André Jerenz

Y.

Revenue Management and Survival Analysis in the Automobile Industry

With a foreword by Prof. Dr. Ulrich Tüshaus

GABLER EDITION WISSENSCHAFT

Contents

List of Figures xiii							
Lis	st of Ta	ables .		xv			
Nomenclature							
1	Intr	oductio	n	1			
	1.1	Motiva	ation	1			
	1.2	Outlin	e and Research Contribution	2			
2	Rev	enue M	anagement and the Automobile Industry	5			
	2.1	Conce	pt of Revenue Management	5			
	`	2.1.1	Definition of Revenue Management	5			
		2.1.2	The History of Revenue Management	7			
		2.1.3	Industry-Specific Applications of Revenue Management	9			
		2.1.4	The Revenue Management Framework	9			
		2.1.5	Conditions for the Application of Revenue Management	11			
	2.2	The A	utomobile Industry	14			
		2.2.1	State of the Global Automobile Industry	14			
		2.2.2	The German Automobile Industry	15			
		2.2.3	Segmentation of the German Passenger Car Market	15			
		2.2.4	The German Used Car Market	17			
	2.3	Reven	ue Management in the Automobile Industry	19			
		2.3.1	Current Applications of Revenue Management	19			
		2.3.2	Assessment of the Automobile Industry	20			
	2.4	Price-	Based Revenue Management in the Used Car Sector	23			
		2.4.1	Selling Process of Used Vehicles	23			
		2.4.2	Analysis of Current Pricing Strategies	24			
		2.4.3	Potential for Improvement	26			

		2.4.4	Outline of the Approach	28
	2.5	Summ	ary	30
3	Mod	eling ti	he Price-Based Revenue Management Problem	31
	3.1	Introdu	uction	31
		3.1.1	Statement of the Dynamic Pricing Problem	31
		3.1.2	Literature Review	32
		3.1.3	Outline	33
	3.2	Basic	Continuous-Time Model	35
		3.2.1	Statement of the Basic Control Problem	35
		3.2.2	Dynamic Programming Approach	37
		3.2.3	Stochastic Dynamic Program for the Intensity Control	
			Problem	40
		3.2.4	Closed Form Solutions	42
	3.3	Stocha	astic Discrete-Time Model	44
		3.3.1	Statement of the Discrete-Time Control Problem	44
		3.3.2	Solution Algorithm	45
	3.4	Finite	Price Sets	48
		3.4.1	Solution for Continuous-Time Models	48
		3.4.2	Solution for Discrete-Time Models	51
	3.5	Extens	sions of the Basic Problem	54
		3.5.1	Current Value Formulation	54
		3.5.2	Inventory Costs	55
		3.5.3	Values Associated with Terminal State	57
	3.6	The Co	omplete Model	59
	3.7	Summ	ary	61
4	Surv	vival Ar	nalysis: Estimation of the Price-Response Function	63
•	41	Reserv	vation Price and Price Response Function	64
	7.1	411	The Reservation Price Concent	64
		412	Classification of Estimation Methods	66
		413	Further Discussion of Non-Experimental Market Data	00
		ч .1.5	Methods	67
		4.1.4	Time Duration Market Data	68
		4.1.5	Application to the Used Car Sector	69
	4.2	Surviv	al Analysis	70
		4.2.1	Introduction	70
		4.2.2	Basic Concepts and Notation	73
		4.2.3	Estimation of the Survivor Function	75
	4.3	Param	etric Regression Modeling	81
		4.3.1	The Cox Proportional Hazards Model	81
		432	Accelerated Failure Time Models	85
		433	Summary	88
		т.э.э	Summury	00

	4.4	Estima	ation of the Price Response Function
		4.4.1	Relationship between Asking Price and Time on Market 90
		4.4.2	Hedonic Pricing: Estimation of Expected Market Value 91
		4.4.3	Estimation of the Expected Survival Functions
	4.5	Summ	ary
5	Vali	dation	of the Survival Analysis Approach
	5.1	Introd	uction
	5.2	Used (Car Study
		5.2.1	Dataset and Descriptive Statistics
		5.2.2	Model Building 101
	5.3	Cox M	fodel
		5.3.1	Model Identification 104
		5.3.2	Adequacy Checking of the Cox Model 107
		5.3.3	Internal Validation of the Cox Model
	5.4	Accele	erated Failure Time Model 116
		5.4.1	Model Identification
		5.4.2	Assessment of Model Fit for the Log-Logistic Distribution . 118
		5.4.3	Internal Validation of the Log-Logistic AFT Model 120
	5.5	Spline	Regression Extended Model 123
		5.5.1	Model Selection for Spline Regression Extension
		5.5.2	Regression Splines 124
		5.5.3	Model Development 125
		5.5.4	Validation of the Extended Log-Logistic Model 126
	5.6	Preser	ntation of the Extended Log-Logistic Model
	5.7	Summ	nary
6	Con	nputati	onal Analysis: Proof of Concept
	6.1	Gener	al Description of the Revenue Management Program 135
		6.1.1	The Optimization Module
		6.1.2	The Demand Forecasting Module
	6.2	Case S	Study for a Selected Used Vehicle
		6.2.1	Description of a Selected Example
		6.2.2	Estimation of the Individual Price Response Function 138
		6.2.3	Estimation of Market Value Applying Hedonic Price
			Modeling
		6.2.4	Determination of the Optimal Pricing Strategy
		6.2.5	Comparison of Expected versus Observed Revenue 145
	6.3	Assess	sment of Potential for Profit Enhancement
		6.3.1	Calculation of Discounted Profit for Observed Sales 147
		6.3.2	Determining Expected Profit Applying Optimal Pricing
			Strategies
		6.3.3	Comparison and Analysis

,

	6.4	Summary	2				
7	Conclusions and Further Directions						
	7.1	Directions for Future Research	3				
	7.2	Summary	5				
Ref	erenc	es	7				
Ind	ex		7				

۱

,