970-1986, and 1987-2010.

5.1.1 Data Set Summary (1970-2010)

The data for this time period (Table 5.1) represents a good range of variability (years) in the dependent and independent variables. The mean for combine sales in this time period is 14,711 units per year, with a standard deviation of 10,266. The mean for real interest rate in this time period is 4.16%, with a standard deviation of 2.34%. The mean for deflated net cash income in this time period is $86,069 million dollars, with a standard deviation of $16,120 million dollars. The mean for combine capacity index in this time period is 184, with a standard deviation of 36.

The complete data set for 1970-2010 can be found in the Appendix (A.15).

Table 5.1: Data Set Summary (1970-2010)

	Minimum	Maximum	Mean	Standard Deviation
Combine Sales	4,631	35,082	14,711	10,266
Real Interest Rate (%)	-2.25	8.12	4.16	2.34
Deflated USDA (U.S.) Annual Net Cash Income (Million $)	61,387	150,859	86,069	16,120
IRS Section 179 Maximum Allowable Deduction ($)	0	500,000	38,146	96,777
Lagged EPA Engine Emissions	0	1	0.1	0.3
Total Harvestable Acres (Million A)	215.3	292	251.1	17.4
Combine Capacity Index	130	256	184	36

5.1.2 Regression Model Summary (1970-2010)

The signs on all coefficients from the model output were as expected (Table 5.2). With the exception of the lagged EPA Mandate coefficient, all coefficients were very close to being statistically significant (T-statistic greater than 1.50 and P-value less than 0.10). The overall fit of the model is acceptable: R-Squared of 80.5% and adjusted R-Squared of 77.0%. This would suggest that the model explains an acceptable amount of variability in the data set, which may also suggest that the model could provide an acceptable prediction of future estimates. The T-statistic measures the statistical significant of a variable. If the absolute value of the T-statistic is greater than 1.50, the variable is generally considered statistically significant. The P-value measures the probability of the statistical significance on the variable. If the P-value is less than 0.10, there is high probability that the variable is statistically significant.

This model suggests that the lagged EPA mandate dummy variable is not statistically significant; this is unexpected. Perhaps this can be explained by the product value proposition that manufacturers create with new combines having new diesel engine emission technology that may offset the emission sales pull ahead that manufacturers perceive to expect. The Variance Inflation Factor (VIF) measures the impact of multicollinearity among each independent variable in the model. As a general rule, if the VIF of a variable is below 5.0, then there is little concern for multicollinearity. In this model, there is little concern for multicollinearity among the variables. The Durbin-Watson (D-W) statistic is 1.09, suggesting that there is positive serial correlation. A Durbin-Watson statistic of 2.0 would suggest no positive serial correlation. One method to resolve positive serial correlation in this model would be to determine if an omitted variable is causing the issue.

5.1.3 Regression Model Output (1970-2010)

Table 5.2: Regression Model Output (1970-2010)

Variable	Model	Coefficient	SE Coefficient	T	P	VIF
Constant		20476.00	18526.00	1.11	0.28	
Real Interest		-849.90	466.70	-1.82	0.08	1.97
Deflated Net Cash Income		0.09	0.06	1.56	0.13	1.54
IRS Section 179		0.03	0.01	1.88	0.07	3.20
Lagged EPA Mandate		1202.00	2901.00	0.41	0.68	1.26
Planted Acres		124.12	51.58	2.41	0.02	1.33
Capacity Index		-231.76	40.17	-5.77	0.00	3.50
Standard Error	4920.99					
R-Squared	80.50%					
R-Squared (adjusted)	77.00%					
Durbin-Watson	1.09					

5.1.4 Correlation Summary (1970-2010)

When reviewing the correlation activity between independent variables, deflated net cash income depicts a high correlation with the real interest rate and capacity index (Table 5.3). This may help explain why the deflated net cash income coefficient is not more significant. The IRS Section 179 coefficient and capacity index coefficient are highly correlated. The high correlation between these two variables may be contributing to the positive serial correlation; however, because the IRS Section 179 and capacity index variables both belong in the model no further action was taken and the variables were left in the model.

5.1.5 Correlation Output (1970-2010)

Table 5.3: Correlation Output (1970-2010)

	Interest	Net Income	IRS	Lagged EPA	Acres
Net Income	-0.439				
Standard Error	0.004				
IRS	-0.327	0.016			
Standard Error	0.037	0.923			
Lagged EPA	0.010	-0.046	0.389		
Standard Error	0.953	0.776	0.012		
Planted Acres	0.260	-0.093	-0.197	-0.212	
Standard Error	0.101	0.562	0.218	0.184	
Capacity Index	0.178	-0.400	0.653	0.362	-0.269
Standard Error	0.265	0.010	0.000	0.020	0.090

5.2 Regression Model (1970-1986)

5.2.1 Data Set Summary (1970-1986)

Those who are familiar with the history of the United State agricultural economy are likely aware of the late 1970s to early 1980s when the agriculture economy experienced a period of depression that eventually recovered by the mid-1980s. With that in mind and using the same data set applicable to the time period of 1970-1986, a regression model was estimated to compare against the 1970-2010 results. The data for this time period (Table 5.4) excludes the variables for the IRS Section 179 tax code and lagged EPA emissions because they were not applicable during this sub-time period. The mean for combine sales in this time period is 24,457 units per year, with a standard deviation of 9,285. The mean for real interest rate in this time period is 3.69%, with a standard deviation of 2.93%. The mean for deflated net cash income in this time period is $92,209 million dollars, with a standard deviation of $21,398 million dollars. The mean for combine capacity index in this time period is 149, with a standard deviation of 16.

The complete data set for 1970-1986 can be found in the Appendix (A.16).

Table 5.4: Data Set Summary (1970-1986)

	Minimum	Maximum	Mean	Standard Deviation
Combine Sales	7,660	35,082	24,457	9,285
Real Interest Rate (%)	-2.25	8.12	3.69	2.93
Deflated USDA (U.S.) Annual Net Cash Income (Million $)	69,755	150,859	92,209	21,398
Total Harvestable Acres (Million A)	215.3	292	261.3	22.8
Combine Capacity Index	130	173	149	16

5.2.2 Regression Model Summary (1970-1986)

Model results are not as expected during this time period, primarily because the coefficient for the real interest rate variable has a positive sign (Table 5.5). The coefficient for deflated net cash income is zero which is not expected, either. Planted acres and capacity index variables do have the expected coefficient signs. The T-statistic measures the statistical significant of a variable. If the absolute value of the T-statistic is greater than 1.50, the variable is generally considered statistically significant. The P-value measures the probability of the statistical significance on the variable. If the P-value is less than 0.10, there is high probability that the variable is statistically significant. In this model, planted acres and capacity index were determined to be statistically significant variables. The Variance Inflation Factor (VIF) measures the impact of multicollinearity among each specific independent variable in the model. As a general rule, if the VIF of a variable is below 5.0, then there is little concern for multicollinearity. In this model, there is little concern for multicollinearity. The Durbin-Watson (D-W) statistic is 1.90, suggesting that there is little concern for positive serial correlation in this model. A Durbin-Watson statistic of 2.0 would yield no positive serial correlation

5.2.3 Regression Model Output (1970-1986)

Table 5.5: Regression Model Output (1970-1986)

Variable	Model	Coefficient	SE Coefficient	T	P	VIF
Constant		72320.00	16650.00	4.34	0.00	
Real Interest		278.90	466.20	0.60	0.56	2.71
Deflated Net Cash Income		0.00	0.05	0.06	0.96	1.68
Planted Acres		238.84	49.14	4.86	0.00	1.83
Capacity Index		-749.10	114.40	-6.55	0.00	4.89
Standard Error	3322.08					
R-Squared	90.40%					
R-Squared (adjusted)	87.20%					
Durbin-Watson	1.90					

5.2.4 Correlation Summary (1970-1986)

When assessing the correlation between independent variables, it is evident that capacity index is highly correlated with all other variables (Table 5.6). While this may suggest that capacity index needs removed from this sub-period model, due to the T-statistic being highly significant it was left in the model.

5.2.5 Correlation Output (1970-1986)

Table 5.6: Correlation Output (1970-1986)

	Interest	Net Income	Acres
Net Income	-0.417		
Standard Error	0.096		
Planted Acres	0.471	-0.337	
Standard Error	0.056	0.187	
Capacity Index	0.786	-0.616	0.660
Standard Error	0.000	0.008	0.004

5.3 Regression Model (1987-2010)

5.3.1 Data Set Summary (1987-2010)

The data for this time period (Table 5.7) represents a recent historical sales trend, following the mid-1980s farm economy crisis. The mean for combine sales in this time period is 7,808 units per year, with a standard deviation of 1,835. The mean for real interest rate in this time period is 4.5%, with a standard deviation of 1.8%. The mean for deflated net cash income in this time period is $81,720 million dollars, with a standard deviation of $9,262 million dollars. The mean for the IRS Section 179 tax code in this time period is $65,167, with a standard deviation of $120,212. The mean for combine capacity index in this time period is 208, with a standard deviation of 24.

The complete data set for 1987-2010 can be found in the Appendix (A.17).

Table 5.7: Data Set Summary (1987-2010)

	Minimum	Maximum	Mean	Standard Deviation
Combine Sales	4,631	10,691	7,808	1,835
Real Interest Rate (%)	0.82	7.32	4.5	1.8
Deflated USDA (U.S.) Annual Net Cash Income (Million $)	61,387	97,311	81,720	9,262
IRS Section 179 Maximum Allowable Deduction ($)	0	500,000	65,167	120,212
Lagged EPA Engine Emissions	0	1	0.13	0.34
Total Harvestable Acres (Million A)	234.1	254.3	243.9	5.9
Combine Capacity Index	176	256	208	24

5.3.2 Regression Model Summary (1987-2010)

Model results are not as expected for this time period. The coefficient for the real interest rate variable has a positive sign which is not expected (Table 5.8). This may suggest that the real interest rate variable should be removed from this sub-period model. The other variables do have the expected coefficient signs. The fit of this later sub-period model (R-Squared of 37.6% and adjusted R-Squared of 15.5%) is not as good of a fit as the model from the 1970-2010 time period. This may suggest that there are not enough years in the analysis to create enough variability within the independent variables. The T-statistic measures the statistical significant of a variable. If the absolute value of the T-statistic is greater than 1.50, the variable is generally considered statistically significant. The P-value measures the probability of the statistical significance on the variable. If the P-value is less than 0.10, there is high probability that the variable is statistically significant. The IRS Section 179 and planted acres variables are the only statistically significant variables identified in the model. The Variance Inflation Factor (VIF) measures the impact of multicollinearity among the variable in the model. As a general rule, if the VIF of a variable is below 5.0, then there is little concern for multicollinearity. The IRS Section 179 variable indicates a VIF of 5.30, but because it is a statistically significant variable it was left in the model. The Durbin-Watson (D-W) statistic is 1.23, suggesting that there is concern for positive serial correlation. A Durbin-Watson statistic of 2.0 would yield no positive serial correlation. One method to resolve positive serial correlation in this model would be to seek out if an omitted variable is causing the issue.

5.3.3 Regression Model Output (1987-2010)

Table 5.8: Regression Model Output (1987-2010)

Variable	Model	Coefficient	SE Coefficient	T	P	VIF
Constant		-28019.00	18235.00	-1.54	0.14	
Real Interest		395.40	310.60	1.27	0.22	2.53
Deflated Net Cash Income		0.03	0.04	0.58	0.57	1.35
IRS Section 179		0.01	0.01	1.50	0.15	5.30
Lagged EPA Mandate		252.00	1075.00	0.23	0.82	1.36
Planted Acres		140.83	65.99	2.13	0.05	1.23
Capacity Index		-14.82	26.38	-0.56	0.58	3.23
Standard Error	1686.44					
R-Squared	37.60%					
R-Squared (adjusted)	15.50%					
Durbin-Watson	1.23					

5.3.4 Correlation Summary (1987-2010)

When assessing the correlation between independent variables, it is evident that the IRS Section 179 variable is creating multicollinearity with the real interest rate and lagged EPA variables (Table 5.9). The multicollinearity issue is especially reinforced with the VIF for the IRS Section 179 variable at 5.30. This issue may further explain why the real interest rate and lagged EPA variable coefficients are not statistically significant. Because the IRS Section 179 variable is statistically significant in the model, the variable was not removed from the analysis.

5.3.5 Correlation Output (1987-2010)

Table 5.9: Correlation Output (1987-2010)

	Interest	Net Income	IRS	Lagged EPA	Acres
Net Income	-0.414				
Standard Error	0.044				
IRS	-0.7	0.304			
Standard Error	0.000	0.149			
Lagged EPA	-0.068	0.105	0.327		
Standard Error	0.753	0.624	0.119		
Planted Acres	0.236	-0.182	-0.122	-0.301	
Standard Error	0.266	0.396	0.569	0.154	
Capacity Index	-0.469	0.049	0.8	0.282	-0.118
Standard Error	0.021	0.821	0.000	0.182	0.584

5.4 Prediction Modeling (1970-2010 Regression Data)

Utilizing the 1970-2010 regression results that were generated with Minitab software, future predictions were made on an annual basis through 2020. The limitation for future predictions was that net cash income and planted acre estimates are only forecasted to 2020 by the USDA.

5.4.1 Inflation

The predicted inflation data were collected using a ten-year forecast available from USDA. Inflation estimates can be found in Table 5.10. Generally, inflation is predicted to gradually increase over the next ten years.

Table 5.10: USDA Inflation Predictions

Year	Inflation%
2011	1.1
2012	1.1
2013	1.1
2014	1.3
2015	1.6
2016	1.7
2017	1.8
2018	1.8
2019	1.8
2020	1.8

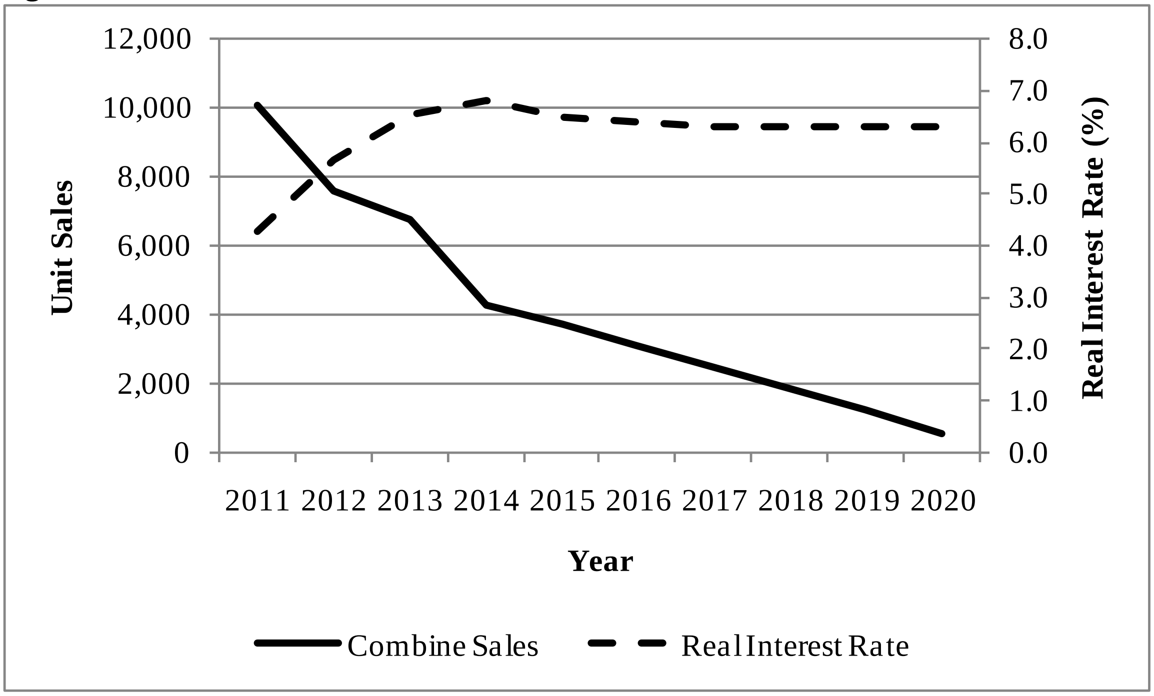
Source: (USDA, 10 year forecast 2011)

5.4.2 Interest

The predicted interest rate data were collected utilizing a USDA ten-year forecast (USDA, 10 year forecast 2011). For each predicted year, a resulting real interest rate was calculated using equation 6 and the forecasted USDA data for 2011 through 2020.

The data for USDA interest forecasts and real interest rate conversions can be found in the Appendix (A.18). A graph representing predicted combine sales versus predicted real interest rates can be found in Figure 5.1. As expected, as interest rates increase through 2014, combine sales decrease. What is unexpected is that as interest rates level off at 2015 and beyond, combine sales continue to steadily decline.

Figure 5.1: Predicted Combine Sales vs. Predicted Real Interest Rates



5.4.3 Net Cash Income

To use the forecasted net cash income in the prediction modeling, the net cash income needed to compensate for inflation. A forecasted Personal Consumption Expenditure (PCE) Index was calculated using the USDA inflation forecasts (Table 5.10), as follows:

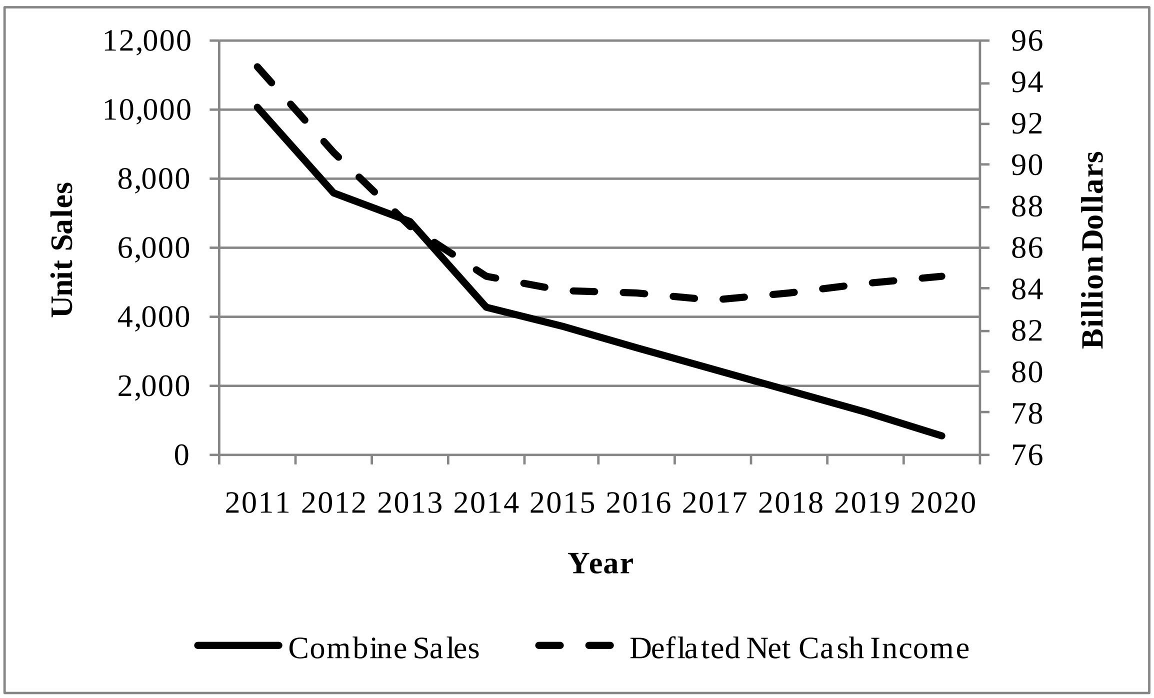
$$PCE\ Index\ Forecast = Previous\ PCE\ \times (1 + current\ year\ inflation). \quad (8)$$

Forecasted net cash income data were collected using a USDA ten-year forecast (USDA, 10 year forecast 2011). To compensate for inflation overtime, the USDA net cash income estimates were deflated using the PCE index forecast with 2010 used as the base year. The forecasts for deflated USDA net cash income were calculated as follows:

$$Deflated\ USDA\ Net\ Cash\ Income = \left(\frac{Current\ Year\ USDA\ Net\ Cash\ Income}{Current\ Year\ PCE\ \ Index}\right) \times Year\ 2010\ PCE. \quad (9)$$

Data for the forecasted USDA net cash income and calculated deflated net cash income can be found in the Appendix (A.19). A graph of predicted combine sales versus predicted deflated net cash income is displayed in Figure 5.2. As expected, combine sales and predicted deflated net cash income are highly correlated through 2014. What is unexpected is that combines sales continue to steadily decline in 2015 and beyond, while deflated net cash income more or less stabilizes in the out years.

Figure 5.2: Predicted Combine Sales vs. Predicted Deflated Net Cash Income



5.4.4 IRS Section 179 Tax Code

No information related to future predictions for the IRS Section 179 tax code could be identified beyond the 2011 tax year. For tax year 2011, the IRS allows for a maximum deduction amount of $500,000 (United State Internal Revenue Service 2011). For prediction modeling purposes, in years 2012-2020, a maximum deduction of $500,000 was carried forward and assumed.

5.4.5 EPA Emissions

Within the time period of 2011-2020, the Environmental Protection Agency (EPA) will mandate one remaining off-road diesel engine emission compliance level; Final Tier 4 in 2014. To remain consistent with earlier regression modeling, a dummy variable lagged by one year prior to the mandate was used to identify the “sales pull ahead” year (2013) that would be expected prior to the EPA emission mandate year (Table 5.11).

Table 5.11: Lagged EPA Engine Emission Prediction

Engine Tier Emission Level	EPA Mandate Year	Lagged EPA Emission Dummy Variable
4 (Final)	2014	2013

Source: (United States Environmental Protection Agency 1996)

5.4.6 Acres

The predicted harvestable planted acres were collected using a USDA ten-year forecast (USDA, 10 year forecast 2011). The following harvestable planted crop types were aggregated from 2011-2020 (Table 5.12).

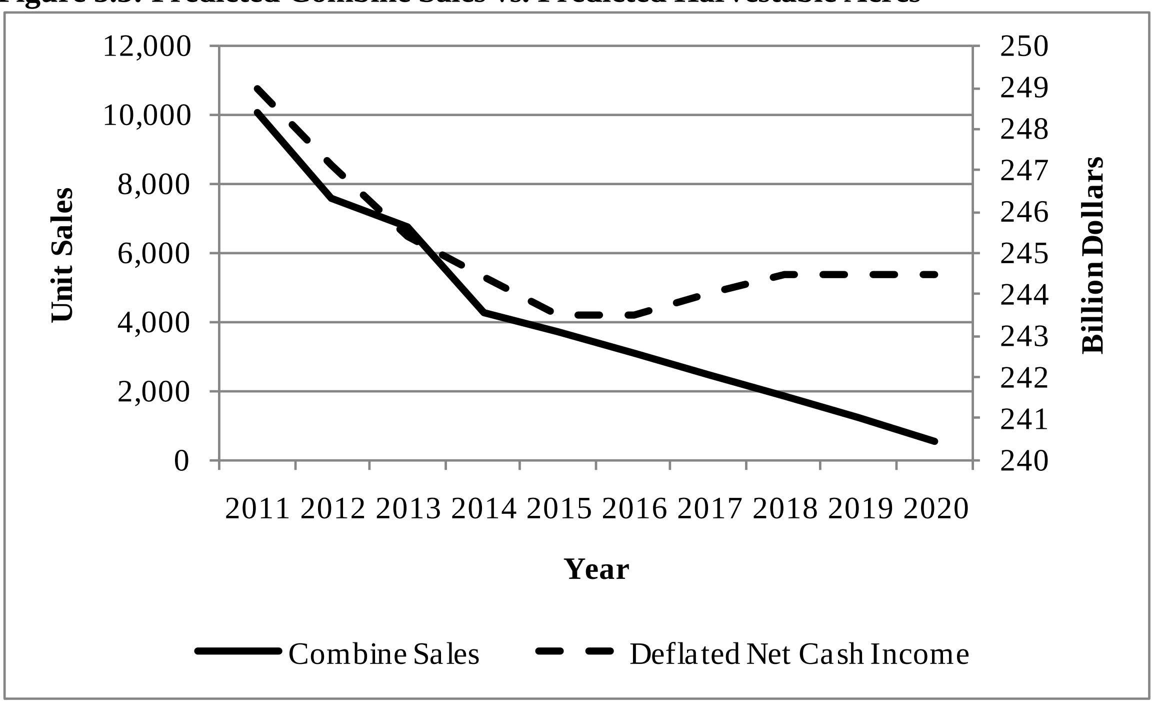
Table 5.12: USDA Planted Acres (Predictions)

Harvestable Crop Types
All Wheat
Barley
Corn
Oats
Rice
Sorghum
Soybeans

Source: (USDA, 10 year forecast 2011).

Predicted planted acres for canola, dry edible beans, rye and sunflowers were not available from USDA. Because these four crop types were not forecasted by the USDA and given their relative small influence on total planted acres in the model, 2010 planted acres for those crops were assumed to occur and were carried forward through 2020. Data for the aggregated calculation of USDA harvestable planted acre predictions can be found in the Appendix (A.20). A graph representing predicted combine sales versus predicted harvestable acres can be found in Figure 5.3. As expected, predicted combine sales are highly correlated with predicted harvestable acres through 2015. What is unexpected is that combine sales continue to steadily decline in 2016 and beyond, while acres increase through 2018 and level off from 2019-2020.

Figure 5.3: Predicted Combine Sales vs. Predicted Harvestable Acres

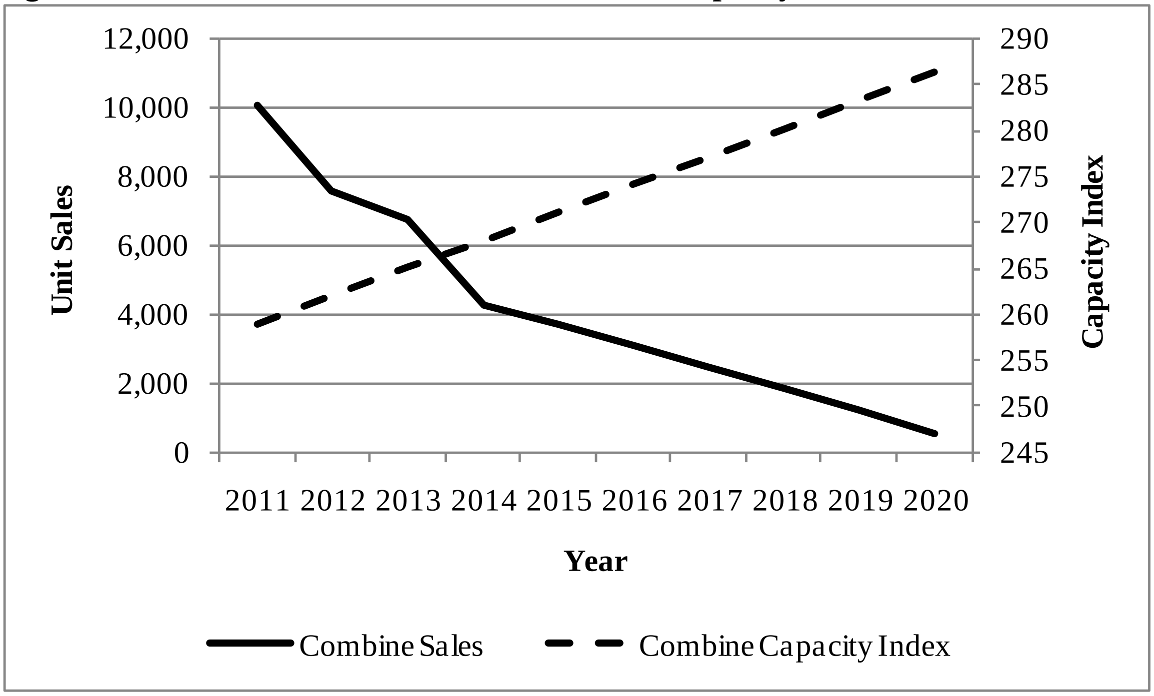


5.4.7 Technology / Capacity Index

Predictions for the combine capacity index were made by plotting a linear trend line against the historical data (1970-2010), and then calculating capacity forward to 2020. A graph representing predicted combine sales versus predicted capacity index can be found in

Figure 5.4. As expected, combine sales and combine capacity are predicted to be inversely correlated; as combine sales decline over time, combine capacity increases over time.

Figure 5.4: Predicted Combine Sales vs. Predicted Capacity Index



5.4.8 Predictions Summary

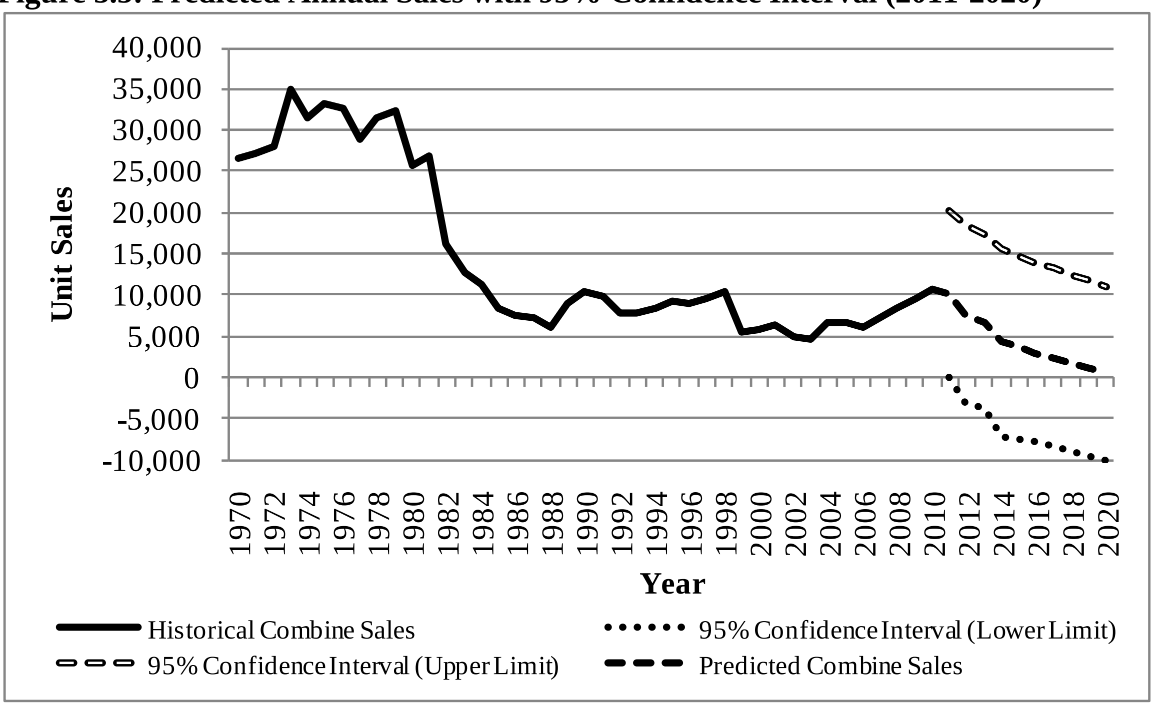
Future combine sales were estimated using Minitab software with a confidence interval of 95% (Table 5.13). When dealing with regression model predictions, it is possible to predict the value of the dependent variable (combine sales) based on given independent variable estimates. When these estimates are entered into the prediction model, it is also possible to calculate a confidence interval for the dependent variable. A graph representing the predicted annual sales with a 95% confidence interval from 2011-2020 can be found in Figure 5.5. The confidence interval gives information on the expected mean of the dependent variable, for a given year. A confidence interval for predicted combine sales generates a range of values (lower and upper limits) around which the “true” mean can be expected to be located with 95% certainty. The complete data set for the sales prediction modeling can be found in the Appendix (A.21).

The prediction modeling suggests that from 2011-2020, industry combine sales steadily decrease to a mere 529 units in 2020. By 2014, the prediction modeling suggests that annual industry combine sales drop below 5,000 units, which has not occurred at any year since 1970. These predictions suggest a sobering combine sales outlook for the United States. It is evident that several of the regression model variables are adversely working against industry combine sales through 2020. However, the only variable used in the model that may explain why sales continue to drop beyond 2015 is capacity because interest, income and acres more or less remain steady. Furthermore, while the predictions do suggest negative sales within the lower limit of the 95% confidence interval, realistically this cannot happen. Given the historical cyclic nature of United States production agriculture industry, coupled with the fact that combine sales have not declined most recently since 2006, the predictions suggest that the combine industry may be due for a marketplace downturn in the near-term. Experience would suggest or support a sales decline; however, to what extent the sales decline through 2020, will likely prompt further discussion and a need for additional modeling. From a new combine manufacturing standpoint, an industry combine sales decline should be expected if machine capacity continues to steadily increase over time. Combine manufacturers whose sales are not positioned to capitalize on global growth are at risk of domestic market contraction given the model predictions. This phenomenon will only be compounded by the fact that the United States has a relatively fixed amount of farm production acres, which can only improve crop production outputs by way of yield advancements. If combine capacity growth exceeds crop production output growth, less combines can be expected to be sold over time in the United States.

Table 5.13: Predicted Annual Combine Sales (1970-2010 Regression Data)

Year	Combine Sales	Standard Error (SE)	95% Confidence Interval (CI)
2011	10,094	5,000	(-67, 20,255)
2012	7,593	5,316	(-3,210, 18,397)
2013	6,785	5,127	(-3,635, 17,206)
2014	4,296	5,580	(-7,044, 15,635)
2015	3,681	5,448	(-7,391, 14,754)
2016	3,056	5,370	(-7,857, 13,970)
2017	2,466	5,290	(-8,284, 13,216)
2018	1,869	5,242	(-8,783, 12,522)
2019	1,200	5,202	(-9,372, 11,772)
2020	529	5,166	(-9,969, 11,027)

Figure 5.5: Predicted Annual Sales with 95% Confidence Interval (2011-2020)



5.6 Prediction Modeling (1987-2010 Regression Data)

In an attempt to factor-in combine sales predictions using the most recent sales period, the 1987-2010 regression model data were utilized. Minitab software was used to predict the future sales forecast on an annualized basis through year 2020.

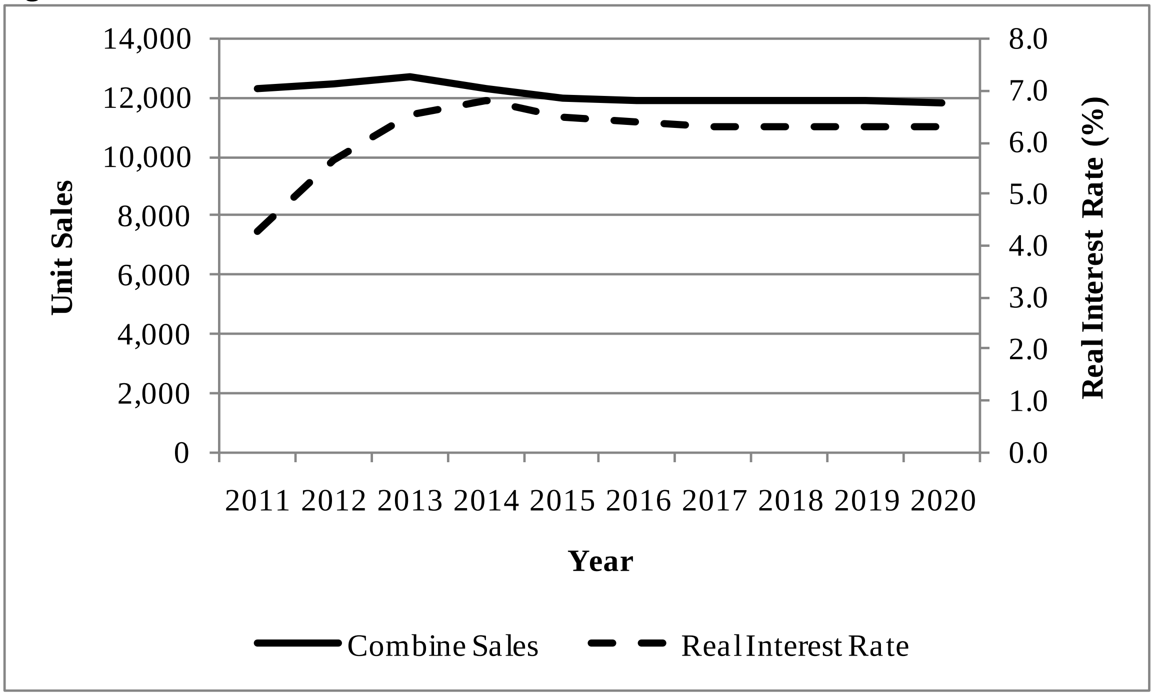
5.6.1 Inflation

The predicted USDA inflation data from Table 5.10 were assumed for this sub-period sales prediction modeling. In general, inflation is expected to gradually increase over time.

5.6.2 Interest

The predicted USDA interest data and resulting real interest rate conversations from the Appendix (A.18) were assumed for this sub-period sales prediction modeling. Figure 5.6 overviews the predicted combine sales relative to predicted real interest rates. It is unexpected that combine sales increase from 2011-2013 as interest rates rise. It is expected that as interest rates remain unchanged from 2015-2020, combine sales remain more or less constant.

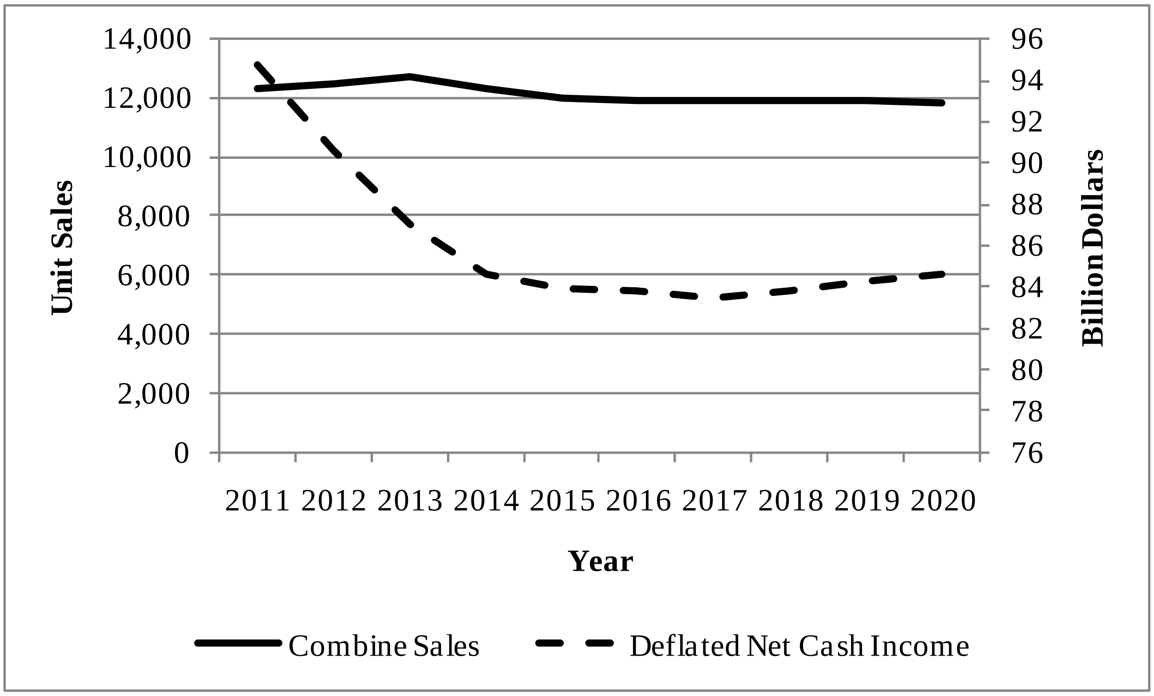
Figure 5.6: Predicted Combine Sales vs. Predicted Real Interest Rates



5.6.3 Net Cash Income

The predicted deflated net cash income data can be found in the Appendix (A.19) and were assumed for this sub-period sales prediction modeling. Figure 5.7 depicts predicted combine sales versus predicted deflated net cash income. It is unexpected to see deflated net cash income steadily decrease from 2011-2014, as combine sales increase. From 2015-2020, it would be expected that combine sales remain flat with very little change in deflated net cash income.

Figure 5.7: Predicted Combine Sales vs. Predicted Deflated Net Cash Income



5.6.4 IRS Section 179 Tax Code

For tax year 2011, the IRS allows for a maximum deduction amount of $500,000 (United State Internal Revenue Service 2011). For prediction modeling purposes, in years 2012-2020, a maximum deduction of $500,000 was carried forward and assumed.

5.6.5 EPA Emissions

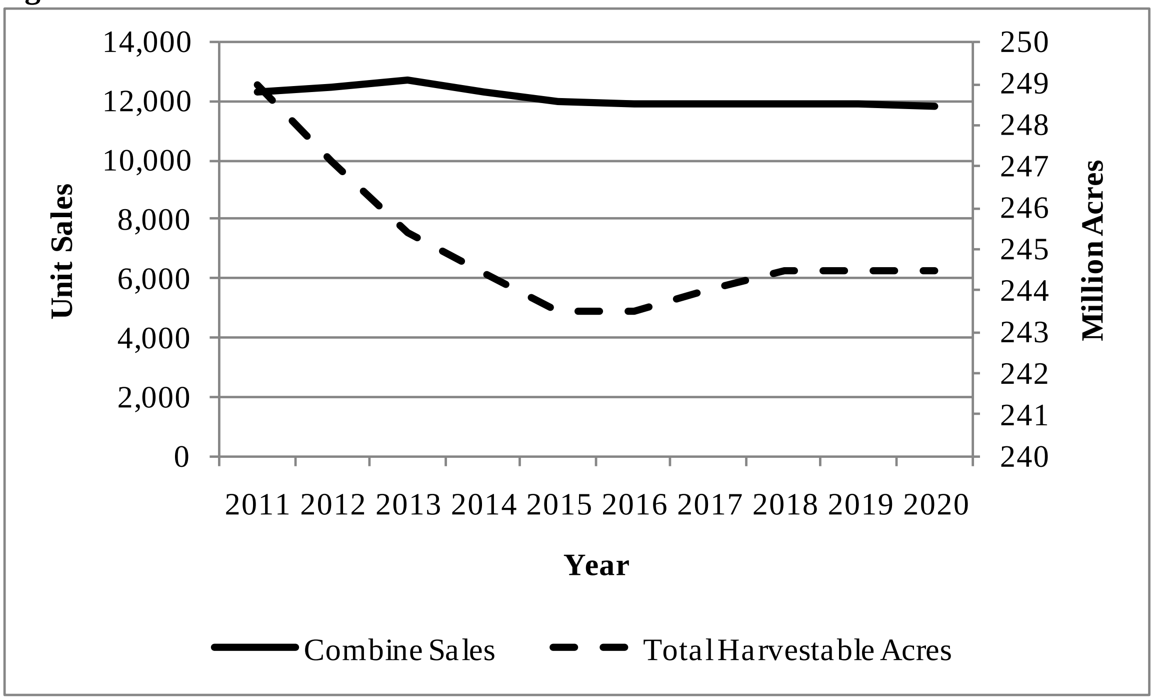
To remain consistent with earlier regression modeling, a dummy variable lagged by one year prior to the mandate was used to identify the “sales pull ahead” year (2013) that would be expected prior to the EPA emission mandate year (Table 5.11).

5.6.6 Acres

The predicted harvestable planted acres from the USDA ten-year forecast found in the Appendix (A.20) were assumed for this sub-period sales prediction modeling. A graph representing predicted combine sales versus predicted harvestable acres can be found in

Figure 5.8. It is not expected to see an increase in combine sales from 2011-2013, as harvestable acres steadily decline. From 2015-2018, it is not expected to see flat combine sales as harvestable acres increase. As expected, from 2019-2020, combine sales remain flat while harvestable acres remain flat.

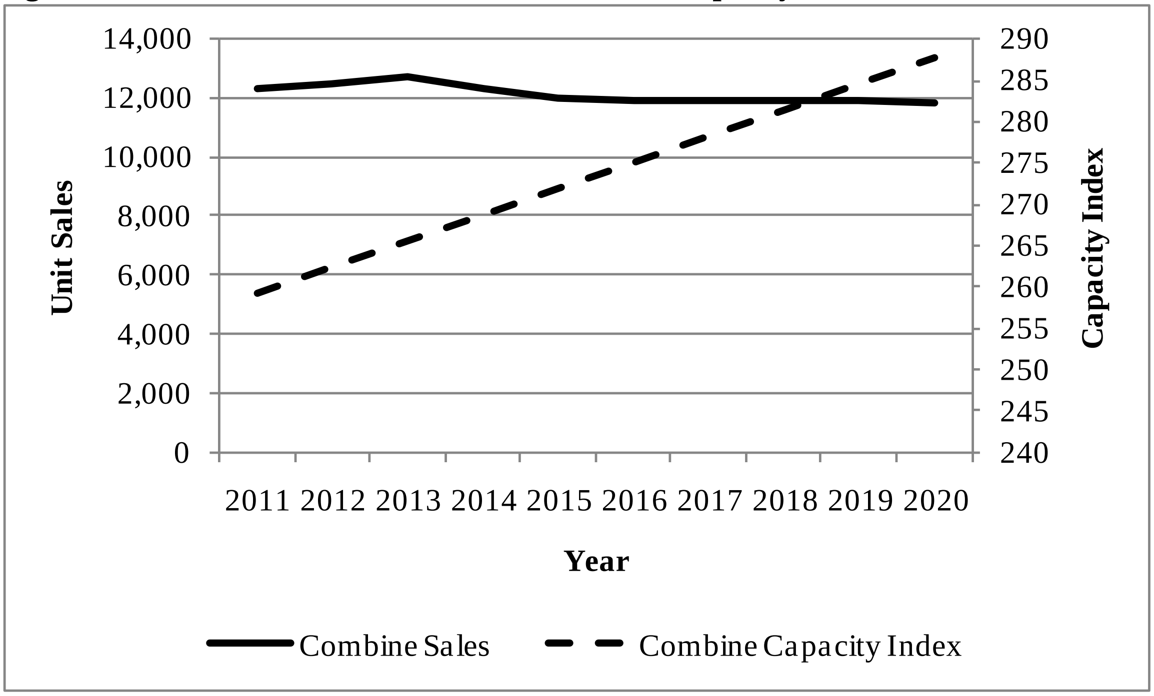
Figure 5.8: Predicted Combine Sales vs. Predicted Harvestable Acres



5.6.7 Technology / Capacity Index

Predictions for the combine capacity index were forecasted by plotting a linear trend line against the historical data (1987-2010), then calculating capacity forward to 2020. A graph representing predicted combine sales versus predicted capacity index can be found in Figure 5.9. It is unexpected that combine sales are minimally changed by the combine capacity increase over time. It would be expected to see a negative correlation for predicted combine sales versus predicted capacity index.

Figure 5.9: Predicted Combine Sales vs. Predicted Capacity Index



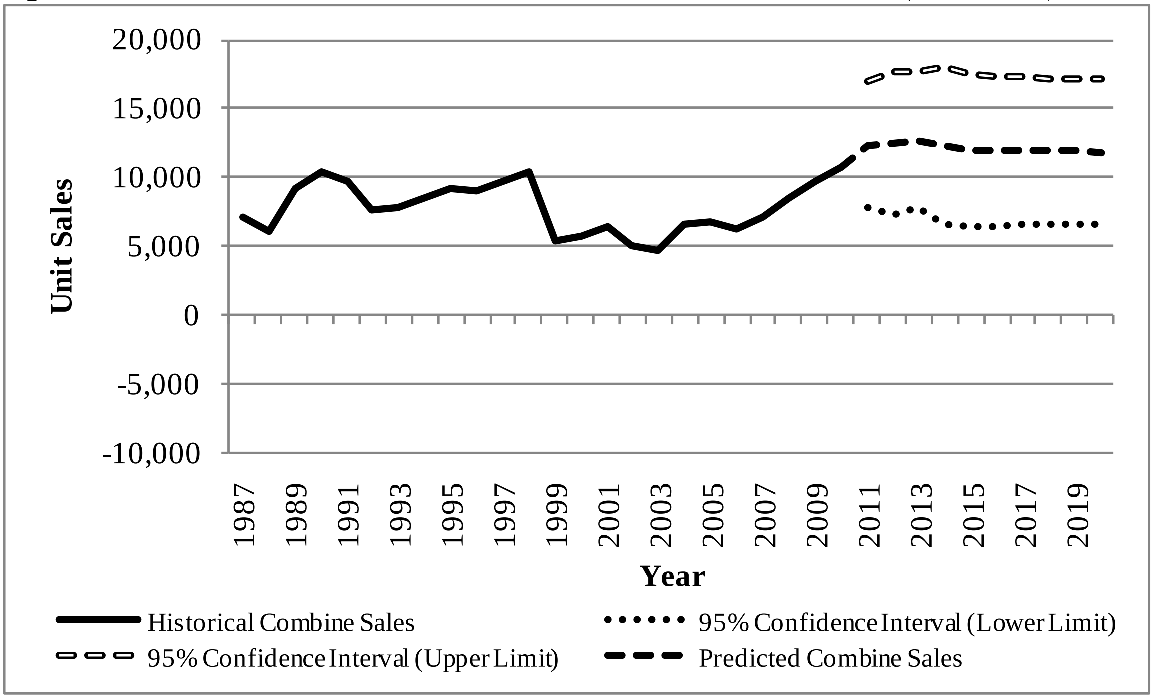
5.6.8 Predictions Summary

Future combine sales were estimated using Minitab software with a confidence interval of 95% (Table 5.14). A graph representing the predicted annual sales with a 95% confidence interval from 2011-2020 can be found in Figure 5.10.The confidence interval gives information on the expected mean of the dependent variable, for a given year. A confidence interval for a predicted combine sales generates a range of values (lower and upper limits) around which the "true" mean can be expected to be located with 95% certainty. The complete data set for the sales prediction modeling can be found in the Appendix (A.22). The prediction modeling suggests that from 2011-2020, industry combine sales remain generally flat around 12,000 units per year. These prediction results are drastically different from the 1970-2010 regression model prediction results. It is evident that the regression model from the 1987-2010 sub-period generates relatively strong, yet consistent sales predictions. Additionally, the 95% confidence interval lower limit predictions do suggest a more realistic expectation as they are all positive. What these predictions also suggest is that the combine industry would remain rather stable around 12,000 units per year for the foreseeable future, and that the marketplace would not experience a downturn. Given the incremental industry sales growth year-over-year from 2006-2010 and the projected strong industry sales in 2011, experience would suggest that a decline in sales should be expected simply based off the high levels of used, late-model combines that are subsequently being created in the marketplace. Looking back at recent history, a similar trend of year-over-year industry growth occurred from 1992-1998, resulting in a sharp downturn in the marketplace in 1999.

Table 5.14: Predicted Annual Combine Sales (1987-2010 Regression Data)

Year	Combine Sales	Standard Error (SE)	95% Confidence Interval (CI)
2011	12,356	2,158	(7,803, 16,908)
2012	12,489	2,445	(7,330, 17,647)
2013	12,708	2,357	(7,735, 17,681)
2014	12,320	2,716	(6,589, 18,051)
2015	12,003	2,631	(6,452, 17,553)
2016	11,911	2,587	(6,453, 17,369)
2017	11,882	2,537	(6,529, 17,236)
2018	11,917	2,519	(6,603, 17,232)
2019	11,879	2,512	(6,580, 17,179)
2020	11,841	2,507	(6,551, 17,131)

Figure 5.10: Predicted Annual Sales with 95% Confidence Interval (2011-2020)



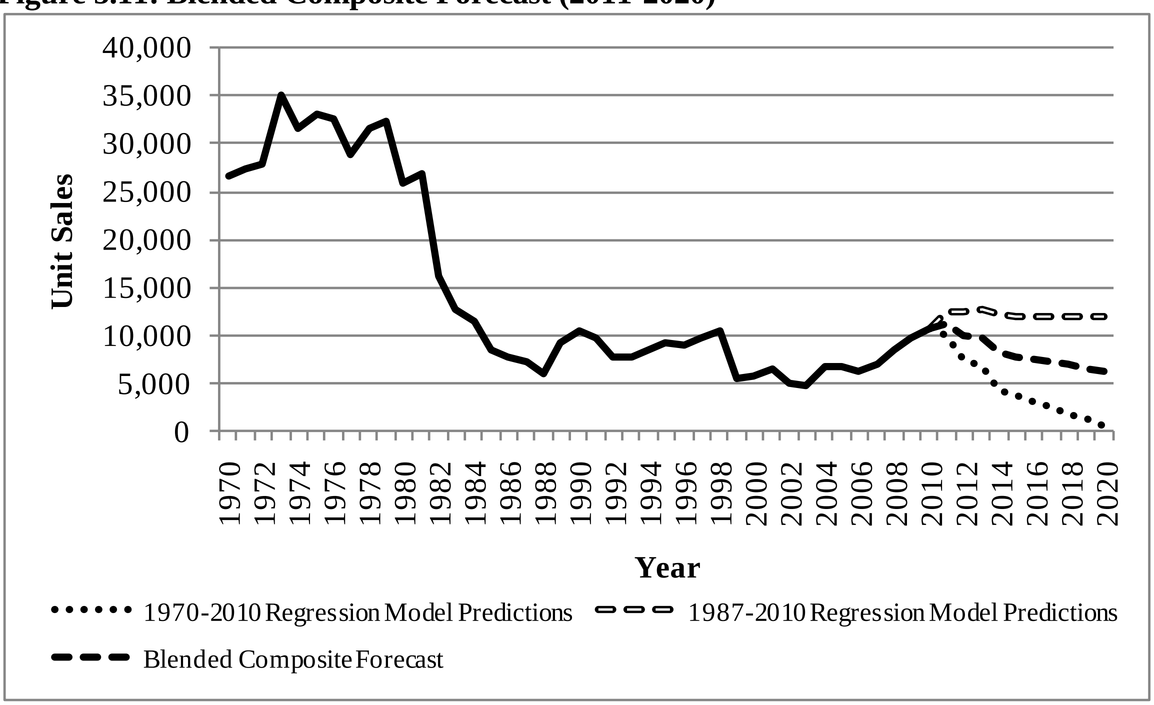
5.6 Prediction Modeling (Blended Composite Forecast)

After further analysis of the sales predictions from both the 1970-2010 model and the 1987-2010 model, it was deemed appropriate to suggest a blended composite forecast. While the 1970-2010 estimated regression model resulted in five out of the six variables being statistically significant, the resulting future sales predictions seemed too drastically low over time. Conversely, while the 1987-2010 regression model data was not as statistically significant as the 1970-2010 model, the 1987-2010 model generated sales predictions based off a more recent sales trend after the late 1970s to mid-1980s farm economy depression. Thus, a blended composite sales forecast was derived by calculating the mean of predicted sales from both the 1970-2010 regression model predictions and the 1987-2010 regression model predictions (Table 5.15). A graph representing the blended forecast composite can be found in Figure 5.11. This blended forecast suggests an average look at how the industry combine sales could perform given the worst-case (1970-2010 model predictions) and best-case (1987-2010 model predictions) scenarios. While the blended composite results may not be a statistically valid method, it does create an opportunity for further discussion around predicting future U.S. combine sales.

Table 5.15: Blended Composite Sales Forecast

Year	1970-2010 Regression Model Predictions	1987-2010 Regression Model Predictions	Blended Composite Sales Forecast
2011	10,094	12,356	11,225
2012	7,593	12,489	10,041
2013	6,785	12,708	9,747
2014	4,296	12,320	8,308
2015	3,681	12,003	7,842
2016	3,056	11,911	7,484
2017	2,466	11,882	7,174
2018	1,869	11,917	6,893
2019	1,200	11,879	6,540
2020	529	11,841	6,185

Figure 5.11: Blended Composite Forecast (2011-2020)



CHAPTER VI: SUMMARY AND CONCLUSIONS

The overall intent of this thesis was to better understand the historical factors that affect annual unit sales volume of combines in the United States and create an empirical regression model that could predict future sales. While the 1970-2010 regression model variables did respond as expected, perhaps there are still other factors to consider that might further refine and improve the model and its presumably lower-than-expected predictions. Some of the 1987-2010 regression model variables did not respond as expected, perhaps there are still other factors to consider that might further refine and improve the model and its presumably higher-than-expected predictions

Considerations for future model refinement might include surveying customers to understand if other factors affect combine purchases that may have been excluded in this work. For example, including a factor in the model that compensates for used combine inventory levels may improve model accuracy; however this factor must be credibly measured within the scope of the industry. Certainly within Deere & Company, there are internal economists that predict equipment sales on a more frequent basis. I purposefully did not engage with these individuals during this project for fear that it may bias the results and lessen the overall personal learning experience. It will be worthwhile to share the results within the organization to understand what information may be new or of particular value. In the end, it is fair to assume that forecasting equipment sales is not an easy process. To reach a high degree of confidence with any forecast modeling requires significant time, sound understanding of the market principles and continuous updating of the data. Even if those objectives are met, sales predictions or estimates are only a snapshot in time that are short-lived and are likely to never be 100% accurate.

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APPENDIX A

A.1 Survey Description

This is a short, five-question survey to understand what economic factors drive sales or demand for combines in the United States on an annual basis.

A.2 Survey Opening Instructions

This survey information will be utilized as part of an academic research project, for a master's degree thesis. The student completing the master's degree is a John Deere Company marketing employee. None of this information will be held against a person that completes the survey, nor will the information be shared beyond the academic-intended audience. In particular, the thesis project involves creating a regression model to forecast or predict the annual sales of new combines in the United States, for a given year. Specifically, the information gathered from this survey will be used to determine the factors (or independent variables) that contribute to the overall sale or demand of NEW combines in the United States, on an annual basis (dependent variable). The target audience for this survey is intended to be John Deere dealership sales professionals who have credible experience selling new combines, to end-user farmers/producers. If you choose to complete the survey, please think in broad terms. Think in terms of what general economic factors drive sales or demand for combines in the United States on an annual basis. Try not to think in terms of what generates new combine sales by a specific manufacturer, by a specific dealer organization, or even within a specific market. Simply put, answer this question given your background and experience; "What causes a farmer in the United States to purchase a combine?" To complete this survey should only take a few minutes and there will be no compensation or formal recognition for a completed survey. If you don't feel comfortable completing a survey once you have started, simply exit out of the survey. Anyone who submits a survey will remain anonymous.

A.3 Survey Question #1: Results

Respondent	State 1	State 2	State 3	State 4	State 5	Total
1	Nebraska	Iowa				2
2	Kansas					1
3	Kansas	Colorado				2
4	Nebraska					1
5	Kansas					1
6	Kansas					1
7	Arkansas					1
8	Kansas					1
9	Nebraska					1
10	Illinois					1
11	Illinois					1
12	Illinois					1
13	Illinois					1
14	Illinois					1
15	Illinois					1
16	Missouri					1
17	Illinois					1
18	Illinois	Iowa				2
19	Missouri					1
20	Missouri					1
21	Illinois					1
22	Nebraska					1
23	Missouri					1
24	Illinois	Iowa				2
25	Ohio					1
26	Ohio					1
27	Ohio					1
28	Ohio					1
29	Indiana	Michigan	Ohio			3
30	Missouri					1
31	Colorado	Kansas	Nebraska	Oklahoma	Texas	5
32	Texas					1
33	Kansas					1
Minimum						1
Maximum						10
Mean						3.58
Standard Deviation						2.87
State Count						12

A.4 Survey Question #1: Summary Results

State (Geography)	State Summary (Count)	Percent of Total
Arkansas	1	2%
Colorado	2	5%
Illinois	10	23%
Indiana	1	2%
Iowa	3	7%
Kansas	7	16%
Michigan	1	2%
Missouri	1	2%
Nebraska	5	12%
Ohio	5	12%
Oklahoma	1	2%
Texas	2	5%
Total	43	100%

A.5 Survey Question #2: Summary Results

Respondent	Years
1	4
2	10
3	20
4	11
5	4
6	11
7	25
8	4
9	15
10	20
11	25
12	25
13	25
14	25
15	25
16	16
17	15
18	25
19	10
20	7
21	25
22	13
23	25
24	6
25	11
26	18
27	5
28	13
29	25
30	8
31	16
32	25
33	25
Minimum	4.00
Maximum	25.00
Mean	16.27
Standard Deviation	7.85

A.6 Survey Question #3: Results

Respondent	1 to 5 combines per year	6 to 10 combines per year	11 to 15 combines per year	16 to 20 combines per year	More than 21 combines per year
1	X				
2					X
3			X		
4		X			
5					X
6	X				
7					X
8		X			
9		X			
10	X				
11		X			
12		X			
13			X		
14		X			
15	X				
16			X		
17		X			
18			X		
19	X				
20	X				
21					X
22		X			
23		X			
24		X			
25					X
26	X				
27	X				
28	X				
29				X	
30					X
31					X
32					X
33			X		

A.7 Survey Question #3: Summary Results

	1 to 5 combines per year	6 to 10 combines per year	11 to 15 combines per year	16 to 20 combines per year	>21 combines per year
Count	9				
Count		10			
Count			5		
Count				1	
Count					8

A.8 Survey Question #4: Results

Respondent	EPA Emissions	Interest Rates	Incentives	Technology / Capacity Index	IRS Section 179	Cash Receipts	Acres	Trade-In	Futures Pricing	Price Increase / Inflation	Roll Pattern	High Combine Wear
1					2	3			4		1	5
2		3		5		1		4			2	
3				1			2	4			5	3
4			1	5	4						2	3
5			5		3	4					2	1
6				5	2	1					3	4
7		5			4			2			3	1
8				5	3	4			1		2	
9				5	4	1		3			2	
10			2	3	5			4			1	
11		3	2				4				1	5
12					3	2	5	4			1	
13	5		3	4				2			1	
14				5	2	1	4		3			
15				3	5	2			4			1
16					1			2	4		3	5
17	5			4	3						1	2
18			1	5	3						2	4
19	5			4		3					1	2
20			3		4	5			1		2	
21			2	5	3			4			1	
22	5	4			3	1						2
23					1	2	4		3	5		
24		1		4	2			5			3	
25		5		3	2	4					1	
26	5			3	2			4			1	
27	5			2				4			1	3
28	2			4	3					5	1	
29					1	3		2			5	4
30	2	3			5			4			1	
31		4			3	2					1	5
32	1	2		4	3							5
33					2	1	4				3	5

A.9 Survey Question #4: Summary Results

Respondent	EPA Emissions	Interest Rates	Incentives	Technology / Capacity Index	IRS Section 179	Cash Receipts	Acres	Trade-In	Futures Pricing	Price Increase / Inflation	Roll Pattern	High Combine Wear
Average Rank	3.9	3.3	2.4	4.0	2.9	2.4	3.8	3.4	2.9	5.0	1.9	3.3
Responses	9	9	8	20	27	17	6	14	7	2	28	18

A.10 Survey Question #4: Reversed Average Rank Results

Respondent	EPA Emissions	Interest Rates	Incentives	Technology / Capacity Index	IRS Section 179	Cash Receipts	Acres	Trade-In	Futures Pricing	Price Increase / Inflation	Roll Pattern	High Combine Wear
1					4	3			2		5	1
2		3		1		5		2			4	
3				5			4	2			1	3
4			5	1	2						4	3
5			1		3	2					4	5
6				1	4	5					3	2
7		1			2			4			3	5
8				1	3	2			5		4	
9				1	2	5		3			4	
10			4	3	1			2			5	
11		3	4				2				5	1
12					3	4	1	2			5	
13	1		3	2				4			5	
14				1	4	5	2		3			
15				3	1	4			2			5
16					5			4	2		3	1
17	1			2	3						5	4
18			5	1	3						4	2
19	1			2		3					5	4
20			3		2	1			5		4	
21			4	1	3			2			5	
22	1	2			3	5						4
23					5	4	2		3	1		
24		5		2	4			1			3	
25		1		3	4	2					5	
26	1			3	4			2			5	
27	1			4				2			5	3
28	4			2	3					1	5	
29					5	3		4			1	2
30	4	3			1			2			5	
31		2			3	4					5	1
32	5	4		2	3							1
33					4	5	2				3	1

A.11 Survey Question #4: Weighted Response Calculation Results

	EPA Emissions	Interest Rates	Incentives	Technology / Capacity Index	IRS Section 179	Cash Receipts	Acres	Trade-In	Futures Pricing	Price Increase / Inflation	Roll Pattern	High Combine Wear
Reversed Average Rank (RAR)	2.1	2.7	3.6	2.1	3.1	3.6	2.2	2.6	3.1	1.0	4.1	2.7
Count	9	9	8	20	27	17	6	14	7	2	28	18
RAR x (Count/33)	0.6	0.7	0.9	1.2	2.5	1.9	0.4	1.1	0.7	0.1	3.5	1.5

A.12 Deflated USDA Annual Net Cash Income Data

Year	USDA (U.S.) Annual Net Cash Income (Million $)	Personal Consumption Expenditures Index	Deflated USDA (U.S.) Annual Net Cash Income (Million $)
1970	18,016.8	23.289	85,795.1
1971	17,675.0	24.313	80,622.7
1972	22,798.7	25.251	100,130.7
1973	35,559.8	26.141	150,859.3
1974	34,383.5	28.509	133,753.0
1975	29,107.7	31.458	102,615.4
1976	29,490.4	33.351	98,063.4
1977	27,392.1	35.299	86,059.3
1978	32,668.7	37.584	96,397.3
1979	32,618.3	40.518	89,279.0
1980	33,202.1	44.988	81,847.2
1981	31,557.4	49.581	70,586.4
1982	36,848.3	52.669	77,588.6
1983	36,989.4	55.082	74,473.7
1984	36,044.5	57.306	69,754.8
1985	45,582.8	59.298	85,250.5
1986	46,490.3	61.033	84,475.9
1987	52,637.0	62.71	93,087.2
1988	53,700.2	65.02	91,593.5
1989	53,503.7	67.996	87,264.2
1990	53,832.7	70.876	84,233.0
1991	51,392.5	73.988	77,032.4
1992	56,900.8	76.189	82,825.0
1993	60,766.7	78.067	86,324.4
1994	53,675.7	79.524	74,854.0
1995	54,478.3	81.423	74,201.3
1996	60,931.5	83.083	81,332.7
1997	60,941.7	85.026	79,487.4
1998	57,740.9	85.845	74,594.0
1999	57,934.2	86.875	73,956.4
2000	57,368.2	89.099	71,405.8
2001	62,054.9	91.142	75,508.0
2002	50,844.3	91.855	61,386.8
2003	72,144.2	94.151	84,979.1
2004	83,667.4	96.068	96,585.7
2005	86,652.9	98.754	97,311.5
2006	68,441.4	101.803	74,557.9
2007	77,679.7	104.311	82,587.3
2008	90,407.0	107.954	92,875.0
2009	69,127.6	108.29	70,794.3
2010	92,500.0	110.901	92,500.0

A.13 Real Interest Rate Data

Year	Real Interest Rate	Fed Reserve Bank Prime Loan Rates (nominal)	Personal Consumption Expenditures Index	Inflation
1969			22.198	
1970	0.0285	7.91	23.289	0.049
1971	0.0128	5.73	24.313	0.044
1972	0.0134	5.25	25.251	0.039
1973	0.0435	8.03	26.141	0.035
1974	0.0161	10.81	28.509	0.091
1975	-0.0225	7.86	31.458	0.103
1976	0.0078	6.84	33.351	0.060
1977	0.0093	6.83	35.299	0.058
1978	0.0243	9.06	37.584	0.065
1979	0.0451	12.67	40.518	0.078
1980	0.0381	15.26	44.988	0.110
1981	0.0786	18.87	49.581	0.102
1982	0.0812	14.85	52.669	0.062
1983	0.0594	10.79	55.082	0.046
1984	0.0769	12.04	57.306	0.040
1985	0.0624	9.93	59.298	0.035
1986	0.0525	8.33	61.033	0.029
1987	0.0532	8.21	62.71	0.027
1988	0.0544	9.32	65.02	0.037
1989	0.0602	10.87	67.996	0.046
1990	0.0554	10.01	70.876	0.042
1991	0.0390	8.46	73.988	0.044
1992	0.0318	6.25	76.189	0.030
1993	0.0345	6.00	78.067	0.025
1994	0.0519	7.15	79.524	0.019
1995	0.0629	8.83	81.423	0.024
1996	0.0611	8.27	83.083	0.020
1997	0.0596	8.44	85.026	0.023
1998	0.0732	8.35	85.845	0.010
1999	0.0672	8.00	86.875	0.012
2000	0.0650	9.23	89.099	0.026
2001	0.0451	6.91	91.142	0.023
2002	0.0386	4.67	91.855	0.008
2003	0.0158	4.12	94.151	0.025
2004	0.0226	4.34	96.068	0.020
2005	0.0330	6.19	98.754	0.028
2006	0.0473	7.96	101.803	0.031
2007	0.0545	8.05	104.311	0.025
2008	0.0154	5.09	107.954	0.035
2009	0.0293	3.25	108.29	0.003
2010	0.0082	3.25	110.901	0.024

A.14 USDA Total Planted Harvestable Acres Data 1970-2010 (Million Acres)

Year	Corn	All Wheat	Soybean	Oats	Sorghum	Barley	Rice	Dry Edible Beans	Rye	Sunflower	Canola	Total Harvestable Acres
1970	66.8	48.7	43.1	24.5	17.0	10.5	1.8	1.5	1.4	0.0	0.0	215.3
1971	74.1	53.8	43.5	22.0	20.8	11.1	1.8	1.4	1.8	0.0	0.0	230.3
1972	67.0	54.9	46.9	20.2	17.3	10.6	1.8	1.5	1.1	0.0	0.0	221.3
1973	72.3	59.2	56.5	19.1	19.2	11.2	2.2	1.4	3.5	0.0	0.0	244.6
1974	77.9	71.0	52.5	18.1	17.7	9.1	2.6	1.6	3.2	0.0	0.0	253.7
1975	78.7	74.9	54.6	17.4	18.2	9.6	2.8	1.5	3.2	0.8	0.0	261.7
1976	84.6	80.4	50.3	17.6	18.4	9.2	2.5	1.5	3.0	0.8	0.0	268.3
1977	84.3	75.4	59.0	18.5	17.4	10.4	2.2	1.4	2.9	2.1	0.0	273.6
1978	81.7	66.0	64.7	16.4	16.5	9.9	3.0	1.5	3.0	2.8	0.0	265.5
1979	81.4	71.4	71.4	14.1	15.6	8.1	3.1	1.5	3.1	5.3	0.0	275.0
1980	84.0	80.8	69.9	13.2	15.8	8.3	3.3	1.8	2.6	4.0	0.0	283.7
1981	84.1	88.3	67.5	13.6	16.1	9.7	3.8	2.3	2.6	4.0	0.0	292.0
1982	81.9	86.2	70.9	14.2	16.1	9.6	3.3	1.9	2.6	5.0	0.0	291.7
1983	60.2	76.4	63.8	20.3	11.7	10.4	2.2	1.2	2.7	3.1	0.0	252.0
1984	80.5	79.2	67.8	12.2	16.2	12.0	2.9	1.5	3.0	1.5	0.0	276.8
1985	83.4	75.5	63.1	13.2	18.3	13.1	2.5	1.6	2.5	3.1	0.0	276.3
1986	76.6	72.0	60.4	14.6	15.3	13.0	2.4	1.7	2.3	2.0	0.0	260.3
1987	66.2	65.8	58.2	17.9	11.8	10.9	2.4	1.8	2.4	1.8	0.0	239.2
1988	67.7	65.5	58.8	13.9	10.3	9.8	2.9	1.5	2.4	2.0	0.0	234.8
1989	72.3	76.6	60.8	12.1	12.6	9.2	2.7	1.9	2.0	1.9	0.0	252.1
1990	74.2	77.3	57.8	10.4	10.5	8.2	2.9	2.2	1.6	1.9	0.0	247.0
1991	76.0	70.0	59.1	8.7	11.0	8.9	2.9	1.9	1.7	2.7	0.1	243.0
1992	79.3	72.3	59.3	8.0	13.3	7.8	3.2	1.6	1.6	2.2	0.2	248.8
1993	73.3	72.2	59.4	7.9	10.5	7.8	2.9	1.8	1.5	2.8	0.2	240.3
1994	79.2	70.4	61.9	6.6	9.8	7.2	3.4	2.0	1.6	3.6	0.4	246.1
1995	71.2	69.2	62.5	6.3	9.5	6.7	3.1	2.1	1.6	3.5	0.4	236.1
1996	79.5	75.6	64.2	4.7	13.2	7.2	2.8	1.8	1.5	2.6	0.4	253.5
1997	80.2	71.0	70.9	5.2	10.1	6.9	3.1	1.9	1.4	2.9	0.7	254.3
1998	80.2	65.9	74.0	4.9	9.6	6.3	3.3	2.0	1.6	3.6	1.1	252.5
1999	77.4	62.8	73.8	4.7	9.3	5.2	3.6	2.0	1.6	3.6	1.1	245.1
2000	79.5	62.5	74.5	4.5	9.2	5.8	3.1	1.8	1.3	2.8	1.6	246.6
2001	75.8	59.6	74.1	4.4	10.3	5.0	3.3	1.4	1.3	2.7	1.5	239.4
2002	79.1	60.4	73.8	5.0	9.6	5.1	3.2	1.9	1.4	2.6	1.5	243.6
2003	78.7	61.7	73.4	4.6	9.4	5.3	3.0	1.4	1.4	2.3	1.1	242.3
2004	80.9	59.7	75.2	4.1	7.5	4.5	3.3	1.4	1.4	1.9	0.9	240.8
2005	81.8	57.2	72.1	4.2	6.5	3.9	3.4	1.7	1.4	2.7	1.2	236.1
2006	78.3	57.3	75.5	4.2	6.5	3.5	2.8	1.6	1.4	2.0	1.0	234.1
2007	93.6	60.4	63.6	3.8	7.7	4.0	2.8	1.5	1.4	2.1	1.2	242.1
2008	86.0	63.1	75.7	3.2	8.3	4.2	3.0	1.5	1.3	2.5	1.0	249.8
2009	86.4	59.2	77.5	3.2	7.0	3.6	3.0	1.5	1.3	2.1	0.8	245.6
2010	88.2	53.6	77.4	3.2	6.0	3.0	3.5	1.7	1.2	2.1	1.5	241.4

A.15 Regression Model Data Set (1970-2010)

Calendar Year	US Industry Combine Sales	Real Interest Rate	Deflated USDA Annual Net Cash Income (M$)	IRS Section 179 Max Allowable Deduction ($)	Lagged EPA Engine Emissions	Total Harvestable Acres (Million A)	Combine Capacity Index
1970	26,720	2.85	85,795	0	0	215.30	130
1971	27,269	1.28	80,623	0	0	230.30	131
1972	27,901	1.34	100,131	0	0	221.30	133
1973	35,082	4.35	150,859	0	0	244.60	132
1974	31,595	1.61	133,753	0	0	253.70	131
1975	33,091	-2.25	102,615	0	0	261.70	135
1976	32,521	0.78	98,063	0	0	268.30	140
1977	28,813	0.93	86,059	0	0	273.60	142
1978	31,492	2.43	96,397	0	0	265.50	146
1979	32,246	4.51	89,279	0	0	275.00	150
1980	25,760	3.81	81,847	0	0	283.70	158
1981	26,831	7.86	70,586	0	0	292.00	160
1982	16,205	8.12	77,589	0	0	291.70	166
1983	12,755	5.94	74,474	0	0	252.00	165
1984	11,420	7.69	69,755	0	0	276.80	169
1985	8,411	6.24	85,250	0	0	276.30	171
1986	7,660	5.25	84,476	0	0	260.30	173
1987	7,174	5.32	93,087	0	0	239.20	176
1988	5,995	5.44	91,593	0	0	234.80	179
1989	9,110	6.02	87,264	0	0	252.10	185
1990	10,433	5.54	84,233	0	0	247.00	189
1991	9,715	3.90	77,032	0	0	243.00	189
1992	7,704	3.18	82,825	0	0	248.80	193
1993	7,846	3.45	86,324	0	0	240.30	195
1994	8,486	5.19	74,854	0	0	246.10	198
1995	9,188	6.29	74,201	0	1	236.10	199
1996	9,011	6.11	81,333	0	0	253.50	200
1997	9,644	5.96	79,487	0	0	254.30	200
1998	10,368	7.32	74,594	0	0	252.50	200
1999	5,445	6.72	73,956	0	0	245.10	204
2000	5,663	6.50	71,406	0	1	246.60	207
2001	6,423	4.51	75,508	0	0	239.40	207
2002	5,038	3.86	61,387	24,000	0	243.60	210
2003	4,631	1.58	84,979	100,000	0	242.30	220
2004	6,665	2.26	96,586	102,000	0	240.80	230
2005	6,735	3.30	97,311	105,000	1	236.10	231
2006	6,169	4.73	74,558	108,000	0	234.10	236
2007	7,103	5.45	82,587	125,000	0	242.10	238
2008	8,464	1.54	92,875	250,000	0	249.80	245
2009	9,690	2.93	70,794	250,000	0	245.60	255
2010	10,691	0.82	92,500	500,000	1	241.40	256
Minimum	4,631	-2.25	61,387	0	0	215.30	130
Maximum	35,082	8.12	150,859	500,000	1	292.00	256
Mean	14,711	4.16	86,069	38,146	0.10	251.14	184
Std. Dev.	10,266	2.34	16,120	96,777	0.30	17.42	36.25

A.16 Regression Model Data Set (1970-1986)

Calendar Year	US Industry Combine Sales	Real Interest Rate	Deflated USDA (U.S.) Annual Net Cash Income (Million $)	Total Harvestable Acres (Million A)	Combine Capacity Index
1970	26,720	2.85	85795.1	215.30	130
1971	27,269	1.28	80622.7	230.30	131
1972	27,901	1.34	100130.7	221.30	133
1973	35,082	4.35	150859.3	244.60	132
1974	31,595	1.61	133753.0	253.70	131
1975	33,091	-2.25	102615.4	261.70	135
1976	32,521	0.78	98063.4	268.30	140
1977	28,813	0.93	86059.3	273.60	142
1978	31,492	2.43	96397.3	265.50	146
1979	32,246	4.51	89279.0	275.00	150
1980	25,760	3.81	81847.2	283.70	158
1981	26,831	7.86	70586.4	292.00	160
1982	16,205	8.12	77588.6	291.70	166
1983	12,755	5.94	74473.7	252.00	165
1984	11,420	7.69	69754.8	276.80	169
1985	8,411	6.24	85250.5	276.30	171
1986	7,660	5.25	84475.9	260.30	173
Minimum	7,660	-2.25	69,755	215.30	130
Maximum	35,082	8.12	150,859	292.00	173
Mean	24,457	3.69	92,209	261.30	149
Std. Dev.	9,285	2.93	21,398	22.83	16

A.17 Regression Model Data Set (1987-2010)

Year	US Industry Combine Sales	Real Interest Rate	Deflated USDA (U.S.) Annual Net Cash Income (Million $)	IRS Section 179 Maximum Allowable Deduction ($)	Lagged EPA Engine Emissions	Total Harvestable Acres (Million A)	Combine Capacity Index
1987	7,174	5.32	93,087	0	0	239.20	176
1988	5,995	5.44	91,593	0	0	234.80	179
1989	9,110	6.02	87,264	0	0	252.10	185
1990	10,433	5.54	84,233	0	0	247.00	189
1991	9,715	3.90	77,032	0	0	243.00	189
1992	7,704	3.18	82,825	0	0	248.80	193
1993	7,846	3.45	86,324	0	0	240.30	195
1994	8,486	5.19	74,854	0	0	246.10	198
1995	9,188	6.29	74,201	0	1	236.10	199
1996	9,011	6.11	81,333	0	0	253.50	200
1997	9,644	5.96	79,487	0	0	254.30	200
1998	10,368	7.32	74,594	0	0	252.50	200
1999	5,445	6.72	73,956	0	0	245.10	204
2000	5,663	6.50	71,406	0	0	246.60	207
2001	6,423	4.51	75,508	0	1	239.40	207
2002	5,038	3.86	61,387	24,000	0	243.60	210
2003	4,631	1.58	84,979	100,000	0	242.30	180
2004	6,665	2.26	96,586	102,000	0	240.80	230
2005	6,735	3.30	97,311	105,000	1	236.10	231
2006	6,169	4.73	74,558	108,000	0	234.10	236
2007	7,103	5.45	82,587	125,000	0	242.10	238
2008	8,464	1.54	92,875	250,000	0	249.80	245
2009	9,690	2.93	70,794	250,000	0	245.60	255
2010	10,691	0.82	92,500	500,000	0	241.40	256
Minimum	4,631	0.82	61,387	0	0	234.10	176
Maximum	10,691	7.32	97,311	500,000	1	254.30	256
Mean	7,808	4.50	81,720	65,167	0	243.94	208
Std. Dev.	1,835	1.80	9,262	120,212	0.34	5.92	24

A.18 USDA Interest Rate Forecast and Real Interest Rate Conversions (2011-2020)

Year	Interest Rate	Inflation	Real Interest Rate
2011	5.4	1.1	4.25
2012	6.8	1.1	5.64
2013	7.7	1.1	6.53
2014	8.2	1.3	6.81
2015	8.2	1.6	6.50
2016	8.2	1.7	6.39
2017	8.2	1.8	6.29
2018	8.2	1.8	6.29
2019	8.2	1.8	6.29
2020	8.2	1.8	6.29

A.19 USDA Deflated Net Cash Income Conversions (2011-2020)

Year	USDA (U.S.) Annual Net Cash Income (Million $)	Personal Consumption Expenditures Index	Deflated USDA (U.S.) Annual Net Cash Income (Million $)
2011	95,814.2	112.12	94,771.7
2012	92,581.5	113.35	90,577.8
2013	89,908.8	114.60	87,005.9
2014	88,609.8	116.09	84,648.4
2015	89,250.4	117.95	83,917.7
2016	90,638.5	119.95	83,798.3
2017	91,808.3	122.11	83,379.0
2018	93,989.9	124.31	83,851.0
2019	96,093.0	126.55	84,211.4
2020	98,210.7	128.83	84,545.4

A.20 USDA Total Planted Harvestable Acres Predictions 2011-2020 (Million Acres)

Year	Corn	All Wheat	Soybean	Oats	Sorghum	Barley	Rice	Dry Edible Beans	Rye	Sunflower	Canola	Total Harvestable Acres
2011	92.0	57.0	78.0	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	249.0
2012	91.5	55.5	78.3	3.0	6.0	3.2	3.2	1.7	1.2	2.1	1.5	247.2
2013	91.0	54.0	78.5	3.0	6.0	3.2	3.2	1.7	1.2	2.1	1.5	245.4
2014	90.5	53.0	79.0	3.0	6.0	3.2	3.2	1.7	1.2	2.1	1.5	244.4
2015	90.5	52.0	79.0	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	243.5
2016	90.5	51.5	79.5	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	243.5
2017	91.0	51.5	79.5	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	244.0
2018	91.5	51.5	79.5	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	244.5
2019	92.0	51.0	79.5	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	244.5
2020	92.0	51.0	79.5	3.0	6.0	3.2	3.3	1.7	1.2	2.1	1.5	244.5

A.21 Predictions Data Using 1970-2010 Regression Model

Year	US Industry Combine Sales	Real Interest Rate	Deflated USDA (U.S.) Annual Net Cash Income (Million $)	IRS Section 179 Maximum Allowable Deduction ($)	Lagged EPA Engine Emissions	Total Harvestable Acres (Million A)	Combine Capacity Index
2011	10,094	4.25	94,772	500,000	0	249.00	259
2012	7,593	5.64	90,578	500,000	0	247.15	262
2013	6,785	6.53	87,006	500,000	1	245.40	265
2014	4,296	6.81	84,648	500,000	0	244.40	268
2015	3,681	6.50	83,918	500,000	0	243.50	271
2016	3,056	6.39	83,798	500,000	0	243.50	274
2017	2,466	6.29	83,379	500,000	0	244.00	277
2018	1,869	6.29	83,851	500,000	0	244.50	280
2019	1,200	6.29	84,211	500,000	0	244.50	283
2020	529	6.29	84,545	500,000	0	244.50	286
Minimum	529	4.25	83,379	500,000	0	243.50	259
Maximum	10,094	6.81	94,772	500,000	1	249.00	286
Mean	4,157	6.13	86,071	500,000	0	245.05	273
Std. Dev.	3081	0.72	3,752	0	0.32	1.74	9

A.22 Predictions Data Using 1987-2010 Regression Model

Year	US Industry Combine Sales	Real Interest Rate	Deflated USDA (U.S.) Annual Net Cash Income (Million $)	IRS Section 179 Maximum Allowable Deduction ($)	Lagged EPA Engine Emissions	Total Harvestable Acres (Million A)	Combine Capacity Index
2011	12,356	4.25	94,772	500,000	0	249.00	259
2012	12,489	5.64	90,578	500,000	0	247.15	262
2013	12,708	6.53	87,006	500,000	1	245.40	266
2014	12,320	6.81	84,648	500,000	0	244.40	269
2015	12,003	6.50	83,918	500,000	0	243.50	272
2016	11,911	6.39	83,798	500,000	0	243.50	275
2017	11,882	6.29	83,379	500,000	0	244.00	278
2018	11,917	6.29	83,851	500,000	0	244.50	281
2019	11,879	6.29	84,211	500,000	0	244.50	285
2020	11,841	6.29	84,545	500,000	0	244.50	288
Minimum	11,841	4.25	83,379	500,000	0	243.50	259
Maximum	12,708	6.81	94,772	500,000	1	249.00	288
Mean	12,131	6.13	86,071	500,000	0	245.05	273
Std. Dev.	310	0.72	3,752	0	0.32	1.74	10