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Drone Technology in Agriculture Appraisal

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Drone Technology in Agricultural Appraisals

Abstract

The purpose of this project is to conduct a cost-benefit analysis of implementing a UAV/drone technology within agricultural appraisals. This project is categorized into four categories; introduction, literature review, methodology, and conclusions. The methodology portion of the project is a capital budget analysis measuring the effectiveness of UAVs within the appraisal department. The capital budget will be further developed by conducting a Present Value (NPV) analysis. The NPV analysis consists of a five-year NPV analysis measuring changes in productivity and total revenue caused by UAV technology.

Results were found by using @Risk simulation to simulate data gathered during the project. Data was gathered by doing filed experiments on drone effectiveness during the appraisal process. The simulated data was incorporated into various budgets and used to create a five-year NPV analysis. Three separate scenarios were created, representing a Best-Case, Average-Case, and Worst-Case scenario. An NPV analysis was conducted for each of the three scenarios. Data for all three scenarios was found by conducting field experiments data. Also, all three scenarios have a discount rate of 10%. For each scenario, Year 1 includes the initial investment of purchasing the drone.

The conclusion portion of this project will include a summary of the project, point out potential weaknesses within the project, and state the final consensus about UAV technology used within the agricultural appraisal industry. Thought the course of this project, the terms UAVs and drones will be used interchangeably. The final consensus about UAV use within agriculture appraisal is that despite the legal and time risks, UAVs are still beneficial to agricultural appraisers. As mentioned in the report, done use can increase efficiency and accuracy when inspecting larger tracts of land. UAVs allow appraisers to view areas of the property that are difficult to assess due to weather, accessibility, or terrain.

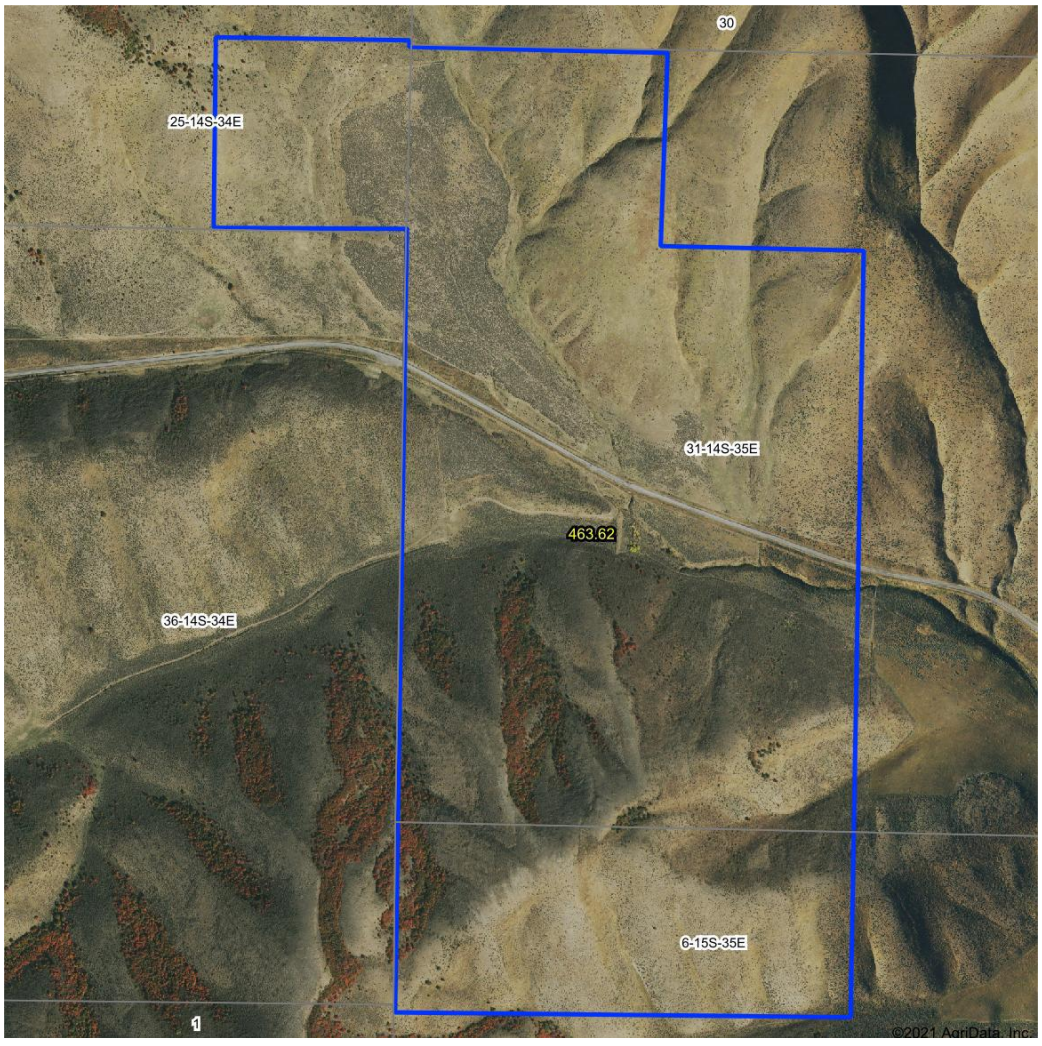
Introduction

Within the Farm Credit System, the appraisal staff has specific needs that can be addressed by the implementation of Unmanned Aerial Vehicles (UAV) technology. One of the main challenges facing agriculture appraisers is the ability to inspect properties that are difficult to access. Limited access can be caused by weather, the size of the property, or lack of physical/legal access. The inability to fully inspect a property creates a weak base for land value evaluations. Many of these properties are being appraised for various lending institutions and are used for collateral analysis. Many appraisal practices have started to use UAVs, more commonly known as drones, in an attempt to better inspect properties for both chattel and appraisal inspections. Chattel inspections are valuation services for personal property. Personal property is an item that is not permanently fixed to land, such as tractors, livestock, and crop inventories. Appraisals are valuation services of real estate and any of its permanent fixtures.

UAVs allow appraisers to inspect properties that have limited access. Deploying a drone can be a much quicker and more efficient way to view large or difficult-to-access properties. UAV can also be used during chattel inspections. For example, an appraiser can deploy a UAV and use areal footage to gather real-time information on livestock numbers, feed inventory, property lines, and equipment quality. The information gathered by a UAV can then be used in the appraiser's analysis of the subject property. The use of UAVs will not only save time but also allow for a more detailed analysis of the subject property.

The Pleasant View Livestock appraisal is a perfect example of when UAV technology can be extremely beneficial. The subject property is located in Oneida County, Idaho. As can be seen from the Aerial Map, the only access to the property is through State Highway 38, which cuts through the property. From State Highway 38, the only other access to the property is from an unmaintained dirt/UTV road located on the property.

Areal Map



The subject property is mountains and cannot be fully seen from the road. The Gate Access photo shows a dirt road used to access more remote areas within the subject property. As can be

seen from the Gate Access photo, the heavy snowpack is prohibiting access and use to the road. Limited access prevented the appraisers from viewing property lines, fencing conditions, and the overall quality of the grazing lands.

Gate Access Photo

The implementation of a UAV technology would allow the appraisers to get a more accurate view of the subject property by survey fencing conditions and inspect difficult-to-access portions of a property. The information gathered would be used to produce a more robust appraisal report and more confidence in collateral evaluations. The implementation of drone technology would also save time and provides greater efficiency during appraisal inspections.

While many appraisers and appraisal institutions see the benefit of UAV technology, these institutions are also aware of the risks that may be associated with UAV use. Risks include both

legal risk and privacy risk. Legal risk deals with limitations and standards set by the Federal Aviation Administration (FAA). The FAA sets standards about what types of UAVs are allowed, and how will these UAVs be monitors. Legal risks also include any specific area or location that prohibits the use or operation of any UAV, such as near local airports.

Most of the legal concerns described above are addressed by the FAA and can be found on their website. By operating within the bounds of the FAA, appraisers can successfully operate drones while maintaining a professional demeanor. The FFA has classified four different categories of drones that are approved for operations over people (FAA). The majority of appraisers will operate within Category 1 and/or Category 2.

Category 1:

- Is a small, unmanned aircraft that weighs less than 0.55 pounds.
- Cannot have any exposed rotating parts that would lacerate human skin.
- Must comply with standard remote identification.
- Can only be operated over moving vehicles if the overflight is transitory.
- Does not require a means of compliance.

Category 2:

- Cannot cause injury to a human by causing a transfer of 11 ft-pounds of kinetic energy upon impact from a rigid object.
- Cannot have any exposed rotating parts that would lacerate human skin.
- Must comply with standard remote identification.
- Can only be operated over moving vehicles if the overflight is transitory.
- Must have FFA-accepted means of compliance.

Category 3:

- Cannot cause injury to a human by causing a transfer of 25 ft-pounds of kinetic energy upon impact from a rigid object.
- Cannot have any exposed rotating parts that would lacerate human skin.
- Cannot be operated over open-air assemblies of human beings.
- Can only be operated over moving vehicles if the overflight is transitory.
- Must have FFA-accepted means of compliance.

Category 4:

- Must receive an airworthiness certificate from the FAA.
- Drones must also follow Remote ID policies. Remote ID provides a foundation of safety and security among drone operators. Using Remote ID, drones will broadcast location, altitude, and drone identity during flight.
- Authorized individuals from public safety organizations may request information about drone operators from the FFA. There are three ways that a drone pilot will be able to meet the identification requirements (FAA).

Standard Remote Drones

- Remote ID capability is built into the drone.
- Between take-off and shutdown, the drone will broadcast.
    - Drone ID
    - Drone location and altitude
    - Drone velocity
    - Control station location
    - Time mark

    - Emergency status

Drone with Remote ID Broadcast Module

- Remote ID capability through module attached to the drone.
- Limited to visual line of sight operations.
- Between take-off and shutdown, the drone will broadcast
    - Drone ID
    - Drone location and altitude
    - Drone velocity
    - Take-off location
    - Time mark

FAA-Recognized Identification Area (FRIA)

- Intended for drones without Remote ID or broadcasting capabilities.
- Drones without remote ID must operate within a visual line of sight.
- Anyone can fly in an FRIA area.
- FRIA location can only be requested through a community-based organization or educational institute.

In addition to FAA regulations, appraisers must also navigate privacy concerns associated with UAV use. Privacy risk deals with using UAVs to invade personal privacy. Examples of an invasion of personal privacy could consist of flying a drone over someone's house or property without permission. It also includes taking photos or videos of personal property without permission. Many popular press articles can be found discussing public privacy issues surrounding drones.

In the popular press article titled, Navigating the legal issues surrounding UAVs (Welte), the author Peter Welte discusses constitutional questions surrounding the legality of UAV technology. In regards to the right to privacy, citizens are still entitled to privacy. Does this right still hold true even with the advancement of new drone technologies? In regards to illegal search and seizure, how do drones fit into the equation? In the olden days, the government could not enter your property without a warrant or if the illegal contraband was hidden "in plain sight". Questions have now arisen from what plain sight means. Do images captured by a drone flowing 1000 ft overhead count as "plain sight"? These are now concerns that law and policymakers will have to grapple with as drone technology continues to become more advanced. The FAA is seeking to identify policy models that benefit both public and private interests.

In the article, Eyes in the Sky (Rice), author Stephen Rice discusses issues facing common place drone use. In general, many members of the public have concerns about unknown drones flying overhead. The public wants to know how this will affect their privacy. According to the article, the Federal Aviation Administration (FAA) regulations do not specifically address flight over residential areas. As long as the UAS operator is compliant with FAA regulations, there is no federal restriction flight over residential areas. Furthermore, the experience would suggest that the vast majority of UAS violators are not caught. The article goes on to mention a study conducted by Dr. Scott Winter. Dr Winter wanted to examine public privacy concerns related to drones. This was done by creating a scale in which to measure public concern. A group of online volunteers was asked to participate in the study. The results concluded that

1. People generally see the need/benefit in drones but want to make sure that drone technology is regulated
2. Public privacy concerns are a function of who is flying the drone.
3. People are less concerned about hobbyist and commercial drones, and more concerned about government drones
4. Gender plays a role. On average, females are more concerned about privacy, compared to males.
5. Public support for drones depends on political affiliation
    a. Liberals show less support
    b. Conservatives show more support.

In general, Dr. Winters concluded that people do not like to be watched. Being watched includes being videotaped and/or taking unwanted photos.
While the use of UAVs may be beneficial and increase efficacy, appraisers need to be aware of legal or privacy issues that may arise. Appraisers must learn to navigate these concerns if they are to operate a UAV both legally and ethically.

Literature Review

The following literature review is designed to give insight and perspective to different areas of UAV use. This section consists of ten academic articles that highlight various topics in which UAVs are currently being used or studied. The literature review will focus on four main topics;

1. Drone use in agriculture
2. Policy and regulation
3. Technology in the appraisal industry
4. Risk management within banking

Each article has been chosen to highlight a particular area pertaining to UAVs and/or agricultural appraisals.

The first topic gives an overview of how drones are currently being used. As mentioned in the introduction section of this research paper, Drones are becoming increasing popular and more common place. Drone technology allows appraisers to gather more data while conduction onsite property inspections. This increase in data allows appraisers to more be more accurate in valuing properties. While appraisers may see drones as useful technology, there are some disadvantages associated with drones. Some of these disadvantages include, regulatory and legal issues. Also, acquiring the proper training can be a lengthy and legal process.

The first article is *Application of Drone in Agriculture* (Ahirwar), by S. Ahirwar. This article presents a high-level overview of how drones can be used in a variety of industries. The article also provides deeper insights into how drones are currently being used within production agriculture. Drone technology is rapidly growing in a variety of industries. By reviewing how drones are used in other industries, we can gain a deeper understanding of how drones can be used within agriculture.

In the article, Ahirwar does a breakdown and explanation of what UAVs are. “Unmanned Aerial Vehicles (UAV) are devices that can fly a pre-set course with the help of an autopilot and GPS coordinates. The immediate advantages of using drones offer a less stressful environment and

allow for better decision making" (Ahirwar). The article then discusses the many different industries drones can be used in. One of the main industries in which drones are being applied is in the military. The military uses drones as target decoys, for combat missions, research and development, and aerial surveillance. Other industries that have deployed the use of drones include; delivery services, security and law enforcement, search and rescue, the film industry, agriculture, wildlife and monitoring, and disaster management.

The article also does a deeper analysis of how drones are used in the specific industry of agriculture. Within agriculture, drones are now being used for soil and field analysis, 3-D maps, mapping patterns, and detailed irrigation analysis. Drones are also being used for planting in small acreage farms. Drone planting systems have decreased the cost by 85 percent for smaller farming operations. Crop spraying is another area where drones are used. Through the use of drone technologies, crops can now be more accurately sprayed with fertilizer or pesticide.
One of the biggest applications of drone use is in monitoring plant health. Drones software can also monitor plant health by pinpointing exact locations of plant disease or areas of poor irrigation. Drones with thermal sensors can identify specific parts of a field that are dry and in need of improvement. Drones can also be used to calculate the vegetation index of growing crops. This index can be used to describe the relative density and health of the crop.
All of the information and data captured by the drone can be used to make a better management decision. Management decisions include; when to apply fertilizer, how to better manage irrigation, and assess the overall health of the crop. Correct analysis of this information can save farmers time, money, and improve efficiency.

The article *Viewing valuations from the sky*: UAV in the appraisal industry this an article that provides and overview of drone use. Unlike the previous article, this article focuses specifically on the application of UAV technology within the appraisal industry.

In this article, the author discusses the use of UAV images, their disadvantages, and their advantages. According to the article, there are a plethora of advantages to using UAV in appraisal work. UAVs are an easy to carry tool that appraisers can easily while doing routine inspections. UAVS allow appraisers to measure, map, photograph, and video specific properties. The increase use of UAVs is transforming the real estate valuation sector.

In addition to increases benefits, UAV use also has its disadvantages. The first disadvantage is privacy. As more laws and regulations are passed, the use of UAVS becomes limited. While the regulations have good intentions to protect the privacy of the public, they also limit the efficiency of many appraisers. The second issue is feasibility. While UAVs are usefully, they also require maintenance and specific skills to operate. Many appraisers may feel that the cost of maintenance and training is too high and not worth taking. The third issue is necessity. Free areal imagery is becoming more sophisticated and available. As free images become more available, it poses opposition to the need of UAVs.

The second topic focuses specifically on technology. The following articles are chosen because they highlight a specific aspect of technology being used with by UAVs or appraisers. As can be seen from simple observance, technology is become an integrated part of everyday business. The appraisal industry is no exception. As the appraisal process becomes more refined, appraisers are

going to rely more and more on technology. As mentioned in the introduction section of this paper, the purpose of this project is to evaluate what effect UAV use has on agricultural appraisers. UAV technology not only can increase efficiency, but it can also create a large pool of available data.

The following article address how UAVs can be used to improve efficacy within appraisal departments. In the article *Drones in appraisal; Drone use in land classification*, the author Pei-Chun Chen discusses how drones can be used to classify different land types. This article addresses the complexity of evaluating land types in Taiwan. Economic development and social changes have led to increasingly complex land use. Agricultural land use in Taiwan is highly complex and involves mostly intensive farming. The high demand for land now requires a quick and efficacy way to monitor and classify different land types.

An experiment was conducted in which a drone was used to classify land types on five separate farming sites. All farming sites were located in Taiwan. Each sight had good growing conditions and is favorable for agriculture production. Each site also had a variety of crops; include rice, corn, and other vegetables. After selecting the sites, aerial imaging was performed using UAVs. Images captured by the UAVs were processed and analyzed using a software program. The program then separated the images into different classifications based on photo traits and previous samples. The results of image interpretation were compared with ground truth data (reference data) that were obtained in field studies. An error matrix was incorporated to compensate for any differences between the field data and areal images. This is known as a Kapa value. Kapa values range between 0-1. The high value indicates more accuracy.
The results indicated that that the accuracy varied depending on the crop growth stage. For example, newly sprouted rice was often classified along with other growing vegetables. Also, buildings with green roofs are often classified as growing vegetation. The overall accuracy of the images was unsatisfactory, resulting in a 60%-88% accuracy. Even with low accuracy, UAV use will continue to become more prevalent in agriculture. The decrease in the number of workers in the agricultural industry renders UAV technology an effective tool for agricultural land management.

In the article, *Computer-Assisted Appraisal: A California Saving and Loan Case Study*, author Joseph Eckert looks at how technology is advancing within the appraisal industry. The appraisal industry relies how on individuals and their opinion of value. Opinion of value is a relative term and is open to personal viewpoints and interpretation.

While the appraisal technique and process has been refined over the years, (Author) feels that the process is limited in two ways. First, the appraisal process is limited in that fact that the manual process does not fully incorporate the dynamics of the surrounding real estate market. Second, once a loan is made, any review of the subject property must be evaluated manually.

Often times in mortgage lending, local only the local real estate market is evaluated. When mortgage loans are sold on the secondary market, the appraisal of the local real estate market is no longer sufficient. As the mortgage loan sector continues to grow, new techniques are needed to help manage risk.

One solution that the author offers is Computer-Assisted Review Appraisal (CARA). This model is based on econometrics and forecasting techniques that prove statistically based quality-control and risk management. Computer-assisted programs allows appraisers to pull comparable sales from a much larger data base. Since the model is based on statistics, it also helps prevent some of the objectivity that may appear in appraisal reports. As the appraisal process continues to become more refined, the reliance on technology will continue to grow.

In the article, *The mass appraisal of the real estate by computational intelligence*, the author, Vilius Kontrimas and Verkias Antanas, looks at new technologies that are being implemented within the appraisal industry. The author begins by giving an overview of the three approaches to value properties. The three approaches are; the income approach, the cost approach, and the sales comparison approach.

For mass appraisals, the sales comparison approach is the most commonly used approach. Ordinary least squares (OLS) is often used to build models in sales comparison approach. These methods are being compared against computational intelligence approaches, such as multiplayer perception (MLP) and support vector machines (SVM). All of the computational approaches were used to build a weighted data-depended committee. Experiments by the Register center of Lithuania have shown that they result from the computational methods are very promising. In some cases, performance of the intellectual computational methods is higher than models Register center.

The third topic is policy. While UAV are undoubtingly growing, so is FAA policy and regulation. Change regulations, restricted fly areas, and licensing requirements are becoming increasingly complex. The following article takes a deeper dive into how policy is affecting of the use of technology. The restrictive nature of policy not only affects the appraisal industry, but can be applied to almost any industry.

The following article, *Politics & technology: U.S. policies restricting unmanned aerial systems in agriculture* (Freeman), by authors P.K. Freeman and R.S Freeland, discusses some of the political issues surrounding drones. This article begins by doing a brief explanation of why the issue of UAS (Unmanned Areal Systems) is relevant today. As can be seen, by simple observation, UASs have dramatically increased in popularity.
With the ability to be used in a variety of industries, UAS has improved efficiency and work capabilities. Technological advances have allowed for instant data. This, once again, increases efficacies and productivity. However, even with the advancements made in technology, people still have apprehensions about drone technology.

As an attempt to analyze these issues, Freeman and Freeland conducted a study. The study wanted to explore four issues relating to drone police. The first issue was to identify why policy debates have emerged. Over the past few years, controversy in the United States concerning the domestic use of UAS has become more prevalent. The second issue was to analyze the impact of UAS legislation on agriculture. To accomplish this task, policy dating back to 2012 was reviewed. The third issues were to try and suggest policy operations for the successful integration of UAS. The fourth issue was to describe the factors influencing UAS policy

decisions. During this discussion, issues such as economic impact, size, and lobbying activity were analyzed.
The study found some interesting results. The points listed below can be used to summarize the findings of the case study.

1. The study indicated that legislation at the federal, state and local levels that would limit UAS operations has mushroomed. The FAA would mandate congress to open US airspace for UAS use by 2015.
2. Americans uneasiness with UAS is based in large part on the highly publicized UAS involvement in War and the concern for public safety as private property rights
3. UAS involvement in agriculture is rapidly growing. Other nationals are also implementing the use of UAS in agriculture.
4. Some of the current proposed legislation would severely limit the commercial use of drones. These limitations could also affect agricultural use.
5. Issues of personal privacy (first amendment and fourth amendment) will be settled in court.
6. There are interest groups lobbying for and against domestic UAS implementation. Despite the economic development of the industry, the general citizenry remains wary.

The fourth topic discussed in this literature review is banking. Appraisers are often times asked to evaluate collateral for banks. The banking industry is a huge industry that is constantly looking for ways to mitigate and manage risk. This section is intended to connect how UAV technology can mitigate risk through the appraisal process.

The following article is, *PRECISION AGRICULTURE AND ACCESS TO AGRI-FINANCE* (Lundblad and Rissanen), by authors Lowe Lundblad and Anna-Liisa Rissanen. This article focuses on how precision technology, such as UAV, can make farmers better loan applicants. The article describes three of the main risks that lending institutions are facing. The first, and perhaps the most prevalent, is asymmetric information. Asymmetric information occurs when there is an imbalance of information between two parties. In the case of the lending institutions, the two parties would be the lending institution and the customer.

The second risk is adverse selection. As described by C.A Wilson, “A common characteristic of a large class of markets is that one side of the market is more informed than the other about the properties of one of the goods being traded” Wilson (1979, p. 313). In other words, adverse selection occurs when people take advantage of asymmetric information.

The article further describes the effects of adverse selection by introducing the concept of “lemons”. For example, the car market is divided into two categories, new cars, and used cars. Used cars are further divided into high-quality and low-quality cars. Low-quality cars are considered to be lemons. The owner/seller of a used car has more knowledge about the car than any potential buyer. This can be viewed as asymmetric information. Adverse selection comes into effect when a used car is being sold. Since the potential buyer of a car has little information, they are forced to pay a higher price regardless of car quality. Since the seller of the car was able to leverage the asymmetric information to gain a higher price, this can be viewed as an adverse selection.

Similar issues can be found in the banking industry. Within the banking industry, poor loan applications can be considered lemons. Banks do not always have the resources to fully screen out bad/poor loan applications. This allows poor loan applicants to leverage asymmetric information and received better loan terms. While poor loan applicants may receive better loan terms, good loan applicants are not getting their optimal loan terms because the lemons pull the cost of capital and collateral requirements higher.

The third risk is moral hazard. In addition to adverse selection, asymmetric information can be divided into moral hazard. Moral hazard occurs when one participant enters into an agreement but does not act in good faith by changing their actions after the conditions of the agreement have been set forth. Many banks and lending institutions faced moral hazards during the 2008 housing crisis. During the crisis, many individuals entered into a mortgage agreement knowing that they could not repay the full loan amount. The inability to repay loans caused banks to foreclose on many customers. Dishonest actions can be viewed as moral hazard. Whenever asymmetric information is involved, there is a potential cost of dishonesty. Dishonesty cost occurs whenever a good is sold and the quality is misrepresented. Dishonest transactions tend to drive honest transactions from the market.

As mentioned in previous articles, moral hazard is a major risk that lending institutions face. To help offset any financial loss, banks require borrowers to secure their loans through collateral. In the article, *Does collateral fuel moral hazard in banking* (Niinimäki), by author J-P Niinimäki. This article presents the idea of how collateral may be fueling moral hazards. This article was written in 2008, while banks and the American economy were experiencing a financial crisis. According to the author, banks finance risky projects by securing the project against collateral. Banks can liquidate collateral if projects fail to be profitable. If the collateral value appreciates, the bank enjoys handsome profits. If collateral values depreciate, then banks suffer a financial loss. During the 2008 financial crisis, numerous subprime banks were failing. Depreciating collateral values was a large contributing factor to the financial crisis. Niinimäki poses the question of whether banks gamble with the future value of the collateral.

The article goes on to list a series of observations that connect the relationship between collateral and risk management.

- Observation 1: The ratio of collateral to loan size is high
- Observation 2: A major portion of collateral consists of real estate.
- Observation 3: Collateral value can fluctuate substantially.
- Observation 4: Banking crises are commonly preceded by depreciation in the value of real estate.

There is evidence to suggest that lending decisions are often based on collateral and that this lending method leads to crisis. The article also makes the distinction between inside and outside collateral. Inside collateral is collateral that the borrower uses in the project. Inside collateral is funded with loan capital. Outside collateral is collateral that the borrower pledgers that is not used in the project.

In conclusion, the author found that many banks refrain from the costly effort of borrower evaluation because many lending decisions are based on collateral. Consequently, banks are

willing to finance unproductive loans based on the assumption of collateral values. If collateral depreciates, then banks will suffer a loss. This type of problem normally occurs when loans are protected with inside capital.

The following article takes a deeper look into factors that influence farmland values. As mentioned previously, farmland is often pledged as collateral to satisfy loan agreements. The value of agricultural land is important because as land values change, so do does collateral values.
According to the article, *Trends in US Farmland Values and Ownership* (Nickerson), author Cynthia Nickerson states that a combination of macroeconomics and partial specific qualities are affecting land values. Nickerson also mentions how farm real estate is the principal source of collateral for farm loans.

Through a series of studies, the author found that farmland represents a significant investment and a large portion of the wealth of many us farmers. Studies suggest that nonfarm factors could be contributing to the relative changes in crop and pasture values. Theory would indicate that farmland values are driven by returns that can be expected. Farm incomes and land values were closely linked in the first half of the 20th century, but have become less so since (Shalit and Schmidt, 1982), with little correlation at the national level in recent decades
Macroeconomics measures suggest that, in the long run, farmland values are becoming less correlated with farm-related factors. A lack of correlation with net farm incomes, declining rent-to-value ratios, and low levels of affordability all suggest that nonagricultural factors are increasingly important in determining farmland values.

In the article, *The reporting of risk in real estate appraisal property risk scoring*, the author Alastair Adair, discusses risk management in appraisal work. The purpose of this article is to look how the UK and its valuation process. Over the past few years, the UK has been criticized for inconsistencies in valuation services. According to the Investment Property Forum, “a new approach can combine conventional analysis with a more comprehensive survey of business risk.

A project was conducted which examined the investment decisions to the property industry. During the study, the author found Financial risk management through the lens of the D&B credit rating model. Throughout the course of the paper, the author applied standard credit-rating techniques to property pricing. The standard credit-rating technique is based on the D&B model.

Methodology

The methodology for this project is approached through the use of a capital budget. Capital budgeting is a planning process that allows companies to analyze different financial investments. Capital budgeting requires an in-depth analysis of any financial project. This is done by estimating the future cash inflow and cash outflows for the project. The future cash flows are then discounted into their net present value. For this project, the analysis will be of the effect of

purchasing and implementing a UAV policy within an agricultural appraisal department. The capital budget for this project will be further developed by conducting a Present Value (NPV) analysis.

Two important aspects of the NPV analysis are the time value of money and the discount rate. Time value of money is the idea that the value of money at the present time is worth more than the same amount in the future. In other words, a dollar today is worth more than a dollar tomorrow. The time value of money is often driven by inflation, interest, and any risk associated with uncertainty. Net Present Value provides a simple way of comparing and equalizing the present cashflows with the future cash flows. This project will assume the length/life of the UAV will last five years.

The discount rate is an important aspect of any NPV analysis. The discount rate can be used to measure the cost of borrowing capital, rate of return needed from outside investments, or rate of return that can be gain from other investments. For this particular project, the discount rate represents the Threshold Rate of Return or TRR. The TRR is the rate of return required by a company in order for it to pursue an investment. Since UAV use requires additional training, licensing, and certifications, a TRR of 10% is required.

The NPV is able to discount future cash flows back into present values.

This allows investors or analysis to accurately compare future cash flows with today's dollars. If the present value of cash inflows exceeds the present value of cash outflows, then the NPV will be positive. Conversely, if the present value of cash outflows exceeds the value of cash inflows, then the NPV will be negative. A positive NPV indicates that the rate of return is greater than the discount rate used in the analysis. Conversely, a negative NPV indicates that the rate of return is less than the discount rate used in the analysis.

The NPV analysis measures the impact of UAVs impact on efficiency within an appraisal department. This was done by comparing a five-year NPV analysis across three separate scenarios. The three scenarios represent a worst-case, average-case, and best-case scenario that may occur within an appraisal department.

Below is a mathematical equation and explanation of the NPV analysis. The NPV is determined by looking at cash inflows - cash outflows over the next ten years. For this project, an NPV will be calculated for each of the three scenarios.

$$NPV = \sum_{n=1}^{N} C_n (1+r)^{-n} - C_0$$

$\sum_{n=1}^{N}$ represents the sum of cash inflows – cash outflows over a given period. For this project, N will be 5 years, while n represent any single year.
C_n represents the Net Cash Flow at time n. This value will be derived from each capital budget.
$(1+r)^{-n}$ represents the rate of return. For this project, the rate of return is 10%.

C_o represents the initial cast investment for each scenario.
N represents the maturity of the investment after 5 years.

The first step of the analysis was to create a basic budget representing financial costs and benefits for UAV usage. The second step was to convert the UAV budgets from deterministic to stochastic. The third step was to create three separate scenarios representing the impact UAVs would have on appraisal efficiency. The fourth and final step was to use @Risk to simulate the NPV results for all three scenarios. This project makes the assumption that the appraisal team will purchase six new UAV machines.

The table below, Drone Policy Budget 2021, represents figures and dollar amounts used to estimate the annual cost of implementing a UAV policy within an appraisal department. The budget assumes that a team of six appraisers will each purchase a UAV and be involved in the NPV analysis. As can be seen from the budget, costs for the UAV budget are broken into Long Term Costs and Yearly Costs. Long Term Costs are costs that only occur once every few years, such as; the actual purchase of a drone and costs associated with FAA commercial licensing regulation. The drone price was adjusted by using the Risk Triangle function in @Risk. The function included a range of drone prices between $1,500-$3,000 per drone. These prices represent common prices for DJI drones. By implementing the Risk Triangle function, drone prices were changed from deterministic to stochastic.

Licensing includes both FAA instruction courses and exams. The FAA webpage indicates that commercial licensing costs are an average of $160. An additional $50 was included to account for any miscellaneous or additional costs that may be incurred during the exam.

Drone Policy Budget 2021				
Number of Drones	6			
Long Term Cost (Occur Every Other Year)				
Item or Variable	Unit	Number of Units	Cost/Unit	Total Cost
Drone	drones	6	$ 2,166.67	$ 13,000.00
Licencing				
Exam	Exam	6	$ 160.00	$ 960.00
Course	Exam	6	$ 50.00	$ 300.00
Total			$ 2,376.67	$ 14,260.00
Yearly Cost (Occur Every Year)				
Insurance	month	12	$ 80.00	$ 5,760.00
3rd Party Liability				
Personal liability				
Other Liability				
Other				
Up grades	other	6	$ 100.00	$ 600.00
Maintenance	other	6	$ 100.00	$ 600.00
Total Yearly Cost			$ 280.00	$ 6,960.00
Total Cost			$ 2,656.67	$ 21,220.00

Yearly Costs occur every year and include items such as; insurance, maintenance, and miscellaneous cost. Insurance costs are from several drone insurance agencies, such as Skywatch.ai and Drone Insurance.com. Typically, three aspects are included in a drone insurance package. These aspects are Third Party Liability, Personal Liability, and Drone protection. Third-Party Liability covers any instance in which a drone may cause damage to any physical structure. Personal Liability insures against any personal injury that may be caused by a drone. Drone Protection insures the physical drone itself, in case of a malfunction or damages. As can be seen from the budget above, the Total Cost to operate six drones within the appraisal department is $21,220.

UAV benefits are found by first determining how many chattel and appraisal inspections are completed within a given year. For a team of six appraisers, it is estimated that roughly 180 chattel inspections and 150 appraisal inspections are completed within a year. A cost matrix was then used to estimate revenue generate by each appraisal and chattel inspection. The chart below, Appraisal Value Matrix, displays the values associated with different types of appraisals.

Appraisal Value Matrix		
		Appraisal
Open Land (no value in improvements, no water rights)		$ 1,750.00
Open Land (no value in improvements, w/water rights)		$ 2,000.00
Land with Home and or Farm Buildings		$ 2,500.00
Land with bldgs and Grazing Rights		$ 3,000.00
Land, Grazing Rights-no improvements		$ 2,000.00
Dairy Facility		$ 3,000.00
Dairy Facility and Farmland		$ 4,000.00
Green House, Layer Facility, P&M Facility		$ 4,000.00
Turkey or Mink Facility		$ 3,000.00
Turkey or Mink Facility and Farmland		$ 4,000.00
Value Assigned for Additional Appraisal Services		
Chattle Inspections (per category)	$ 400.00	
	Stochastic Value	2925
	Appraisal AVG	$ 2,925.00

Chattel inspections generate $400 of revenue and appraisal generate between $1,750-$4,000 per appraisal. The revenue per appraisal varies depending on the size and complexity of the operation. Revenue generated by appraisals was converted from deterministic to stochastic through the use of @Risk. @Risk was used to fit a distribution of possible appraisal values. This distribution was then written to excel and used in the Drone Policy Benefits budget.

As mentioned previously, three scenarios were created. Each scenario uses six drones and assumes the same cost and benefit data. The major difference between the three scenarios is the change in Increased Efficiency caused by UAVs. Efficiency increase was based on small-scale experiments done out in the field. The experiments consisted of measuring the amount of time to inspect a field using drones vs the amount of time to inspect a field with a vehicle. Efficiency is used to adjust the total number of inspections, both chattel, and appraisal, that are completed by the appraisal staff. For each scenario, Increased Efficiency was made stochastic. This was done by fitting the distribution of values for each scenario. This distribution was then written to excel and used in the final NPV analysis.

The graph below, Drone Policy Benefits 2021 Scenario 1, represents benefits that are derived from done use within the appraisal department.

Scenario 1, represents the worst-case scenario. For this scenario, it is estimated that the implementation of UAV will increase efficiency between 1%-2.5%. As can be seen from the table, under scenario 1, the appraisal department will complete 3.24 more chattel inspections and 2.7 more appraisal reports. These improvements equate to roughly a $9,193.5 increase in revenue.

Drone Policy Benefits 2021, Scenario 1		
Number of Drones		6
Scenario 1 (Worst Case)		
Increased Efficiency	1.80%	2%
Chattel		
	Current	New
Chattel Value	$ 400.00	400
Chattels done per year	180	183.24
Improvement		3.24
Revenue	$ 72,000.00	$ 73,296.00
Appraisal		
	Current	New
Appraisal Value	$ 2,925.00	$ 2,925.00
Appraisal completed	150	152.7
Improvement		2.7
Revenue	$ 438,750.00	$ 446,647.50
	$ 510,750.00	$ 519,943.50
Difference/Benefit		$ 9,193.50

The graph below, Drone Policy Benefits 2021 Scenario 2, represents benefits that are derived from done use within the appraisal department for Scenario 2. Scenario 2, represents the average-case scenario. For this scenario, it is estimated that the implementation of UAV will increase efficiency between 1.5%-3%. Increased efficiency was made stochastic by fitting the distribution of values between 1.5% and 3%. Appraisal Value was made stochastic by fitting the distribution of appraisal values. As can be seen from the table, under Scenarios 2, the appraisal department will complete 4.05 more chattel inspections and 3.375 more appraisal reports. These improvements equate to roughly an $11,491 increase in revenue.

Drone Policy Benefits 2021, Scenario 2		
Number of Drones		6
Scenario 2 (Average Case)		
Increased Efficiency	2.3%	2%
Chattlel		
	Current	New
Chattel Value	400	400
Chattels done per year	180	184.05
Improvement		4.05
Revenue	$ 72,000.00	$ 73,620.00
Appraisal		
	Current	New
Appraisal Value	$ 2,925.00	$ 2,925.00
Appraisal completed	150	153.375
Improvement		3.375
Revenue	$ 438,750.00	$ 448,621.88
	$ 510,750.00	$ 522,241.88
Difference/Benefit		$ 11,491.88

The graph below, Drone Policy Benefits 2021 Scenario 3, represents benefits that are derived from done use within the appraisal department for Scenario 3. Scenario 3, represents the best-case scenario. For this scenario, it is estimated that the implementation of UAV will increase efficiency between 2%-4%. Increased Efficiency was made stochastic by fitting a distribution of values between 2% and 4%. Appraisal Value was made stochastic by fitting a distribution between the range of appraisal values. As can be seen from the table, under Scenarios 3, the appraisal department will complete 5.22 more chattel inspections and 4.35 more appraisal reports. These improvements equate to roughly a $14,811.75 increase in revenue.

Drone Policy Benefits 2021, Scenario 3		
Number of Drones		6
Scenario 3 (Best Case)		
Increased Efficiency	2.9%	3%
Chattel		
	Current	New
Chattel Value	$ 400.00	400
Chattels done per year	180	185.22
Improvement		5.22
Revenue	$ 72,000.00	$ 74,088.00
Appraisal		
	Current	New
Appraisal Value	$ 2,925.00	$ 2,925.00
Appraisal completed	150	154.35
Improvement		4.35
Revenue	$ 438,750.00	$ 451,473.75
	$ 510,750.00	$ 525,561.75
Difference/Benefit		$ 14,811.75

Results

Results were found by using the information in the Drone Cost and Drone Benefit budgets to create a five-year NPV analysis. The graph below, NPV Analysis, displays the NPV analysis for all three scenarios. As can be seen from the graph, all three scenarios are discounted five years into the future. Also, all three scenarios have a discount rate of 10%. For each scenario, Year 1 includes the initial investment of purchasing the drone. As mentioned previously, the Efficiency Increase for each scenario is a stochastic value.

NPV Analysis

Scenario 1 (Bad)			
Efficiency Increase		2%	
	Cost	Benefit	Return
Year 1	$ 21,220.00	$ 9,193.50	$ (12,026.50)
Year 2	$ 6,960.00	$ 9,193.50	$ 2,233.50
Year 3	$ 8,220.00	$ 9,193.50	$ 973.50
Year 4	$ 6,960.00	$ 9,193.50	$ 2,233.50
Year 5	$ 8,220.00	$ 9,193.50	$ 973.50
		NPV	($6,848.52)

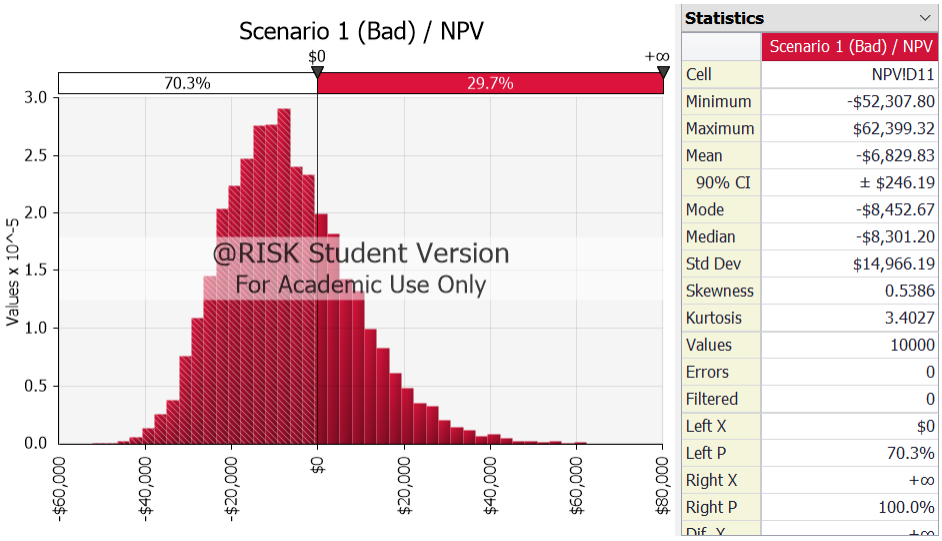
Scenario 2 (Average)			
Efficiency Increase		2%	
	Cost	Benefit	Return
Year 1	$ 21,220.00	$ 11,491.88	$ (9,728.13)
Year 2	$ 6,960.00	$ 11,491.88	$ 4,531.88
Year 3	$ 8,220.00	$ 11,491.88	$ 3,271.88
Year 4	$ 6,960.00	$ 11,491.88	$ 4,531.88
Year 5	$ 8,220.00	$ 11,491.88	$ 3,271.88
		NPV	$2,735.39

Scenario 3 (Bad)			
Efficiency Increase		3%	
	Cost	Benefit	Return
Year 1	$ 21,220.00	$14,811.75	$ (6,408.25)
Year 2	$ 6,960.00	$14,811.75	$ 7,851.75
Year 3	$ 8,220.00	$14,811.75	$ 6,591.75
Year 4	$ 6,960.00	$14,811.75	$ 7,851.75
Year 5	$ 8,220.00	$14,811.75	$ 6,591.75
		NPV	$16,578.82

The final step to the methodology process was to evaluate the results for each of the three scenarios. Once the five-year NPV was calculated, @Risk was used to simulate results for each of the three scenarios. Each simulation consists of 10,000 iterations. The @Risk simulation is a tool that allows for better risk management. Through the simulation process, random variables are drawn out of the data pool. The random pools of data represents different situations or

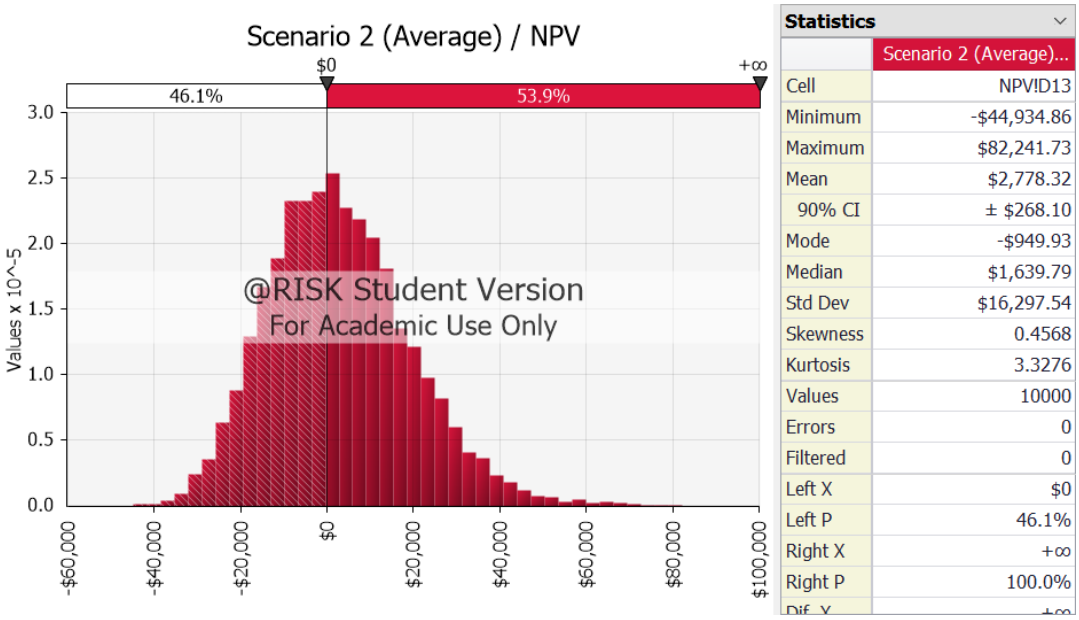
conditions that appraisers may encounter. Through the simulation process, appraisers are able to get an accurate reading on exactly what risks are driving poor results. By property identifying these risks, appraisers can become better managers. In addition to identifying drivers of risk, the simulation process also calculates probability of profits. The simulation process is able to measure 10,000 different price and cost outcomes, and display profits in the form of a percent.

The graph below, Scenario 1 (Bad)/NPV, represents results from Scenario 1. As can be seen from the graph, there is a 70% probability that UAV use will cause a decrease in profits. Under Scenario 1, the implementation of drones would cause an average loss of -$ 6,829. The majority of the loss is caused by high drone costs and inadequate efficiency within the appraisal department. Under the given scenario, an average 1.8% increase in efficacy equates to three additional chattel inspections and two additional appraisals being completed within the year. As can be seen in the graph, the additional appraisal work does not produce sufficient revenue to pay for UAV use.



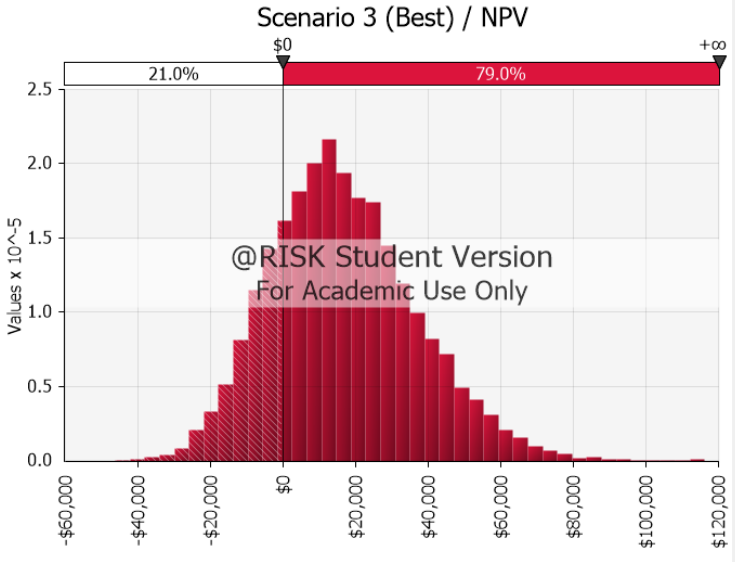
Statistics	Scenario 1 (Bad) / NPV
Cell	NPV!D11
Minimum	-$52,307.80
Maximum	$62,399.32
Mean	-$6,829.83
90% CI	± $246.19
Mode	-$8,452.67
Median	-$8,301.20
Std Dev	$14,966.19
Skewness	0.5386
Kurtosis	3.4027
Values	10000
Errors	0
Filtered	0
Left X	$0
Left P	70.3%
Right X	+∞
Right P	100.0%
Dif. X	+∞

The graph below, Scenario 2 (Average)/NPV, represents results from Scenario 2. As can be seen from the graph, there is a 46.1% probability that UAV use will cause a decrease in profits. Under Scenario 2, the implementation of drones would cause an average gain of $ 2,788. The majority of the gain is caused by the increased efficiency within the appraisal department. Under the given scenario, an average increase of 2.9% equates to four additional chattel inspections and three additional appraisals being completed within the year. As can be seen in the graph, the additional appraisals work produces sufficient revenue to pay for UAV use.



Statistics	Scenario 2 (Average)...
Cell	NPV!D13
Minimum	-$44,934.86
Maximum	$82,241.73
Mean	$2,778.32
90% CI	± $268.10
Mode	-$949.93
Median	$1,639.79
Std Dev	$16,297.54
Skewness	0.4568
Kurtosis	3.3276
Values	10000
Errors	0
Filtered	0
Left X	$0
Left P	46.1%
Right X	+∞
Right P	100.0%
Dif. X	+∞

The graph below, Scenario 3 (Best)/NPV, represents results from Scenario 3. As can be seen from the graph, there is a 21.0% probability that UAV use will cause a decrease in profits. Under Scenario 3, the implementation of drones would cause an average gain of $ 16,598. The majority of the gain is caused by increased efficiency within the appraisal department. Under the given scenario, an average increase of 2.9% equates to five additional chattel inspections and four additional appraisals being completed within the year. As can be seen in the graph, the additional appraisals produce sufficient revenue to pay for UAV use.



Statistics	Scenario 3 (Best) / N...
Cell	NPV!D15
Minimum	-$46,219.45
Maximum	$116,174.25
Mean	$16,598.58
90% CI	± $330.41
Mode	$12,304.79
Median	$14,994.62
Std Dev	$20,085.70
Skewness	0.4174
Kurtosis	3.2243
Values	10000
Errors	0
Filtered	0
Left X	$0
Left P	21.0%
Right X	+∞
Right P	100.0%
Dif. X	+∞

Conclusion

The conclusion portion of this project will relay a brief summary of the project, point out potential weaknesses within the project, and state the final consensus about drone use in agricultural appraisal.

The purpose of this project is to evaluate the benefits of implementing UAV policy within agricultural appraisals. This paper will be categorized into four categories, including; introduction, literature review, methodology, and conclusions. The introduction builds a foundation as to why UAV policy is relevant within agricultural appraisal departments. The introduction also provides insight into FAA regulations and other factors influencing UAV policies. The literary review gives insight into a wide range of UAV topics; including, UAV policy, UAV security, collateral evaluations, and UAV applications within agriculture. The methodology portion of the project measures the effectiveness of UAVs within the appraisal department. This is done by doing a cost-benefit analysis and a five-year NPV analysis of UAVs. The conclusion portion of the paper provides finals insights and thoughts related to UAV policy and its application within agricultural lending.

While the methodology in this report is sound and reliable, there are still areas for improvement. One area of improvement is the percent of efficiency increases found within the three scenarios. Recall that Scenario 1 had an efficiency increase between 1%-2.5%, Scenario 2 had an efficiency increase between 1.5%-3%, and Scenario 3 had an efficiency scenario between 2%-4%. These numbers were found based on small-scale experiments done out in the field. Some of the difficulties encountered during these experiments include poor weather and property accessibility. Poor weather such as windy conditions would limit the effectiveness of the drone during the experiment. Much of this project was conducted during the winter months when the weather is less favorable. Property accessibility was another factor that should be addressed. The properties used in the drone experiment were chosen at random. As a result, many of the properties had easy access via public roads. The abundance of available roads made drone use less effective. It is recommended that any future studies of UAV efficiency should include a more robust set of infield experiments.

The final consensus about UAV use within agriculture appraisal is that despite the legal and time risks, UAVs are still beneficial to agricultural appraisers. As mentioned in the report, done use can increase efficiency and accuracy when inspecting larger tracts of land. UAVs allow appraisers to view areas of the property that are difficult to assess due to weather, accessibility, or terrain. UAV can also assist in chattel inspections and offer a fast and reliable method to inspect and secure collateral. While UAVs can be beneficial, there are some drawbacks. These drawbacks include legal ramifications and additional time spend to obtain commercial licensing. While insurance and proper licensing can help protect against legal ramifications, it is important to note that not all legal risks can be avoided. Individual appraisers and/or companies need to assess their own risk tolerance and determine if UAVs are worth the legal risk. In regard to this report, the benefits of drones with agricultural appraisals outweigh any of the risks associated with UAVs. This decision is based on data found through the NPV analysis as well as personal experience of using UAVs in agricultural appraisals.

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