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Spatial and Temporal Aspects of Potatoes for Chipping: Current Practices and Future Directions

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ABSTRACT

Sixteen Pennsylvania potato chip makers are surveyed about their potato acquisition and storage practices. The feasibility of storing potatoes for chipping at the plant is examined. Storage of potatoes by the firms appears to be economically attractive, especially for four to six months. The implications of increased at-plant storage on movements of potatoes are discussed.

INTRODUCTION

Although potatoes are produced in most states, this production is not distributed in the same proportions as population. Furthermore, potato production in any state is seasonal while consumption generally is not. As a result much of the crop is transported a considerable distance to consumers, either as tablestock or as processed products. The high transportation cost relative to the value of the potatoes makes the economics of potato production particularly vulnerable to changes in transportation prices. Beilock and Dunn (1982) and Meyer and Phelps (1986) are just two studies that have examined this relationship. In general high transportation costs for raw potatoes encourage processing potatoes near the producer rather near the consumer. The exception is potato chips.

Potato chips, which are fragile and have a very low density, must be produced near the consumer. A shelf life of four to six weeks requires chips be made as needed. As a result, chip production is fairly constant throughout the year.

Potato production is not. The fall crop, by far the largest, is the source of potatoes for chipping during the fall and winter. Only the fall crop is stored. Chips in the late fall and winter months are made from potatoes out of storage, using either locally-grown potatoes or potatoes from other regions. Spring and summer potatoes are chipped as they become available. Since they are followed by the dominant fall crop, spring and summer potatoes are used soon after harvest without any long-term storage. Because these seasonal crops are grown in different regions, chipping potatoes must be shipped to the consumption area. Traditionally chipping-stock potatoes have been stored where they are produced and shipped to chippers as needed.

Potatoes must be handled carefully during harvesting and storage in order to ensure the quality of the final product. Because a potato is still a living organism through storage, bruises incurred in harvest or while entering storage will heal during storage if proper storage and handling practices are followed. Bruises incurred during removal from storage do not have time to heal before processing. The best storage practices include high humidity and temperatures of 50 degrees F. Before chipping the potatoes must be warmed to 60 degrees F. for reconditioning to lower sugar levels. Potatoes should be processed into chips within two to four weeks after reconditioning. For chippers, control of these storage and handling requirements is important from a quality control perspective.

Storage at the chipping plant may offer another advantage to a chipper. The storage facilities at the chipping plant will generally be larger than the on-farm facilities, which should make at-plant storage somewhat less expensive. As a result storage at the chipping plant may be cheaper as well as reducing damage and perhaps providing a higher quality product than on-farm storage.

Since current practices generally involve moving potatoes to the chipping plant as needed, storage at the plant would necessitate movement to the plant at harvest. It may also involve supplying the plant for the storage season from a different origin. This paper will: (1) examine current potato acquisition and storage practices for Pennsylvania potato chip manufacturers; (2) determine the economic feasibility of storing chipping potatoes in Pennsylvania; and (3) discuss the likely implications of increased at-plant storage on movements of potatoes. Although the results are specific to Pennsylvania, they have implications for much of the nation's potato industry.

CURRENT INDUSTRY PRACTICES

A survey designed to collect data describing current storage facilities, practices, purchasing patterns, and raw product costs was conducted in the fall and winter of 1987–88. Sixteen large Pennsylvania potato chipping firms participated. Fifteen of these firms accounted for 78% of all potatoes used for chips in Delaware, Maryland,

TABLE 1

Percentage of Monthly Purchases for Fifteen Pennsylvania Chip Manufacturers from Pennsylvania and Other Supply States. (1986–87 crop year)

	PA	NY	OH	ND	MN	MI	FL	NC	VA	NJ	DE	MD	TOTAL
Aug.	69.8	12.7	—	—	—	—	—	—	12.7	4.8	—	—	100
Sept.	54.0	36.5	—	9.5	—	—	—	—	—	—	—	—	100
Oct.	36.5	47.9	—	15.6	—	—	—	—	—	—	—	—	100
Nov.	42.2	19.7	—	36.8	1.3	—	—	—	—	—	—	—	100
Dec.	39.7	22.4	—	36.7	1.3	—	—	—	—	—	—	—	100
Jan.	30.9	22.5	7.1	39.5	—	—	—	—	—	—	—	—	100
Feb.	33.3	19.2	9.0	38.5	—	—	—	—	—	—	—	—	100
March	25.5	13.2	10.1	51.2	—	—	—	—	—	—	—	—	100
April	21.7	14.4	—	52.0	—	—	11.9	—	—	—	—	—	100
May	—	—	—	—	—	—	100.0	—	—	—	—	—	100
June	—	—	—	—	—	—	47.3	48.6	4.1	—	—	—	100
July	12.5	—	—	—	—	—	—	31.1	33.1	14.2	8.3	0.8	100
							Annual totals						
1,000 cwt.	1959.3	1062.5	466.6	1483.0	17.6	4.6	1401.8	729.6	363.7	209.5	55.4	13.3	5,363.2
%	24.6	13.6	2.5	23.0	0.1	—	18.9	9.4	5.0	1.9	1.0	0.1	100

	Pennsylvania and vicinity	Midwest	Early South	Intermediate	
	2,179.2 cwt.	1,243.3 cwt.	1,519.3 cwt.	423.4 cwt.	
	40.6%	23.1%	28.3%	8.0 %	100

Source: Survey data, 1987.

New Jersey, Pennsylvania, Virginia, and the District of Columbia during the 1986–87 crop year. Nationally the group surveyed accounted for about 18% of the potatoes used for chips. Raw product price data were collected for each of the past five years.

About 12% of U.S. potato production is made into chips. The portion of the eastern crop used for chipping is considerably greater than this, perhaps as much as one-third. Although the respondent firms used considerably more potatoes than are produced in Pennsylvania, less than half of Pennsylvania-grown potatoes are used for chips. Pennsylvania chip manufacturers purchase potatoes from several supply regions, with the source varying with the time of the year. Table 1 shows the origin of chipping potatoes by month for the participating firms. From the beginning of the fall-crop harvest until the harvest of the spring crop in Florida in April, Pennsylvania chippers obtain their potatoes from the Midwest (36.3%) or Pennsylvania and vicinity (63.7%). From April until early August, chippers buy newly harvested potatoes from the Southeast. Most potatoes used by Pennsylvania chippers in August come from Pennsylvania. As the storage season progresses, though, the portion of raw product from in-state sources declines. From November through the remainder of the storage season many Red River Valley (North Dakota-Minnesota) potatoes are chipped, in part because survey respondents believe these potatoes store better. Pennsylvania chippers believe Red River Valley potatoes incur fewer storage losses resulting from tuber defects or mechanical damage during harvest. This preference for Red River Valley potatoes reduces the Pennsylvania growers' share of the chipping potato market.

The methods of transporting potatoes to the plant depends on their origin. The extreme involves deliveries to some plants in horse-drawn wagons by Amish growers. More conventional types are summarized in Table 2 for the various regions. The most common mode is truck, prima-

TABLE 2

Transportation by Region

Type of Transportation	Number of Firms Using Type of Transportation: PA and vicinity (PA NY OH)	Early South (FL NC)	Intermediate (VA NJ DL MD)	Midwest (ND MN MI)
Rail	0	0	0	5
Piggyback rail	0	1	0	0
Company trucks	2	1	1	0
Seller's trucks	9	8	7	5
Independent trucks	14	14	13	11

Some firms use more than one type of transportation for shipments from the same origin.

rily trucks belonging to third parties. Some of the seller's trucks may actually be contracted through brokers rather than operated by the seller. Only one firm used their own trucks for potatoes from beyond a 30 mile radius of the plant. The modal distribution changed little over the five years with the exception of some movement away from rail due to scheduling problems and competitive truck rates. Three of the chippers said they had changed from rail to truck for their shipments from North Dakota because problems with rail.

Some chippers have sufficient storage capacity for several months, while others have limited storage capacity and meet raw product needs by purchasing potatoes when needed. The longest period any of these chippers held potatoes was 5.75 months.

The dependence of the industry on newly-harvested potatoes in May, June, and July can create problems. In 1987 the Florida potato crop failed. A serious shortage of chipping stock arose because the stored potatoes from the fall crop were almost gone but no other region was in production. Unwilling to raise the retail prices for such a short-run problem, some Pennsylvania chippers instead resorted to rationing. They allowed established customers to buy only a fraction of their usual order, and did not sell to new customers at all. A freeze in 1989 in Florida reduced the crop somewhat. In addition, rains delayed planting in North Carolina, Virginia, and Delaware. As a result chipping potatoes were more expensive than usual this spring. In theory the industry could store potatoes into May as a form of insurance. So far limited capacity, the losses from such long-term storage, and the higher quality chips made from new potatoes have kept them from doing this. Improving technology and two small crops in three years may cause chippers to consider such storage policies.

STORAGE FEASIBILITY

The feasibility of storage at the chipping plant was studied. This involved a comparison of the costs of owning and operating a storage facility with the price differentials associated with buying potatoes on the open market. The firm would prefer to store the potatoes itself if the storage cost is less than the price differentials they would pay on the open market. These open market purchases are usually through brokers from farmer-owned storage.

The weighted average monthly cost of chipping-stock purchases was calculated for each firm using the prices and quantities from each firm's purchase under contract and in the open market. These prices were delivered prices and included the transportation costs from the seller. From this a weighted average industry cost was calculated. Each firm's monthly raw-product costs were weighted by its proportion of total raw product used. Monthly costs were used to reflect the market's valuation of the costs of storage including all storage losses. A five-year industry average was calculated. A five-year period was used to reduce the distortions caused by variation in year-to-year potato production and prices. Raw-product costs for firms using their own long-term stored potatoes were excluded in order to more accurately reflect the potential gains from storage.

A modular storage design was used to evaluate the profitability of different sized facilities. A modular unit also adds flexibility, both for expansion and for storage management. The envisioned basic storage structure is a wood-frame, metal-clad building with a concrete floor. Each unit measures 48 ft. x 84 ft. x 16 ft. and has a capacity of 12,000 cwt. This size unit and its configuration provide the greatest amount of capacity per investment dollar, while still remaining compatible with constraints imposed by the environmental systems' capacities. Furthermore, it was judged to be of an appropriate size for potato reconditioning. The capacity of an individual storage unit should not exceed one month's production needs. The details about the storage facility, its costs, and the underlying assumptions in the cost estimates may be found in Powell et al. (1989).

The potatoes would be stored in 1,200 crates, each holding 1,000 lb. Potatoes are stored in crates rather than in bulk for greater ease of handling and to reduce losses. Survey respondents with crate storage had average losses of 3.2% compared to 10.3% by firms with bulk storage, where both groups stored for similar durations. The greater losses in bulk storage appear to be caused by increased bruising of tubers during handling, pressure bruising of tubers at the bottom of the pile, and lack of control over quality changes that cause deterioration but may escape notice in bulk storage. The additional investment in crates and the larger area required for crate storage is offset to some extent by lower losses and the lower construction costs for walls that are not required to bear the lateral pressure of a pile of bulk potatoes. The costs of constructing bin storage facilities built in 1988 in western New York were virtually identical to the investment costs for the crate facility used here.

The attractiveness of an investment in storage facilities for chipping potatoes depends on how long the potatoes are to be stored. The planning horizon and the time value of money, or discount rate, are also important. The potential investment in storage is analyzed using the internal rate of return (IRR), which is the interest rate at which the net present value ofthe cash flow from the investment equals zero. Since the investment would occur at the beginning of the period and the returns would occur each year as potatoes are stored, the investment is analogous to a 20 year annuity. As such, the relationship between the initial investment and the annual cash flow defines the internal rate of return.

Based on manufacturers' estimates of the life of various pieces of equipment and the expected life of the crates, the storage facilities in this study are assumed to have a 20 year life with no salvage value at the end. While the building would probably last longer, the chip market and current seasonal chipping potato prices may not continue. A few additional years of net cash inflows would increase the IRR only marginally.

The facility can be used to store potatoes from one month to six months. The profitability of each period is different since the price differentials between months differ and the cost of holding potatoes increases with time in storage, both because of additional cash expenses and because of increased storage losses. As a result the attractiveness of owning storage may vary with the pattern of storage. For purposes of illustration several examples are presented in Table 3.

The storage facility is assumed to be filled during September and October, half in each month. Three sizes of facilities are examined, a single 12,000 cwt. module, a six module, 72,000 cwt. unit, and a ten module, 120,000 cwt. unit. Each facility is analyzed for several utilization patterns. In particular using the entire contents of the entire facility in each month from November until April, the larger facilities at constant rates for all months from November to April, andthen the larger facilities for multi-month combinations, but less than the entire storage season.

Costs (shown in Table 4 for the 12,000 cwt. unit) included in the feasibility study include: all costs of construction for the facility except the costs of the land; operating costs for the facility including taxes, insurance, sprout inhibitor, dry-rot inhibitor, labor, utilities, maintenance, and storage losses; and the costs of the potatoes, including transportation.

The prices paid for potatoes rise during the storage season. The later prices are higher than prices earlier in the season since they compensate the seller for providing storage and absorbing the storage losses, whether spoiled potatoes or shrink. The differential per month ranges from 30 to 57 cents per cwt., with the largest differential for April and the second largest for November. North Dakota potatoes that come into Pennsylvania are competitively priced on a delivered basis, so these higher prices are not a reflection of the transportation costs from North Dakota.

The internal rates of return are higher for the longer periods of storage, going from a negative return for November to over 22% for April. The low returns for the shorter periods are primarily a reflection of the small differentials between harvest prices and the November, December, and to some extent the January prices. These small differentials reflect the adequacy of existing storage facilities and methods (generally on-farm storage in bulk) for these shorter periods. As time in storage increases the losses from bulk storage and handling increase. As a result on-farm storage in Pennsylvania beyond January 1 is unusual. So also is storage at the plants. More often chippers buy potatoes out of storage in other regions after January 1.

TABLE 3

Internal Rates of Return for Selected Sizes of Storages Employing Various Utilization Patterns

	Monthly Utilization (cwt.)						
	November	December	January	February	March	April	IRR[a]
12,000 cwt.	12,000	—	—	—	—	—	<0.0
Storage	—	12,000	—	—	—	—	3.5%
Capacity	—	—	12,000	—	—	—	9.3%
	—	—	—	12,000	—	—	12.8%
	—	—	—	—	12,000	—	16.5%
	—	—	—	—	—	12,000	22.9%
72,000 cwt.	72,000	—	—	—	—	—	<0.0
Storage	—	72,000	—	—	—	—	5.3%
Capacity	—	—	72,000	—	—	—	11.4%
	—	—	—	72,000	—	—	15.2%
	—	—	—	—	72,000	—	19.2%
	—	—	—	—	—	72,000	26.0%
	12,000	12,000	12,000	12,000	12,000	12,000	13.4%
	—	14,400	14,400	14,400	14,400	14,400	15.5%
	—	—	18,000	18,000	18,000	18,000	18.2%
	—	—	—	24,000	24,000	24,000	19.8%
	—	—	—	—	36,000	36,000	22.8%
120,000 cwt.	120,000	—	—	—	—	—	<0.0
Storage	—	120,000	—	—	—	—	5.9%
Capacity	—	—	120,000	—	—	—	12.2%
	—	—	—	120,000	—	—	16.0%
	—	—	—	—	120,000	—	20.1%
	—	—	—	—	—	120,000	27.0%
	20,000	20,000	20,000	20,000	20,000	20,000	14.2%
	12,000	12,000	24,000	24,000	24,000	24,000	16.2%
	—	24,000	24,000	24,000	24,000	24,000	16.7%
	—	—	30,000	30,000	30,000	30,000	19.1%
	—	—	—	40,000	40,000	40,000	21.3%
	—	—	—	—	60,000	60,000	23.8%

[a]IRR is calculated on net cash inflows discounted annually and rounded to the nearest tenth of a percent

To some extent the lower returns for the early months may reflect the power of the chippers in negotiating grower contracts. Grower contracts often require the growers to provide some storage. Most of the chippers felt the higher price paid for contracted stored potatoes covered the costs of storage. However, the differentials paid are usually a flat rate per month, such as 35 cents per cwt. The operating costs of a storage facility have a large component that does not depend on the length of the storage period, perhaps 25 cents per cwt., with a considerably smaller amount that varies with time in storage. This latter amount is mostly storage losses. The effect of this large fixed component, the counterpart of terminal costs in transportation, is that storage differential that are a flat rate per month are generally inadequate for short storage periods. The investment in the facilities produces another fixed component, this associated with owning the facilities. Even though November had the second largest monthly price differential, 48 cents per cwt. higher than October, this differential does not offset the fixed component when costs for the investment are included. To owners of an existing facility, these investment costs are sunk costs. As a result they may be willing to store for short periods without full coverage of these costs.

For the 12,000 cwt. unit, the marginal operating costs of an additional month in storage is about 11 cents per cwt. Since the monthly differentials are about three times this amount, as the length of the storage period increases so does the profitability of operating the facility. The internal rates of return for storage into January through April generally exceed 10% on a before-tax basis, and in later months are above 15%.

IMPLICATIONS FOR POTATO PRODUCTION AND MOVEMENTS

Storage at the chipping plant would be most profitable for January through April. This period is now characterized by large inflows from other states, especially North Dakota. If potato chipping firms in Pennsylvania, and presumably other northeastern states, were to invest in large scale, at-plant storage it would alter the timing and possibly the source of many of the fall-crop potato movements.

Since the potatoes would be moved into storage in September and October, the potatoes must be delivered to the plant in these months instead of throughout the storage period, as needed. This would require more transportation in September and October and less in the remaining months of the storage period. Of course, September and October are months when agricultural transportation is already busy. For the movements from North Dakota to Pennsylvania, this would entail moving almost 1.5 million hundredweight in two months, a movement that has been spread over eight months. A similar shift would occur for the shorter New York to Pennsylvania movement. If the incentives for at-plant storage exist in Pennsylvania chippers, they may also exist for chippers in other states. If other chippers also shifted their transportation needs to September and October it would aggravate what is already a difficult seasonality problem in agricultural transportation. In addition to the difficulty in finding and scheduling trucks and rail cars, congestion at origins and destinations could be a problems.

When asked if more storage in Pennsylvania had potential, fifteen of the sixteen chippers responded yes. Six mentioned transportation problems that might be avoided. Of these three were

TABLE 4

Operating Expenses and Storage Incentives for a 12,000 cwt. Facility[1]

Store Until	Operating Expenses									Storage Incentive[10]
	Taxes[2]	Insurance[3]	Mertect[4]	CIPC[5]	Labor[6]	Utilities[7]	Maintenance[8]	Losses[9]	Total	
	(cents/cwt.)									
November	1.3	5.5	2.0	0.0	5.0	3.4	6.6	10.7	34.6	68
December	1.3	5.5	2.0	0.0	5.0	4.0	6.6	15.3	39.9	101
January	1.3	6.9	2.0	8.0	5.0	4.8	6.6	21.0	55.6	147
February	1.3	6.9	2.0	8.0	5.0	5.5	6.6	29.2	64.5	177
March	1.3	6.9	2.0	8.0	5.0	6.0	6.6	39.2	75.0	211
April	1.3	8.2	2.0	8.0	5.0	6.3	6.6	50.9	88.4	268

[1]A single unit holding 12,000 cwt. of potatoes, all of which are assumed to be used in the month indicated.
[2]Taxes are based on the market value (cost in this case) of the structure at an annual rate of 0.254%.
[3]Insurance is paid quarterly at 0.2% of the market value (cost in this case) of the structure and 0.2% on the value of the potatoes (at purchase cost) in storage during that quarter.
[4]Mertect materials and labor. Applied when placed in storage.
[5]Contracted CIPC application to inhibit sprouts. Applied in November but used only on potatoes to be stored after December.
[6]$0.025/cwt. for labor when placed in storage and again when removed from storage.
[7]Utilities vary with utilization because empty units are not heated, cooled, or ventilated, but a $10/month charge is assessed even when the storage is empty.
[8]Maintenance is based on 0.5% of structure cost plus 2.0% of crate cost.
[9]Dollar value of weight and quality losses.
[10]Difference between weighted average price/cwt. September and month indicated.

l interested in avoiding shipment in the winter and three were interested in avoiding the difficulty in shipping long distances.

Several of the chipping firms said they preferred Red River Valley potatoes for storage because they store better. Pennsylvania potatoes, even when they are the same cultivars, apparently do not have the appropriate characteristics to handle long-term storage well. If this continues, more at-plant potato storage might not result in more Pennsylvania potatoes being chipped at the expense of out-of-state potatoes. Agricultural scientists in Pennsylvania and other northeastern states are working on varietal improvements that will result in greater storability. If this research is successful, the presence of long-term storage facilities at the chipping plant and the transportation bottlenecks that may result from consolidating long distance potato movements into the harvest season may combine to increase the market share of locally grown potatoes.

CONCLUDING COMMENTS

Investment in storage facilities for chipping potatoes in Pennsylvania is economically attractive for some periods of storage. The added control by the firm over their raw-material supplies has benefits beyond the simple cash flow issues. The convenience of having raw product on site rather than depending on well-timed deliveries could avoid unforeseen delays that might result from bad weather. It also would provide the firm with more control over the quality of the raw product. Those who wish to store potatoes for late fall and early winter may even believe the convenience and control to be sufficiently important to offset the lower internal rates of return during these periods. Changing the storage location from the farm to the chipping plant could affect the origin of the potatoes chipped. Eastern chippers might use more eastern potatoes than they do now if they did their own storing.

This research assumes the monthly price differentials will persist. Obviously these differentials arose because of current practices. If a substantial shift in seasonal demand for potatoes and potato transportation should occur this would increase prices of both in September and October and decrease them in later months. This would at least partially reduce the attractiveness of at plant storage.

The economics of storage would differ in other areas. The advantages of reduced handling in the storage period and chipper control over reconditioning make on-site storage worth considering. Incentives may exist for more at-plant storage for potato chip manufacturers in many states. If the incentives are sufficient, the movement of potatoes could become much more seasonal.

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ENDNOTES

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