Temporal Cost Analysis of a New Development in Controlled Atmosphere Storage: The Case of Vidalia Onions

by

C. T. Hancock
Graduate Student
Department of Agricultural Economics
University of Georgia
Athens, GA

J. E. Epperson
Professor
Department of Agricultural Economics
University of Georgia
Athens, GA

Introduction

The Vidalia onion is a unique sweet onion of the Yellow Hybrid Granex variety which is solely produced in a region including all or parts of 20 counties in southeastern Georgia. The unique characteristics of the onion are a sweet taste and low pungency levels (Smittle). These characteristics provide for product differentiation within the yellow onion market in the United States. Moreover, a recent analysis disclosed an average premium of $12.55 per 50 lb. bag for Vidalia onions over the primary competing sweet onion produced in Texas, based on the years 1982 through 1988 (Centner et al.).

In an effort to sustain and enhance product differentiation, producers of Vidalia onions prompted the U. S. Department of Agriculture to enact an interim Vidalia Onion Marketing Order in 1989 restricting the use of the name, "Vidalia Onion," to only onions produced within the specified territory of southeastern Georgia (*Federal Register* 1989). The final rule for issuance of the order also provides for a check-off system to raise funds for advertising and research (*Federal Register* 1990).

The production region for Vidalia onions is limited to those counties in southeastern Georgia outlined in the 1989 Marketing Order (*Federal Register* 1989). Yields of Vidalia onions have been variable from year to year, with an average yield of 300 (50 lb.) bags per acre (Georgia Cooperative Extension Service). Total shipments for the years 1982-1989 are given in Table 1.

The agricultural practices for producing Vidalia Onions are not largely different from the production of other yellow onions. The Georgia

Table 1

Average Monthly FOB Prices and Shipments for Vidalia Onions, 1982-1989

Month	Year	FOB Price[a]	Shipments
		($/50 lb. bag)	*(50 lb. bags)*
May	1982	23.40	273,455
June	1982	23.00	27,345
May	1983	13.40	456,602
June	1983	5.67	356,198
May	1984	26.11	163,723
June	1984	26.42	175,477
May	1985	23.75	155,738
June	1985	21.00	174,665
May	1986	16.58	389,268
June	1986	10.86	170,732
May	1987	18.29	479,669
June	1987	12.17	249,131
May	1988	7.45	641,826
June	1988	5.50	290,174
April	1989	17.33	184,275[b]
May	1989	12.88	174,925[b]

Source: U.S. Department of Agriculture.

Note: Estimation of the relationship between FOB Price and Shipments yielded the expected sign. However, the farm level demand was shown to decline for the month of June:

$$P_i = \underset{(7.41)}{27.91} \underset{(-2.10)}{-3.15E\text{-}5S_i} \underset{(-3.13)}{-6.47D} \quad ,$$

where P_i is FOB price, S_i represents shipments, i is month, D is an intercept dummy variable with values of 1 for the month of June and 0 otherwise, the values in parentheses are t statistics, the F value is 5.37, R^2 is 0.45, and the DW statistic is 1.33.

[a]Large-to-Jumbo size.

[b]Preliminary data.

Vidalia onion harvest season normally begins in mid to late April and continues to mid June. Onion producers stagger plantings in an attempt to stabilize the supply of onions over the course of the seasonal market. As with most fresh vegetable and fruit crops, sweet onions must be harvested in a timely manner to achieve desired quality. Once harvested, sweet onions must be marketed in a relatively short period of time because of perishability.

Nevertheless, data show that shipments peak around the second to third week of May (U.S. Department of Agriculture). Onion prices also follow a seasonal trend, with the highest prices received in the earliest portion of the season (U.S. Department of Agriculture). Average monthly FOB prices for large-to-Jumbo Vidalia onions are presented in Table 1 for the years 1982-1989.

In order to provide producers with greater marketing flexibility, research has been conducted to ascertain the feasibility of storage for sweet onions. Two types of storage have been considered because of success with apples: cold storage and controlled atmosphere (C.A.) storage (Shotzko and O'Rourke). Traditional cold storage simply involves refrigeration, whereas C.A. storage encompasses a mixture of gases, temperature, and humidity, regulated in a sealed storage facility.

Experimentation with cold storage of sweet onions beyond a period of six weeks has not been successful (Smittle). However, Smittle found that storage of Vidalia onions in a prescribed atmosphere at near-freezing temperatures (1 degree Celsius) and a relative humidity of 70 percent caused negligible losses in the percentage of marketable bulbs after a storage period of six months. Smittle's most current, unpublished, research results indicate that storage losses under optimal conditions are expected to be 1 percent of total volume.

The effects of C.A. storage on the unique characteristics of the Vidalia Onion were also examined. The sugar-to-pungency ratio increased 39 percent during a storage period of six months, while the post-storage consumer panel preference rating increased 12 percent relative to the pre-storage rating (Smittle).

Controlled atmosphere storage is more costly than traditional cold storage primarily because of the added equipment required to monitor and regulate the atmospheric mixture and the added cost of construction. From an operating standpoint, however, the refrigeration component for C.A. storage is the primary-cost producing factor, especially in light of the low level of humidity which must be maintained according to Smittle and engineers with the Southern Company, a parent corporation which provides electrical power in Georgia.

A C.A. storage facility normally is constructed in a compartmental fashion. Any number of rooms may be housed under one roof. The actual volume for each room and the number of rooms are determined by expected temporal demand.

The principal thrust of this research is to determine the cost of C.A. storage for Vidalia onions. Temporal allocation is used to assign costs incurred over the storage period. Per unit cost analysis is used to determine the break-even selling price in each month of storage with respect to three alternative interest rates and storage volumes. Costs are derived from construction estimates for C.A. storage and the expected operating charges for a facility located in the production region of Georgia.

Methodology

Data used to derive cost estimates for C.A. storage were obtained from studies conducted by Shotzko and O'Rourke and Motsinger, engineers with the Southern Company, representatives for six storage design and engineering firms in the state of Washington, and a Horticulturist with the University of Georgia in 1989.

Data for large operations came primarily from the study by Shotzko and O'Rourke which pertains to the cost of C.A. storage for apples. From this study it was ascertained that the construction cost of a facility which can store the equivalent of 350,000 50 lb. bags of onions was

$67.20 per square foot in 1989 dollars. The cost per square foot for a smaller facility, of course, would be higher. Indeed, the cost of constructing a facility with a capacity of 7,000 bags was estimated to be $81.80 per square foot.

Based on the Washington apple facility costs for large (350,000 bag) structures and the Georgia estimates for small (7,000 bag) structures, linear extrapolation was used to obtain facility cost estimates by size of operation as depicted in Table 2. A capacity range of 10,000 to 250,000 bags was selected as the basis for the cost analysis because the low end of the range could accommodate the needs of an individual grower/handler while the upper end represents enough space to store a third to a half of the seasonal aggregate crop should coordinated storage efforts be deemed appropriate.

The construction costs shown in Table 2 include buildings, machinery, and equipment. The cost of storage bins with a capacity of 17.5 bags of onions each are depicted separately in Table 2.

Annual fixed costs for a C.A. storage facility for sweet onions are presented in Table 3 by level of capacity and category of fixed cost. Interest on investment is shown for three alternative interest rates. Not shown, though treated as a fixed cost, is handling labor. Handling labor is required to place onions in storage, remove onions from storage, and regrade onions removed from storage. Handling labor requirements were estimated to be 0.01914 hours per 50 lb. bag for a storage season (Motsinger). An applicable average wage rate of $4.70 per hour (including FICA) for handling labor was obtained from the Georgia Agricultural Statistics Service.

Depreciation as shown in Table 3 was computed using the straight-line method given a useful life of 30 years for the storage facility and 10 years for the storage bins (Shotzko and O'Rourke). Salvage values were assumed to be zero. Taxes on the storage facility and bins were based on 40 percent of the original cost with a tax rate of 25 mills. The information on tax assessment and rate was obtained from tax assessment offices in three counties in the center of the Vidalia onion growing region in 1989. Annual insurance and repair costs each were computed based on 1 percent of the original cost of the facility and bins (Motsinger). Annual inventory insurance cost was estimated at just under $0.13 per bag based on responses from four Vidalia onion producers utilizing short-term conventional storage in 1989. Average annual interest on investment was computed based on the useful lives of the storage facility and the bins for each of the interest rates depicted in Table 3.

Cumulative fixed and variable costs per 50 lb. bag of sweet onions by month of storage are presented in Table 4. Values are depicted by level of storage capacity for alternative rates of interest. Per unit costs by category were computed based on a 1 percent spoilage rate in storage (Smittle).

The costs which vary over the course of the storage period include the cost of electricity, supervisory labor, and the opportunity cost of storage, Table 4. Each of these cost items are briefly discussed in turn.

The estimated cost of electricity is based on the expected amount of time individual compressors, motors, and heaters will run during storage. There are two phases in C.A. storage.

The first, referred to as Phase I, which takes about five days, involves purging the atmosphere from the storage area, filtering the removed air to within the desired tolerances of gaseous composition, then readmitting the dried, filtered air through cooling condensers to the storage cells. To accomplish this, relatively large capacity compressors and other equipment requiring comparably large levels of power for operation are necessary.

The second phase (Phase II) involves maintaining the appropriate atmospheric mixture at desired temperature and humidity levels. The same volumes of air have to be displaced for drying, cooling, and circulation purposes, but at a much reduced power consumption rate. The large equipment used in the Phase I pulldown is complemented by smaller equipment used to maintain the desired atmospheric formula.

Table 2

Estimated Facility and Storage Bin Costs by Level of Capacity, 1989

Capacity	Estimated Floor Space	Cost of Facility		Cost of Bins[a]
		Per Square Foot	Total	
(50 lb. bags)	(sq. ft.)	----------(dollars)----------		
10,000	1,571	81.67	128,339	25,620
50,000	7,857	79.97	628,336	128,038
250,000	39,286	71.46	2,807,357	640,013

[a]The cost of bins was estimated to be $44.80 each in 1989 dollars (Shotzko and O'Rourke).

Table 3

Annual Fixed Cost of Controlled Atmosphere Storage of Sweet Onions by Level of Capacity, Category of Fixed Cost, and Alternative Rate of Interest

Capacity	Depreciation	Taxes and Insurance	Repairs	Inventory Insurance	Interest on Investment by Rate of Interest[a]		
					10%	12.5%	15%
(50 lb. bags)		----------(dollars)----------					
10,000	7,938	3,079	1,540	1,299	10,939	14,269	17,767
50,000	39,236	15,127	7,564	6,495	53,719	70,068	87,238
250,000	185,009	68,947	34,474	32,475	244,264	318,473	395,400

[a]The range of interest rates was selected based on the ranges of the prime and mortgage rates over the past 10 years (U.S. Department of Commerce).

Table 4

Per Unit Cost of Controlled Atmosphere Storage and Break-Even Price for Sweet Onions by Month of Storage, Level of Capacity, and Alternative Rate of Interest

Month	Fixed Cost by Alternative Rate of Interest[a] 10%	12.5%	15%	Cost of Electricity[b]	Supervision Labor[c]	Opportunity Cost of Storage by Alternative Rate of Interest[d] 10%	12.5%	15%	Production and Marketing Cost[e]	Break-Even Price by Alternative Rate of Interest 10%	12.5%	15%
	(dollars / 50 lb. bag)											
	10,000 Bag Facility											
1	2.60	2.93	3.29	0.12	0.00	0.12	0.15	0.18	8.66	11.49	11.86	12.25
2	2.60	2.93	3.29	0.22	0.00	0.25	0.31	0.37	8.66	11.72	12.12	12.53
3	2.60	2.93	3.29	0.32	0.00	0.37	0.46	0.56	8.66	11.95	12.38	12.83
4	2.60	2.93	3.29	0.42	0.01	0.50	0.62	0.75	8.66	12.18	12.64	13.12
5	2.60	2.93	3.29	0.52	0.01	0.62	0.78	0.94	8.66	12.41	12.90	13.42
6[f]	2.60	2.93	3.29	0.61	0.01	0.75	0.94	1.14	8.66	12.62	13.15	13.70
	50,000 Bag Facility											
1	2.56	2.89	3.24	0.12	0.00	0.12	0.15	0.18	8.66	11.46	11.82	12.20
2	2.56	2.89	3.24	0.22	0.00	0.25	0.31	0.37	8.66	11.68	12.08	12.48
3	2.56	2.89	3.24	0.32	0.00	0.37	0.46	0.56	8.66	11.91	12.34	12.78
4	2.56	2.89	3.24	0.42	0.01	0.50	0.62	0.75	8.66	12.14	12.60	13.07
5	2.56	2.89	3.24	0.52	0.01	0.62	0.78	0.94	8.66	12.37	12.86	13.37
6[f]	2.56	2.89	3.24	0.61	0.01	0.75	0.94	1.14	8.66	12.58	13.11	13.65
	250,000 Bag Facility											
1	2.37	2.67	2.99	0.12	0.00	0.12	0.15	0.18	8.66	11.29	11.62	11.97
2	2.37	2.67	2.99	0.22	0.00	0.25	0.31	0.37	8.66	11.52	11.88	12.26
3	2.37	2.67	2.99	0.32	0.00	0.37	0.46	0.56	8.66	11.74	12.14	12.55
4	2.37	2.67	2.99	0.42	0.01	0.50	0.62	0.75	8.66	11.97	12.40	12.84
5	2.37	2.67	2.99	0.52	0.01	0.62	0.78	0.94	8.66	12.20	12.66	13.14
6[f]	2.37	2.67	2.99	0.61	0.01	0.75	0.94	1.14	8.66	12.42	12.91	13.42

Note: See Table 3 and the text for explanations regarding the selected range of interest rates and rates of return on securities.

[a]Fixed costs include depreciation, taxes, and insurance on the facility, estimated repairs, interest, insurance on the inventory, and handling labor.

[b]Based on $0.075/kwh.

[c]Supervisory labor based on an estimated requirement of 2 hours per month to monitor 10,000 bags (Motsinger).

[d]Based on the average FOB price ($14.69/50 lb. bag) of large to Jumbo Vidalia onions during the last half of the normal fresh market season, 1982-1989 (U.S. Department of Agriculture).

[e]Total budgeted cost per bag for production and marketing Vidalia onions (Georgia Cooperative Extension Service).

[f]The last month encompasses 25 days of storage.

Data on electricity requirements for C.A. storage of apples are not readily applicable to the storage of sweet onions due mainly to the large difference (20-25%) in humidity levels. Power cost was estimated to be $0.075 per kilowatt-hour based on input from engineers with the Southern Company in 1989. The pulldown in Phase I was estimated to draw 33.333 kilowatts per hour ($2.50 per hour), and Phase II, the maintenance phase, was estimated to draw 18.667 kilowatts per hour ($1.40 per hour) according to engineers with the Southern Company in 1989.

Foregone interest or opportunity cost of storage was assessed at rates of 10, 12.5, and 15 percent per annum for the months of storage, based on $14.69 per bag, which was the average FOB price of large to Jumbo Vidalia onions during the last half of the normal fresh market season from 1982 to 1989 (U.S. Department of Agriculture). The range of rates for the opportunity cost of storage was deemed acceptable because it represents a realistic range of performance from securities over the past decade. Supervision labor estimates were based on 0.0002 hours per bag per month (Motsinger). Supervision involves monitoring the C.A. equipment and other facility inspection details. The wage rate was $6.72 per hour (inclusive of FICA) for supervisory labor in 1989 (Georgia Agricultural Statistical Service).

The cost of producing and marketing Vidalia onions, $8.66 per bag in 1989 dollars, was obtained from the Georgia Cooperative Extension Service. The break-even price for a 50 lb. bag of Vidalia onions is equal to the per unit cost of production and marketing plus the per unit fixed and variable cost of storage by month of the storage period, Table 4.

Results, Conclusions, and Implications

As expected and as shown in Table 4, the break-even price of Vidalia onions by month of storage decreases as the capacity level of the storage facility increases and as the rate of interest decreases. Thus, the most favorable scenario in the analysis involves a 250,000 bag facility and an interest rate of 10 percent. Accordingly, the break-even price ranges from $11.29 to $12.42 per bag depending on the number of months that storage is utilized. Conversely, the least favorable scenario encompasses a 10,000 bag facility and an interest rate of 15 percent. In this instance the break-even price ranges from $12.25 to $13.70 depending on the length of storage.

Since C.A. storage of sweet onions is such a new development, there are no data on prices of Vidalia onions over the technically feasible storage period. Thus, conclusions regarding the economic feasibility of C.A. storage of Vidalia onions cannot be drawn at this time.

Should prices of Vidalia onions follow the pattern of apple prices over the storage period, Vidalia onion prices will tend to rise as the cost of storage rises. However, there is concern that such a pattern will not follow for Vidalia onions.

From 1982 through 1989 when the Vidalia onion season has lasted eight weeks or longer, prices have ranged from $4.50 to $7.50 per bag in the latter weeks of the season. Such prices have been associated with rapidly declining shipment volume. Such cases might indicate that consumers accumulate large inventories of Vidalia onions expecting a shorter (normal) season or that the demand for Vidalia onions is truly quite seasonal.

If consumers have been holding large inventories in the latter weeks of the longer seasons, the advent of commercial C.A. storage for Vidalia onions may foster a change in consumer expectations such that price movements of Vidalia onions over the storage period will tend to parallel those in the scenario for apples. On the other hand, if the demand for Vidalia onions during the latter part of the longer seasons has actually been declining quite rapidly without inventory accumulation, one might infer that the latent demand for Vidalia onions over the technically feasible storage period is insufficient to cover the cost of storage.

To the extent that the latent, out-of-season demand for Vidalia and perhaps other sweet onions is substantial, the advantages of produce and menu merchandizing involving sweet onions can be extended for most of the year resulting in markedly greater benefits to the food industry. Construction of a C.A. storage facility was recently completed in the Vidalia growing area.

Others are planned or currently under construction. Clearly, several years of adjustment are in store for the sweet onion segment of the produce industry.

References

Centner, T. J., S. C. Turner, J. T. Bryan, and W. O. Mizelle, Jr. *Product Differentiation Protection: Vidalia Onions as a Case Study of Regional Specialty Crops*. Georgia Agr. Exp. Sta. Res. Rep. 576, 1989.

Federal Register. Vol. 54, No. 50: 10972-10978, March 16, 1989.

Federal Register. Vol. 55, No. 6: 715-723, January 9, 1990.

Georgia Agricultural Statistic Service. "Wage Rates For Hired Workers - 1985-1988," *Georgia Agricultural Facts*, 1988.

Georgia Cooperative Extension Service, "Onions - Transplanted or Direct Seeded Onion Budget," *Georgia Crop Enterprise Budgets*, Georgia Agr. Exp. Sta., Ext. Agr. Econ. Dept., University of Georgia, 1986.

Motsinger, L. R. "An Economic Analysis of Storage Alternatives for Southeastern Red Delicious Apples." M.S. Thesis, University of Georgia, 1983.

Schotzko, R. T. and A. D. O'Rourke. "The Economic Feasibility of a Fruit Packing and Storage Facility in Port of Pasco North District, Basin City." Unpublished report furnished to the Port of Pasco. Dept. of Agr. Econ., Washington State University, November 1985.

Smittle, D. A. "Evaluation of Storage Methods for 'Granex' Onions." *J. Amer. Soc. Hort. Sci.* 113(1988):877-880.

U.S. Department of Agriculture, Agricultural Marketing Service. "Southeastern Fruit and Vegetable Report." Thomasville, Georgia, 1982-89.

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business, 1980-1989.*