Factors Affecting U.S. Farmer's Expenditures on Farm Machinery 1960-2010

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Abstract

Mechanization and technological advancement has been the cornerstone of agricultural prosperity in the United States and has served as a flagship to the rest of the world. Farm machinery and equipment sales for the three largest manufactures in 2011 reached nearly $60 billion and higher sales are projected for the future. Many factors have been attributed to this increase in sales including high commodity prices, low interest rates, and favorable government policies toward agricultural producers. This study will seek to model producer production expenses on farm machinery and equipment and decipher which factors are significant for explaining demand for farm machinery.

Keywords: Farm machinery, depreciation, crop insurance, farm expenditures

Introduction

The invention and innovation of the iron/steel plow in early 1800's essentially started the multibillion dollar farm machinery manufacturing industry that exists today in the United States. Farm machinery has progressively become larger, more efficient, and consequently more expensive. This growth in farm machinery technology occurred concurrently with other changes in the U.S. agricultural structure. Rising agricultural exports, increasingly available credit, advancement in input sophistication, proliferation of information, and changing involvement

from federal, state, and local governments have all significantly altered the state of agriculture from its early roots in the United States.

Large farm expenditures, like farm machinery, naturally receive more attention from farmers, loan officers, and other stakeholders when considering a purchasing decision. Large expenditures represent the undertaking of some level of risk because they are often financed with debt. Willingness to take on risk usually takes into account several factors including those found on past balance sheets and some unquantifiable factors that lie in the producer's mind and gut. Yet, as an aggregated group, agricultural producers or farm machinery consumers follow some very broad, but significant macroeconomic factors when making purchasing decisions. Factors such as interest rates, commodity prices, and input prices are general indicators, but can convey important information about what is going on in the agricultural sector and what type of environment producers are experiencing. Modeling factors like these to predict future expenditures on farm machinery will be the main goal of this research paper and could have several useful outcomes for machinery consumers and producers, as well as other players in the market

Variables of Interest

Machinery Expenditures

Modern day farm machinery manufacturing in the U.S. is dominated by four major companies, which also comprise most of the world's manufacturing of agricultural equipment. Recent year equipment models from these companies have incorporated cutting edge global positioning systems (GPS) as well as other impending precision agriculture technologies. These progressions represent a serious commitment to a new style of farming and an innovative focus

on efficiency. Similar significant steps in technology transitions have taken place several times during our study period 1960-2010. Gross yearly expenditures in U.S. dollars on farm machinery and equipment (MacExp) will be the dependent variable used in this model. A lagged dependent variable (MElg) could also be a possible factor affecting demand. It is logical to assume that previous year expenditures will likely have some effect on current expenditures being that farm machinery is a durable good. It is expected that a lagged machinery variable will be significant and have a negative coefficient. The negative coefficient is anticipated because purchases made in previous years will reduce from current year purchases. Farm machinery and/or equipment will henceforth include gross yearly expenditures on tractors, combines, mechanical implements, and large trucks used for transportation of product and other machinery. Data on farm machinery expenditures is from the United States Department of Agriculture (USDA) Economic Research Service's (ERS) farm income data files. Yearly statistics are deflated to 1960 consumer price index (CPI) levels.

Cash Receipts

Cash receipts represent not only yearly changes in commodity prices, but growing or declining production of specific or aggregated products. Cash receipts were chosen as an explanatory variable because it reflected both aspects of the income source for producers. For the purpose of this study only cash receipts from machinery intensive products such as corn, soybeans, wheat and cotton were included. Using total U.S. cash receipts would have included high value, but labor intensive products like fruits, vegetables, and certain nuts which could possibly skew the data. Yearly cash receipt figures were deflated to 1960 CPI levels.   It is expected that as gross yearly cash receipt increase, farm machinery expenditures should rise as

well. Increasing cash receipts could possibly indicate increasing income and a more viable time to make equipment purchases.

Debt to Equity

The debt to equity (DE) ratio is used as an explanatory variable in the model to measure year to year financial wellbeing of U.S. farmers. The debt to equity ratio measures to what level of a firm's assets is financed utilizing credit. Larger ratios indicate more assets are being financed with debt, which depending on several factors can indicate looming problems or potentially rapid growth within the firm. The highest DE ratio during the study period was 1985 after the height of the federal governments crack down on high inflation. U.S. farmer's had just experienced a 29% drop in farmland value[1] which dramatically reduced their asset equity. Previous studies have shown a positive relationship, meaning the ratio was used as an indicator of wealth and ability to purchase equipment. A negative relationship could also exist because growth in debt, from a group often characterized as conservative, could be a signal that the economic environment is compelling farmer's to increase their financial leverage through debt. The trending use of debt and equity throughout the study period should create some interesting results when ran through the model.

Other Purchased Input Costs

Production inputs are often the largest cost to agricultural producers and can fluctuate as much as prices that farmers receive for their products. Input costs can include fuel, seed, fertilizer, insurance, other chemicals, repairs, electricity, and labor, among other things. Input cost data was collected from the USDA ERS and considers all input costs except machinery and dwellings. The expected sign of the input coefficient is mixed. On one hand, short term increases

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[1] Calomiris, Charles W., R. Glenn Hubbard, and James H. Stock. "Growing in Debt: The 'Farm Crisis' and Public Policy." *Brookings Papers on Economic Activity* 02 (1986): 441-79. *NBER*. Web. 05 Jan. 2013.

in input prices could drain available cash flows and credit lines thereby hampering farmer's abilities to purchase machinery and equipment. Yet, rising commodity prices can respond to increases in input prices thereby negating higher cost to producers. Higher input costs could also signal to producers to invest in more efficient machinery, much like higher fuel prices have pushed people to buy more fuel efficient automobiles.

Net Farm Income and Price per Acre

Agricultural producer's income should always have a strong effect on machinery expenditures. Higher incomes should incentivize increased investment in farm activities as they are generating profits to shareholders. Low profits could push less efficient producers out of the market to pursue better means of generating wages. Deflated average yearly U.S. net farm income spiked in the early 1970's followed by a slump during the middle of the 1980's crisis. Overall, incomes for U.S. farmers have improved over the decades. A positive relationship is expected between net farm income and machinery expenditures.

Recently, a lot of attention has been placed on the increasing sale prices of quality farm land. Record level commodity prices have increased the value of agricultural lands and demand has been steadily increasing as well. Increasing prices on this essential input could have an impact on machinery expenditures. Land is different than other inputs in that it does not depreciate or run out, and outside extreme circumstances it is not being created. Price per acre statistics collected from the USDA Farm Income data files are deflated to 1960 CPI levels and will be used as an explanatory variable. Looking at the yearly data, average U.S. deflated farm acreage price in 2010 was $290.55 which is close to record price in 1980 ($289.43) before the farm crisis set in. Farmland prices are not expected to have a significant impact because of the availability of credit, but a negative relationship should exist between machinery expenditures.

Interest Rates

It is expected that interest rates will be one of the most important factors effecting demand in this model. Interest rates represent the cost of capital that farmers face when making a purchase decision using outside capital. Large farm purchases, like agricultural machinery, are usually financed with debt. Higher interest rates cause final purchase prices to increase and could delay purchase decisions until more favorable rates appear in the market. When collecting interest rate data, the objective was to find rates that were closely connected to agricultural credit line rates. The Agricultural Finance Databook from the Federal Reserve Bank of Kansas City provided quarterly and yearly average farm machinery and equipment interest rates for 1977 to 2010. These same interest rates could not be found for years 1960 to 1976. To correct for the missing data points two separate approaches were taken. First, average yearly prime interest rates were simply plugged into the missing points from their corresponding year. The second and more involved approach took the average difference between the prime rate and the farm machinery rate for years 1977 to 2010. This calculated average difference was then applied to the corresponding prime rate for the missing years and the new values are used to fill the missing data years. Both interest rate approaches will be tested in the model. The variable IRA will represent Interest Rate Adjusted, meaning it has the average difference values mentioned in the second approach. The variable IRPI represents Interest Rate Prime Interest, meaning the average yearly prime interest rate was used to fill in missing values mentioned in the first approach. A significant negative relationship is expected between interest rates and farm machinery expenditures.

Agricultural Exports

Developing nations such as the BRIC and MIST states (Brazil, Russia, India and China & Mexico, Indonesia, South Korea and Turkey respectively) have been experiencing tremendous growth over the years with more growth in the forecast. These expanding nations, among many others, are fueling their growth with many resources including bulk food commodities. U.S. exports of corn, wheat, soybeans and other product have been increasing and commodity prices reflect this newfound demand. Increasing exports denote increasing outside market demand which often moves in noticeable trends. These trends can encourage the prospect of future profits and stable to higher commodity prices. Broader markets can also insulate producers from domestic and foreign demand/supply shocks. Export figures are not always widely publicized or announced to the general public and for this reason the export variable is lagged in the model. The lagged export coefficient is expected to have a positive coefficient because of the optimistic outlook it has on prices. Agricultural export data are measured in total yearly dollar values and are deflated to 1960 CPI levels.

Crop Insurance

Crop insurance has expanded its reach and impact within recent years, which has been criticized as an underhanded way of providing price/income support to American farmers; violating various trade agreements. Yet, as long as it exists, crop insurance can be utilized as a tool to reduce risk associated with production/price and therefore reduce income risk. The Federal Crop Insurance Program essentially started in 1989 and has seen growth ever sense. Various forms of government sponsored crop insurance have existed since the 1930's, but it wasn't until 1989 that Congress significantly expanded the program. New rules, provisions, and subsidies made coverage for the average farmer sensible. The program offers a variety of

different plans and options, but all come with the benefit of having some percentage of government subsidy covering premium costs. This cost sharing approach has made crop insurance very popular with farmers. Agriculture is by far one of the riskiest business ventures, with several threats to income and profitability coming every season. Yet, crop insurance protects farmers from several risk factors including low yield, crop damage/destruction, and price protection. Basically, the lower end of the income possibility distribution curve has been cut-off because crop insurance guarantees a level of income security. With less income risk farmers, could feel more comfortable making large purchase decisions, i.e. farm machinery. Crop insurance allows a farmer's worst year to still be one where the bills are getting paid and the chance to try again next season is still alive. To incorporate this potentially important factor into the model two approaches were taken. The first variable looks at a ratio of subsidies given out by the program and the number of acres enrolled in the crop insurance program in a given year. This ratio, represented by the abbreviation CISA, measures the amount of subsidies in dollars per acre. The second variable to be tested in the model is a ratio of indemnity payments to premiums paid by policy holders represented by the abbreviation CIIP. This ratio will measure yearly levels of insurance policy payouts compared to the premiums that producers pay for having policy coverage. Data for these figures were collected from the USDA Risk Management Agency (RMA), which oversees the implementation of the Federal Crop Insurance Program. Data collected was refined to only include insurance numbers concerning machinery intense commodities which includes corn, cotton, oats, rye, soybeans, wheat, and barley. Using total U.S. statistics would have included high value and labor intensive products like coffee, tree fruits, and grapes. It is the expectation that crop insurance will possibly have a significant impact and will have a positive relationship to machinery expenditure. Higher ratios of subsidies per

acre and indemnity payments to producer premiums should be encouraging for U.S. farmers as a whole.

Depreciation Policies

The global financial crisis of 2008 spurred governments around the world, including the United States, to implement programs and policies to jump start economic growth and recovery. The U.S. government took several steps to remedy the economy including ramping up depreciation policies. Depreciation allows owners of physical property to account for losses in value of their assets which are used to create income for their businesses. Depreciation limits have recently been expanded and increased to encourage consumers to purchase machinery and equipment, and thereby stimulating the economy. Farmers have been utilizing these recent incentives and have begun buying and upgrading their machinery. Farm machinery sales have been increasing the past few years and favorable changes in depreciation tax policies coupled with high commodity prices could explain why. The idea that depreciation policies could have an effect on machinery expenditures has stimulated its own variable(s) within the model.

In the process of collecting data to accurately model depreciation, several problems arose. The preferred method of collecting the data would have been to find yearly figures on the total amount of depreciation claimed by U.S. farmers according to Schedule F: Farm Profit and Loss tax form. Despite assistance from the Internal Revenue Service, this type of data has only been recently collected and published for the public. Tax years 2003 through 2009 are available to the public via the IRS Statistics website. The next best alternative would be to find a proxy that corresponds highly to depreciation levels. Research on the subject turned up no accurate proxy. Next, an attempt was made to test the feasibility of creating an index to measure the "utility" of

yearly depreciation policies. Depreciation policies have several components which make it difficult to measure including assets that are included/excluded, limits on depreciation amounts, changes in asset lifespans, bonus depreciation, accounting method (ex. sum-of-years) among many other measures. The difficulties in creating this index were beyond the scope of this paper and alternative methods were considered. The conclusive solution was to create dummy variables to represent broad changes in deprecation polices over the study period. While resulting coefficients would not display effects of depreciation components individually, they will show effects that different policies had on machinery expenditures. If significance is present in the dummy variable variables, further examination can take place to distinguish important differences between policies.

Table 1: Depreciation Policies in Affect during 1960-2010

Policy	Model Abbreviation	Start Year	End Year
Bulletin F	BullF	1954	1961
Kennedy's Special Guidelines	SpecGuide	1962	1970
Asset Depreciation Range	ADR	1971	1980
Accelerated Recovery System	ARCS	1981	1985
Modified Accelerated Recovery System	MARCS	1986	Present

While this approach was not originally preferred, the variables should be satisfactory to measure significant changes in depreciation policies. Expected coefficient significance and sign for the five dummy variable policies cannot be determined a priori.

Technical Change

The fifty year study period most likely witnessed the most rapid technological change than any other period in history. This change did not pass over agricultural and in fact witnessed some of the greatest strides in the last half-century. Farm machinery and equipment made most of its technical improvements through increased efficiency of operation and use of other inputs.

Increased efficiencies cause shifts in production functions upward and changes relative prices of inputs and outputs.[2] Capturing farm machinery technical changes, as well as other inconspicuous changes, can be done by using linear and exponential time trend variables. The linear and exponential time trend variable will be represented by TIME and T2 respectively.

Results and Analysis

The observations collected during the time series period between 1960 and 2010 are subject to several statistical problems including autocorrelation. Within the five decades, reoccurring effects of the broader economic or business cycles can distort obtained results and skew interpretations. All models will include a lagged dependent variable (MElg) because of its expected significance and as a strategy to correct autocorrelation. Additional tests will be conducted to further detect autocorrelation. Heteroskedasticity is also a problem found in some time series data and steps will be taken to test for it in final models. Another potential problem with the variables is multicollinearity because many of them are focused on the income of U.S. farmers. Simple tests can be done to detect multicollinearity, but some association between variables might be acceptable since this model will be used to predict future machinery expenditures.

Various combinations of variables were tested to find the best model to explain machinery expenditures; the final model is presented below:

$$Y = \beta_o + \beta_1 *MElg + \beta_2 *Receipts + \beta_3 *NFI + \beta_4 *Inputs + \beta_5 *DE + \beta_6 *IRA + \beta_7 *Exlg + \beta_8 *Acre + \beta_9 *CIIP + \beta_{10} *TIME + \beta_{11} *T2$$

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[2] As explained by Abebe, Dahl, and Olson . "The Demand for Farm Machinery." *Staff Papers Series: University of Minnesota Institute of Agriculture, Forestry, and Home Economics* P89.47 (1989): 1-75. *AgEcon Search*. Web. 15 Feb. 2012.

No serious autocorrelation or heteroskedasticity was encountered as evidence from the Godfrey LM test and the White test so the model equation is estimated using ordinary least square (OLS). The final model results indicate an R-squared value of 0.97 and an adjusted R-squared value of 0.96. It is important to note that due to multicollinearity accepted in the model goodness of fit statistics could be slightly misleading.

The coefficient of lagged machinery expenditures (MElg) is positive and highly significant. These results indicate that previous year expenditures are important for determining current year machinery purchases. The coefficient is positive and opposite of what was anticipated. This could be due to historical trends in machinery expenditures because sales of farm machinery usually follow trends that last multiple years. During the 1970's expansion period in agriculture, machinery expenditures saw year after year of growth. Therefore, a relationship can be developed that higher equipment sales over previous years could predict higher sales in the following year. This variable is not necessarily following the expected logic, but is detecting trends that often occur in machinery expenditures.

The cash receipts variable also does not have the anticipated coefficient sign, but is statistically insignificant. This suggests that prices received for commodities and outputs are not necessarily important in determining machinery expenditures. Commodity prices, for most of the study period, have remained stable when compared to the recent volatility in grain and oilseed prices. Since the price component of cash receipts has remained fairly stable, increased output, due to increased demand and improved efficiencies, has determined yearly cash receipt values additional.

The coefficient for net farm income is positive and statistically significant. This result indicates that as farm incomes increase, farmers will consume more farm machinery and

equipment. The coefficient for purchased inputs is positive and also significant. The anticipated coefficient sign was debatable, but follows a logical conclusion. Higher prices or increased use of purchased inputs can encourage farmers to acquire new equipment that will better utilize inputs and operate more efficiently.

The debt to equity ratio coefficient is negative and insignificant. The coefficient results were somewhat unexpected. This variable was meant to measure financial standing of farmers through the study period, which is a major decision factor for credit lenders. The coefficient sign was negative which indicates that as debt, when compared to equity, increases machinery expenditures will decrease. The anticipated positive coefficient seemed likely because a lower ratio is a sign of better financial capacity and ability to make and finance large purchases. Yet, the results could be explained by the rapid decline in 1980's farmland values. Both nonreal estate and real estate debt peaked around 1984 and saw decline into the 1990s, but the decline in equity values greatly outweighed the plunge in debt. Machinery expenditures, in these same years, were at their lowest levels in decades when deflated to 1960 CPI. This could possibly explain the relationship generated by the model, but in any circumstance the variable is insignificant.

As expected, both interest rate variables were highly significant and exhibited a negative relationship to machinery expenditures. Two interest rate variables were tested to select the preferred method of dealing with missing data. The IRA variable was preferred over the IRPI for significance and positive effects of the R-squared value. Variable IRA uses prime interests for 1960 through 1976 and farm machinery loan interest rates for 1977 through 2010. This relationship infers that as interest rates increase machinery expenditures will decrease. Interest rates are one of the simplest and most visible indicators for farmers to gauge market conditions and should be a primary factor.

The lagged agricultural export variable (Exlg) exhibited the correct coefficient sign, but was insignificant. The average price per farmland acre (ACRE) variable had a positive coefficient, but was insignificant as well. Both these variables were suspected to not be highly significant in the results. According to the Variance Inflation test within SAS, both of these variables have problems with multicollinearity and could be removed from the model without serious implications.

Both time trend variables (TIME & T2) were significant. The linear trend variable exhibited a positive coefficient while the exponential trend variable had a negative coefficient. These variables pickup technical changes in farm machinery as well as other factors not addressed by other variables within the model.

Testing results of both crop insurance variables concluded with insignificant findings. The variable CISA, which tested a ratio of subsidies to crop insurance acres enrolled, exhibited a negative coefficient in numerous models. The CIIP variable, a ratio of government subsidies to producer premiums, produced the correct coefficient sign, but was ultimately insignificant in various models. The standard error also very high compared to the coefficient and is probably misleading. The negative coefficient of CISA and insignificance of both variables is possibly due to the positioning of the relatively short time period in which the Federal Crop Insurance Program has been in effect.

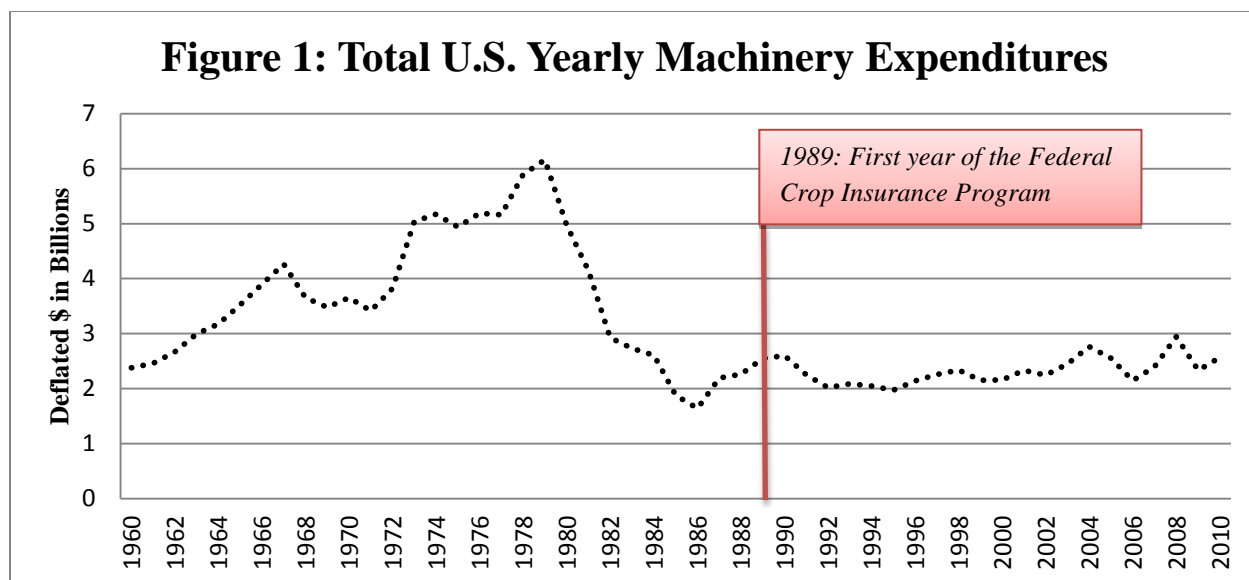## Figure 1: Total U.S. Yearly Machinery Expenditures

Figure 1 illustrates deflated machinery expenditures used in this study from 1960 through 2010 using a dotted line. The flag marks the year 1989 to indicate the beginning of the Federal Crop Insurance Program. Notice that the period before 1989 includes several years of high expenditures followed by the 1980's financial decline. With the availability of crop insurance beginning near the lowest expenditure point in the study period, it is possible that the statistical software interpreted the introduction of crop insurance as a variable which stabilized or reduced farm machinery expenditures. Testing the influence of crop insurance with this model's methods could improve overtime as more observations are taken into account. Yet, it is also possible that crop insurance has no significant impact on the demand for farm machinery and equipment.

Finally, depreciation policies were tested for their ability to predict gross machinery expenditures. Five dummy variables were available to test changes and significance of differing depreciation policies. Several models were tested, none of which boasted a significant policy or collection of policies. Coefficient signs also changed when implemented differently, but were mainly negative. The variability in depreciation policy coefficients signs makes it difficult to confidently make interpretations of their influence. Because of this difficulty and their

insignificance, all depreciation variables have been left out of the final model. It is possible that more in depth research and analysis into this area could develop a better way to test changes in depreciation. An index measuring depreciation utility or collecting actual data figures could certainly produce clearer results.

Conclusions and Summary

Some results from investigating this model were very interesting. Several variables such as net farm income, lagged machinery expenditures, and interest rates were expected to be very significant and the results backed up these expectations. Before running test models the purchased inputs variable significance and overall effect was debatable. Yet, the results find that input prices and quantities are very important for predicting machinery expenditures. Then there are the variables that had the opposite than expected sign and/or were insignificant. Cash receipts, debt to equities, lagged agricultural exports, crop insurance, and farm real estate prices all were insignificant in the final model. Despite these results, on an individual basis the importance of these factors change from farmer to farmer.

Implications

As stated before, the main goal of this paper was to develop a model in which future year's machinery expenditures can be approximately predicted. Forecasting these figures and knowing the more significant factors of demand have implications for several entities in contact with farm machinery. Starting at the source, machinery manufactures such as John Deere and AGCO need to make reliable predictions for the future demand for their products. Knowing market conditions for any firm is crucial for efficient production and sales. Manufacturers keep a

close eye on factors such as interest rates which incentivize or deter famers from using credit to purchase equipment. Stockholders of these publicly traded manufactures should also be aware of factors which effect the consumption of the company's products.

Firms responsible for making loans and other forms of credit available to farmers could also benefit the application of this model. Financing of large machinery purchases is often only possible for farmers through credit lending institutions. Anticipating demand for credit lines and where to focus advertising/marketing is key for these institutions. If rates are especially good lenders what to make sure their customers know that now is the time to buy equipment. They could also use the model to point out other important factors to their customers. If input prices are increasing they can explain the benefits of having newer and more efficient machinery on their farms. The same implications apply to local dealers of agricultural machinery. Dealers obviously want to move product out of their inventories and understanding market conditions can allow them to price and incentivize in an effective way.

Farmers are the last component in the farm machinery chain, but the implications of these results could benefit the consumer the most. Everyone in the chain has the goal of putting machinery on their customer's farms. Agricultural producers need to be just as discerning and knowledgeable when it comes to major farm management decisions. Interest rates and income are inherent factors, yet further examining their input costs, tax policies, and crop insurance coverage could also influence their decisions. Farmers are subject to several risks and influences, so making appropriate and informed decisions can be crucial to firm stability and longevity.

Elected officials and government entities with their hand in agriculture should be aware of all the factors that affect their constituents. When drafting and implementing policies and programs the expected results need to be carefully studied and possible unintended consequences

need particular attention. The government is highly involved in directing and influencing other actors in agriculture so any actions, big or small, need to be analyzed for these potential effects. Continued understanding of what farmers and other actors respond to can be essential in developing quality policies.

There is quite a bit room for expansion on this subject. Different approaches to measuring crop insurance and tax policies being the main ones. Crop insurance continues to be increasingly utilized by farmers in the United States and depreciation, among other tax policies, is continually changing as well. Agriculture presents numerous factors for study that are changing, appearing, and fading constantly.

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Appendix A: Statistical Model Results

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	-901.13861	631.86358	-1.43	0.1620	0
MElg	Lagged Machinery Expenditures	1	0.47128	0.09237	5.10	<.0001	11.06600
Receipts	Cash Receipts	1	-5.00553E-8	3.294705E-8	-1.52	0.1370	13.81874
NFI	Net Farm Income	1	0.06651	0.02042	3.26	0.0024	3.58222
Inputs	Other Purchased Input Costs	1	0.16296	0.04396	3.71	0.0007	22.30964
DE	Debt to Equity Ratio	1	-8.04517	21.66241	-0.37	0.7124	6.42874
IRA	Adjusted Interest Rate	1	-122.85643	26.88673	-4.57	<.0001	6.25850
Exlg	Lagged Ag. Exports	1	0.00352	0.03378	0.10	0.9176	11.27526
CIIP	Crop Ins. Indemnity to Premiums	1	52.79126	68.26217	0.77	0.4441	4.04189
Acre	Price Per Acre	1	2.42864	2.86473	0.85	0.4019	22.21217
TIME	Linear time trend	1	34.27251	25.93044	1.32	0.1942	137.45350
T2	Exponential time trend	1	-1.40419	0.58627	-2.40	0.0216	209.06144

Appendix B: Deflated 1960 CPI Variables measured in Billions of U.S. Dollars