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G. PRICE ELASTICITY OF DEMAND -- LITERATURE REVIEW AND APPLICATION

More than 25 price elasticity studies were reviewed to determine which ones were most applicable for the analysis of child restraint systems. Summaries of the 10 most applicable studies follow. The summaries include the strengths and weaknesses of each study in the context of the CRS environment and the price elasticity estimates most relevant to the CRS study. These studies were selected because the work was respected for its applicability to air travel.

This appendix divides the studies into two groups—those based on data collected after airline deregulation and those based on data collected during the regulated time period prior to 1978. Complete bibliographies of these studies are listed in Appendix H, References.

Finally, a description of the analytical method used to implement the price elasticities is given. The reasons for choosing this method and its properties are provided.

STUDIES BASED ON DATA COLLECTED AFTER AIRLINE DEREGULATION

The five studies in this section develop price elasticity of demand values for various types of market segments. Each study is based on data collected after the 1978 airline deregulation.

- **Apogee Research Incorporated, 1994** (see citation number 4 in the references). Apogee developed three models for business travel and three models for nonbusiness travel to project future air travel demand. The business travel models incorporated economic measures, such as corporate profits, gross domestic product (GDP), total business sales, and employment. The nonbusiness travel models included measures of disposable income, gross domestic product, and personal consumption expenditures. After developing these models, Apogee found the nonbusiness travelers to be more price-sensitive than the business travelers. The price elasticity estimates varied more for the nonbusiness travelers than they did for the business travelers. Also, the price elasticity for nonbusiness travelers was generally in the elastic range, while business travelers were price-inelastic. This study presented the following price elasticities:

Nonbusiness, disposable income model	-0.86
Nonbusiness, personal consumption expenditures model	-1.21
Nonbusiness, GDP model	-1.13
Business, GDP model	-0.58
Business, corporate profits/employment model	-0.61
Business, sales model	-0.58

In general, nonbusiness travelers exhibited elastic demand in two out of three models, with an average value of -1.1. Business travelers exhibited inelastic demand in all three models, with an average value of -0.59. These elasticity estimates were for nationwide travel and are not attributable to any more detailed passenger groupings other than business and nonbusiness passengers.

- ***Directions: The Final Report of the Royal Commission on National Passenger Transportation*, 1992** (see citation number 9 in the references). This study evaluated the effect of price changes on intercity travel within Canada. Nine econometric models of intercity passenger travel demand were used to calculate price elasticities for four Canadian travel markets. The identical travel market data base was used as input data for each model.

  This study directly compared the results of nine econometric models for both short- and long-haul markets. Because a consistent data base was used, the results of the nine models provided a homogeneous range of price elasticities for each market. However, several of the models produced price elasticity estimates that were outside the range of values found in the U.S. studies—the air traveler price elasticity estimates found in U.S. studies generally ranged from -0.8 to -2.7. The results of the Canadian study were adjusted to conform to the range of U.S. values by discarding any price elasticity estimates outside of that range. The result was that no clear relationship exists between price elasticity and trip length. Therefore, the Canadian study was not used to determine air traveler price elasticity differences by distance.

  However, this study suggested that low-income travelers have higher price elasticities than high-income travelers and nonbusiness travelers have higher price elasticities than business travelers, as follows:

Business, low-income	-3.51
Business, high-income	-1.57
Nonbusiness (group), low-income	-4.50
Nonbusiness (group), high-income	-4.38

  The price elasticity values produced by this model are high, and the Canadian study recognizes that they are high. But the trend was consistent with the opinions of expert panelists, who stated that low-income air passengers probably exhibited more price-elastic behavior than high-income travelers and nonbusiness travelers probably exhibited more price-elastic behavior than business travelers.

- **Oum, Gillen, and Noble, 1986** (see citation number 30 in the references). This study derived a model for business and nonbusiness travel demand. Route-specific aggregate cross-sectional data from 200 intra-U.S. routes were used, but the data were not available separately for business and nonbusiness travel. The researchers were able to aggregate the flights into three fare classes: first class, standard economy, and discount. The following summarizes the results of this study:

First class price elasticity range:	-0.6 to -0.8
Standard economy price elasticity range:	-1.2 to -1.4
Discount price elasticity range:	-1.5 to -2.0

Oum, Gillen, and Noble state that, "a majority of first class users are business travelers." If it is assumed that first class passengers represent the same price elasticity behavior as business travelers, and discount economy passengers are representative of nonbusiness travelers, this study then suggests that price elasticity values for business travelers are less elastic than those for nonbusiness travelers—approximately 50 percent less elastic. In addition, this study may support price elasticity values ranging from -1.5 to -2.0 for nonbusiness travelers.

- **Oum, Zhang, and Zhang, 1993** (see citation number 32 in the references). This research analyzed the competitive interaction among airlines serving the same route markets. The authors were concerned that very few airlines dominated a large number of routes, thus creating oligopolies—especially on routes connected to major hubs. In particular, the authors investigated the cross-sectional price elasticity difference for passengers traveling between 20 city-pairs, based on the Chicago O'Hare hub, for both American Airlines and United Airlines. For these 20 city-pairs, there was no correlation between an increase in trip distance and a change in price elasticity. The price elasticity values ranged from -1.24 to -2.34 with an average value of -1.58. Both Las Vegas and Reno exhibited price elasticities of greater magnitude than -2.0. These two destinations primarily attract nonbusiness passengers. For this reason, the results of this study suggest that nonbusiness price elasticities have magnitudes greater than -2.0.

- **Oum, Waters, and Yong, 1992** (see citation number 31 in the references). This study surveyed transport demand price elasticities from previous research. In addition to air travel demand, it investigated the demand elasticities for automobile, urban transit, rail, and freight transportation. The cross-sectional air travel price elasticities were drawn from 13 separate studies. Only two studies disaggregated the air passengers by business or leisure travel purposes. The results of those two studies are:

Leisure travel price elasticity:	-1.52
Business travel price elasticity:	-1.15

Other studies based on cross-sectional data did not differentiate among passenger types. The values of the price elasticities from those studies ranged from -0.76 to -4.51. Two conclusions were drawn from reviewing this study. First, the business travel price elasticity is lower than the leisure travel estimate—in this case about 25 percent lower. Second, the literature provides a wide range of price elasticity values, but this study did not specify which type of passenger had the greatest elasticity.

STUDIES BASED ON DATA COLLECTED PRIOR TO AIRLINE DEREGULATION

The following studies used data collected prior to the airline deregulation of 1978. The results and conclusions of these studies are still applicable, but they should be interpreted in the context of the deregulated environment.

- **Abrahams, 1983** (see citation number 1 in the references). This study analyzed the demand for air carrier services resulting from fare, traffic, and service quality. The premise of this study was that air fare and the value of time spent using air carrier services were the two major costs faced by air travelers. The study used data of domestic U.S. city-pairs collected during the period from 1973 through 1977. The major findings of this study are:

Florida vacation city-pair price elasticity:	-1.98
Transcontinental city-pair price elasticity:	-1.81
Hawaiian-West Coast city-pair price elasticity:	-1.68
Eastern medium-haul city-pair price elasticity:	-1.22

Vacation travelers, assumed to be nonbusiness passengers, dominated the first three route segments. Each of these markets was quite price-elastic with values ranging from approximately -1.7 to -2.0 during the period of airline regulation. Nonbusiness travelers in today's market may exhibit more price-elastic behavior because of the deregulated, price-sensitive environment.

- **De Vany, 1983** (see citation number 8 in the references). This study estimated the value of time in air travel. It is based on the increased awareness of such qualitative and quantitative aspects as congestion and delays. De Vany analyzed the top 600 U.S. domestic travel markets in 1968. He derived a "full price elasticity" that was the sum of price and time elasticities. This sum did not vary significantly with distance—its value was approximately -1.5 for trip distances ranging between 28 and 2500 miles. Similar to the Ippolito study, the price elasticity component of the full price elasticity did increase with distance as shown:

Trip Distance (one way)	Time Elasticity	Price Elasticity	Full Price Elasticity
28 miles	-0.76	-0.76	-1.52
400 miles	-0.51	-1.02	-1.53
650 miles	-0.45	-1.07	-1.52
1500 miles	-0.39	-1.14	-1.53
2500 miles	-0.37	-1.17	-1.54

De Vany stated, " These estimates are calculated from the regressions of fare and time on miles and are subject to error." These results are questionable because, in models with two correlated variables, one often influences the other. Therefore, it may be more appropriate to consider the full price elasticity instead of the price elasticity alone. This study did not differentiate between business and nonbusiness travel. The dominant number of business travelers on short trips may have increased (made less negative) that price elasticity; the greater number of nonbusiness travelers on longer trips may have reduced (made more negative) that price elasticity value. In general, this article suggested that the air travel demand is elastic.

- **Ippolito, 1981** (see citation number 18 in the references). This study estimated the impact of quality-of-service variables—flight frequency, availability of seating, flight distance—on the level of air carrier demand. The study drew its data from a sample of 105 flight segments in 1976. Ippolito confined his study to flight segments in which one air carrier held a monopoly. He found that price elasticity increased with flight distance. His results are summarized below:

One-way trip distance of 440 miles price elasticity:	-0.5
One-way trip distance of 830 miles price elasticity:	-1.0

These results are difficult to apply to the CRS study because they are based on pre-deregulation data and they involve monopoly routes. Price competition is totally removed from Ippolito's analysis. The results of this study were not applied to the CRS analysis because the proportion of business to nonbusiness travelers was not specified. It is possible that business travelers dominated the shorter distance trips and caused the inelastic demand, but the study does not address this issue.

- **Morrison and Winston, 1985** (see citation number 24 in the references). This study estimated intercity vacation and business traveler transportation demand. It drew upon data from the 1977 Census of Transportation National Travel Survey, which contains a sample of trips with round-trip distances greater than 200 miles. The model developed by Morrison and Winston first assumed selection of a destination city and then determined the mode of transportation that would be used destination city and then determined the mode of transportation that would be used to reach that destination. The four transportation modes considered were automobile, bus, rail, and airplane. Morrison and Winston presented elasticity estimates for three components of air travel demand—cost, travel time, and time between departures. Their price elasticities for air travel were:

Vacation trip price elasticity:	-0.378
Business trip price elasticity:	-0.181

The above price elasticity values are considerably lower than those listed in the previously cited studies—studies of data of later origin show more elastic demand. Morrison and Winston recognized that these values were low and that the demand for air travel is probably elastic. In fact, the authors state in their footnote number 25 that other studies (e.g., De Vany) find the demand for air travel to be price-elastic. Morrison and Winston note that the estimates provided by De Vany include all three components contained in their Table 3 (cost, travel time, and time between departures). It is likely that price elasticities obtained from the mode choice elasticities and destination choice elasticities reported would be consistent with the findings of some other studies.

In addition, because their model used three correlated variables, one may influence the other. Therefore, it may be more appropriate to consider all three elasticity components instead of the price elasticity alone. It is also possible that, before deregulation, air passengers displayed less price-sensitive behavior because of the limited fare choices available to them.

The relationship between the two above estimates indicates that the business price elasticity can be 50 percent lower than the nonbusiness value.

- **Straszheim, 1978** (see citation number 39 in the references). This research estimated the air traveler price and income demand functions for various classes of service. Straszheim examined the role of pricing and the impact of introducing special services at discount rates on the growth of the airline market. Data from North Atlantic routes were used because that was the only market with data available on disaggregated levels of service. Straszheim conducted regressions on the U.S. GDP and the fares for different classes of service for the period 1952 through 1973. The results of his study are:

First class price elasticity:	-0.6
Peak period economy price elasticity:	-1.9
Average economy price elasticity:	-1.5
Standard economy price elasticity:	-1.1
Promotional economy price elasticity:	-2.7
High discount economy price elasticity:	-1.8

These results show that first class traveler price elasticity is 60 percent to 70 percent lower than the economy travelers' values. If it is assumed that first class passengers represent the same price elasticity behavior as business travelers, and discount economy passengers are representative of nonbusiness travelers, then the relationship between the two passenger price elasticities is consistent—business travelers exhibit less price-elastic behavior than nonbusiness travelers. Straszheim stated that, "from examination of historical data it is evident that a large tourist market exists which is responsive to lower priced air service. . ." in spite of the various restrictions placed on their travel. To investigate the economy traveler further, he concentrated on the period from 1963 through 1973, when different types of economy fares were introduced. Those results follow:

Peak period economy price elasticity:	-1.0
Excursion economy price elasticity:	-1.8
Discount economy price elasticity:	-2.7

For this pre-deregulation period, data showed relatively high price elasticities for economy travelers—predominantly nonbusiness travelers, according to expert panelists and several literature sources. This study adds to the evidence that nonbusiness price elasticities may be greater in magnitude than -2.0. Although this study of the North Atlantic region consisted of international traffic between the U.S. and Europe, the driving force behind the model was the U.S. GDP, so the elasticities may be biased toward U.S. travelers.

SUMMARY OF PRICE ELASTICITY LITERATURE FINDINGS

None of the literature reviewed contained price elasticity estimates for Family Travel Units (FTUs). Some price elasticity estimates were available, however, for nonbusiness travelers, the passenger group thought to be similar to FTUs in price sensitivity. To determine values for FTU price elasticity estimates, FTUs were assumed to be the most price-sensitive nonbusiness travelers.

The literature review provided price elasticity information in the following four areas:

- The overall range of price elasticity estimates
- Price elasticities for business and nonbusiness travelers
- Price elasticities for different trip lengths
- Price elasticities by income level

The price elasticities in the literature ranged from -0.6 to -4.5. However, most of the studies presented values in the range of -0.8 to -2.7. Five of the studies provided evidence that nonbusiness price elasticities may be greater in magnitude than -2.0 [Oum, Zhang, and Zhang; Oum, Waters, and Yong; Abrahams; Straszheim; *Directions*].

Six studies demonstrated that business travelers were less price-elastic than nonbusiness travelers—the approximate difference was 50 percent lower values for business travelers [Oum, Waters, and Yong; Oum, Gillen, and Noble; Morrison and Winston; Straszheim; *Directions*; Apogee 1994].

Results of two studies demonstrated that differences in price elasticities corresponded to different trip lengths. However, both were eliminated because they both used pre-deregulation data, one of them only considered monopolistic markets [Ippolito], and the other involved two correlated variables and did not differentiate between the types of travelers [De Vany].

Only one study provided any information regarding price elasticity differences for passengers of different income levels [*Directions*]. This study demonstrated that low-income travelers had greater price elasticities than high-income travelers.

Exhibit G-1 summarizes these studies.

EXHIBIT G-1
Summary of Price Elasticity of Demand Studies

Article	Specific Focus of Study	Value (or range of values)
Oum, Zhang, & Zhang, "Inter-firm Rivalry and Firm-specific Price Elasticities in Deregulated Airline Markets," 1993.	United and American Airlines' hubs (20 city-pairs)	-1.58 to -2.34
Oum, Waters, & Yong, ". . . Price Elasticities of Transport Demand . . ." 1992.	Trip purpose (business, nonbusiness) Mixed or unknown	-1.15 to -1.52 -0.76 to -4.51
Oum, Gillen, & Noble. "Demands for Fareclasses. . . in Airline Markets," 1986.	First class Standard economy Discount economy	-0.58 to -0.82 -1.23 to -1.36 -1.50 to -1.98
Directions: The Final Report. . . on National Passenger Transportation, 1992.	Business Nonbusiness Short trip (less than 500 miles) Long trip (greater than 500 miles)	-1.57 to -3.51 -4.38 to -4.50 -1.16 to -2.70 -1.34 to -2.56
Apogee, ". . . the Impact of Telecommunications on Business and Pleasure Travel," 1994.	Business travel Nonbusiness travel	-0.59 -1.10
Morrison & Winston, ". . . the Demand for Intercity Passenger Transportation," 1985.	Business trips Nonbusiness trips	-0.18* -0.38*
Abrahams, "A Service Quality Model of Air Travel Demand," 1983.	Transcontinental Florida vacation city-pairs Hawaiian-West Coast city-pairs Eastern medium-haul city-pairs	-1.81 -1.98 -1.68 -1.22
Ippolito, "Estimating Airline Demand. . .," 1981.	440 mile trip (one way) 830 mile trip (one way)	-0.53 -1.00
Straszheim, "Airline Demand Functions in the North Atlantic and their Pricing Implications," 1978.	First class Economy, peak period Economy, average Economy, standard Economy, promotional Economy, high discount	-0.65 -1.92 -1.48 -1.12 -2.74 -1.82
De Vany, "The Revealed Value of Time in Air Travel," 1983.	28 mile trip (one way) 400 mile trip (one way) 650 mile trip (one way) 1500 mile trip (one way) 2500 mile trip (one way)	-0.76 -1.02 -1.07 -1.14 -1.17

* The authors note that these values are low. When these values are combined with the two time components developed by the authors, the nonbusiness elasticity estimate becomes -0.859.

The studies most applicable to this analysis were then selected from Exhibit G-1. Several studies were not used in the analysis for the following reasons:

- Oum, Zhang, and Zhang—The Chicago hub was not indicative of the entire U.S. nor of business or pleasure travelers.
- Oum, Waters, and Yong—the types of passengers subject to these values were unknown.
- *Directions*—There was no clear distinction between price elasticity values for short and long trips. The relative differences between business and nonbusiness travel and passenger incomes verified panelists' opinions.
- Apogee—The estimates were used to determine the relative difference between business and nonbusiness traveler price elasticities, but did not segment passengers by distance or trip purpose.
- Morrison and Winston—Panelists' opinion was that these values were inconsistent with the level of price elasticity for U.S. air travelers. However, these values did exhibit the relative price elasticity differences between business and nonbusiness travel.
- Ippolito—This study did not differentiate between business and nonbusiness travel. The dominant number of business travelers on short trips may have made those price elasticities more inelastic, and the greater number of nonbusiness travelers on longer trips may have made those price elasticity values more elastic.
- De Vany—This study did not differentiate between business and nonbusiness travel. The dominant number of business travelers on short trips may have made those price elasticities more inelastic, and the greater number of nonbusiness travelers on longer trips may have made those price elasticity values more elastic.

The fact that many studies were not considered directly applicable to the CRS analysis illustrates the difficulty of determining values for use in this study. Exhibit G-2 lists the studies determined to be applicable to this analysis.

EXHIBIT G-2
Applicable Price Elasticity of Demand Studies

Author	Specific Focus	Value (or range of values)
Oum, Gillen, & Noble	First class Standard economy Discount economy	-0.58 to -0.82 -1.23 to -1.36 -1.50 to -1.98
Abrahams	Transcontinental Florida vacation city-pairs Hawaiian-West Coast city-pairs Eastern medium-haul city-pairs	-1.81 -1.98 -1.68 -1.22
Straszheim	First class Economy, peak period Economy, average Standard economy Promotional economy High discount economy	-0.65 -1.92 -1.48 -1.12 -2.74 -1.82

The price elasticities shown for first class travel were not used because they are generally indicative of business travel. In addition, the transcontinental price elasticity obtained from Abrahams was not used because there was no apparent differentiation between business and nonbusiness travelers.

The studies used provide a conservative range of price elasticities because they are not based on the most current data and the panelists suggested that air fare price elasticities may have been increasing over time.

Business travel. Business travel price elasticities were developed but not used in the seven scenarios in the CRS analysis. They were not used because none of the scenarios pass the increased air carrier CRS costs on to business travelers. However, the analysis can accommodate such a scenario, so the values were developed. The business traveler price elasticities are approximately 50 percent of the nonbusiness elasticities, based on a review of five sources [Oum, Waters, and Yong; Oum, Gillen, and Noble; Morrison and Winston; Straszheim; *Directions*]. This proportion was applied to the estimates for nonbusiness travelers to develop the following price elasticity values for business travelers.

EXHIBIT G-3
Price Elasticity of Demand Parameter Values for Business Travelers
(and percentage of business enplanements)

Travel Distance (One Way)	Annual Household Income Less Than $40,000	Annual Household Income Greater Than or Equal To $40,000
Less than 500 miles	-1.2 (2.1% of business enplanements)	-0.9 (2.6% of business enplanements)
Greater than or equal to 500 miles	-0.9 (39.2% of business enplanements)	-0.7 (56.1% of business enplanements)

Source of price elasticity estimates: Oum, Waters, and Yong; Oum, Gillen, and Noble; Morrison and Winston; Straszheim; *Directions.*
Source of passenger percentages: U.S. Travel Data Center

The simple average of these four business traveler price elasticities is -0.9; the weighted average -0.8.

LINEAR DEMAND, ELASTICITY, AND REVENUE

This study assumes a linear functional form for the demand for air travel. This form was selected over a non-linear, constant elasticity model, because of the FAA's concerns that the elasticity of demand was unlikely to remain constant over the large increases in air fares considered in some scenarios. Linear demand curves, on the other hand, have the property that demand becomes more elastic as the price level increases.

As noted in Chapter 2, the elasticity estimates documented in this report were used to estimate the slopes of the demand curves and, in turn, the impact on demand of increases in air fares resulting from certain CRS policies. However, given that demand will become more elastic as price increases (assuming a linear form), the elasticity values documented here should be thought of as "initial" values. In other words, these point estimates depict the elasticity value at that particular point on the demand curve (i.e., corresponding to that combination of price and quantity) in effect *prior* to the increase in air fares. The elasticity will be greater following an increase in price (given the combination of higher price and lower quantity demanded).

A further consequence of selecting the linear function form for the demand curve is that air carriers will not experience a zero net revenue gain when the initial elasticity is set to -1.0 (except for infinitesimally small increases in air fares). In fact, given this functional form, air carriers will also experience a loss in revenues for some initial elasticity values between 0.0 and -1.0 if the price increases are sufficiently large. An explanation for this phenomenon is provided by the following proof.

Proof that a zero net change in air carrier revenues for a linear model implies an initial elasticity value, E, such that -1 < E < 0.

Let P = Price
Q = Demand
R = Revenue = PQ
E = Elasticity = $\frac{\Delta QP}{\Delta PQ}$

Assume a zero net change in air carrier revenues following an increase in air fares. Hence,

$$R_1 = R_2 \quad \text{or} \quad R_1 - R_2 = 0$$

Proof:

Rewriting the expression for the new revenue following the price increase, R_2, we get the following,

$$R_2 = P_2 Q_2 = (P_1 + \Delta P)(Q_1 + \Delta Q)$$

Or,

$$R_2 = P_2 Q_2 = P_1 Q_1 + P_1 \Delta Q + \Delta P Q_1 + \Delta P \Delta Q.$$

Note, however, that $P_2 Q_2 = P_1 Q_1$. Hence we can subtract these terms from both sides of the expression to get the following:

$$P_1 \Delta Q + \Delta P Q_1 + \Delta P \Delta Q = 0$$

Dividing both sides by Q_1 and ΔP, and rearranging terms we get:

$$\frac{\Delta Q P_1}{\Delta P Q_1} = -1 - \frac{\Delta Q}{Q_1}$$

Note here that the term on the left-hand-side is our expression for elasticity. Hence, this expression suggests that the initial value of E will be different from - 1 if there is to be no net change in total revenues. In fact, since $-1 < \_Q/Q_1 < 0$ we know that the following must be true.

$$-1 < E = \frac{\Delta Q P_1}{\Delta P Q_1} < 0$$

Hence, given the assumption of a linear demand curve, a zero net revenue change implies that the initial elasticity value, E, lies between zero and - 1.. Furthermore, the value of E will approach - 1 as the change in price becomes infinitesimally small (i.e., as $\Delta Q/Q_1$ approaches zero).

This proof provides an explanation of why air carriers experience a loss of revenue for an initial elasticity value of -1.0 (see Table 7-5) as well as for an initial value of -0.8 when the price increase is sufficiently large (e.g., greater then 50% of the adult fare).

APPENDIX H
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