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Profitability of On-Farm Cold Storage in the New Mexico Pecan Industry

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Abstract

Pecan producers face limited pricing power in traditional markets and must explore tools to reduce costs or capture added revenue. This study evaluates the feasibility of on-farm cold storage as a capital investment strategy in New Mexico. A 30-year financial model was developed, considering construction, equipment and operating expenses, with revenues estimated from seasonal price differentials and quarantine cost avoidance to assess key return measures. Findings highlight net present values ranging from -$2.5 million to $1.2 million, depending on selling strategy. While on-farm cold storage offers potential for greater control and profitability, outcomes are highly sensitive to price volatility, introducing vulnerability to year-to-year cash flows.

Keywords: cold storage, farm profitability, marketing strategies, New Mexico agriculture, on-farm investment, pecans, value-added agriculture

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Introduction

Pecans are an important specialty crop grown in many southern states. Leading pecan-producing states include Georgia, New Mexico, Arizona, Texas, and Oklahoma. New Mexico's 2021 pecan production of 78.7 million pounds accounted for approximately one-third (30.8%) of the total U.S. production, behind Georgia's 88.6 million. Pecans represented 25% of the state's total crop revenue, with $190 million in cash receipts in 2021.

Traditionally, southwestern producers have sold in-shell pecans in late fall or early winter. They rely on other supply chain participants to process the nuts and market them. Some producers, often larger operations, have expanded into downstream activities such as cleaning and shelling. One hesitation for producers in exploring options to expand downstream in the supply chain may be related to the fact that pecans require cold storage to maintain quality.

Pecans contain high levels of unsaturated oils that can easily go rancid. As such, pecans require cold storage to maintain quality. Without cold storage, in-shell pecan storage life is only several months (e.g., four months if stored at 70 °F). When stored at colder temperatures, the storage life increased dramatically. For example, in-shell storage life is estimated to be between 2 and 5 years when stored at 0 °F (Byford, 2005). Traditionally, pecan storage has been the responsibility of downstream supply chain participants (e.g., processors).

Purpose

This report explores the financial feasibility of cold storage capacity deployed at the farm level to support extended pecan marketing strategies in New Mexico. The analysis is framed around a representative cold storage facility that could be owned and operated by a single large producer or jointly utilized by multiple producers through coordinated arrangements. In either case, the economic drivers of feasibility are storage capacity utilization, marketing timing, and exposure to seasonal price volatility, rather than the ownership structure alone.

Potential benefits of on-farm or coordinated cold storage include greater marketing flexibility, the ability to target sales opportunities outside the traditional harvest window, and, in quarantine areas, avoidance of third-party cold storage costs required for regulatory compliance. At the same time, the investment introduces substantial fixed capital requirements and increases exposure to inter-year price variability, making capital constraints and risk-sharing central considerations in assessing the practicality of such investments.

Background

Pecan Cold Storage

As indicated earlier, pecans are high in unsaturated fats, a trait responsible for their distinct flavor and health benefits. While pecans' high oil content offers benefits and contributes to their desirability, it also makes them vulnerable to deterioration from heat and oxidation. The storage

life of pecans before shelling, or "in-shell," can be extended from approximately 4 months when stored at 70 °F to 5 years if frozen at 0 °F (Byford, 2005). Some estimates suggest that the extension could even be greater (e.g., up to 8 years) (Picha, 2015). Regardless of the maximum storage life, the seasonal nature of pecan yields requires stabilization via cold storage to ensure a profitable and steady supply of pecans year-round.

Current Pecan Cold Storage Practices

Pecans are typically harvested and transported from the producers to centralized buyers while still in the shell. The nuts are then stored and shelled throughout the remainder of the year. Distributors, manufacturers, and exporters buy pecans throughout the year, either shelled or in-shell, for further distribution, processing, and sale to end users. Some growers may use forward contracting with their respective supply chain partners, thus locking in a price before harvest (Florkowski and Hubbard, 1994; Lillywhite, 2003).

The seasonal inventory cycle generally peaks during late winter or early spring, after which withdrawals pull the inventory down to a low in the fall. The pattern observed is consistent over time, with the same pattern observed over many years.

Pecan Marketing Structure and Price Reporting Limitations

The U.S. pecan industry is characterized by a relatively large number of producers and a comparatively small number of downstream shellers, processors, and exporters. While no comprehensive national dataset exists documenting exact counts, available evidence suggests that pecan production is distributed across several thousand farms nationwide (USDA-NASS, 2020). Industry directories and secondary sources indicate that approximately 35 to 45 pecan shelling operations are active nationally, depending on classification and data source (American Pecan Council, 2024).

This asymmetry between widespread production and more concentrated downstream handling shapes price discovery in the pecan market. Prices are commonly determined through private negotiation, including forward contracting and inventory-based purchasing by downstream firms, rather than through transparent spot markets. Shellers and large buyers typically acquire substantial volumes during the harvest period and manage inventories throughout the year to supply domestic and export demand as it arises.

This market structure contributes to the limited availability of publicly reported domestic monthly pecan prices, particularly outside primary harvest and holiday marketing windows. In contrast, export quantities and values are consistently reported through USDA's Foreign Agricultural Service (USDA-FAS), making export prices one of the few sources of monthly pecan price information. Given that exports account for a substantial share of U.S. pecan production and that domestic and export prices exhibit moderate correlation on an annual basis, export value seasonality is used in this analysis as a proxy for potential domestic seasonal price movements. This approach is applied with caution, recognizing that monthly domestic price behavior may

differ in magnitude and timing from export markets. Additional discussion of how these market dynamics relate to observed pricing behavior is provided below.

Potential Benefits of On-Farm Cold Storage

The analysis described in this report accounted for two potential benefits or revenue streams associated with on-farm cold storage—potential seasonal price differentials and reducing or eliminating quarantine costs.

Seasonal Price Differentials

Many agricultural commodities exhibit seasonal price variation as the market responds to supply and demand factors. Pecans in the Southwest are harvested in late fall and early winter. During and shortly after this period, many pecans enter the supply chain. On the demand side, domestic consumers tend to buy more pecans and pecan-containing products during the winter holiday (Capps, Goodwin, and Burns, 2022). These supply and demand forces result in natural seasonal price fluctuations. Unfortunately, little seasonal pecan price data are publicly available for domestic markets.

While monthly prices for domestic pecans are limited, monthly prices for pecan exports are available through the USDA Foreign Agricultural Service (FAS) Global Agricultural Trade System (GATS) database. Using export value and quantity, prices for exported pecans can be approximated. A seasonal price index for pecan exports, based on data from January 1989 through November 2023, indicates that average monthly export prices have historically risen by more than 19% between a typical low point in March and a high point in September over the 35-year period. In more recent years, export prices have generally been lower during mid-to-late winter and have tended to peak in December.

Export and Domestic Pecan Markets

While monthly prices for domestic pecan markets are unavailable, monthly export values may serve as a potential proxy, as exports make up a large portion of U.S. production, and annual prices in domestic and export markets are both available and correlated.

Table 1 presents U.S. pecan production and export quantities over the last 15 years and associated exports. In the previous 15 years, almost one-half of pecans produced in the United States have been exported, ranging from a low of 30% in 2022 to a high of 59% in 2018. As exports make up a large percentage of domestic production, it is reasonable to assume that the export market significantly impacts the domestic market and domestic prices.

Table 1. U.S. Domestic Pecan Production and Exports

Year	Pecans Produced (lbs.)	Quantity Exported (lbs.)	Percent Exported
2008	202,080,000	115,488,578	57%
2009	302,020,000	107,683,782	36%
2010	293,740,000	101,721,387	35%
2011	269,700,000	104,640,304	39%
2012	302,300,000	151,731,649	50%
2013	266,330,000	121,344,489	46%
2014	264,150,000	151,939,544	58%
2015	254,290,000	148,002,314	58%
2016	268,770,000	138,167,063	51%
2017	304,850,000	170,948,660	56%
2018	240,930,000	141,103,617	59%
2019	255,600,000	138,379,588	54%
2020	304,050,000	143,364,014	47%
2021	256,450,000	142,843,723	56%
2022	277,700,000	82,871,886	30%
Average	270,864,000	130,682,040	49%

Source: USDA-NASS, USDA-FAS

Export-Domestic Annual Price Correlation

A close relationship between annual pecan export and domestic prices per pound can be observed using data drawn from the USDA National Agricultural Statistics Service (USDA-NASS) and USDA FAS databases (USDA-FAS, 2024; USDA-NASS, 2024). Between2008 and 2022, the two price series exhibited a correlation coefficient of approximately 0.6, indicating a moderate relationship between domestic prices and export values over the past 10 to 15 years. However, this relationship appears to have weakened in more recent years (see Table 2).

Table 2. Correlation Coefficients Between Domestic and Export Prices, Various Periods

Period	Correlation Coefficient
2008–2022 (last 15 years)	0.61
2013–2022 (last 10 years)	0.57
2018–2022 (last 5 years)	-0.12

Source: USDA-NASS, USDA-FAS 2023

Analysis of price data from commodities with characteristics like pecans can help validate whether the correlation between annual and monthly domestic import and export prices is reasonable. For example, apples share several features with pecans. Both crops are seasonally harvested, both utilize cold storage, and the U.S. is a major exporter of both—approximately one-third of the U.S. apple crop is exported (Agricultural Marketing Resource Center, 2024). Importantly, monthly domestic and export prices for apples are available from 2013 to 2024.

A correlation coefficient of 0.57 is observed between these domestic and export prices for apples. When simple seasonal indexes for domestic and export prices are created, it can be observed that seasonal price fluctuations of domestic and export prices show patterns like each other, as well as seasonal fluctuations in pecan export prices. This similarity is discussed more in Appendix II Apple Price Seasonality.

Reducing Quarantine Costs

Some pecan growers in New Mexico have suffered pecan weevil infestations (*Curculio caryae*). Endemic to North America, the adults of this species emerge from the soil in late summer. After mating, the females lay their eggs in walnuts and pecans. While the shells are still soft, the insect can bore into the kernel and deposit eggs. The resulting larvae consume the nut flesh before exiting, falling to the ground, and entering a dormant state until the following monsoon restarts the cycle. An air blast sprayer is used to apply insecticides directly to the trees, targeting the weevil in the adult stage (Mulder and Grantham, 2017).

Current New Mexico Department of Agriculture protocols center on the mandatory quarantine and treatment of in-shell pecans transported from Chaves, Eddy, Lea, and Otero counties. Nuts must be frozen for seven days if below 0 °F, or 14 days at 12.2 °F, or immersed in 140 °F water for 5 minutes before shipping (21 NMAC 21.17.36). For a pecan producer, these requirements entail additional costs before the crop can be marketed. For example, the producer may need to pay for a cold storage facility to hold the crop at the required temperature and time before marketing it. Avoiding this third-party cost, a potential benefit of on-farm cold storage is included in the analysis described below.

Methodology and Assumptions

The potential financial returns associated with on-farm cold storage are estimated using a capital investment model. The model uses the assumptions described below to forecast cash flows. Cash outflows include construction and operating costs for the cold storage facility. Cash inflows include potential seasonal price differentials and quarantine-related cold storage cost savings. Projected cash flows from the model can be used to calculate the standard investment return measures, including net present value, internal rate of return, and discounted payback period.

Methodology

The capital investment model used to explore the potential benefits of on-farm pecan cold storage was developed in Microsoft Excel. As previously indicated, cash flows include benefits of potential seasonal price premiums and savings from eliminating third-party quarantine costs. Costs included various fixed and variable expenditures associated with constructing and operating the facility. All revenues and costs are assumed to remain constant over the life of the model, and prices are measured in "real" terms. Net cash flows are assumed to occur over a 30-year investment period.

Discount Rate

As the project's cash flows are projected to occur over a long period, it is important to identify an appropriate discount rate to convert future cash flows into current dollars. The discount rate is used to calculate the present value of future cash flows while accounting for the time value of money. As a rule, the discount rate should reflect the owner's cost of capital, either equity or debt, or a combination of the two. From an equity standpoint, one measure that could be used is the returns available via investment in the stock market. The average real rate of return for the S&P 500 over the last 30 years, when dividends are included, has been 6.81%.[1] Interest rates for New Mexico agriculture returns range from 7% to 9% on similar investments, depending on the precise characterization of the farm business, land type, and operational details. New Mexico State Cooperative Extension Enterprise budgets and this analysis assume 8.75%.

Measures of Return

Three measures of return are used to characterize the-investment: net present value (NPV), internal rate of return (IRR), and discounted payback period (DPP). The measures provide general insights into an investment's viability. The definition of each measure of value and its general purpose for supporting conclusions follows.

Net Present Value

The net present value, or NPV, is the sum of an investment's annual discounted net cash flows over its lifetime, in this case, 30 years. By discounting future net flows, NPV accounts for the potential returns that an investor could have earned if the same capital were invested in an alternative asset for the same period. Typically, higher values of NPV signal a favorable investment, but a positive value must be at least observed to indicate that discounted cash inflows (benefits) exceed discounted cash outflows (costs).

Internal Rate of Return

The internal rate of return, or IRR, provides a similar measure of investment return as the NPV, except that the return is measured in a percentage term. Mathematically, it uses the same formula as the NPV calculation but solves the equation for the discount rate associated with an NPV of zero. Estimated internal rates of return are compared to an individual business's cost of capital. An IRR greater than the cost of capital indicates that the investment should be undertaken.

Discounted Payback Period

The discounted payback period, or DPP, is the number of years that it will take for discounted cash flows to pay for the initial investment. Typically, lower values for DPP signal a favorable investment because the investor is expected to "make their money back" in a shorter period.

[1] Calculated using a geometric mean.

Key Assumptions

Data used to inform model assumptions were obtained from various sources, including interviews with industry members familiar with on-farm cold storage and secondary sources (e.g., published tariff rates from local utilities, equipment specifications and costs from distributors, and historical prices from public agencies). The data and corresponding model assumptions are outlined in the sections below.

Infrastructure

Infrastructure for the project includes land and the cold storage facility.

Land

The analysis assumes the cold storage facility requires 1 acre of land. The land is assumed to be in immediate proximity to commercial pecan orchards in New Mexico and near necessary utilities. The land is valued at $30,000 per acre.

Building

The assumed cold storage facility is a purpose-built, subfreezing warehouse designed to store approximately 1.15 million pounds of in-shell pecans using reusable wooden containers stacked to maximize vertical space. Facility size, container configuration, insulation, and cooling system specifications are selected to reflect commercially feasible on-farm cold storage design. Detailed engineering considerations and design assumptions are provided in Appendix I. The cold storage facility is assumed to be 2,860 square feet (52’ x 55’) with a 30’ ceiling. The building is a steel frame with 6-inch insulated walls. The insulation is composed of glass fiber sandwiched by non-porous plastic surfacing. The building is built on a 1’ concrete slab floor supported by 2’of gravel. Construction costs are estimated to equal $500,000 with a salvage value of $55,000. The model assumes that the building has a useful life of 30 years. More information about facility engineering and design considerations can be found in Appendix I.

The facility described above has an interior volume of 85,800 cubic feet, sufficient to hold 600 wooden storage containers measuring 4’ x 4’ x 4’ stacked five high in 10 rows with 12 stacks per row. Each container can hold 1,920 pounds of in-shell pecans for a maximum facility capacity of 1,152,000 pounds. The analysis assumes the building operates at full capacity continuously for 30 years. Assuming an annual average yield of 1,680 pounds per acre (USDA-NASS, 2023), the facility would support one or several farms consisting of approximately 685 acres.

Estimated Costs

Additional costs beyond land and buildings for an on-farm cold storage facility include equipment and other operating expenses, such as utility and labor costs. The key assumptions related to these costs are described below.

Equipment

A redundant, one-stage heating and air conditioning system controls the facility's climate. Two compressors are installed in parallel, each able to maintain a temperature under 0 °F by supplying two pairs of condenser and evaporator units. Using a digital controller, load cycling can be managed such that optimal cooling can be maintained while remaining below peak energy demand of 50 kW, a threshold that, if exceeded, would result in considerable energy cost increases. The total cost of the system, including installation, is assumed to be $50,000 with a salvage value of $5,000. The system's usable life is assumed to be 20 years, after which a new system will be purchased and the old system sold for the salvage value the following year.

Other equipment needed for the on-farm cold storage operation includes a forklift and wooden storage containers. A single forklift is used to stack, unstack, and load the containers. It is estimated to cost $40,000 and have a 20-year useful life with a salvage value of $4,000. The containers are assumed to cost $286 each and have a useful life of 20 years with a salvage value of $5 each. Pecans are assumed to be stored in reusable wooden storage containers for the duration of the storage period. These containers remain on-site and are used solely for internal stacking and handling within the cold storage facility. When pecans are shipped off-farm, including shipments subject to quarantine requirements, they are assumed to be transferred into industry-standard flexible intermediate bulk containers ("superbags"), consistent with prevailing commercial and regulatory practices. Costs associated with superbags used for quarantine compliance are included in the avoided third-party quarantine cost estimates described below.

Electricity

The analysis assumes that the facility can maintain subfreezing temperatures while limiting peak monthly electrical demand to 48.69 kW, slightly below the 50kW cap for small commercial customers. Going above the 50kW peak demand level would result in significantly increased costs. Annual electricity use is estimated to be 50 kWh per square foot, representing the midpoint of the industry average range of 40–60 kWh per square foot (Faramarzi, Coburn, and Sarhadian, 2002). The total annual electricity use of 143,000 kWh is averaged across calendar months, with weights assigned based on each month's average temperature. Electricity use and cost estimates are provided in Table 3.

A 7% Gross Receipts Tax (GRT) is applied to baseline monthly electricity expenditure. The GRT varies between 4.8750% and 8.9375% within New Mexico, but an expected value of 7% is used for this analysis (New Mexico Taxation and Revenue Department, 2024). A monthly service fee of $83 is also included in the calculation of monthly electricity costs. The model assumes that electricity costs cease at the time of sale (e.g., if pecans are sold in June, all electricity costs for the following months are zero).

Table 3. Assumed Monthly Electricity Use and Corresponding Cost

Month	Cost / kW	Use (kWh)	Cost / kWh	Baseline Monthly Cost	Total Monthly Cost	Cumulative Cost
January	$13.93	8,966	$0.01152	$780	$918	$918
February	$13.93	9,877	$0.01152	$791	$929	$1,847
March	$13.93	10,942	$0.01152	$803	$942	$2,790
April	$13.93	12,157	$0.01152	$817	$957	$3,747
May	$13.93	13,373	$0.01152	$831	$972	$4,719
June	$18.63	14,588	$0.03963	$1,483	$1,670	$6,390
July	$18.63	14,588	$0.03963	$1,483	$1,670	$8,060
August	$18.63	14,132	$0.03963	$1,465	$1,651	$9,712
September	$18.63	13,373	$0.03963	$1,435	$1,619	$11,331
October	$13.93	12,005	$0.01152	$815	$955	$12,286
November	$13.93	10,181	$0.01152	$794	$933	$13,219
December	$13.93	8,814	$0.01152	$778	$916	$14,135

Labor

Though a significant amount of labor is associated with pecan production and storage, a majority might be considered a sunk cost from the point of view of cold storage. That is, most related labor would be required whether an on-farm cold storage facility existed or not. Additional labor is, however, required for loading and unloading pecans and facility maintenance (e.g., monitoring cooling systems). An estimated 60 hours of labor at a rate of $15 per hour for a total of $900 annually is included to account for this cost, based on the median wage data for farm workers in New Mexico from the Bureau of Labor Statistics (BLS, 2023).

Operating Loan Interest Expenses

The owner is assumed to secure an operating loan at the end of January each year, equal to the expected income from the sale of the pecans, to cover expenses until selling later in the year. Under a 10-year average price of $2.24 per pound, the anticipated revenue from selling 1,152,000 pounds of pecans is $2,580,480. Farm operating loans typically carry interest rates ranging from 5% to 10%, and it is assumed a loan is taken out at a 7% annual interest rate, with no significant transaction or additional fees. The total annual interest cost is calculated on the assumption that the loan is repaid at the end of the month in which the sale occurs. Consequently, if the sale is delayed beyond January, the interest costs increase by $15,053 for each month of delay, summarized in Table 4. This operating loan functions analogously to a seasonal operating credit line secured against stored inventory, with financing costs increasing as the marketing window is extended.

Table 4. Estimated Operating Loan Interest Expense by Month Pecans Are Sold

Sale Month	Total Interest Expense
February	$15,053
March	$30,106
April	$45,158
May	$60,211
June	$75,264
July	$90,317
August	$105,370
September	$120,422
October	$135,475
November	$150,528
December	$165,581

Insurance

The model assumes that stored pecans can be insured at an annual rate of 0.45% of their value. Following a similar approach as used in the calculation of interest for operating loans, the insurance cost is based on pecan values using the 10-year average price of $2.24. If the pecans are stored for the entire year and sold in December, the total cost amounts to $10,644. However, it is assumed that insurance premiums cease at the point of sale, meaning the total premium depends on the month of sale. Table 5 summarizes the total insurance expenses based on the sale month.

Table 5. Total Estimated Insurance Expenses by Sale Month

Sale Month	Total Insurance Expense
February	$968
March	$1,935
April	$2,903
May	$3,871
June	$4,838
July	$5,806
August	$6,774
September	$7,741
October	$8,709
November	$9,677
December	$10,644

Miscellaneous Overhead

The model includes a $5,000 per year miscellaneous cost to account for remaining incidental or administrative expenditures that derive from the cold storage operation. These costs may include normal maintenance and repairs, cleaning, waste management, or other fringe expenses not captured by the preceding cost estimates.

Shrink and Storage Loss

The analysis assumes that pecans entering cold storage have been adequately dried prior to storage consistent with standard post-harvest practices, resulting in minimal additional weight loss during storage. Under these conditions, incremental shrink attributed to cold storage is assumed to be negligible relative to other modeled costs and is therefore not explicitly deducted from salable volume.

This assumption is consistent with industry guidance indicating that properly dried in-shell pecans stored at subfreezing temperature experience limited additional moisture loss over time. Any unanticipated quality or quantity loss would reduce realized returns and represents an additional source of downside risk not explicitly modeled.

Estimated Cash Inflows

As indicated earlier, the model accounts for two potential revenue streams: the capture of possible seasonal price differentials and the elimination of third-party quarantine costs when quarantine is required.

Cash Inflows Associated with Seasonal Price Differentials

The revenues associated with earning differential prices are the additional revenue for the farm associated with selling pecans after January, the traditional month in which sales are made. Table 6 shows average differentials between export prices in January and other months for the last ten years (2013 through 2022).

Table 6. Monthly 2022 Export Prices, Price Differentials, and 10-Year Average Differentials

Month	Price/lb. (2022)	Differential (2022)	Average Differential (2013–2022)
January	$1.95		
February	$1.78	-$0.17	+$0.00
March	$2.07	+$0.12	-$0.01
April	$1.31	-$0.64	-$0.11
May	$2.12	+$0.17	-$0.02
June	$2.37	+$0.41	+$0.06

Table 6 (cont.)

Month	Price/lb. (2022)	Differential (2022)	Average Differential (2013–2022)
July	$2.38	+$0.43	+$0.07
August	$3.19	+$1.24	+$0.15
September	$3.82	+$1.87	+$0.22
October	$2.91	+$0.96	+$0.29
November	$2.00	-$0.04	+$0.23
December	$3.32	+$1.37	+$0.29

Also shown in Table 6, average price differentials from February through May are negative, indicating that stored pecans during these periods would be expected to result in a loss. In contrast, price differentials from June through December are positive, suggesting expected positive revenue flow.

It should be noted that while the average price differential is positive, the differential in any given year may be positive or negative. Over the last 10 years (10 years used in the averages shown above), the number of months with positive differentials ranged from zero (2020) to 11 (in 2017). Specific months ranged from 30% positive differentials over the last 10 years (April) to 90% (October and November). Figure 6 shows the price differential for four of the last 10 years. Careful observation of Figure 6 shows that marketing later in the year, while offering potentially higher prices, results in greater price variability.

It should also be noted that whereas positive price differentials are often observed later in the marketing year, the differential must be large enough to cover the additional costs associated with storing the pecans (i.e., the "cost of carry" or the total cost of holding the pecans).

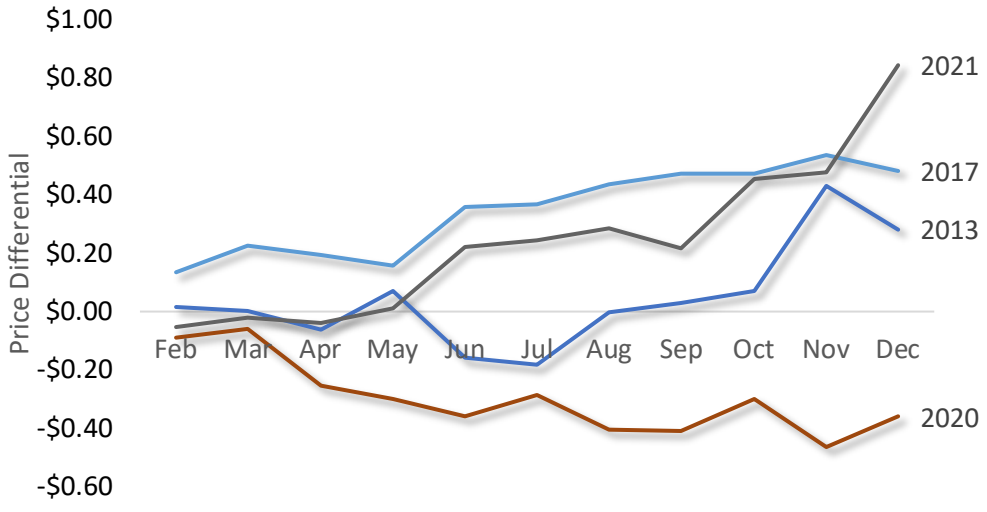


Figure 6. Price Differentials of Four Randomly Selected Years in the Last 10 Years

Cash Inflows Associated with Avoided Quarantine Costs

The analysis assumes that producers in quarantined areas of New Mexico and Texas must pay $30 per pallet (about 2,000 pounds of pecans) to store the nuts for 10 days at 0 °F. The $30 fee translates to an average cost of $0.015 per pound. The required 7-day countdown can only commence once the center of a pecan mass—typically stored in a 36" x 36" x 48" duffle or "superbag"—has reached the designated temperature. Additionally, there is a cost of $30 each for the super bag itself, which averages $0.01 per pound. Due to the latent heat within the mass, an extra three days of cooling is necessary before the countdown begins. For a facility with this capacity (i.e., 1,152,000 pounds), the total cost for a 10-day quarantine would be approximately $28,800 annually. By investing in on-farm cold storage, producers could avoid this expense.

Assumed Selling Behavior

It is assumed that the facility consistently operates at full capacity. Inventory is sold every year within a specific month for 30 consecutive years.

Results

Summarized in Table 7 are the net present value (NPV), internal rate of return (IRR), and discounted payback period (DPP) for the investment. For example, the first line shows returns associated with storing pecans for one month and selling the entire inventory in February. In this case, the 10-year average price differential is $0.00 per pound, resulting in an NPV of nearly -$800,000, and a DPP exceeding the investment's lifespan.

If the entire inventory were sold in any month before September, a negative NPV is predicted. September through December show positive returns to the cold storage investment. Based on the 10-year price differentials described above in Table 7, investment returns are maximized with sales in October, where the investment's present value is over $1 million, and the internal rate of return is nearly 25%. The returns are calculated using the 10-year average price differential. As previously discussed, price differentials for any given month or year can vary significantly, hence returns in any given year may be positive or negative.

Table 7. Measures of Return by Sell Month, Average Price Differential at Maximum Capacity

Month	NPV	IRR	DPP
February	-$781,611	ND	>30
March	-$785,036	ND	>30
April	-$2,477,892	ND	>30
May	-$1,514,180	ND	>30
June	-$793,199	ND	>30
July	-$797,238	ND	>30

Table 7 (cont.)

Month	NPV	IRR	DPP
August	-$13,911	8.5%	>30
September	$639,263	17.4%	8
October	$1,236,827	24.9%	5
November	$386,288	14.2%	10
December	$868,597	20.3%	6

Note: ND = Not Determinable

Figure 7 illustrates the minimum price differential needed to have a net present value of 0 (the point at which the investment becomes successful). This "hurdle" price increases over the year, from $0.065 to $0.214 per pound, as electricity, tax, operating loan, and insurance costs increase the longer the pecans are held in storage. Figure 7 shows the 10-year average monthly price differential obtained from UDSA Foreign Agricultural Service monthly export values. If the differentials shown for exports held in the domestic market, then pecans sold out of storage before August would fail to meet the hurdle price and would result in a negative NPV.

The average monthly differential from January, depicted by the columns in Figure 7, shows a notable increase in the later months, as previously discussed. However, price differentials have varied significantly from year to year over the past decade. The range of differentials, illustrated by the vertical lines, also tends to increase in the later months. For instance, in September, the difference between the lowest and highest observed differentials was $2.28, over four times greater than the range for February. Additionally, the differential ranges for the fall and winter months—from August to December—consistently exceeded $1.00.

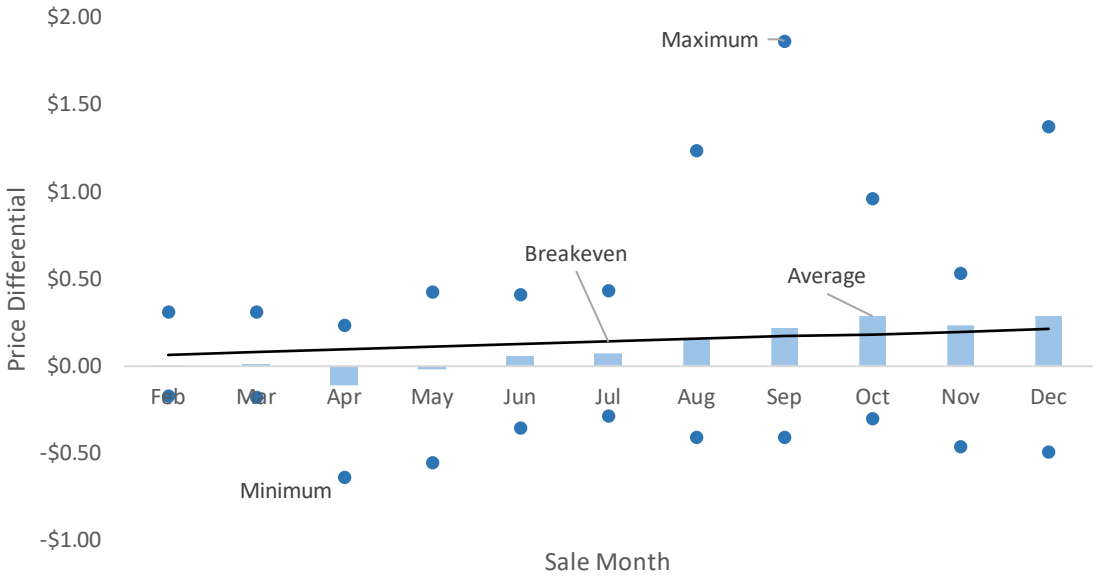


Figure 7. Minimum Price Differential Needed for Positive Investment Return and Average Differential, 2013–2022

One way of exploring the effect of variability in monthly price differentials on the investment returns is to look at a cumulative frequency distribution. For example, Figure 8 illustrates the cumulative frequency distribution for price differentials observed each October from 2013 to 2024. A differential of $0.18 or less, the hurdle price for October sales, was observed only 30% of the time, or three out of the last 10 years. This finding suggests a 70% likelihood of achieving a sufficiently high seasonal differential to justify the investment based on the last decade of pecan sales and assumptions outlined above. Notably, three of the differentials even exceeded $0.40, more than twice the hurdle price.

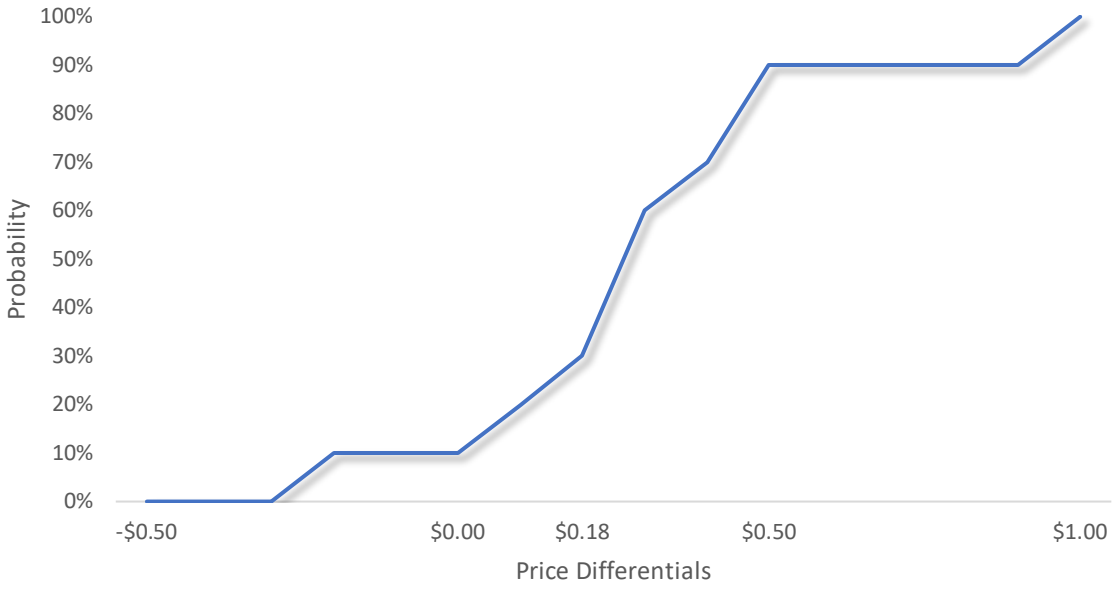


Figure 8. Cumulative Frequency Distribution, USDA Foreign Agricultural Service October Export Value Differentials, 2013–2022

Source: USDA-FAS

Using average differentials, a marketing strategy that held pecans until after August would result in positive investment returns measured by NPV or IRR. While evidence suggests that on-farm cold storage could produce positive investment returns, the year-to-year variability observed in Figures 6 and 7 suggests the strategy could suffer significant negative differentials in any particular year, increasing the importance of cash flow management. These dynamics imply that while extended marketing windows may increase expected returns, the associated cash flow volatility and capital intensity may limit feasibility for smaller producers unless capital requirements and price risk are shared across several operations or supported by access to substantial operating credit lines. Even with sufficient credit, however, prolonged exposure to adverse price differentials can increase financing costs and balance-sheet risk.

Many producers do not face quarantine requirements and the corresponding costs associated with quarantine; thus, the current model overstates the returns to cold storage. Removing the benefit of

avoiding third-party quarantine costs in the model reduces the internal rate of return (IRR) by approximately 3.8% for each sales scenario. For example, if a producer marketed their pecans in October, the month with the largest price differential, the IRR would decrease from 24.9% to 21.1%.

Conclusion

Agricultural producers, including pecan producers, are price takers with little control over the price they receive for their products. One way in which pecan producers may gain more control over their prices is by adding market flexibility made available through storage. Due to their high oil content, pecan storage requires the use of cold storage facilities. This analysis has explored potential investment returns associated with building and operating an on-farm pecan cold storage facility. Key findings suggest that, while investment shows financial potential, significant downside risk is also present.

Using the assumptions described in the body of the paper, including average pecan export value differentials, an investment in on-farm cold storage could produce positive returns. However, returns are directly related to the season in which the pecans are sold. The ability to extend marketing windows beyond the traditional early winter window will likely increase price volatility and corresponding volatility in revenue and profits. The increased volatility would likely increase cash flow requirements and expose investors to significant risk.

While the analysis reported in this paper suggests that on-farm cold storage may have promise as a potential marketing tool and a means of providing more control over prices received for their pecans, producers should conduct their due diligence to ensure that model assumptions are consistent with their unique circumstances. Additionally, producers should be prepared for potential increases in price variability impacting cash flows and the need for additional capital should persistent negative price differentials be encountered over the investment lifespan.

Limitations and Future Research

Limitations

Several limitations to the research described in the body of the report should be acknowledged. A significant limitation is the availability of monthly price data for pecans. Some monthly data are available for portions of the year, but a government-validated dataset for domestic monthly prices is not available. The use of monthly USDA-FAS export values may not accurately reflect domestic price differentials.

Even if domestic and export differentials are identical, the analysis described above relied primarily on export value (price) differentials observed over the last 10 years. Agricultural markets and policy remain dynamic and future market behavior may not remotely resemble past data, voiding the results provided in this research.

Given the industry's reliance on production contracts, it is unclear whether pecans can be marketed effectively outside traditional market windows. Producers using on-farm cold storage may have difficulties in marketing their pecans on a month-to-month basis.

The results of this study are based on a relatively simple model. They are intended to provide general insights into the potential feasible investment opportunity under basic assumptions. Like all investments, many factors cannot be readily quantified and predicted. Investors should consider any analysis as guidance rather than conclusive facts. Interested stakeholders should conduct their due diligence, including obtaining and validating investment and operating costs and expected revenues.

Future Research

Future research regarding the economic and financial viability of on-farm cold storage may include updates to the analysis that use newly available domestic prices and resulting seasonal price differentials in domestic prices. Given the potential increased price volatility, the analysis could benefit from a more in-depth analysis, including Monte Carlo simulation to explore tradeoffs between risk from price differential volatility and potential benefits.

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Appendices

Appendix I. Cold Storage

The potential for better marketing control and the increasing need for local biological control have made on-farm cold storage an attractive investment for some producers. However, the complexity and costs of such a project can pose challenges.

Cold storage facilities maintain an internal temperature below freezing using heavy insulation and specialized air conditioning systems. The structure is often a steel frame, either self-supporting or supported using an internal storage rack system. Pecan warehouses typically require a standalone building, given the use of heavy wooden storage crates. Ceiling heights of 20’ or greater are considered desirable for five-high stacks of the 4’ x 4’ containers standard in nut storage, a strategy that limits the facility's footprint.

With internal temperatures persistently under 32 °F, increased floor thickness or insulation is essential to prevent structural stress from ground freezing, a principle known as “frost heave.” Considering the requirement of expensive floor solutions, conserving square footage is a high priority in facility design.

Various wall and ceiling insulation materials are suitable for cold storage facilities. Fiberglass, mineral wool, polystyrene, polyurethane, and natural fibers have all been successfully implemented and possess unique strengths and weaknesses. Due in part to the low cost, ease of installation, and availability, a combination of fiberglass cloth and polystyrene boards over 6 inches thick is a standard solution.

Arguably, the most critical design feature is the choice of cooling system. One- or two-stage anhydrous ammonia systems are the most common in commercial-grade cooling, and they are desired for their cost and engineering efficiency. Unfortunately, even trace amounts of ammonia inside a storage space can permanently discolor in-shell pecans, ruining their market value. Though single-stage hydrofluorocarbon-based systems (HFC) are increasingly rare in the commercial sector due to regulatory pressure, they remain a good candidate for small installations where the required system size is limited and food products are present. New commercial cold storage systems increasingly rely on cascade designs with an internal CO_2-based system that poses less inventory or personnel risk and is more environmentally sensitive. Aside from the increased complexity and cost, CO_2 coolants are incompatible with older systems designed for HFCs, unlike ammonia, which is interchangeable with only slight system modifications. Thus, retrofitting older systems, while possible, is often unpreferable for food storage, often necessitating investment in an entirely new system.

Removing latent moisture content from the nut is necessary to prevent mold formation during shipping, processing, and storing. It is especially vital, however, before cold storage to avoid condensation in the facility and the formation of large ice crystals inside the nuts or on the exhaust fans. Traditionally, nuts were placed in hot and dry areas for two weeks or more to be dried.

Modern production has sped this process using forced air-drying machinery, commonly installed into harvest wagons for time efficiency. When used for pecan processing, these systems typically force 95 °F air through the mass of pecans as they sit inside the harvest equipment, quickly reducing the moisture content to approximately 4% to 4.5% from between 8% and 30% before storage or transport. Ambient humidity and the stage of nut maturity, early or late in the season, can alter the time required for drying and should be considered carefully before storing.

Appendix II. Apple Price Seasonality

Apples display similar seasonal price fluctuations to that of pecans. Both import and export market prices for apples follow comparable seasonal patterns. When comparing the seasonal price indices for both markets, it is observed that from January to July, prices are below average, before rising sharply toward the end of the year (see Figure 8). This seasonal price trend is based on the average apple prices from 2015 to 2023, with a slight gap in the data from 2013 and 2014 due to the absence of domestic price information.

The primary difference between them lies in the timing of the price spikes. Domestic apple prices typically peak in September, averaging more than 7% above the annual average for that month. In contrast, export apple prices experienced a spike in December, reaching a maximum of 4.9% above the average for that period.

Despite these timing differences, the seasonal price patterns for both markets show strong similarities in month-to-month seasonal fluctuations and price differentials. Given that apples and pecans share many characteristics, it is reasonable to assume that the price seasonality in both domestic and export pecan markets follows a similar pattern.

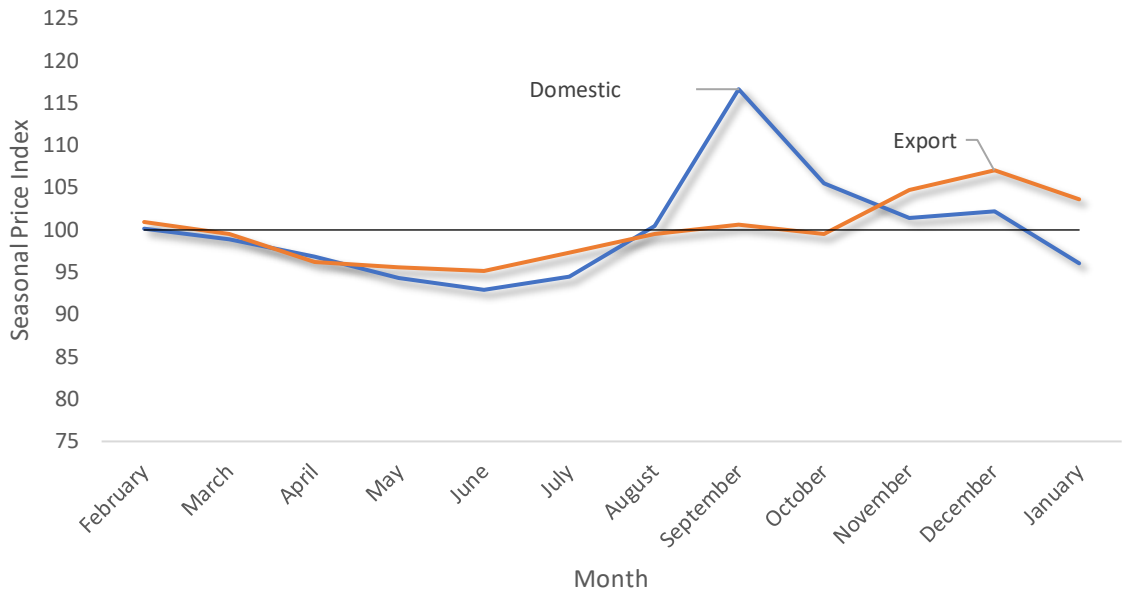


Figure 8. Price Seasonality, U.S. Domestic and Export Markets, 2015–2023

Source: USDA-NASS, USDA-FAS 2024