Estimating the Impact of Seasonal Truck Shortages
To the Pacific Northwest Apple Industry: Transportation Cost Minimization Approach

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ABSTRACT

This research paper focuses specifically on the frequent and persistent problem of truck shortages which occur for shipment of time-sensitive, perishable produce out of the Pacific Northwest. Washington State is the number one apple producing state in the U.S., producing over 2.7 million tons of apples per year valued at over $1 billion. However, without timely and accessible transportation to move the product from production to the table of the consumer, the value to apple producers and the states' economy diminishes rapidly.

This research aims to identify and quantify the change in total transportation cost which occur as a result of seasonal truck shortages and associated rate increases and to provide an avenue for evaluating changes at specific destination markets, modal changes and market competitiveness. This is accomplished by utilizing a cost-minimizing optimization model representing apple shipments from 29 producing supply points to 16 domestic markets and 3 international export markets over four seasons and two mode options (truck and rail).

Total transportation costs increase nearly $12 million as a result of truck shortages, going from $245.6 million without shortages to $257.5 million under the current seasonal situation.

Overall (across all seasons), the export markets of the Nogales, McAllen and the Port of Seattle experience the greatest negative impact as a result of truck shortages, followed by domestic markets within close proximity of Washington at Seattle and San Francisco. The Large markets of New York and Los Angeles also experience relatively large increases in transportation cost per tonmile.

INTRODUCTION

Recent and sustained growth in the demand for U.S. freight shipments, driven by a recovering domestic economy and expanding trade with China, point to increasing freight rates as the demand for freight service exceeds the available supply of equipment and labor (1). Rising fuel costs and truck driver shortages also contribute to rising freight rates and tighter operating margins as transportation and logistics providers seek to allocate service to those shippers who generate the greatest marginal value. Exacerbating this phenomenon on the supply side is the recent implementation of federal hours-of-service regulations which limit truck driver hours of productivity and may increase carriers' costs between 2 and 19 percent (2).

These collective national and international transportation supply and demand forces add increasing concern and importance to regional geographic areas and economies which rely heavily on seasonal freight services, especially time-sensitive, perishable products such as apples from the state of Washington.

Washington State has a long history of apple production, primarily due to the natural climate and environmental conditions in the Columbian basin region where apple orchards are abundant and exceedingly productive. This agricultural industry generates considerable financial and economic value to the states economy, with annual apple crop production valued at over $ 1 billion, not including the multiplier effects due to industry employment, input activities and services and support industries (3).

Contributing to the growth and success of the apple industry in the Pacific Northwest has been a balanced transportation infrastructure including truck, rail and barge alternatives. The competitive interaction between and amongst these modes has led to competitive shipping rates historically for most commodities, but less for seasonal shipment of time-sensitive perishable products. Apple producers and marketing cooperatives seeking to access eastern markets in the early to mid 1950's relied heavily on rail, but began switching to truck as available service and rates became more competitive. The proportion of fresh fruits and vegetables shipped via rail went from 73 percent in 1950 to 39 percent by 1970. Currently, truck shipments of fresh apples from Washington State dominate, accounting for over 90% of apple movements.

The primary reason for this modal change between rail and truck is better service provided by motor carriers, principally related to time, accessibility, reliability and security. Motor truck carriers were also less constrained by regulation and better able to quickly negotiate rate changes and adjust equipment and capital needs. The Staggers Rail Act of 1980 significantly reduced the regulatory burden for the rail industry, and as a result led to a brief increase in the proportion of rail shipments for fresh fruits and vegetables to 14.5 percent by 1983.

The heavy reliance on truck services for apple shipments has led to seasonal capacity constraints as the demand for movement of other goods and commodities compete for motor carrier equipment and service during the time of year when apple movements are in greatest demand, typically in October and November. Sixty-five percent of apple industry representatives listed limited truck availability as the greatest barrier to efficient trade (4). Higher value commodities (and lower risk of spoilage) compete for refrigerated truck service during this time period, leading to higher truck freight rates. Truck shipping rates, as provided by the Yakima Shipper Association, for shipment of apples out of Southcentral Washington increase about 12 percent between the first three quarters of the year and the fourth quarter, as provided in Table 1. This seasonal truck shortage has led to one statewide effort, known as the Washington Fruit Express program where refrigerated rail cars are connected to eastbound Amtrak passenger trains and provide five to six day service to east coast markets (5).

OBJECTIVE

This research paper focuses on estimating the financial impact of seasonal truck shortages for shipment of time-sensitive perishable products (apples) out of Southcentral Washington. This is accomplished by utilizing a cost-minimizing spatial equilibrium model developed from data collected via interviews with apple industry representatives and a combination of secondary freight, production and demand data. Specific attention is given to changes in volume and transportation cost by market destination, modal share between truck and rail, and impact on the relative competitiveness of destination markets with truck shortages. This modeling framework may also be utilized to evaluate additional regional transportation and marketing policy issues.

TRANSPORTATION MODEL

The model used to identify least cost shipments, by mode and destination is developed from industry data regarding origin (supply) points and destination (demand) market locations. The objective function can be specifically stated as follows:

$$Minimize \sum_i \sum_j \sum_k \sum_l c_{ijkl} \; x_{ijkl} \qquad subject\ to:$$

$$\sum_j x_{ijkl} \le S_{ikl} \quad , \quad \forall\, i,k$$

$$\sum_i x_{ijl} \ge D_{jl} \quad , \quad \forall\, j$$

$$x_{ijkl} \ge 0 \quad , \quad \forall\, i, j, k, l$$

Where $c_{i,j,k,l}$ represents the transportation rate from origin i to market j via mode k in season l and $x_{i,j,k,l}$ represents the volume (tons) of apples shipped from origin i to market j via mode k in season l. Thus, the objective is to minimize total cost subject to three separate supply and demand constraints. The first constraint limits total shipments from each origin (i) on mode k to that is available from each supply point within each season, defined by $S_{i,k,l}$. The second constraint assures that the sum of all shipments into each destination market equal or exceeds the demand at each destination point within each season, defined by $D_{j,l.,}$. Finally, the transportation model only allows positive shipments between each origin and destination point.

It is worth noting the specific constraint on shipment origin by mode. In traditional unconstrained transportation optimization models, there would be no constraint on mode for each supply point and the least-cost optimal solution would identify those flows and modes which best satisfy the objective function. In this instance, however, without some constraint on the volume of shipments leaving each origin point by truck and/or rail, all apple shipments from origin points would be entirely on rail given the relatively lower rates for rail shipments and the inability of the model to capture service attributes of each mode such as time, number of transloadings, handling, etc. While this would be a least-cost optimum, it is not realistic of apple shipments out of Southeastern Washington. Thus, the mode constraint on origin of shipments is added to accurately reflect reality and provide a better estimate of impacts in the presence of truck shortages in rate increases.

The number of origin points (i) is 29, representing the majority (by volume handled) of apple storage/processing facilities in Southcentral Washington, geographically dispersed throughout the apple producing region. The quantity of supply from each origin point enters the linear program model as a constant (perfectly inelastic). This particular assumption related to price and quantity responses in the apple supply market is not unduly limiting given the nature of apple production. Most production decisions involving all apple varieties require long-term financial commitments in capital, land and equipment. Once committed, these investments are not likely to be very sensitive to price fluctuations, especially in the short-run. Therefore, the price elasticity of supply is certainly inelastic, if not approaching perfectly inelastic, as illustrated in Figure 1.

The number of destination markets (j) included in the transportation optimization model is 19, predominately large urban/metropolitan cities throughout the United States. The quantity of apples demanded at each destination market by season is also treated as a constant. This assumption is somewhat limiting, given that most consumers are sensitive to price fluctuations for fresh fruits and vegetables, leading to a demand function that is downward sloping to the right instead of perfectly inelastic (Figure 1). Ideally, the demand for apples would enter the optimization model as a stochastic function, estimated separately for each destination market thus capturing the unique market characteristics and consumer preferences across different regions and time periods. However, the data required to obtain these estimated functions are not readily available, especially for the nineteen destination markets and four seasons included in this model.

The implications from treating demand as a fixed constant instead of a downward sloping demand function are graphically presented in Figure 1. Without an associated quantity response to changing prices, the financial impact from an increase in price from P_1 to P_2 is equal to the area a, d, e, b. This is equivalent to the reduction in consumer surplus associated with a price increase. In reality, as prices increase from P_1 to P_2 , consumers will adjust their quantity consumed by substituting away from apples to other products (or away from Washington apples to those produced elsewhere). As a result, the true loss in consumer surplus will be the smaller area defined as a, c, e, b. The shaded area in Figure 1 represents the difference between the two estimation procedures and also represents the amount by which the loss in consumer surplus is overstated by treating demand as fixed.

DATA / INFORMATION

The information and data incorporated into the transportation optimization model were collected from a variety of sources and validated through interviews and conversations with apple industry representatives. The total volume of apple shipments from all 29 origin/supply points is equal to 2.725 million tons. This value represents the average statewide total of fresh apples produced over the past four years as provided by the National Agricultural Statistical Service (NASS) of the United States Department of Agriculture (USDA). The proportion of total shipments allocated to each origin point was obtained via phone/mail survey of managers at apple processing/cold storage facilities in Southcentral Washington as part of the Strategic Freight Transportation Analysis (SFTA) study at the Washington State University School of Economic Sciences (4). This freight research study obtained data regarding volume of outbound apple shipments by storage/packing facility location, by mode of transportation and season. The twenty-nine storage/packing facilities represented a 48% survey response rate and accounted for approximately 30% of the total apple production (tons) in Washington. The proportion of shipments from each origin point was scaled upward to reflect total statewide production, with each shipper originating the proportion of all production equal to their sample proportion. These locations served as a proxy for shipment origins on all movements out of the state of Washington. Likewise, the proportion of shipments originating on each mode and for each season are parameterized from the data collected through these survey responses to reflect accurate shipping characteristics throughout the region.

The quantity of demand shipped into each destination market was derived by utilizing the USDA Fresh Fruit and Vegetables Shipment Arrivals Report 1994-1998. This report, while no longer published, provided the tonnage of shipments going from/to a sample of U.S. cities and included apple shipments from Washington to 16 specific cities. The five year average (1994-1998) of Washington apple shipments into each city was utilized to determine the relative proportion of shipments each city would receive. Total apple exports (to international markets) were determined via conversations with representatives from the Wenatchee Valley Traffic Association and Yakima Valley Shipper Association to be 28 percent of total production. The destinations accounting for apple exports include the Port of Seattle (70%), McAllen, Texas (22%) and Nogales, AZ (8%), as collectively reported by the industry survey. The total production amount of 2.725 million tons was then first reduced by the export volume and then the remainder allocated to each of the destination markets based up the relative proportion each location represented for all apple shipment arrivals. While the origin of shipments is constrained by season and mode, destination markets are only constrained by season and the least-cost combination of flows into each market dictates how (truck or rail) and where (destination cities) the optimal condition is achieved.

Transportation rates for truck shipments by season and destination market were obtained from the Yakima Valley Shipper Association (4). Additional truck rates, obtained from shipper surveys, were added to each processor/packaging origin based upon distance between each specific location and Yakima, WA. All truck rates leaving Southcentral Washington vary by season and destination market, whereas rail rates only vary by destination markets, as illustrated in Table 1. The rail rates for each destination market were obtained from posted Burlington Northern Sante Fe (BNSF) refrigerated car rates and verified with the Yakima Valley Shipper Association.

RESULTS / ANALYSIS

Scenario I: Base / Current Scenario

A base-case scenario is first developed to represent current least-cost shipping flows in the presence of seasonal (4^{th} quarter) truck shortages to identify and compare the implications of regional truck shortages and higher transportation rates including modal changes and market competitiveness. Assuming the data and information collected from shipper surveys, industry representatives, USDA shipment arrivals accurately represent Washington apple movements throughout the U.S., and that shippers seek to minimize transportation cost while maximizing profits by choosing the mode and destination market in their least-cost feasibility set, then the constrained optimization model will solve and reflect near real-world apple flows.

The volumes of apple shipments to each destination for the base-case scenario, by transportation mode are numerically provided in Table 2 and geographically represented in Figure 2. As determined by the modal constraint on shipments ***from*** each supply point, the volume of apples that move per season by mode does not vary. This model construct is developed to compare changes in cost when truck rates during a given period of time increase but the volume shipped on each mode per supply origin remains consistent with historical modal shares. However, the amount that is received into each destination market on each mode does vary, depending upon a variety of factors such as relative geographical proximity between individual supply and destination markets and the relative rates between truck and barge for each origin/destination combination. This model design is very consistent with how shipping decision are made for time-sensitive, perishable produce. The buyer at the destination markets decide how the produce will be transported and timing on when it should be delivered (5).

The largest markets for Washington apples are visually apparent in Figure 2. The export markets comprising the Port of Seattle, McAllen, TX, and Nogales, AZ comprise 28 percent of all apple production and shipments, with the Port of Seattle possessing the large majority at 70 percent of all exports. The dominant domestic markets include Los Angeles, CA (452.4 thousand tons), Chicago, IL (208.3 thousand tons), San Francisco, CA (202.7 thousand tons) and New York, NY (171.7 thousand tons). Collectively, these top four destination markets account for 53 percent of all domestic shipments.

The time of year when the largest volume of shipments is moved is the fourth quarter, representing 31 percent of annual shipments. This coincides with both apple harvest when fresh apples are marketed and the time period when apples from cold storage facilities are being shipped after 90 days of storage. The lowest proportion of apples is shipped during the third quarter, accounting for 19 percent of annual movements.

The optimal base scenario transportation flows reveal the implicit comparative advantages of each mode, where destination markets become more viable on rail as the distance increases. Three destination markets receive apples via rail, including New York, NY, Cincinnati, OH, and Boston, MA. However, distance is not the only factor influencing modal share, given there are longer distance markets with no rail shipments. In these circumstances, rate related factors that capture the competitive backhaul opportunities largely influence least cost transportation flows (5). The largest volume of rail shipments move from Yakima, WA to New York, NY, accounting for over 33 thousand tons per year relative to truck shipments which ship 138.7 thousand tons per year. This represents 19 percent of total shipments into New York, the second largest rail proportion of any destination city. The city with the largest proportion of rail shipments is Cincinnati, OH, with over 30 percent of total apple shipments arriving on rail. Boston, MA receives 5 percent of the 79.7 thousand tons of apples per year on rail. It is interesting to note the time of year when these rail movement occur for these three destination markets. Both Boston and Cincinnati only ship during the 4th quarter of the year, the period when truck rates for refrigerated movements out of Southcentral Washington experience the largest increase. However, rail shipments into New York only occur during the first three quarters of the year with zero rail shipments in the 4th quarter. The relative seasonal rate changes between rail and truck may explain this phenomenon in addition to the relative availability of rail capacity from each supply market.

The noticeable fact that only three of the nineteen destination markets receive any shipments by rail is evidence that those service related modal advantages of truck (as compared to rail), including timeliness, less handling, point-to-point pickup and delivery, and schedule flexibility, as reflected in the rate differential, is significant.

Total transportation cost for moving Washington apples to destination markets in the base scenario exceeds $257 million dollars, as provided in Table 3. The proportion of transportation costs realized in each quarter follows a similar pattern as the volume of optimal shipments within each season. However, while the 4th quarter accounts of 31 percent of the volume shipped, over 33 percent of total transportation costs occur during this time period.

A more detailed evaluation of the relative transportation costs for destination markets, by time of year and mode reveal the different market competitiveness across all markets, as displayed in Table 4. The market with the lowest transportation cost per ton mile (in total) is Pittsburg, PA ($.041 / tonmile), followed by the export market of Nogales, AZ ($.054 / tonmile). The markets with the most expensive transportation costs per ton mile include Seattle, WA ($.081 / tonmile), San Francisco, CA ($.073 / tonmile) and Baltimore, MD ($.067 / tonmile).

On a dollar per tonmile basis, the transportation cost per season for truck shipments is relatively consistent for the first three quarters of the years across all destination markets, going from $.060 / tonmile in the 1st quarter, to $.062 / tonmile in the 2nd quarter and $.066 / tonmile in the 3rd quarter. However, there is a considerable increase in truck transportation costs per tonmile for the 4th quarter up to $.077 / tonmile across all destination markets, representing a 24% increase compared with the average rate of the first three quarters. Those markets experiencing the largest increase between the first three quarters and the 4th quarter include, Seattle, WA, the Port of Seattle, McAllen, TX, and Nogales, AZ.

Scenario II: No Truck Shortage Scenario

If access to truck services was more readily available for shipment of apples out of Southcentral Washington during the 4th quarter of each season, the truck transportation rate during the 4th quarter of each season can be expected to be more consistent with the first three quarters of the year. Thus, in order to compare the change in transportation costs realized as a result of the increased demand for freight services and the reduced availability of refrigerated motor freight services, a second scenario is considered and modeled where the average truck shipping rate per supply/destination market for the first three quarters of the year is applied as the fourth quarter rate. No other changes to the seasonal, modal or supply/destination volume constraints are altered. While there will be no change in the total volume of shipments by season or mode, as discussed above, the modal share of each destination city and the production points supplying each market may change in order to achieve the new least-cost optimal solution. These changes may reveal how truck shortages influence market competitiveness differently, depending on the location of the market, distance from Washington, size of market and apple demand characteristics associated with each market, and transportation technologies/efficiencies and alternatives available to/from each market.

The most noticeable outcome of reducing truck transportation rates during the 4th quarter is a significant reduction in total transportation cost, decreasing from $257.5 million dollars to $245.6 million dollars, a total savings of nearly $12 million (Table 3). As expected, this change is realized entirely during the 4th quarter.

The modal change that occurs as a result of this truck rate reduction is a decrease in the number of destination cities receiving shipments via rail (Table 5). Boston, MA and Cincinnati, OH no longer receive any rail shipments. This volume moved from rail to the now relatively cheaper alternative, truck services and the only market to still receive apple shipments via rail is New York. The collective reduction in rail volume to Boston and Cincinnati is equal to the amount by which rail volume increased to New York (16.7 million tons). Given the constraint on rail shipments from all origin points, this is expected. However, given the change to cheaper truck shipping rates during the 4th quarter and the model requirement that a certain amount of apples move via rail, New York represents the most efficient choice for all rail shipments.

Changes in transportation costs per tonmile by destination market, mode, and season follow a similar pattern as the change in volume for Scenario II, with no differences occurring for the first three quarters (Table 6). Impacts during the 4th quarter are primarily concentrated on those destination cities where modal shifts occurred (Boston, Cincinnati and New York). However, a closer examination of per tonmile changes during the 4th quarter between Scenario I and Scenario II reveal specific market impacts (Table 7). Without truck shortages, the costs per tonmile decrease during the 4th quarter by the largest magnitude for destination cities Seattle (30%), Nogales (31%), Port of Seattle (29.4%), and McAllen (29.4%). Stated differently, truck shortages during the 4th quarter had the greatest increase in transportation costs per tonmile on these markets and destination cities. The decline in transportation costs per tonmile for the 4th quarter across all destination cities between Scenario I and Scenario II is 19 percent.

Overall (across all seasons), the export markets of the Nogales, McAllen and the Port of Seattle experience the greatest negative impact as a result of truck shortages, followed by domestic markets within close proximity of Washington State: Seattle and San Francisco. The Large markets of New York and Los Angeles also experience relatively large increases in transportation cost per tonmile. Markets that experience the smallest increases include Boston, Philadelphia, Baltimore, and Miami. Only one market, Cincinnati, experienced an increase in transportation costs per tonmile as a result of lower 4th quarter truck rates. This increase is attributed to the new global optimal condition where total costs throughout the system are minimized, while individual markets may experience increases. The increase for Cincinnati is due to a change in the collection of supply markets satisfying the demand requirement and the different rates from these supply points. In reality, Cincinnati may be able to find more competitive markets.

SUMMARY AND CONCLUSIONS

This study focuses specifically on the frequent and persistent problem of truck shortages which occur for shipment of time-sensitive, perishable produce out of the Pacific Northwest. Exacerbating this problem recently has been the economic growth occurring in China, truck driver shortages and changes to federal guidelines potentially limiting productive hours of operation for truck operators. Each of these factors influence the demand for motor freight services and in some measure compete for services already in short supply during certain seasons throughout the year.

Washington State is the number one apple producing state in the U.S., producing over 2.7 million tons of apples per year valued at over $1 billion (total transportation cost at $257 million, about 25%). However, without timely and accessible transportation to move the product from production to the table of the consumer, the value to apple producers and the states' economy diminishes rapidly.

This research effort develops a transportation optimization model, richly equipped with recent primary data from surveys, industry representative interviews and several secondary data sources, to identify and quantify the change in total transportation cost which occurs as a result of seasonal truck shortages and associated rate increases. This is accomplished by utilizing a cost-minimizing transportation optimization model representing apple shipments from 29 producing supply points to 16 domestic markets and 3 international export markets over four seasons and two mode options (truck and rail). The average annual statewide production of 2.725 million tons of apples are optimized over destination markets by minimizing overall transportation cost and providing an avenue to evaluate changes in total transportation costs overall and at specific destination markets, and to examine modal changes and market competitiveness.

Two different transportation scenarios were considered and evaluated including one which characterized current apple shipments in the presence of truck shortages and significantly higher transportation rates during the 4^{th} quarter of the year. The second scenario considers apple movements and flows when 4^{th} quarter truck rates are consistent with truck rates over the first three quarters of the year.

Truck shortages increase total annual shipping costs nearly $12 million, as more destination markets receive shipments via rail during truck shortage periods than when trucks are readily available. Not all destination markets are impacted equally as a result of truck shortages, as shipments to the export markets at the Port of Seattle, McAllen and Nogales bear the largest rate per tonmile increase during periods of truck shortages. These are short-haul movements where truck services hold a relative monopoly on freight services and shippers accessing these markets are limited by any available alternatives. Therefore, when trucks are in short supply, rates increase at a faster rate.

This modeling framework worked well for evaluating the impact of truck shortages and attendant rate increases for time-sensitive, perishable products. The model structure and newly developed data and information sources may also be extended to other emerging issues and empirical estimations: estimation of the value of quality of service between different transportation modes from the viewpoint of the shipper/receiver could be determined by evaluating different outcomes between the constrained and unconstrained optimization model; estimating impact of increasing congestion cost for specific destination markets, e.g. Seattle, New York, etc. could be accomplished examining impact of cost driven rates.

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Table 1. Average Truck and Rail Shipping Rates from South-Central Washington to Destination Markets

Destination Market	*Average Truck Rates $/ton*					*Average Rail Rates $/ton*				
	1st qtr.	*2nd qtr.*	*3rd qtr*	*4th qtr.*	*Annual Avg.*	*1st qtr.*	*2nd qtr.*	*3rd qtr*	*4th qtr.*	*Annual Avg.*
New York, NY	181	188	201	201	193	115	115	115	115	115
Philadelphia, PA	172	176	186	192	181	107	107	107	108	107
Atlanta, GA	159	168	175	187	172	100	100	100	100	100
Miami, FL	172	184	187	198	185	134	134	134	134	134
Pittsburg, PA	164	169	171	189	173	98	98	98	98	98
St. Louis, MO	118	122	122	141	125	71	71	71	71	71
Baltimore, MD	172	177	187	193	182	112	112	112	112	112
Boston, MA	181	192	196	208	194	119	119	119	119	119
Cincinnati, OH	144	144	148	207	161	101	101	101	101	101
Columbus, OH	122	126	126	140	128	92	92	92	92	92
Dallas, TX	112	119	124	133	122	70	70	70	70	70
Chicago, IL	112	117	121	133	121	70	70	70	70	70
Detroit, MI	135	135	139	151	140	92	92	92	92	92
Los Angeles, CA	73	77	77	89	79	85	85	85	85	85
San Francisco, CA	59	59	69	74	65	69	69	69	69	69
Seattle, WA	11	11	13	16	13	12	12	12	13	12
Export – Port of Seattle, WA	11	11	13	16	13	12	12	12	13	12
Export – McAllen, TX	134	134	134	189	148	113	113	113	113	113
Export – Nogales, AZ	91	91	91	132	102	132	132	133	133	133
Total	**122**	**126**	**131**	**140**	**130**	**90**	**90**	**90**	**90**	**90**

Table 2. Volume of Apple Shipments from South-Central Washington to Destination Markets, by Mode and Season, Base Scenario - Current Situation

Destination Market	*(1000 Tons)*										
	1st Quarter		*2nd Quarter*		*3rd Quarter*		*4th Quarter*		*Mode Total*		*Total Volume*
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	
New York, NY	35.0	15.3	26.1	9.5	24.9	8.2	52.6	0.0	138.7	33.1	171.7
Philadelphia, PA	23.6	0.0	16.7	0.0	15.6	0.0	24.7	0.0	80.6	0.0	80.6
Atlanta, GA	31.0	0.0	21.9	0.0	20.4	0.0	32.4	0.0	105.8	0.0	105.8
Miami, FL	19.1	0.0	13.5	0.0	12.6	0.0	20.0	0.0	65.3	0.0	65.3
Pittsburg, PA	16.3	0.0	11.6	0.0	10.7	0.0	17.1	0.0	55.7	0.0	55.7
St. Louis, MO	21.8	0.0	15.5	0.0	14.4	0.0	22.8	0.0	74.5	0.0	74.5
Baltimore, MD	31.0	0.0	22.0	0.0	20.4	0.0	32.5	0.0	105.9	0.0	105.9
Boston, MA	23.3	0.0	16.5	0.0	15.4	0.0	20.4	4.0	75.6	4.0	79.7
Cincinnati, OH	12.1	0.0	8.6	0.0	8.0	0.0	0.0	12.7	28.7	12.7	41.3
Columbus, OH	4.3	0.0	3.0	0.0	2.8	0.0	4.5	0.0	14.7	0.0	14.7
Dallas, TX	17.4	0.0	12.3	0.0	11.4	0.0	18.2	0.0	59.3	0.0	59.3
Chicago, IL	61.0	0.0	43.2	0.0	40.2	0.0	63.9	0.0	208.3	0.0	208.3
Detroit, MI	27.6	0.0	19.5	0.0	18.2	0.0	28.8	0.0	94.0	0.0	94.0
Los Angeles, CA	132.6	0.0	93.9	0.0	87.3	0.0	138.7	0.0	452.4	0.0	452.4
San Francisco, CA	59.4	0.0	42.0	0.0	39.1	0.0	62.1	0.0	202.7	0.0	202.7
Seattle, WA	44.0	0.0	31.1	0.0	29.0	0.0	46.0	0.0	150.1	0.0	150.1
Export – Port of Seattle, WA	156.6	0.0	110.9	0.0	103.2	0.0	163.8	0.0	534.4	0.0	534.4
Export – McAllen, TX	49.7	0.0	35.2	0.0	32.7	0.0	52.0	0.0	169.6	0.0	169.6
Export – Nogales, AZ	17.3	0.0	12.2	0.0	11.4	0.0	18.1	0.0	59.0	0.0	59.0
Total	**783.1**	**15.3**	**555.8**	**9.5**	**517.8**	**8.2**	**818.5**	**16.7**	**2,675.2**	**49.8**	**2,725.0**

Table 3. Comparison of Changes in Total Transportation Costs, by Mode and Season, Base Scenario and No Truck Shortage Scenario

Mode	*$ Million*									
	Base Scenario					***No Truck Shortage Scenario***				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total
Truck	67.88	50.08	48.43	85.60	252.01	67.88	50.08	48.43	73.47	239.88
Rail	1.75	1.09	0.94	1.76	5.55	1.75	1.09	0.94	1.92	5.71
Total	**69.63**	**51.17**	**49.37**	**87.36**	**257.56**	**69.63**	**51.17**	**49.37**	**75.39**	**245.59**

Table 4. Transportation Cost of Apple Shipments from South-Central Washington to Destination Markets, by Mode and Season, Base Scenario – Current Situation

Destination Market	***$ / Ton / Mile***										
	1st Quarter		***2nd Quarter***		***3rd Quarter***		***4th Quarter***		***Mode Total***		***Total***
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	
New York, NY	0.064	0.041	0.067	0.041	0.071	0.041	0.071		0.068	0.041	0.063
Philadelphia, PA	0.061		0.063		0.067		0.069		0.065		0.065
Atlanta, GA	0.061		0.065		0.067		0.072		0.066		0.066
Miami, FL	0.054		0.056		0.057		0.062		0.058		0.058
Pittsburg, PA	0.038		0.040		0.040		0.044		0.041		0.041
St. Louis, MO	0.057		0.059		0.059		0.066		0.061		0.061
Baltimore, MD	0.063		0.065		0.069		0.070		0.067		0.067
Boston, MA	0.060		0.064		0.065		0.069	0.040	0.064	0.040	0.063
Cincinnati, OH	0.061		0.061		0.063		0.000	0.044	0.062	0.044	0.056
Columbus, OH	0.052		0.054		0.054		0.059		0.055		0.055
Dallas, TX	0.052		0.055		0.057		0.061		0.056		0.056
Chicago, IL	0.055		0.057		0.059		0.064		0.059		0.059
Detroit, MI	0.058		0.058		0.060		0.066		0.061		0.061
Los Angeles, CA	0.059		0.063		0.063		0.073		0.065		0.065
San Francisco, CA	0.066		0.066		0.077		0.082		0.073		0.073
Seattle, WA	0.068		0.072		0.078		0.101		0.081		0.081
Export – Port of Seattle, WA	0.065		0.068		0.075		0.097		0.077		0.077
Export – McAllen, TX	0.049		0.049		0.049		0.069		0.055		0.055
Export – Nogales, AZ	0.047		0.047		0.047		0.069		0.054		0.054
Total	**0.060**	**0.041**	**0.062**	**0.041**	**0.066**	**0.041**	**0.077**	**0.043**	**0.067**	**0.042**	**0.066**

Table 5. Volume of Apple Shipments from South-Central Washington to Destination Markets, by Mode and Season, No Truck Shortage Scenario

Destination Market	*(1000 Tons)*										
	1st Quarter		*2nd Quarter*		*3rd Quarter*		*4th Quarter*		*Mode Total*		*Total Volume*
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	
New York, NY	35.0	15.3	26.1	9.5	24.9	8.2	35.9	16.7	121.9	49.8	171.7
Philadelphia, PA	23.6	0.0	16.7	0.0	15.6	0.0	24.7	0.0	80.6	0.0	80.6
Atlanta, GA	31.0	0.0	21.9	0.0	20.4	0.0	32.4	0.0	105.8	0.0	105.8
Miami, FL	19.1	0.0	13.5	0.0	12.6	0.0	20.0	0.0	65.3	0.0	65.3
Pittsburg, PA	16.3	0.0	11.6	0.0	10.7	0.0	17.1	0.0	55.7	0.0	55.7
St. Louis, MO	21.8	0.0	15.5	0.0	14.4	0.0	22.8	0.0	74.5	0.0	74.5
Baltimore, MD	31.0	0.0	22.0	0.0	20.4	0.0	32.5	0.0	105.9	0.0	105.9
Boston, MA	23.3	0.0	16.5	0.0	15.4	0.0	24.4	0.0	79.7	0.0	79.7
Cincinnati, OH	12.1	0.0	8.6	0.0	8.0	0.0	12.7	0.0	41.3	0.0	41.3
Columbus, OH	4.3	0.0	3.0	0.0	2.8	0.0	4.5	0.0	14.7	0.0	14.7
Dallas, TX	17.4	0.0	12.3	0.0	11.4	0.0	18.2	0.0	59.3	0.0	59.3
Chicago, IL	61.0	0.0	43.2	0.0	40.2	0.0	63.9	0.0	208.3	0.0	208.3
Detroit, MI	27.6	0.0	19.5	0.0	18.2	0.0	28.8	0.0	94.0	0.0	94.0
Los Angeles, CA	132.6	0.0	93.9	0.0	87.3	0.0	138.7	0.0	452.4	0.0	452.4
San Francisco, CA	59.4	0.0	42.0	0.0	39.1	0.0	62.1	0.0	202.7	0.0	202.7
Seattle, WA	44.0	0.0	31.1	0.0	29.0	0.0	46.0	0.0	150.1	0.0	150.1
Export – Port of Seattle, WA	156.6	0.0	110.9	0.0	103.2	0.0	163.8	0.0	534.4	0.0	534.4
Export – McAllen, TX	49.7	0.0	35.2	0.0	32.7	0.0	52.0	0.0	169.6	0.0	169.6
Export – Nogales, AZ	17.3	0.0	12.2	0.0	11.4	0.0	18.1	0.0	59.0	0.0	59.0
Total	**783.1**	**15.3**	**555.8**	**9.5**	**517.8**	**8.2**	**818.5**	**16.7**	**2,675.2**	**49.8**	**2,725.0**

Table 6. Transportation Cost of Apple Shipments from South-Central Washington to Destination Markets, by Mode and Season, No Truck Shortage Scenario

Destination Market	***$ / Ton / Mile***										
	1st Quarter		***2nd Quarter***		***3rd Quarter***		***4th Quarter***		***Mode Total***		***Total***
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	
New York, NY	0.064	0.041	0.067	0.041	0.071	0.041	0.067	0.041	0.067	0.041	0.059
Philadelphia, PA	0.061		0.063		0.067		0.064		0.063		0.063
Atlanta, GA	0.061		0.065		0.067		0.064		0.064		0.064
Miami, FL	0.054		0.056		0.057		0.057		0.056		0.056
Pittsburg, PA	0.038		0.040		0.040		0.039		0.039		0.039
St. Louis, MO	0.057		0.059		0.059		0.059		0.058		0.058
Baltimore, MD	0.063		0.065		0.069		0.065		0.065		0.065
Boston, MA	0.060		0.064		0.065		0.063		0.063		0.063
Cincinnati, OH	0.061		0.061		0.063		0.062		0.062		0.062
Columbus, OH	0.052		0.054		0.054		0.053		0.053		0.053
Dallas, TX	0.052		0.055		0.057		0.055		0.054		0.054
Chicago, IL	0.055		0.057		0.059		0.057		0.057		0.057
Detroit, MI	0.058		0.058		0.060		0.059		0.059		0.059
Los Angeles, CA	0.059		0.063		0.063		0.062		0.062		0.062
San Francisco, CA	0.066		0.066		0.077		0.069		0.069		0.069
Seattle, WA	0.068		0.065		0.079		0.070		0.070		0.070
Export – Port of Seattle, WA	0.065		0.070		0.075		0.068		0.069		0.069
Export – McAllen, TX	0.049		0.049		0.049		0.049		0.049		0.049
Export – Nogales, AZ	0.047		0.047		0.047		0.047		0.047		0.047
Total	**0.060**	**0.041**	**0.062**	**0.041**	**0.066**	**0.041**	**0.062**	**0.041**	**0.062**	**0.041**	**0.062**

Table 7. Percent Change in Transportation Cost Between Base Scenario and No Truck Shortage Scenario: 4th Quarter

Destination Market	*% Change*				
	4th Quarter		*Mode Total*		*Total Volume*
	Truck	Rail	Truck	Rail	
New York, NY	-5.3%	100.0%	-2.1%	0.0%	-5.8%
Philadelphia, PA	-7.3%		-2.4%		-2.4%
Atlanta, GA	-10.7%		-3.6%		-3.6%
Miami, FL	-8.8%		-2.9%		-2.9%
Pittsburg, PA	-11.0%		-3.7%		-3.7%
St. Louis, MO	-11.1%		-3.7%		-3.7%
Baltimore, MD	-7.4%		-2.4%		-2.4%
Boston, MA	-8.7%	-100.0%	-2.5%	-100.0%	-0.6%
Cincinnati, OH	100.0%	-100.0%	0.0032%	-100.0%	9.9%
Columbus, OH	-10.8%		-3.6%		-3.6%
Dallas, TX	-10.9%		-3.6%		-3.6%
Chicago, IL	-11.4%		-3.8%		-3.8%
Detroit, MI	-10.0%		-3.3%		-3.3%
Los Angeles, CA	-15.4%		-5.3%		-5.3%
San Francisco, CA	-15.6%		-5.4%		-5.4%
Seattle, WA	-30.0%		-13.0%		-13.0%
Export – Port of Seattle, WA	-29.4%		-10.8%		-10.8%
Export – McAllen, TX	-29.4%		-11.3%		-11.3%
Export – Nogales, AZ	-31.0%		-12.1%		-12.1%
Total	-19.0%	-3.5%	-6.7%	-1.2%	-6.6%

Figure 1. Supply and Demand Market Relationships

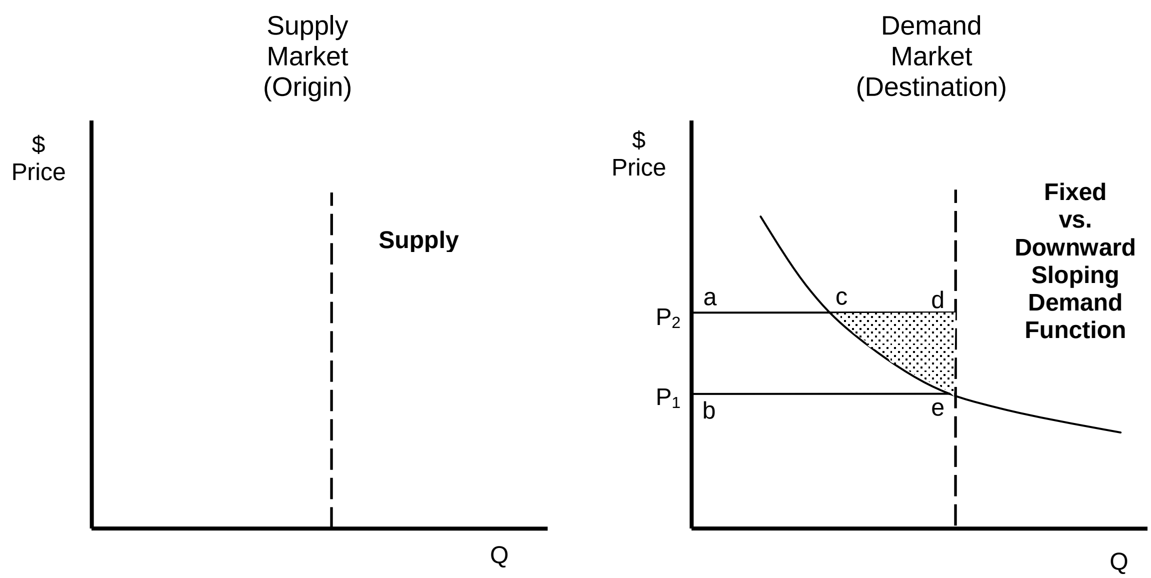

Figure 2. Volume of Apple Shipments (tons) into Destination Markets: Base Scenario

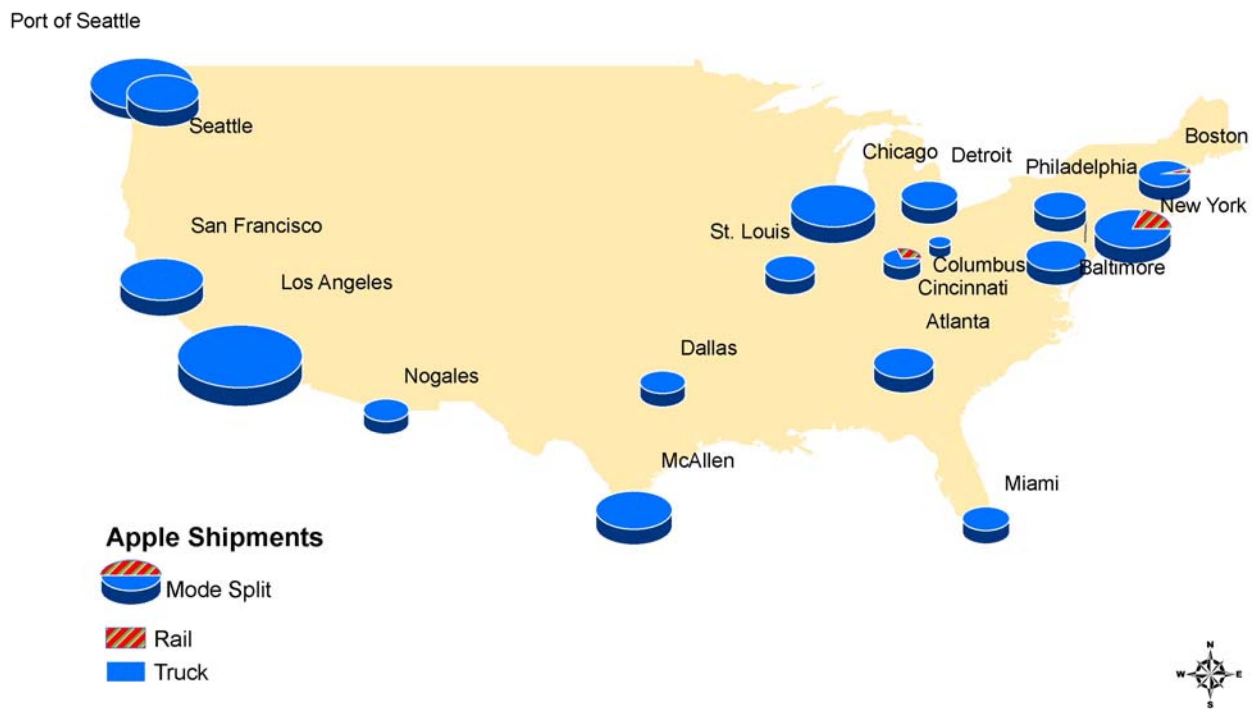

Figure 3. Percent Change in Total Transportation Cost Per Ton Mile between Base Scenario and No Truck Shortage Scenario