Evaluation of Transportation Practices in the California Cut Flower Industry

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In the past two decades, California's share of the national cut flower market has decreased from 64 percent to 20 percent. California growers' largest competitors are South American growers; Colombia controls 75 percent of the US market. South American growers have several competitive advantages, including the favorable trucking rates they enjoy by consolidating all shipments in Miami, Florida prior to US distribution. This paper evaluates the California cut flower industry's current transportation practices and investigates the feasibility and cost of establishing a shipping consolidation center in Oxnard, California. Applying a simple inventory management policy, we estimate a 35 percent system-wide transportation cost decrease of $20 million per year if all California cut flower growers participate in the consolidation center. The California Cut Flower Commission incorporated our findings into an application for federal funds from the US Department of Transportation to construct a new flower transportation and logistics center in California. The state's flower growers are also searching for alternative ways to cooperatively fund a consolidation center.

Key words: freight consolidation; cut flowers; agriculture industry.

California's unique climate is ideally suited for flower cultivation, and the cut flower industry is a major contributor to the state’s economy. In 2006, California led the country with $316 million in cut flower sales, representing 77 percent of the total US production (US Department of Agriculture 2007).

California growers face fierce competition from South American growers. In 2007, South America exported more than $1 billion in blooms, second only to the Netherlands, and controlled approximately 70 percent of the US market (Arbelaez et al. 2007). A trade deal with Colombia, which the US Congress passed in October 2011, will further facilitate the importation of South American blooms and their market dominance (Appelbaum and Steinhauer 2011).

An important competitive advantage for South American growers is a cross-docking and distribution facility, which they share in Miami, Florida. This point of entry for imports provides a single consolidation and pick-up location for South American growers to send their products before shipping them out to the rest of the United States. The Miami consolidation facility allows South American growers to negotiate favorable trucking delivery rates based on the magnitude of their volume. In contrast, California growers ship their flowers individually, and few California growers command the volume necessary to negotiate favorably with trucking companies.

This paper evaluates the California cut flower industry’s current transportation practices and investigates the feasibility and cost of consolidating shipments, focusing specifically on firms represented by the California Cut Flower Commission (CCFC). The CCFC is a state government agency created by the state legislature to promote California-grown cut flowers and foliage. Established in 1990, CCFC represents approximately 250 cut flower and greens farms in California (Williamson 2011). The CCFC proposes Oxnard, in southwestern Ventura county, as the site’s location. Oxnard sits on the Pacific coast, approximately 35 miles southeast of Santa Barbara and 55 miles west of downtown Los Angeles (see Figure 1). Using 2010 sales figures, approximately half of all California production originates in Oxnard or its vicinity; the remainder of the volume is split between San Diego (8 percent) and Watsonville (43 percent), 150 miles south and 300 miles north, respectively. In addition, the CCFC membership distribution—36 growers in Oxnard, 12 in San Diego, and 22 in Watsonville—also favors this location.

Currently, California’s flower farms grow, sell, and ship their products independently; because they have no common pick-up location, a carrier must travel to all grower locations. Whereas South American growers pay for shipping costs, California growers pass on these costs to their customers. If California growers can decrease transportation costs, they can pass these savings on to their customers and provide an added incentive to purchase California cut flowers. Based on how they handle transportation, customers can be classified into two broad categories:

(1) wholesale markets that enter into long-term shipping arrangements with third-party carriers; products bound for different wholesale purchasers can be accommodated on the same truck;

(2) mass markets (e.g., supermarket chains) that employ their own transportation network; thus, flowers purchased by different mass market customers travel in separate trucks.

The remainder of the paper is organized in the following manner. We summarize relevant literature on freight consolidation approaches in the *Relevant Literature* section. Our approach comprises two phases: data collection and modeling. The first phase is the analysis of shipment data from the growers. The *Data Analysis* section includes the results. The second phase evaluates a transportation model that includes a consolidation center to identify the impact of grower participation on transportation costs. We explain the optimization methodology for shipping from a single consolidation center in the *Methodology* section. We present summarized results and analysis in *Results*. Policy implications of the results are provided in *Conclusions*.

Figure 1: CCFC proposes establishing a consolidation center in Oxnard, California to service its growers, grouped primarily in Oxnard, San Diego, and Watsonville.

Relevant Literature

From a survey of 53 US firms, consolidation practices are deemed important because of the opportunity for lower transportation costs and larger shipment loads (Jackson 1985, Hwang 2009). Consolidation can occur in inventory, vehicles, or terminals by using spatial, product, or temporal strategies (Hall 1987, Min and Cooper 1990).

Research on shipment-release policies includes calculating the cost-effective lot size (Gupta and Bagchi 1987), the optimal periods to accumulate volume (Higginson and Bookbinder 1994, Mutlu and Çetinkaya 2010, Marklund 2011), hybrid quantity- and time-based policies (Mutlu et al. 2010), and focusing on recurrent and nonrecurrent approaches (Higginson 1995). Shipment-release policies have been applied to a third-party warehouse's operations (Lee et al. 2003) and a global third-party logistics company's operations (Tyan et al. 2003). Some factors that affect the system-level performance of a distribution network include the number of consolidation points (Ha et al. 1988, Conway and Gorman 2006), warehousing and consolidation combinations (Cooper 1983, Pooley and Stenger 1992), distribution system designs (Cooper 1984), number of transshipment terminals (Popken 1994), and quantity discounts (Russell and Cooper 1992). Quantity-based policies outperform time-based policies (Chen et al. 2005). However, Ülkü (2009) points out that a good consolidation program must consider the service level, such as transit time of an order. Ülkü recommends developing a time-based policy because of varying demand characteristics and operating environments with respect to industry type.

Practical applications and case studies provide further insight on the behavior of real-world scenarios based on consolidation policies. A study by Marcucci and Danielis (2008) asserts that service cost of an urban freight consolidation center (UFCC), delivery time, and annual cost have great influence on whether stores decide to jointly use a UFCC or private transport. On average, logistic managers strongly prefer quality attributes over cost (Danielis et al. 2005). In particular, they are willing to pay for quality, such as reliability and safety, in freight transport services. Russo and Comi (2004) point out that many mathematical models include only the warehouse and the end consumer or the warehouse and the producer, making it difficult to analyze the complexity of the entire system.

Some examples of consolidation have resulted in cost savings in practice. For example, Bausch et al. (1995) examine the case of consolidating shipments of Mobil Oil Corporation's heavy petroleum products. An optimization model consolidates shipments into truckloads and selects truck routes that minimize transportation costs. This consolidation affords Mobil annual transportation cost savings of $1 million. Kellogg Company implements a planning system that aims to reduce inventory and distribution costs by consolidating shipments and managing the production and shipping schedules (Brown et al. 2001). The system has saved Kellogg's millions of dollars since its implementation in the 1990s; Brown et al. estimate savings of $35–$40 million per year as a result of an implementation in Latin America. Consolidation plays a major role in reducing these companies' operational costs.

In the cut flower industry, product quality and freshness is very important. Cut flowers spoil the longer they are in inventory and refrigerated transport; the shipment-release policies discussed in this paper do not consider perishability. Reaching a target lot size may take several days, resulting in some spoiled flowers. We use the freshness of cut flowers as our quality metric; this addresses the concerns of Danielis et al. (2005). The growers cut flowers as close to shipment time as possible and fill orders within a day of their being received to emphasize quick deliveries and reliable service. We formulate a novel fixed-charge transportation problem that considers both the consolidation strategy and perishability of the products over a sufficiently long planning horizon. The product is highly perishable, implying a hard limit on the amount of time it spends in transit and inventory. Depending on volume, products can be shipped using full-truckload (FTL) rates, less-than-truckload (LTL) rates, or courier services, such as FedEx or UPS; each method incurs a successively higher cost per unit; however, it allows for smaller shipments. We then use the perishability element to develop a policy that is simple to understand, is practical to implement, and significantly outperforms current practices. With respect to Russo and Comi (2004), our model includes the farmers, consolidation center, and the customers in an attempt to understand the impact of consolidation across the system, because the size of the shipments leaving the consolidation center depends on the incoming products from the farmers. Our model uses a simple time-based policy to address service level and product quality.

Data Analysis

The required data sources for this study include transportation costs (e.g., FTL, LTL, courier rates) and demand data from cut flower growers. In 2010, 70 growers reported production sales totaling $220 million to CCFC. Of these 70 cut flower producers, 16 participated in the transportation study, accounting for roughly 53 percent (in sales dollars) of the CCFC members' total production volume in 2010. The data include daily customer orders consisting of box dimensions, destinations, and number of boxes.

In 2008, the CCFC conducted a study that required the same demand data we requested and provided us with the data set. Seven growers provided demand data for both 2008 and 2010. Four growers participated only in the 2008 study.

The scatterplots in Figure 2 show a sample of 2008 and 2010 data for two growers. The data include shipping information that spans one year and contains seasonal data. For example, during the week before Valentine's Day and Mother's Day, growers experience a significant increase in outgoing volume compared to the rest of the year; transportation schedules also change during these two weeks to serve the larger-than-average holiday requests. Grower A's data illustrate an increase in sales from 2008 to 2010, while Grower B did not have a significant change in sales. Overall, most growers experienced an increase in sales similar to Grower A. To make use of all available data, we performed a statistical comparison between the two data sets.

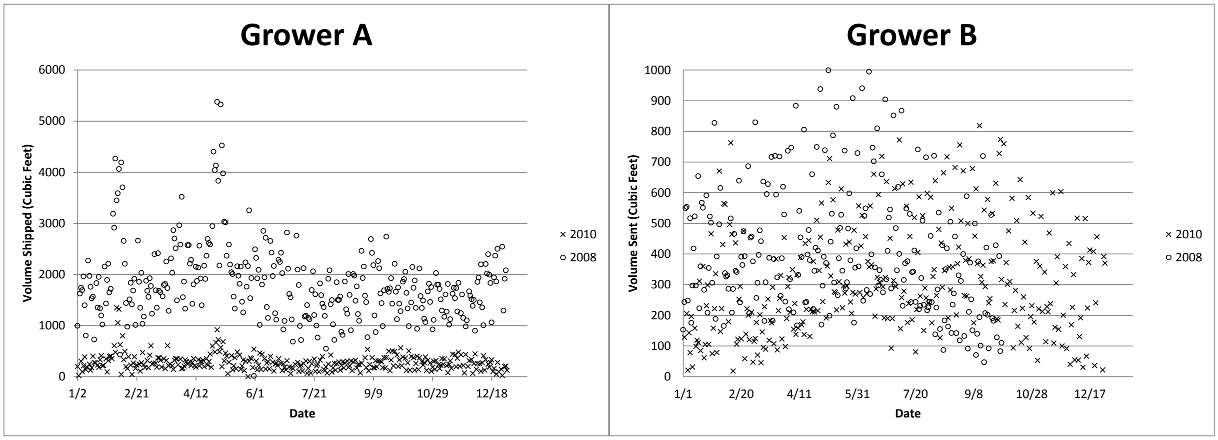

Figure 2: 2008 and 2010 cut flower sales for two sample growers show different growth patterns.

Statistical Analysis

Seven growers provided demand data for 2008 and 2010. Four growers participated only in the 2008 study. The results of a two-sample *t*-test on the 2010 and 2008 data sets of the seven growers would determine whether the four 2008 data sets could be used directly or if an extrapolation should be applied. The average and 95 percent confidence interval (CI) output from this test is based on the difference between 2008 and 2010 data. Table 1 displays average difference, CI lower and upper bounds, and a *p*-value for each farm under the null hypothesis that the 2008 and 2010 data are from the same population.

		95% CI		
Farm	Average difference (2010–2008) (cubic feet)	Lower bound (cubic feet)	Upper bound (cubic feet)	*T*-test of difference, *p*-value
A	1, 321.2	1,219.9	1,422.5	0.000
B	52.9	17.6	88.2	0.003
C	540.4	493.2	587.6	0.000
D	-665.1	-754.7	-575.6	0.000
E	64.1	51.8	76.39	0.000
F	-202.9	-282.3	-123.6	0.000
G	24.9	-9.5	59.4	0.156

Table 1: Two-sample *t*-test results for 2008 and 2010 volume data sets are statistically significantly different.

Growers A, B, C, and E show an increase in sales from 2008 to 2010, while growers D and F show a decrease in sales. The CIs for these growers do not contain zero, indicating that 2008 and 2010 data are statistically different. Therefore, the 2008 data from the four growers who did not submit 2010 data could not be used directly. The average difference in production volume for the growers who submitted data for both 2008 and 2010 is 4.6 percent; therefore, we extrapolated the data for the four growers who submitted data in 2008, but not for 2010, by the same 4.6 percent. The 2008 data from the four growers provide an additional 10 percent in sales dollars. The four growers plus the 16 2010 data sets account for approximately 63 percent (in sales dollars) of the CCFC members' total sales volume for 2010.

We assume that growers who participated in the study and provided shipping data are more willing to participate in the consolidation center, and those who did not participate in the study are not. This assumption raises the concern of selection bias: in the data sample of participants, the average 2010 sales are $6.4 million with a standard deviation of $12.7, while nonparticipants have average 2010 sales of $1.8 million with a standard deviation of $2.1 million. However, growers on smaller farms have a greater incentive for participating in a consolidation center, because they have no chance of negotiating lower transportation rates on their own. Our study accommodates these grower differences by evaluating various scenarios, from a base case in which only participating growers consolidate, up to a full-participation case in which all CCFC growers consolidate. The *Results* section explains these additional scenarios.

Methodology

We consider two models for this study: baseline and consolidation. The baseline model reflects the current transportation practices of CCFC growers. Each order is shipped the first business day after it is received, either through a third-party carrier or via courier when the order is small enough. The growers cut flowers only after receiving an order, and choose the cheapest shipping option for each outgoing shipment.

The consolidation model includes a consolidation center in Oxnard, which all products flow through prior to being shipped to their respective customers. The objective function minimizes the transportation cost of shipping products from the growers to the consolidation center and from the consolidation center to the customers. Appendix A includes the optimization model formulation for the consolidation strategy. The consolidation model also assumes that no consolidation takes place at individual farms; that is, the product is shipped to the consolidation point as soon as an order is received. To account for the product's vulnerability to spoilage and based on CCFC grower feedback, we assume flowers are held at the consolidation point for no more than one day. Finally, the consolidation model does not consider a limited transportation fleet or a finite storage capacity at the consolidation center. Rather, the goal is to observe how the system would behave if these two policy variables are unconstrained, and then use this behavior to determine the required fleet size and facility capacity.

We use the following numerical parameters and assumptions for both models: simulation time is 365 days (i.e., from January 1 to December 31), maximum volume per trailer is 2,600 cubic feet, and approximate weight is 7.2 pounds per cubic foot. The growers provided LTL rates; Supply Chain Coach, a consulting company, provided FTL rates.

Both models include the option to send products via FTL, LTL, or courier. We assume transportation costs are time independent and the cheapest option is always chosen. Courier rates depend on the weight of the shipment. LTL rates are dollars per cubic foot and FTL rates are a fixed total cost; both vary based on mileage between origin and destination. Figure 3 includes sample rates for illustrative purposes. Courier rates are linear and start at zero. The LTL rates are a step function based on number of cubic feet, and the FTL rate is a constant value. Very small shipments can be sent at a lower cost using courier services; however, as volume increases, LTL shipments become cheaper. When volume becomes much larger, an FTL truck is less expensive than the corresponding LTL units.

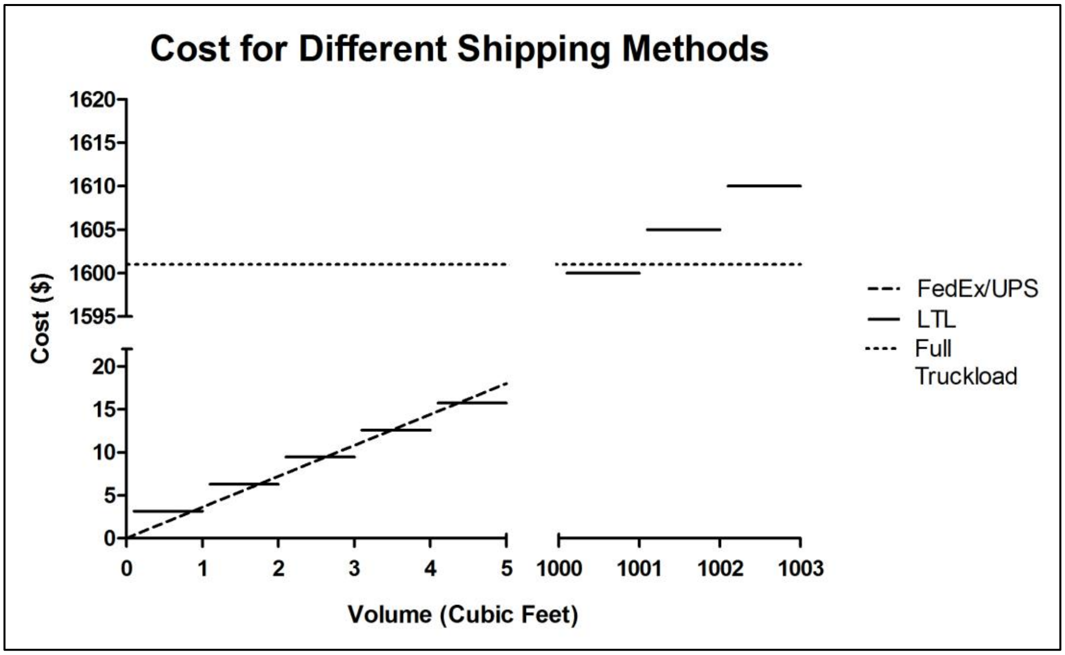

Figure 3: Small shipments have cheaper courier costs, while LTL rates become advantageous as volume increases. For much larger volumes, FTL rates are less expensive than LTL or courier rates.

The consolidation formulation is a special case of a fixed-charge minimum-cost network flow model. Because these general models (e.g., Hochbaum and Segev 1989) are known to be NP-hard and both follow current practices and produce a simple and implementable result, we use the following policy: on a given day, a truck departs the consolidation center for a specific destination only if the facility has some product that must be shipped to its destination on that day. The truck is then filled as completely as possible with newer products heading to the same destination, with priority given to the products with the closest delivery date. Additional trucks are sent to the destination following the same rule. The model retains the option to send any truck using LTL or FTL rates, depending on the volume. It can also send products by courier if the shipping cost is cheaper.

The consolidation model takes advantage of a single pick-up location for all the growers. This allows the growers to send their flowers to one location to be packed onto a truck that, in the baseline model, would have to go to each grower to pick up the same products and would charge LTL rates to each grower.

For the baseline model, the results include the total volume sent by FTL, LTL, and courier, and the total cost for each day and grower. The consolidation model results include (1) the total cost of shipping from each grower to the consolidation center, (2) from the consolidation center to the destinations, and (3) for each day, the volume sent by FTL, LTL, and small packages from the consolidation center.

Results

We evaluated the available data from the 20 growers (the 16 participating in this study plus the 4 extrapolated from 2008 data) using both baseline and consolidation models. However, this data account for only 63 percent of CCFC's 2010 sales volume, thus ignoring possible additional economies of scale. Therefore, we constructed different scenarios based on potential participation to account for the missing growers' volume.

Scenario Construction

The scenario set is based on 2010 aggregate sales figures provided by CCFC. The 50 missing growers were sorted from largest to smallest, and the following scenarios were defined using this sorted list.

Scenario 1: Do not extrapolate to include any of the remaining 50 growers.

Scenario 2: Extrapolate to include 10 of the remaining 50 growers.

Scenario 3: Extrapolate to include 20 of the remaining 50 growers.

Scenario 4: Extrapolate to include 30 of the remaining 50 growers.

Scenario 5: Extrapolate to include 40 of the remaining 50 growers.

Scenario 6: Extrapolate to include all 50 growers.

We evaluated the baseline and consolidation models on these sets of participation scenarios. These scenarios reflect varying levels of participation and likely do not have the same possibility of materializing. However, the potential savings are still worth examining to understand the relationship between participation and potential cost reductions. The next section outlines the results of the scenario runs.

Analysis

Table 2 provides a detailed summary of the base case and consolidation models for Scenario 3, an intermediate participation case. The table includes the annual cost, volume sent via the three shipping options, and the cost difference or savings between the base case and consolidation strategies.

In Scenario 3, the LTL volume decreases from 57 percent to 4 percent of the total volume, while the full-truck volume increases from 37 percent to 96 percent. The volume differences between the base case and consolidation illustrate the benefit of shipping consolidation. The total annual transportation cost decreases by approximately $17 million (37 percent).

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	5,124,687	59,842	1,601,730	701,605	2,363,177
Wholesale	41,797,405	894,737	7,869,273	5,380,923	14,144,934
Total	46,922,092	954,579	9,471,003	6,082,529	16,508,111
Consolidation					
Mass market	2,810,701	1,443	91,661	2,270,072	2,363,1767
Wholesale	26,917,724	1,028	616,450	13,527,456	14,144,934
Total	29,728,425	2,472	708,111	15,797,528	16,508,111
Difference	(17,193,667)	(952,107)	(8,762,892)	9,714,999	

Table 2: Consolidation Scenario 3, in which we extrapolate 20 additional growers, yields an estimated $17M in savings over one year.

Figure 4 shows the annual cost trend when extrapolating for the missing growers using sales as the extrapolation criteria. The cost difference between the base case and consolidation for each scenario grows as more missing growers are added to the simulation; that is, baseline costs grow more rapidly than consolidation costs, because the scope of the inefficiency in the baseline is larger.

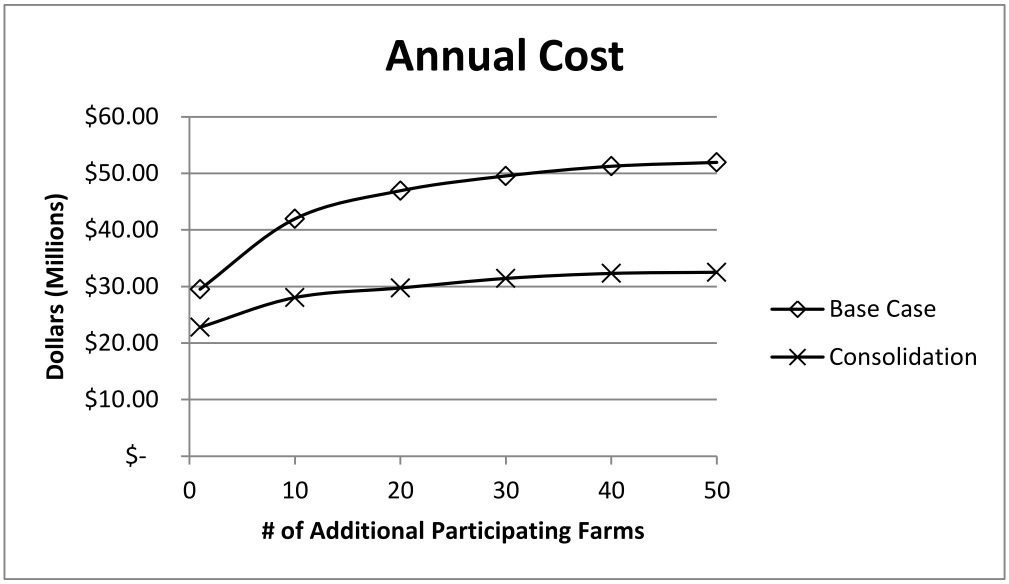

Figure 4; Transportation cost savings from consolidating shipments increase as participation from farms increases.

The difference between LTL volumes increases as the scenarios include more missing growers, with the base case volume increasing more rapidly than the consolidation case. The opposite occurs for the FTL volumes (see Figure 5), which increase more rapidly for the consolidation case than for the base case. This indicates that most growers do not have enough sales volume at specific destinations to send out a full truck, resulting in more costly LTL and courier shipments. Therefore, consolidation would greatly benefit these medium-sized farms. Appendix B includes the detailed results for each scenario.

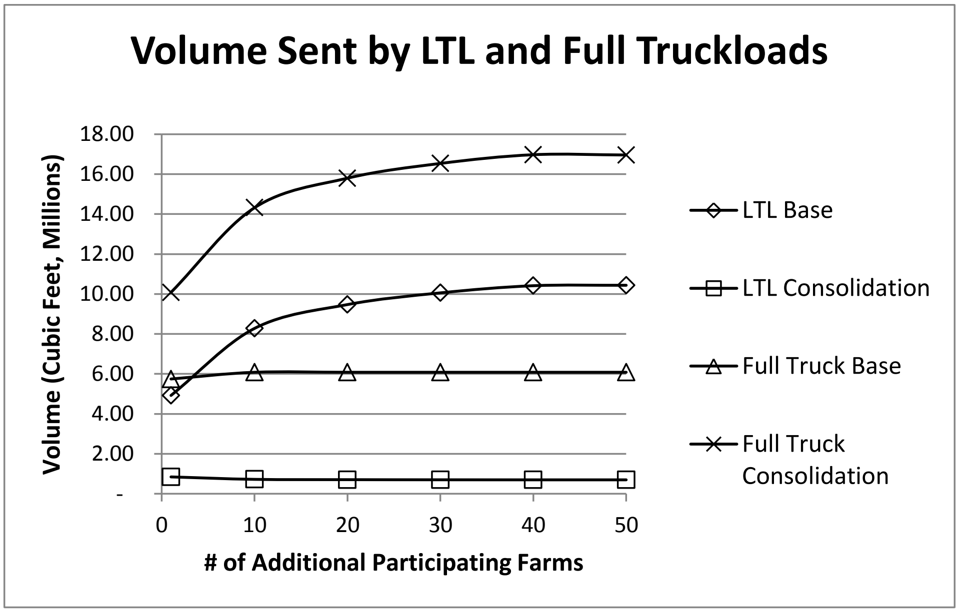

Figure 5: Consolidation takes advantage of the lower transportation costs for full trucks; the base case shows that only a few growers have enough volume to send full trucks. Volume sent as LTL in the consolidation drops significantly when compared to the base case.

Conclusions

The consolidation optimization model evaluates how California flower growers could save on transportation costs by consolidating shipments. It uses a combination of 2010 sales data and extrapolated 2008 data to assess the potential savings from having one pick-up location for carriers to consolidate shipments. If the 20 growers who account for 63 percent of the volume shipped by CCFC members consolidate shipments, these growers would experience approximately a 30 percent decrease in total annual transportation costs relative to the base case. For each scenario in which an increasing share of growers on the largest remaining farms is added to the consolidation option, the model further demonstrates the opportunity for increased cost savings for those growers participating in the consolidation. The results provide a dollar value of potential cost savings to California's growers as a whole, assuming that CCFC or a grower-managed organization (e.g., an agricultural cooperative) manages the consolidation center and the growers' transportation system.

This paper shows the cost savings CCFC members can experience from consolidating their shipments; however, our model does not consider other aspects, such as the cost of implementation and management of the consolidation center. Our model takes a conservative approach and does not consider additional savings from routing strategies. Many of the farms are on country roads and big trucks have a difficult time getting to them; a consolidation facility provides easy entry for the trucks and facilitates cold chain (i.e., temperature-controlled supply chain) transport. However, consolidation can potentially add a delay because the facility must wait for enough volume to almost fill a truck. The model addresses this by implementing a hard time constraint, allowing a maximum of one day for product to be held in inventory.

The analysis helped the California flower growers to understand the benefits of a consolidated distribution system. The results of this study convinced them of the merits of a consolidation strategy and that they should proceed with efforts to achieve consolidation. The CCFC incorporated these findings into an application, made with the support of California's Congressional delegation, for federal funds from the US Department of Transportation's transportation investment generating economic recovery (TIGER) discretionary grant program to construct a new flower transportation and logistics center in California.

If CCFC establishes the consolidation center, the question of how to allocate the costs among the participants will still remain. Our future research endeavors include determining whether a fair cost allocation exists for the participating growers, and whether this can be achieved without sacrificing the optimality or near-optimality of system transportation costs. For example, a fair cost allocation may be achievable only by providing incentives to larger growers to accumulate enough volume to enjoy economies of scale. With the participation of growers on larger farms, those on the small to medium-sized farms can reap the benefits of consolidation.

After this research was completed, Congress passed free trade agreements with Colombia, Korea, and Panama , ensuring that California flower growers continue to face the economic discipline imposed by foreign competition (Appelbaum and Steinhauer 2011). The state's flower growers are also searching for alternative ways to cooperatively fund a consolidation center, but the need for government assistance is underlined by the growers' continuing inability to privately finance consolidation in the current economic climate.

Appendix A: Optimization Model Formulation

We formulated a mixed-integer program (MIP) to model the transportation system with a consolidation center. The model is a fixed-charge network flow problem. The parameters, decision variables, and mathematical formulation for the MIP are listed below. The objective is to minimize transportation costs across the entire system. The decision variables track the number of FTL trucks, LTL trucks, volume sent in a full truck, volume sent in an LTL truck, and volume sent using a courier service for each period of the time horizon. The decision variables are indexed by the period in which the product is ready to be shipped to account for perishability.

Parameters

G: Set of growers.

D: Set of destinations.

t= 1..T: Time index.

α = Conversion factor: 7.2 pounds per cubic foot.

d_{ijt}: Demand at destination *j* to be satisfied by grower *i* that must leave the consolidation center by time t, $\forall\, i \in G, j \in D, t = 1..T$.

c_{jF}: Transportation cost for a full truck from consolidation center to destination *j*, $\forall\, j \in D$, ($/truck).

c_{jL}: Transportation cost for an LTL unit from consolidation center to destination *j*, $\forall\, j \in D$, ($/foot^3).

c_{jU}: Transportation cost for a small shipment (courier) from consolidation center to destination *j*, $\forall\, j \in D$, ($/pound).

θ: Maximum time shipments remain at consolidation center = 1.

κ_F: Maximum capacity for a truck in cubic feet.

κ_L : LTL units in cubic feet = 1.

Decision variables

x_{jtF}: Number of full trucks from consolidation center to destination *j* at time *t*, $\forall j \in D, t = 1..T$.

x_{jtL}: Number of LTL units from consolidation center to destination *j* at time *t*, $\forall j \in D, t = 1..T$.

y_{ijstF}: Amount of product sent by full truck from grower *i* for destination *j* on period *s*, which needs to be sent by period *t*, $\forall i \in G, j \in D, s = 1..T, t = s..\min\{s + \theta, T\}$.

y_{ijstL}: Amount of product sent by LTL truck from grower *i* for destination *j* on period *s*, which needs to be sent by period *t*, $\forall i \in G, j \in D, s = 1..T, t = s..\min\{s + \theta, T\}$.

y_{ijstU}: Amount of product sent by small shipments from grower *i* for destination *j* on period s, which needs to be sent by period *t*, $\forall i \in G, j \in D, s = 1..T, t = s..\min\{s + \theta, T\}$.

Model

Minimize

$$\sum_{t=1..T}\sum_{j\in D}(c_{jF}x_{jtF}+c_{jL}x_{jtL})+c_{jU}\alpha\sum_{i\in G}\sum_{s=1..T}\sum_{t=s}^{\min\{s+\theta,T\}}y_{ijstU} \tag{6}$$

Subject to

$$\begin{aligned}\sum_{i\in G}\sum_{t=s}^{\min\{s+\theta,T\}}y_{ijstF}\le\kappa_F x_{jsF},\quad \forall j\in D,s=1..T\\ \sum_{i\in G}\sum_{t=s}^{\min\{s+\theta,T\}}y_{ijstL}\le\kappa_L x_{jsL},\quad \forall j\in D,s=1..T\end{aligned} \tag{7}$$

$$\sum_{s=\max\{1,t-\theta\}}^{t}y_{ijstF}+y_{ijstL}+y_{ijstU}=d_{ijt},\qquad \forall i\in G,j\in D,t=1..T \tag{8}$$

$$\begin{aligned}y_{ijstF}\ge 0,\ \ \forall i\in G,j\in D,s=1..T,t=1..T\\ y_{ijstL}\ge 0,\ \ \forall i\in G,j\in D,s=1..T,t=1..T\\ y_{ijstU}\ge 0,\ \ \forall i\in G,j\in D,s=1..T,t=1..T\\ x_{jtF}\ge 0,x_{jt}\in\mathbb{Z},\forall j\in D,t=1..T\\ x_{jtL}\ge 0,x_{jt}\in\mathbb{Z},\forall j\in D,t=1..T\end{aligned} \tag{9}$$

Appendix B: Detailed Scenario Generation

This appendix contains the detailed information for each scenario. These scenarios were constructed from a list for all 70 growers, which the CCFC provided. However, 50 growers did not participate in the survey. They were sorted in decreasing order of 2010 sales, and extrapolated according to that order. The *Scenario Construction* subsection shows the list of scenarios.

Tables 3–8 give detailed results of each scenario. Each table contains the estimated annual cost, volume sent by courier, LTL, and FTL, and the breakdown for mass market and wholesale for the base case and the consolidation case. The volume shipped is split into mass market and wholesale because mass market shipments are not sent with wholesale shipments.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	1,675,919.10	7,396.44	415,331.81	621,139.49	1,043,867.75
Wholesale	27,822,232.14	252,718.72	4,508,629.51	5,125,425.30	9,886,773.54
Total	29,498,151.24	260,115.16	4,923,961.33	5,746,564.80	10,930,641.28
Consolidation					
Mass market	1,238,400.68	1,863.86	61,948.46	980,055.42	1,043,867.75
Wholesale	1,537,451.40	1,425.36	784,127.74	9,101,220.44	9,886,773.54
Total	22,775,852.08	3,289.22	846,076.20	10,081,275.86	10,930,641.28
Difference	(6,722,299.17)	(256,825.94)	(4,077,885.13)	4,334,711.06	

Table 3: The estimated cost reduction for a scenario with no extrapolation for missing growers is approximately $7 million.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	4,189,472.76	42,451.64	1,273,200.79	701,605.17	2,017,257.60
Wholesale	37,760,924.95	641,102.14	7,006,316.27	5,380,923.43	13,028,341.84
Total	41,950,397.71	683,553.78	8,279,517.06	6,082,528.60	15,045,599.44
Consolidation					
Mass market	2,789,508.69	1,558.78	83,922.75	1,931,776.07	2,017,257.60
Wholesale	25,241,621.85	1,012.34	639,728.61	12,387,600.89	13,028,341.84
Total	28,031,130.55	2,571.12	723,651.36	14,319,376.96	15,045,599.44
Difference	(13,919,267.17)	(680,982.66)	(7,555,865.70)	8,236,848.36	

Table 4: Extrapolating for 10 of the missing growers yields estimated savings of $14 million.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	5,124,687.27	59,841.93	1,601,729.53	701,605.17	2,363,176.63
Wholesale	41,797,404.55	894,737.29	7,869,273.18	5,380,923.43	14,144,933.89
Total	46,922,091.82	954,579.22	9,471,002.71	6,082,528.60	16,508,110.52
Consolidation					
Mass market	2,810,701.27	1,443.31	91,661.21	2,270,072.12	2,363,176.63
Wholesale	26,917,723.84	1,028.24	616,449.66	13,527,456.00	14,144,933.89
Total	29,728,425.11	2,471.54	708,110.86	15,797,528.12	16,508,110.52
Difference	(17,193,666.71)	(952,107.68)	(8,762,891.84)	9,714,999.52	

Table 5: The estimated cost reduction for a scenario with 20 missing growers is approximately $17 million.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	5,614,389.05	71,258.16	1,763,161.70	701,605.17	2,536,025.03
Wholesale	43,925,351.09	1,028,208.81	8,293,739.01	5,380,923.43	14,702,871.25
Total	49,539,740.14	1,099,466.97	10,056,900.71	6,082,528.60	17,238,896.28
Consolidation					
Mass market	3,171,506.22	1,308.36	98,995.85	2,435,720.82	2,536,025.03
Wholesale	28,248,466.73	1,022.69	603,173.42	14,098,675.14	14,702,871.25
Total	31,419,972.95	2,331.05	702,169.27	16,534,395.96	17,238,896.28
Difference	(18,119,767.19)	(1,097,135.92)	(9,354,731.44)	10,451,867.36	

Table 6: The estimated cost reduction for a scenario with 30 missing growers is approximately $18 million.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total volume (cubic feet)
Base case					
Mass market	5,927,026.41	80,995.47	1,856,033.98	701,605.17	2,638,634.63
Wholesale	45,321,244.38	1,094,864.74	8,558,296.62	5,380,923.43	15,034,084.78
Total	51,248,270.78	1,175,860.21	10,414,330.60	6,082,528.60	17,672,719.41
Consolidation					
Mass market	3,364,901.31	1,361.29	96,635.87	2,540,637.46	2,638,634.63
Wholesale	28,938,817.40	1,033.35	602,803.97	14,430,247.46	15,034,084.78
Total	32,303,718.71	2,394.65	699,439.84	16,970,884.92	17,672,719.41
Difference	(18,944,552.07)	(1,173,465.56)	(9,714,890.76)	10,888,356.33	

Table 7: The estimated cost reduction for a scenario with 40 missing growers is approximately $19 million.

		Volume by shipping method (cubic feet)			
	Annual cost ($)	Courier	LTL	FTL	Total Volume (cubic feet)
Base case					
Mass market	6,020,728.03	81,514.44	1,860,960.69	701,605.17	2,644,080.30
Wholesale	45,916,415.29	1,095,148.82	8,575,590.62	5,380,923.43	15,051,662.87
Total	51,937,143.32	1,176,663.26	10,436,551.31	6,082,528.60	17,695,743.17
Consolidation					
Mass market	3,527,508.25	1,364.10	96,903.96	2,545,812.24	2,644,080.30
Wholesale	28,974,705.56	996.61	602,546.85	14,448,119.40	15,051,662.87
Total	32,502,213.81	4,005.28	699,450.81	16,956,741.59	17,695,743.17
Difference	(19,434,929.51)	(1,172,657.98)	(9,701,555.02)	10,874,212.99	

Table 8: Extrapolating for all 50 missing growers yields approximately $20 million in savings.

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