Baggage Pricing Model: An Ancillary Reveneue Opprtunity

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Speakers' Bio

Prabhupad Bharadwaj is a doctoral research scholar in the Department of Management Studies, Indian Institute of Technology Madras. He is currently working in the area of airline pricing and revenue management, with a focus on ancillary pricing design.

R K Amit is currently an Associate Professor in the Department of Management Studies, Indian Institute of Technology Madras. He completed his undergraduate and postgraduate studies at Indian Institute of Technology Kanpur, and doctoral studies at IISc Bangalore. His research and teaching interests are in the area of game theory and decision theory with applications in operations and supply chain management. He has worked on numerous sponsored research projects on these areas. His research has been published in journals like European Journal of Operational Research, Operations Research Letters, International Journal of Production Economics, and Omega.

Atul Malik is a PhD student in the Department of Management Studies, Indian Institute of Technology Madras. He has more than 15 years of experience in business and technology consulting. His interests are in solving industrial problems using analytics, optimization, supply chain and statistical methodologies. He also has hands-on experience in designing and deploying logistics/supply chain planning and revenue management systems for different domains like pharmaceutical, media, online advertisers, television broadcasting and low-cost airlines. He has immensely contributed to developing **Ancillary RM Solutions** and **RM Pricing Strategies for airlines**.

Shao Hung Goh is an adjunct lecturer in logistics and supply chain management at Singapore Management University and the Singapore University of Social Sciences. Shao Hung has a PhD in Management Science from Lancaster University and has more than 15 years of experience in the logistics and transportation industries.

Presentation Outline

Introduction

Literature Review

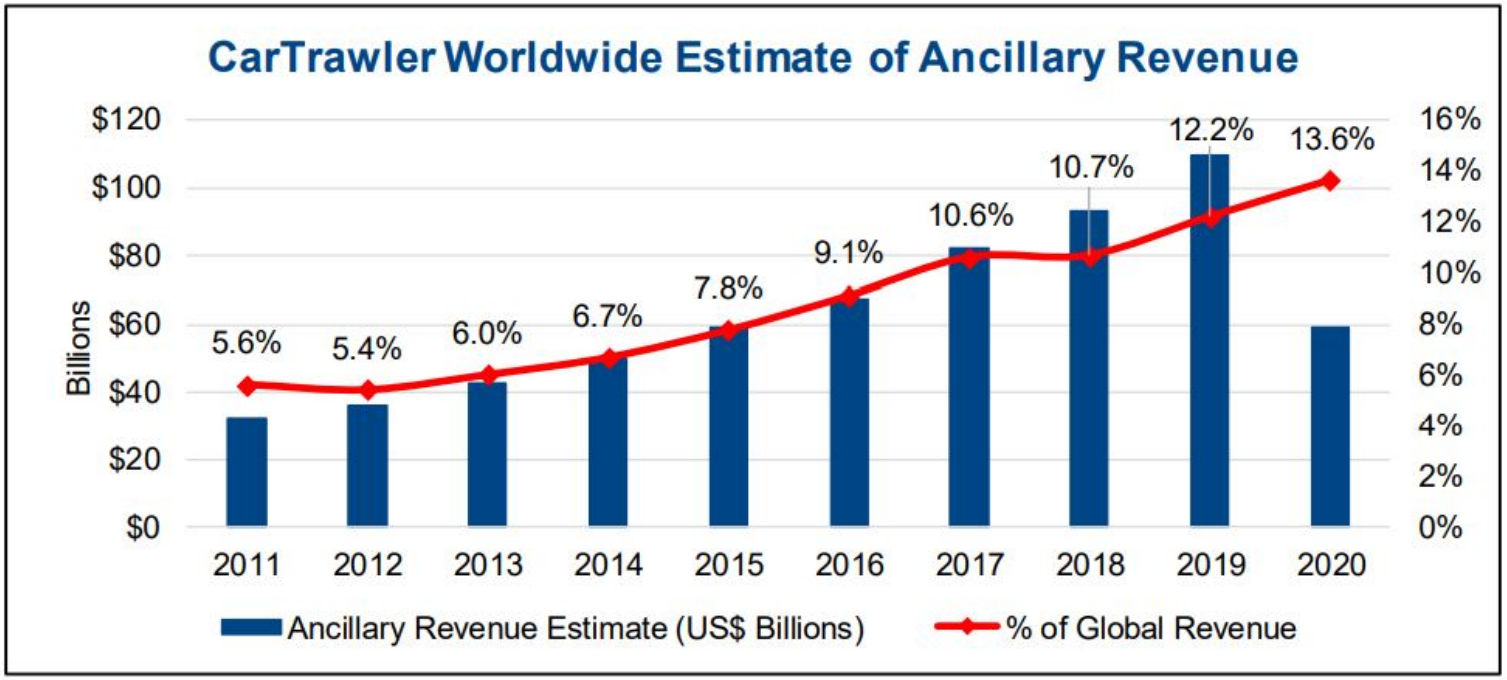
Baggage Pricing Model

Results

Research Takeaways

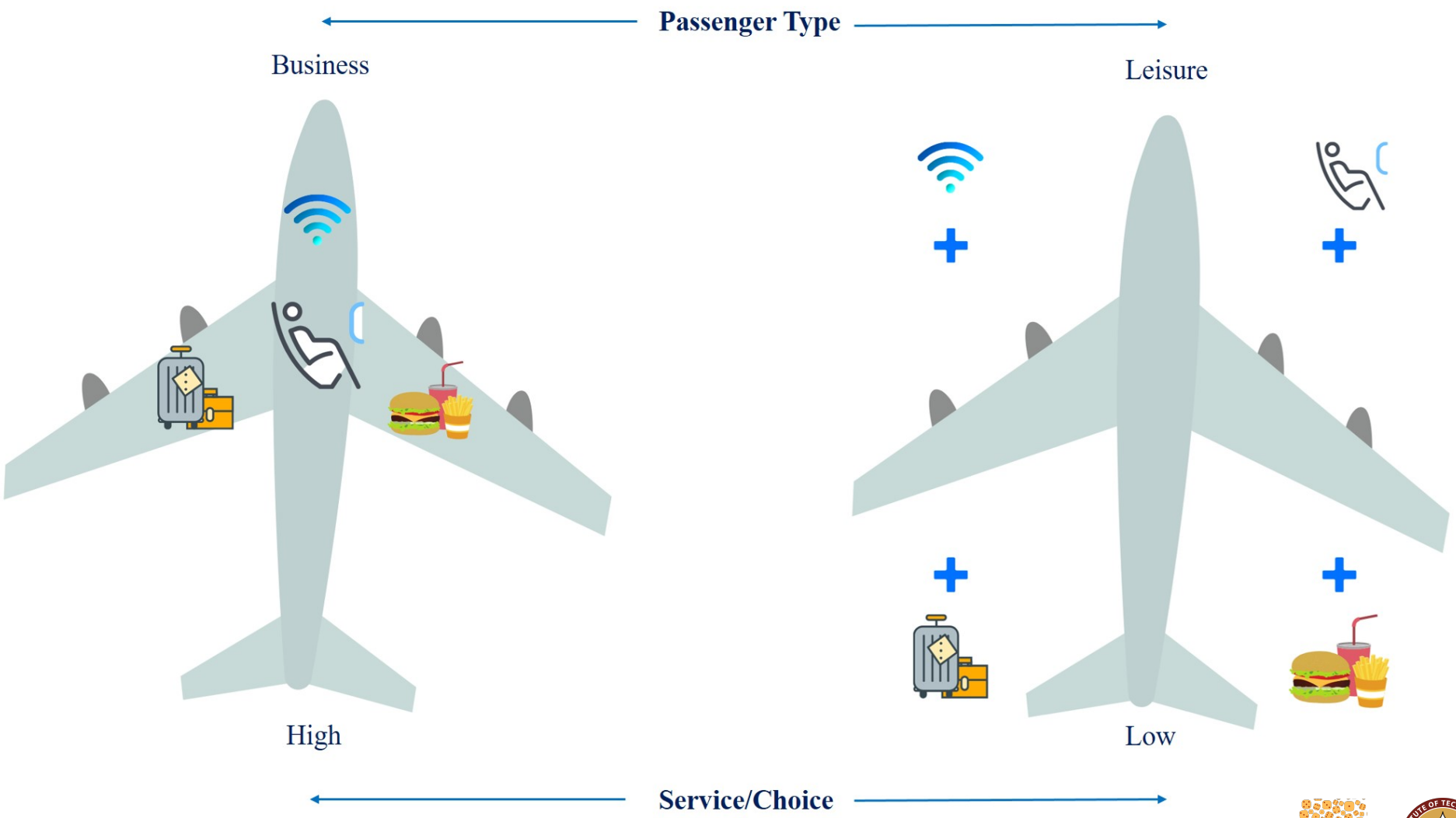
Introduction

- Average revenue per passenger has shown a decreasing trend in spite of a surge in global air travel demand over the years.
- Unbundling of ancillary services from regular airfare has shown promising results in generating extra revenues for airline operators.



Source: IdeaWorks-CarTrawler Ancillary Revenue Press Release - 2020

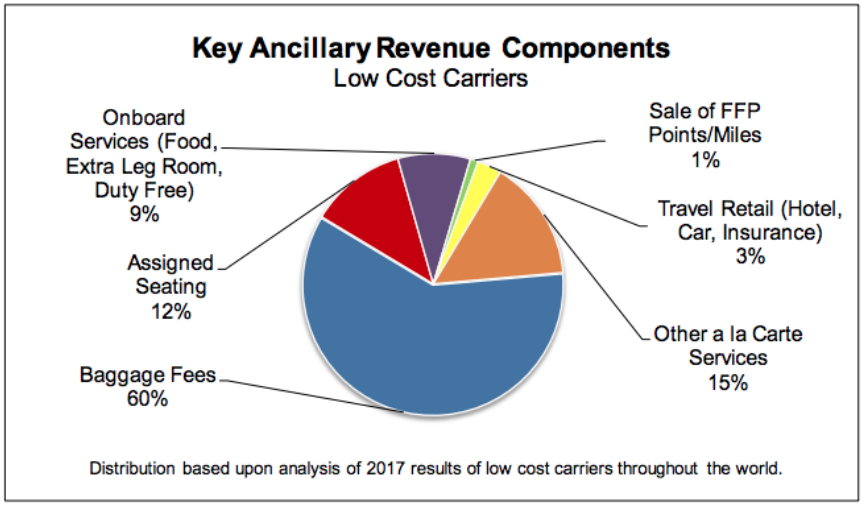
Customer Segmentation Through Bundling and Unbundling



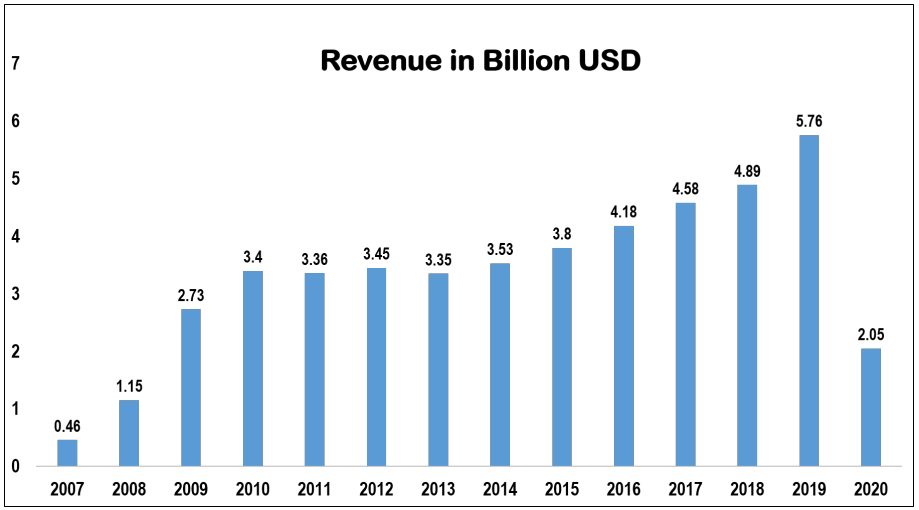
Baggage Revenue Opportunity

Decoupling baggage services from airfare is the most significant change made by airlines in the past decade.

Revenue from baggage fees increased from $464.3 million in 2007 to $5.7 billion in 2019 in the U.S.
- *Bureau of Transportation Statistics*

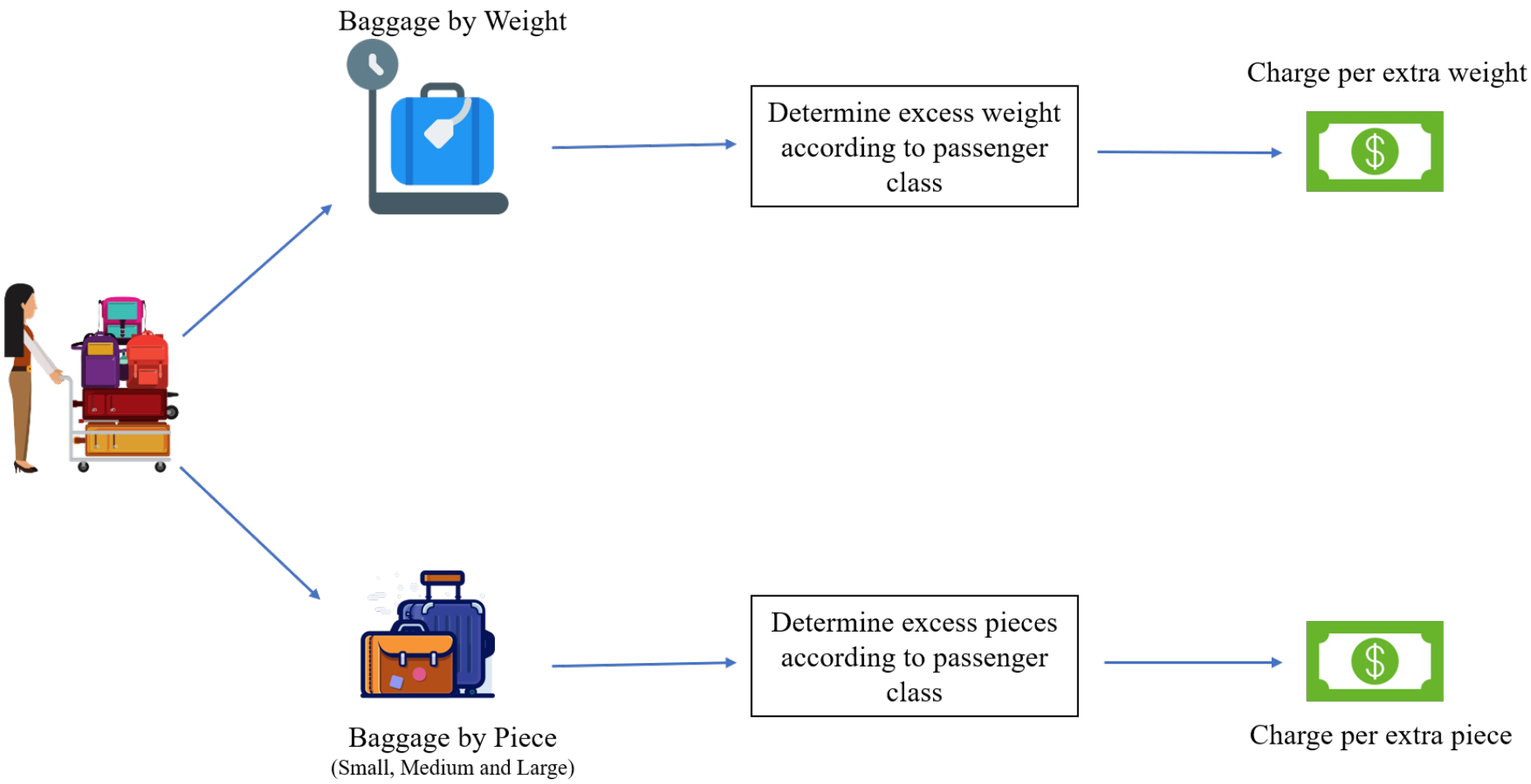


Source: IdeaWorks Ancillary Revenue Report-2018

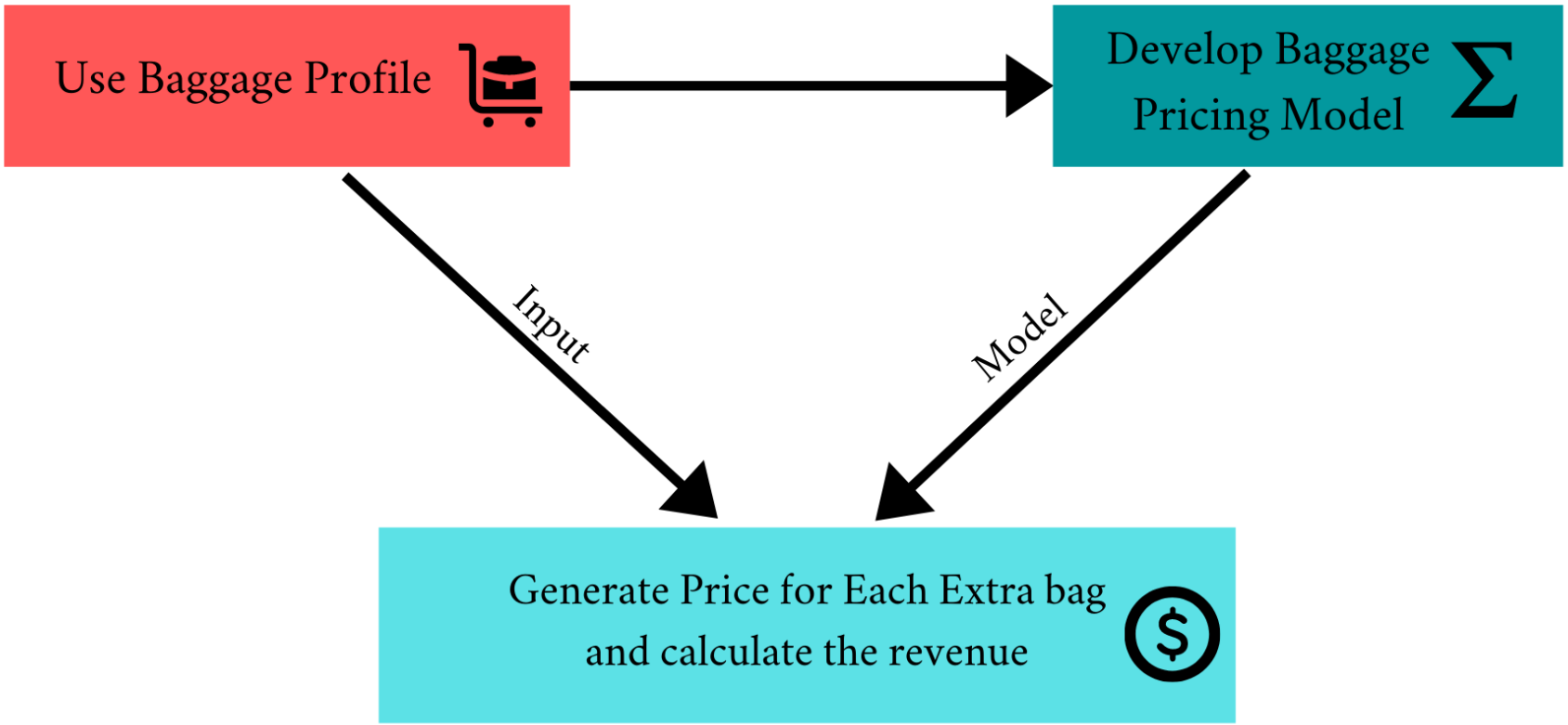


Source: Bureau of Transportation Statistics, Schedule P-1.2

Current Industry Practice



Objectives of Research



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Literature Timeline

2009 — Optimal Baggage-Limit Policy: Airline Passenger and Cargo Allocation
Wai Hung Wong, Anming Zhang, Yer Van Hui, Lawrence C. Leung

2011 — Would the Social Planner Let Bags Fly Free?
Gad Allon, Achal Bassamboo, Martin A. Lariviere

2012 — Baggage Fees and Changes in Airline Ticket Prices
Kevin E. Henrickson and John Scott

2015 — Product Unbundling in the Travel Industry: The Economics of Airline Bag
Jan K. Brueckner, Darin N. Lee, Pierre M. Picard, Ethan Singer

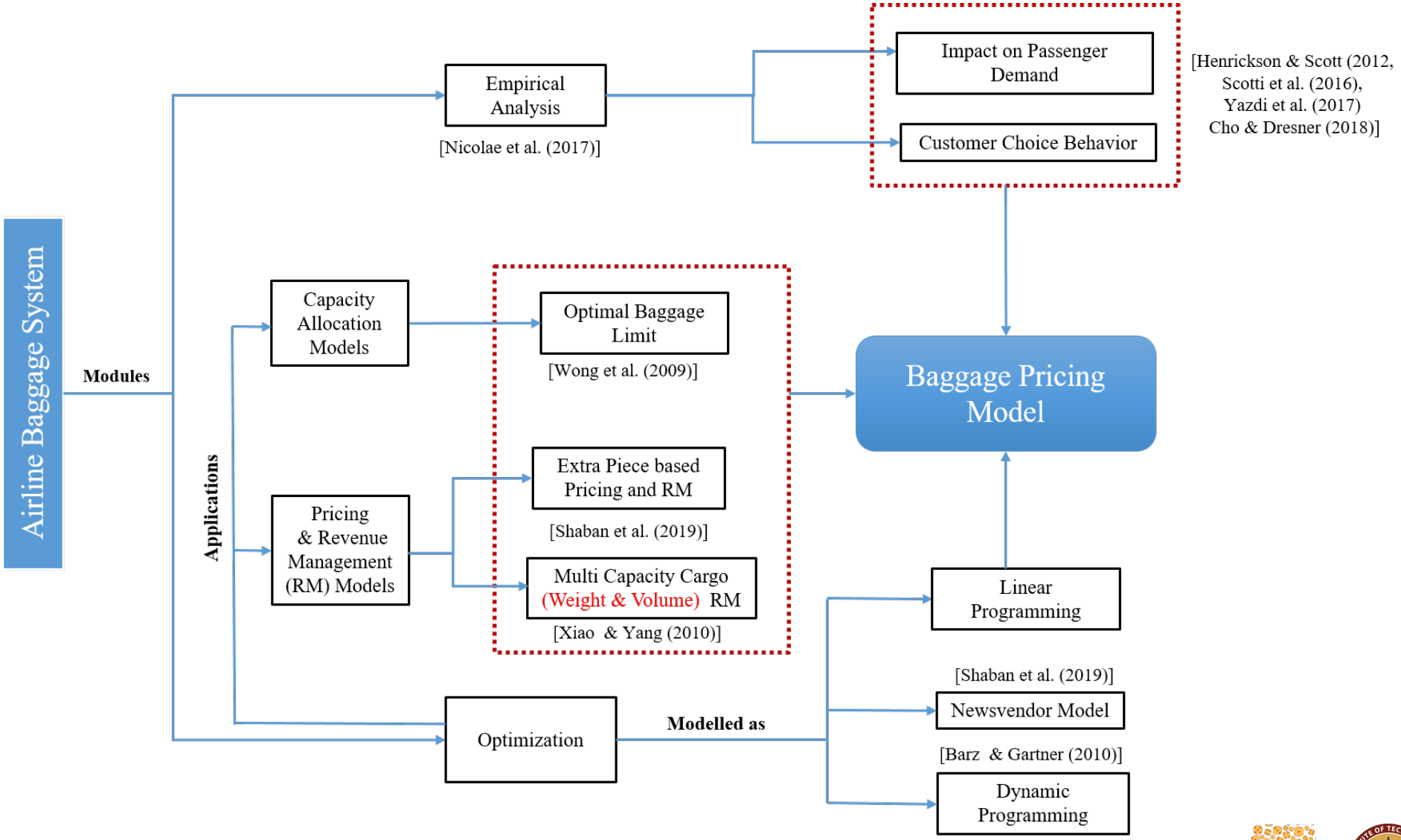
2015 — The impact of baggage fees on passenger demand on US air routes
Davide Scotti and Martin Dresner

2016 — Baggage fees, operational performance and customer satisfaction in the US air transport industry
Davide Scotti, Martin Dresner, Gianmaria Martini

2017 — Airline baggage fees and flight delays: A floor wax and dessert topping?
Amirhossein A. Yazdi, Pritha Dutta, Adams B. Steven

2019 — Price setting for extra-baggage service for a combination carrier using the newsvendor setup
I.A. Shaban, Z.X. Wang, F.T.S. Chan, S.H. Chung, A.E.E. Eltoukhy, T.Qu

Literature Framework



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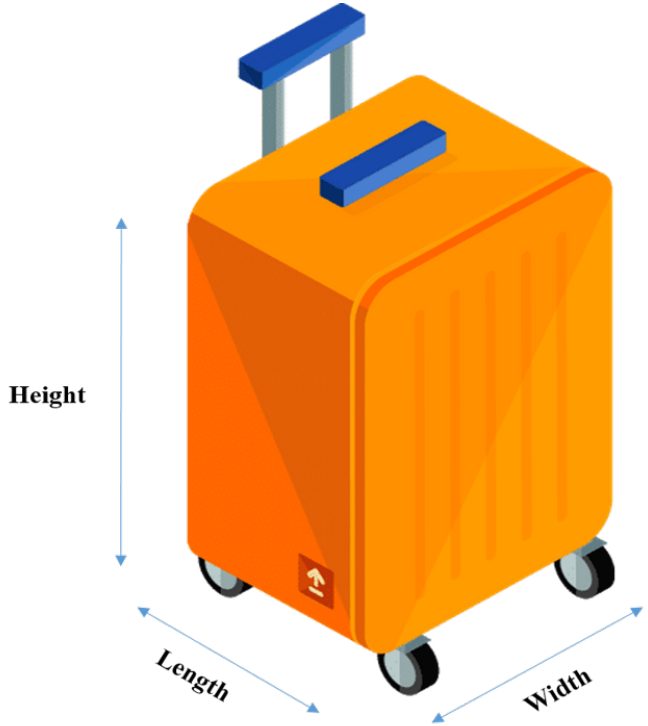
Baggage Profile Information

Bag manufacturers produce luggage according to the prescribed standard of airline operators.



Standard Baggage Dimensions in cm.

Bag Size	Height	Width	Length
Large	76	48	29
Medium	67	45	25
Small	63	36	21

Linear dimension $= Height + Width + Length$

Overview of the Model

We propose a pricing model to generate prices according to the route of the operation and taking baggage profiles (linear area) as an input.

Assumptions for the model:

(1) A single revenue maximizing firm determines the price of each bag.

(2) The model only considers on-spot booking made by the passengers.

(3) All tests are conducted on a single flight-leg.

(4) The baggage pricing structure obtained from the model is homogeneous for passengers.

(5) The aircraft belly capacity is sufficient to accommodate all requests of passenger check-in bags. (this could be constrained in the future models)

(6) Baggage prices are known upfront to the passengers.

Baggage Pricing Model

Notation	Description
i	Passenger number, $i = 1, \ldots, I$ (I = Total passengers in a flight)
k	Bag number carried by a passenger, $k = 1, \ldots, K$ (K = Total bags of a passenger)
w_k^i	Weight of bag k for passenger i
c	Class of a passenger (Economy, Premium economy, Executive etc.)
S_c	Allowable free weight for class c
H_c	Allowable free number of pieces for class c
y	Price per unit kg of weight/1000 km.
$\bar{k}$	Index of extra piece of bag the customer is carrying $= 1, \ldots, (K\text{-}H_c)^+$
$L_{\bar{k}}^i$	Linear area (in cm) for bag $\bar{k}$ of passenger i
D	Traveling Distance in 1000 km. between two airports
$p_{\bar{k}}$	Price/unit cm of linear area/1000km for extra bag $\bar{k}$.
p_0	Base price/unit cm of linear area/1000km

Red coloured variables specify the decision variables for the model

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Red coloured variables specify the decision variables for the model

$$A_1 = \sum_{i=1}^{I} \Big(\sum_{k=1}^{K} w_k^i - S_c\Big)^+ \times D \qquad \text{when } i \in S_c,\ c \in \{1, 2, 3\}$$

$$\text{Maximize} \quad A_2 = \sum_{i=1}^{I} \sum_{\bar{k}=1}^{(K-H_c)^+} L_{\bar{k}}^i \times p_{\bar{k}} \times D$$

$$\text{s.t.} \quad p_{\bar{k}} = p_{\bar{k}-1} + \bar{k} p_0 \qquad \bar{k} = 1, \ldots, (K - H_c)^+$$

$$A_2 = A_1 \times y$$

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Results for Mex-Ord Flight Leg

Linear area-Weight Relationship

Bag Details	h (cm.)	w (cm)	l (cm.)	Linear Area (cm.)	Volume (m^3)	Added Weight (volume $\times 161 kg/m^3$)	Weight/Linear area (kg/cm.)
Large	76	48	29	153	0.105792	17.032512	0.111
Medium	67	45	25	137	0.075375	12.135375	0.089
Small	63	36	21	120	0.047628	7.668108	0.064

Results from the Baggage Pricing Model

y	Decision Variables					Price of extra bags				Objective Value
	p_0	p_1	p_2	p_3	p_4	$\bar{k}=1$	$\bar{k}=2$	$\bar{k}=3$	$\bar{k}=4$	Revenue (in USD)
3	0.047	0.093	0.187	0.327	0.514	35.594	73.721	130.487	211.352	9686.371
3.1	0.048	0.096	0.193	0.338	0.531	36.781	76.178	134.834	218.397	10009.25
3.2	0.049	0.099	0.199	0.348	0.548	37.967	78.635	139.185	225.442	10332.13
3.3	0.051	0.103	0.205	0.359	0.565	39.154	81.093	143.535	232.487	10655.01
3.4	0.053	0.106	0.212	0.371	0.582	40.341	83.551	147.884	239.533	10977.89
3.5	0.054	0.108	0.218	0.381	0.599	41.527	86.008	152.234	246.577	11300.77

Revenue Results

Aeromexico

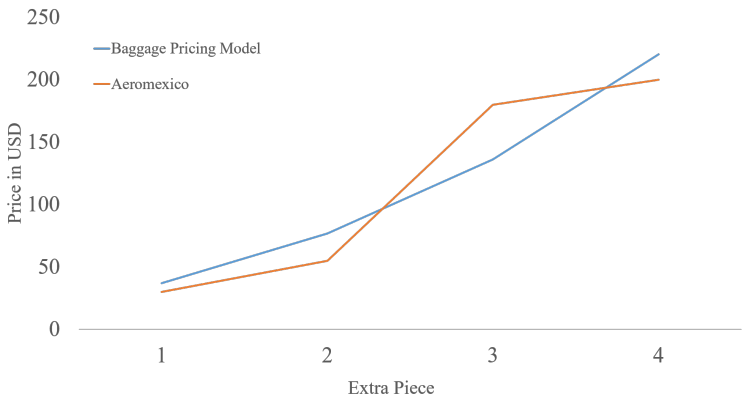
Price/kg-1000 km	Model Revenue ($)	Airline Revenue ($)	% Change in Revenue	Price of extra bags ($)			
				1	2	3	4
3	9686.37	9780	-0.966	35.59	73.72	130.49	211.35
3.1	10009.25	9780	2.290	36.78	76.18	134.83	218.39
3.2	10332.13	9780	5.343	37.97	78.64	139.19	225.44
3.3	10655.01	9780	8.212	39.15	81.09	143.54	232.49

KLM

Price/ kg-1000km	Model Revenue ($)	Airline Revenue ($)	% Change in Revenue	Price of extra bags ($)			
				1	2	3	4
2.6	17100.63	17360	-1.494	62.84	130.15	230.37	373.13
2.7	17758.35	17360	2.295	65.26	135.15	239.22	387.48
2.8	18416.06	17360	6.083	67.67	140.16	248.08	401.83
3.1	20389.21	17360	17.449	74.92	155.18	274.66	444.88

Results from Two U.S. Markets

The model is tested in two different U.S. markets and prices are compared keeping the y value as \$3.1.



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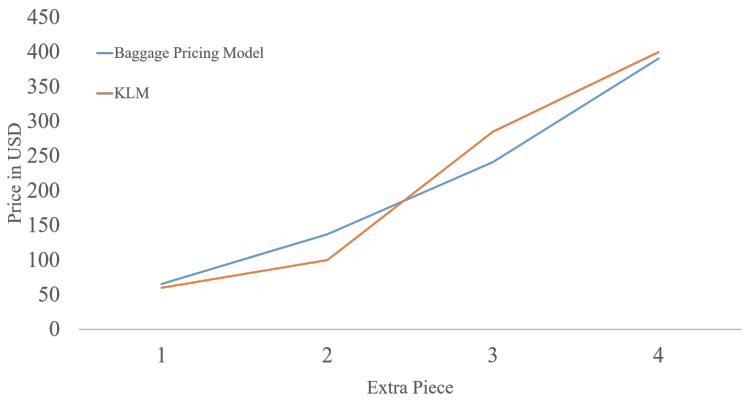
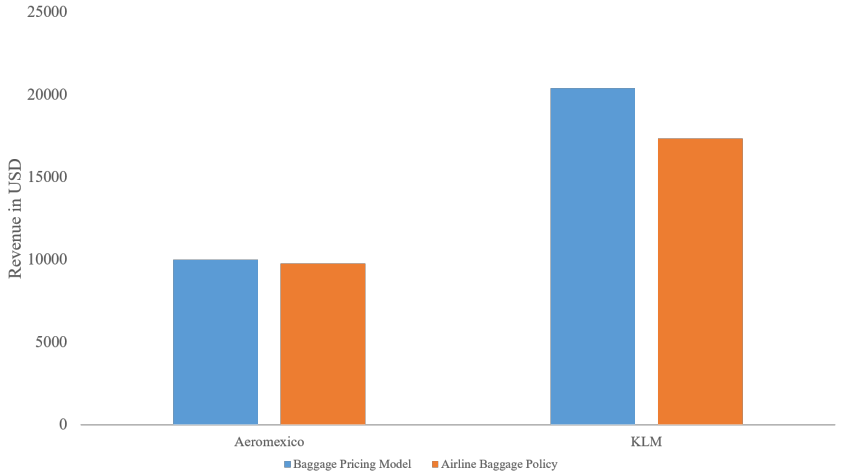


JFK-LHR



Revenue Comparison

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Managerial Implications

- The pricing model offers airline revenue managers to control the price based on the route and market of operation.
- Revenue managers can take leverage to publish the prices according to the flight leg and the freight rate(price/kg-1000km.).
- The pricing policy will preserve the revenue expectation irrespective of demand by piece or by weight from the customer end.
- The baggage tariff structure will help to remove the dilemma of weight and piece-based pricing.

Key Takeaways

- We develop a simpler pricing model taking a linear programming approach keeping the revenue maximization in our interest.
- The baggage pricing model reports a higher revenue as compared to the airline baggage policy
- In continuation of this work, a stochastic programming approach will be adopted to provide a better decision framework.
- We wish to perform numerical tests of the model in different markets with real time data to calibrate the model.
- As baggage policy design involves a capacity allocation and optimal free allowance decision for each class, in future a mathematical approach will be applied to answer that.

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Thank You

Appendix

Model Input Generation

Input	Value
Distance (D)	Distance between airports (in 1000km)
Price/kg of excess weight/1000km (Y)	International freight rate used
No. of passengers in a flight leg (I)	180
No. of bags carried by a passenger (K)	Uniform [1,6]
Passenger class (c)	1 (Economy) 2 (Premium Economy) 3 (Business)
Allowable weight limit (S_c)	Economy: 23kg Premium Economy: 28kg Business: 32kg
Allowable piece limit (H_c)	Economy: 2 bags Premium Economy: 2 bags Business: 3 bags
Linear area of extra bag $\bar{k}$ ($L^i_{\bar{k}}$)	Small ~Uniform [115,125] Medium ~Uniform [135,145] Large ~Uniform [145,158]
Weight of bag k (w^i_k)	Calculated from $L^i_{\bar{k}}$ using the baggage density
Baggage density	$161 kg/m^3$