Negotiation Decision Analysis on Pricing of Mobile Application Development with the Trading Platform under the B2B Market

Jei-Zheng Wu
Department of Business Administration
Soochow University, Taipei, Taiwan
Tel: (+886) 2-2311-1531 ext. 3403, Email: jzwu@scu.edu.tw

Tzu-Wen Yin
Department of Business Administration
Soochow University, Taipei, Taiwan

Abstract. The rapid advancement of wireless network, cloud computing, and mobile technology has fostered developments of mobile services and applications (app hereafter). More and more companies have been launching their apps in mobile platforms. Third-party app developers can help companies to achieve cost-effective and fast development of high quality apps. Most Taiwanese app developers belong to small and medium enterprises who utilize cloud computing services to reduce initial cost and to lower entry barrier. Most of the app developments are in the business-to-business market which is highly competitive and hard to survive without careful pricing and negotiation calculation. This study aims to develop a decision tree analysis (DTA) model for app developers to plan their pricing decisions by considering interactive bargaining with their business customers and interrelated consequences among the sequential decisions. To tackle with challenges of estimating probabilities precisely in existing studies, alternatively the proposed DTA model is embedded with the minimax regret evaluation rather than expected value calculation. Results from one case with real settings suggest decisions for app developers' benefit and to make business dealt which also shows the viability of the proposed model to help set reasonable pricing contracts.

Keywords: mobile application, pricing, bargaining, decision tree analysis, minimax regret

1. INTRODUCTION

The rapid advancement of wireless network, cloud computing, and mobile technology has fostered developments of mobile services and applications (app hereafter). More and more companies have been launching their apps in mobile platforms. Third-party app developers can help companies to achieve cost-effective and fast development of high quality apps. Most Taiwanese app developers belong to small and medium enterprises who utilize cloud computing services to reduce initial cost and to lower entry barrier. Most of the app developments are in the business-to-business (B2B) market which is highly competitive and hard to survive without careful pricing and negotiation calculation. From the app developer's view point, the pricing and negotiation process in B2B market is a multi-stage decision where iteratively responses to uncertain buyer's reaction will affect whether the deal is done or not and will derive the final benefit or loss to the developer.

Decision tree analysis (DTA) is suitable to facilitate the aforementioned pricing and negotiation decision-making process. However, conventional DTA applies the expected monetary value to evaluate alternatives and their consequences (Wu et al., 2015). In practice, it is very hard to assess probabilities for each uncertain event. Therefore, this study aims to develop a hybrid DTA model to embed with the minimax regret assessment to replace the expected value calculation for each uncertain node of DTA. The validity of the proposed approach was examined by considering a numerical example with real settings derived from a Taiwanese app developer.

The remainder of this paper is structured as follows: Section 2 addresses the fundamentals of DTA and minimax regret evaluation; Section 3 shows the proposed DTA model to formulate the app pricing decision; Section 4 explains the case and numerical study; Section 5 provides the conclusion.

2. DECISION TREE ANALYSIS AND MINIMAX REGRET

A decision tree comprises a number of decision nodes (squares) and chance nodes (circles) and branches to connect nodes to form directed acyclic graph, i.e., a tree (Figure 1). An alternative at a decision node is denoted by a branch emanating from the upfront square decision node. Only one alternative can be chosen from all branches emanating from a decision node. A possible outcome of an uncertain event is denoted by the branch emanating from a circled chance node under which is a set of mutually exclusive and collectively exhaustive uncertain situations (Clemen, 1996).

The DTA performs backward evaluation, i.e., starting from the end branches to their roots. Conventionally, each decision is made by choosing the optimal alternative that provides the maximal or minimal sum of the expected values of payoffs corresponding to their consequences. (French, 1988). DTA has become a convenient tool for structuring sequences of decision problems and for solving multistage decision problems from various aspects (Chien and Wu, 2003, 2007; Bakır 2008; Wu et al., 2015). The decision tree is a more general analysis tool than the net present value or discounted cash flow method.

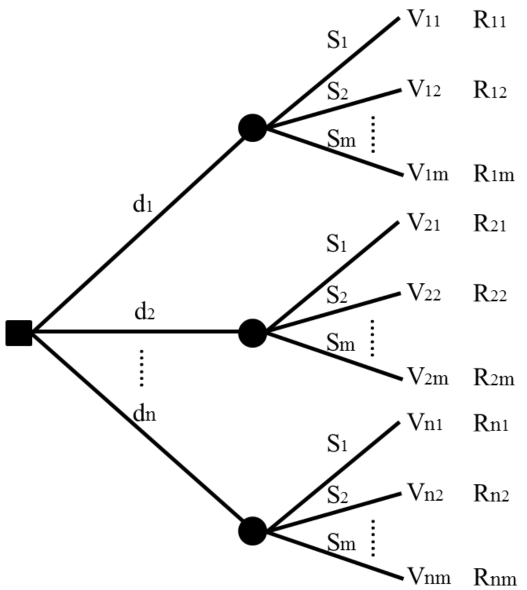

Figure 1: The minimax regret calculation process.

d_i Alternative of decision i=1,2,…,n.

S_j Uncertain situation j=1,2,…,m.

V_{ij} Payoff of decided alternative i under situation j.

R_{ij} Regret of decided alternative i under situation j.

This study develops a hybrid DTA by using minimax regret calculation to replace the expected monetary value calculation. The evaluation process is as follows:

1. Under each uncertain situation j, evaluate the payoff of alternative i to get the maximal payoff V_{ij}^* as in Eq. (1) and its corresponding alternative.
2. After that compute the regret value R_{ij} as defined in Eq. (2).
3. Finally, the best alternative can be chosen based on the minimizing the maximal regret rule.

$$V_j^* = \max_{i=1,2,\dots,n} (V_{ij}) , \forall j = 1,2, \dots , m \quad (1)$$

$$R_{ij} = V_{ij}^* - V_{ij}, \forall i = 1,2, \dots , n, j = 1,2, \dots , m \quad (2)$$

$$d^* = \arg\left\{ \min_{i=1,2,\dots,n} \left[\max_{j=1,2,\dots,m} (R_{ij}) \right] \right\} \quad (3)$$

3. THE APP PRICING DECISION WITH MINIMAX REGRET DECISION TREE

This study develops the minimax regret decision tree to model the app pricing and negotiation process. The proposed model is three-stage. There are two stages for the app developer to provide sequential their price settings and one stage for the developer to decide the level of quality maintenance which reflects the cost and following user preferences. The price settings include the levels of development fee and maintenance fee and possible transaction fee per trade from the buyer's side. The buyer may respond to accept or decline the price settings. After that, the developer may provide an adjust price setting seeking possible acceptance from the buyer. For simplification purpose, we assume that the buyer will simply accept or decline the settings without offering a new price or request for revising the service setting. The final consequences depend on the quality and maintenance of the app. If the users prefer the app, more trade and transactions will be done which contribute to the financial benefit to the buyer and thus increase the likelihood for the buyer to accept the price settings. The details of the DTA settings are shown in Table 1 and the complete decision tree is depicted in Figure 1.

Table 1: Details of DTA nodes and branches.

Node	Decision/ Event	Alternatives/Situations
Decision	1st Price	F_{N1}: High development fee, high maintenance fee, no transaction fee F_{Y1}: Low development fee, low maintenance fee, claim transaction fee F_{C1}: Terminate the trade
Chance	1st Realized demand	A_{Y1}: Accept the price setting A_{N1}: Decline the price setting
Decision	2nd Price	F_{N2}: High development fee, high maintenance fee, no transaction fee F_{Y2}: Low development fee, low maintenance fee, claim transaction fee F_{C2}: Terminate the trade
Chance	2nd Realized demand	A_{Y2}: Accept the price setting A_{N2}: Decline the price setting
Chance	Customization cost	C_H: High customization cost C_L: Low customization cost
Decision	Quality Maintenance	M_H: High engagement M_L: Low engagement
Chance	User Preference	U_Y: Like U_N: Dislike

4. THE CASE AND NUMERICAL STUDY

A case study was conducted on a Taiwanese app developer, O Company, to examine the viability of the proposed model with real settings. O Company receive orders from buyers (also a company) to customize and deliver new apps. The period for benefit and cost evaluation is 5-year. The parameter settings are shown in Table 2. The DTA results are shown in Table 3.

Table 2: Parameters for the numerical study of DTA.

Parameter	Setting
Initial cost	About 1,204,598 TWD including the cost for Google SQL, Google Storage, personnel, Apple App Store management
F_{N1} and F_{N2}	Development: 1,200,000TWD (one time) Maintenance: 600,000TWD (every year) Transactions: no fee
F_{Y1} and F_{Y2}	Development: 600,000TWD (one time) Maintenance: 300,000TWD (every year) Transactions: 5% per transaction
F_{C1} and F_{C2}	No business is dealt. The developer will suffer from the initial cost.
C_H	501,916 TWD
C_L	401,533 TWD
M_H and M_L	Cost depends on the Google SQL and Storage package selection. Personnel expense is also included.
U_Y and U_N	Measured by download counts

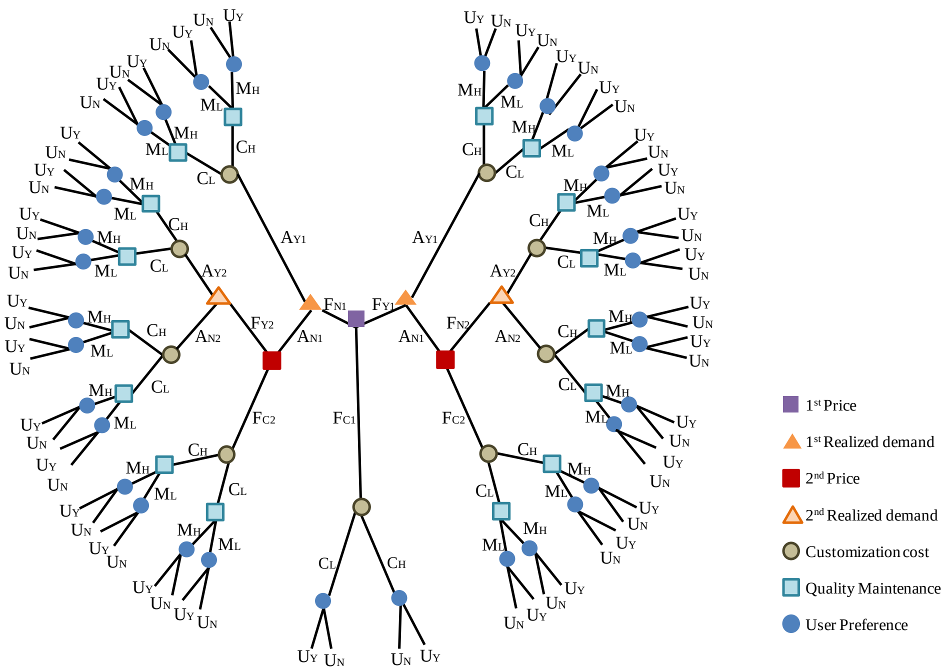

Figure 2: The complete decision tree for app pricing and negotiation.

Table 2: The complete DTA data and results.

Initial Cost	1st Price	Developer's Max Regret	Developer's Regret	Developer's Payoff	1st Realized Demand	Buyer's Max Regret	Buyer's Regret	Buyer's Payoff	2nd Price	Developer's Max Regret	Developer's Regret	Developer's Payoff	2nd Realized Demand	Buyer's Max Regret	Buyer's Regret	Buyer's Payoff	Customized Cost	Quality Maintenance	Developer's Max Regret	Developer's Regret	Developer's Payoff	User Preference	Download Count	Buyerr's 5-year Revenue	Developer's 5-year Revenue
1,204,598	F_{N1}	896,001		449,673	A_{Y1}	1,546,535	0	105,071,407									C_H	M_H	874,113	872,095	61,841	U_Y	180,000	107,334,121	62,460
				350,805			0	90,210,394												874,113	160,709	U_N	155,500	92,324,498	162,316
			896,001	422,422			0	71,709,950										M_L	0	0	933,936	U_Y	125,000	73,639,049	943,276
			236,385	523,307			0	56,545,651												0	1,034,821	U_N	100,000	58,323,107	1,045,170
			0	1,101,388			0	38,348,492									C_L	M_H	545,472	545,472	1,512,519	U_Y	70,000	39,943,977	1,527,644
			0	1,260,786			0	14,388,899												0	1,671,917	U_N	30,500	15,744,788	1,688,636
				1,646,860			0	3,167,318										M_L	1,243,780	0	2,057,991	U_Y	12,000	4,410,991	2,078,571
				17,006			1,546,535	1,546,535												1,243,780	428,137	U_N	2,000	350,000	432,419
					A_{N1}	105,071,407			F_{Y2}	0	0	1,050,491	A_{Y2}	1,070,297	0	51,079,931	C_H	M_H	0	0	2,167,005	U_Y	90,000	52,196,730	2,188,675
											0	656,093			0	41,981,352				0	1,772,607	U_N	75,000	43,007,165	1,790,333
												537,370			0	26,817,053		M_L	644,587	513,121	1,653,884	U_Y	50,000	27,691,223	1,670,423
												11,506			0	14,685,613				644,587	1,128,020	U_N	30,000	15,438,470	1,139,300
											0	291,842			0	11,652,754	C_L	M_H	0	0	1,307,973	U_Y	25,000	12,375,281	1,321,053
											0	81,496			0	6,800,178				0	1,097,627	U_N	17,000	7,474,180	1,108,604
												6,003			175,400	175,400		M_L	915,667	297,845	1,010,128	U_Y	5,500	428,846	1,020,229
												834,170			1,070,297	1,070,297				915,667	181,961	U_N	1,000	475,000	183,780
													A_{N2}	51,079,931	51,079,931	0	C_H	M_H				U_Y		0	0
															41,981,352	0						U_N		0	0
															26,817,053	0		M_L				U_Y		0	0
															14,685,613	0						U_N		0	0
															11,652,754	0	C_L	M_H				U_Y		0	0
															6,800,178	0						U_N		0	0
															0	0		M_L				U_Y		0	0
															0	0						U_N		0	0
							105,071,407	0	F_{C2}	2,260,089	2,260,089	1,209,598					C_H	M_H				U_Y		0	0
							90,210,394	0			1,865,691	1,209,598										U_N		0	0
							71,709,950	0				1,209,598						M_L				U_Y		0	0
							56,545,651	0				1,209,598										U_N		0	0
							38,348,492	0			1,501,440	1,209,598					C_L	M_H				U_Y		0	0
							14,388,899	0			1,291,094	1,209,598										U_N		0	0
							3,167,318	0				1,209,598						M_L				U_Y		0	0
							0	0				1,209,598										U_N		0	0
1,204,598	F_{Y1}	885,065	0	1,318,423	A_{Y1}	779,455	0	55,568,563									C_H	M_H	0	0	2,429,937	U_Y	100,000	56,730,249	2,454,236
			0	759,693			0	43,323,392												0	1,871,207	U_N	78,750	44,362,626	1,889,919
				555,517			0	27,044,517										M_L	762,906	762,906	1,667,031	U_Y	50,500	27,920,962	1,683,701
				302,445			0	21,498,175												457,248	1,413,959	U_N	40,875	22,319,156	1,428,098
			528,467	572,921			0	18,400,867									C_L	M_H	0	0	1,584,052	U_Y	35,500	19,190,875	1,599,892
			885,065	375,722			0	14,079,041												0	1,386,853	U_N	28,000	14,825,832	1,400,721
				117,316			0	3,706,661										M_L	1,204,892	455,604	1,128,447	U_Y	10,000	4,349,728	1,139,732
				829,171			779,455	779,455												1,204,892	181,960	U_N	1,000	181,250	183,780
					A_{N1}	55,568,563			F_{N2}	0		333,611	A_{Y2}	1,224,752	0	86,874,249	C_H	M_H	952,803	952,803	182,903	U_Y	150,000	88,954,991	184,732
												131,841			0	56,545,651				851,918	384,673	U_N	100,000	58,323,107	388,520
											0	619,193			0	41,381,352		M_L	0	0	1,135,707	U_Y	75,000	43,007,165	1,147,064
											0	720,078			0	26,217,053				0	1,236,592	U_N	50,000	27,691,223	1,248,957
											0	1,227,538			0	18,634,903	C_L	M_H	412,304	412,304	1,643,669	U_Y	37,500	20,033,252	1,660,106
											0	1,265,875			0	12,872,469				0	1,682,006	U_N	28,000	14,213,194	1,698,826
												1,639,842			0	3,470,604		M_L	1,206,833	0	2,055,973	U_Y	12,500	4,717,310	2,076,533
												59,041			1,224,752	1,224,752				1,206,833	475,172	U_N	5,000	25,000	479,924
													A_{N2}	86,874,249	86,874,249	0	C_H	M_H				U_Y		0	0
															56,545,651	0						U_N		0	0
															41,381,352	0		M_L				U_Y		0	0
															26,217,053	0						U_N		0	0
															18,634,903	0	C_L	M_H				U_Y		0	0
															12,872,469	0						U_N		0	0
															3,470,604	0		M_L				U_Y		0	0
															0	0						U_N		0	0
							55,568,563	0	F_{C2}	2,475,473		1,209,598					C_H	M_H				U_Y		0	0
							43,323,392	0				1,209,598										U_N		0	0
							27,044,517	0			1,828,791	1,209,598						M_L				U_Y		0	0
							21,498,175	0			1,929,676	1,209,598										U_N		0	0
							18,400,867	0			2,437,136	1,209,598					C_L	M_H				U_Y		0	0
							14,079,041	0			2,475,473	1,209,598										U_N		0	0
							3,706,661	0				1,209,598						M_L				U_Y		0	0
							0	0				1,209,598										U_N		0	0
	F_{C1}	2,523,021	2,523,021	1,204,598													C_H					U_Y		0	0
			1,964,291	1,204,598																		U_N		0	0
			2,305,986	1,204,598													C_L					U_Y		0	0
			2,465,384	1,204,598																		U_N		0	0

The result shows that the developer, O Company, should choose F_{Y1} with low development fee, low maintenance fee, and 5% transaction fee. It is commonly known that mobile commerce is dramatically developing. If the contract ends up with F_{N1} or F_{N2}, the developer will be forced to deal with huge amount of maintenance to ensure the high quality and high demand in the near future. The acceptable high development and high maintenance cost of F_{N1} or F_{N2} cannot justify the extra maintenance cost. In the opposite, the transaction fee allows the developer to receive revenue from the increased demand to cover the increased maintenance cost. On the other hand, the low one-time development and low annual maintenance cost will reduce buyer's risk and entry barrier because it is not easy to predict the increase of future demand even from the buyer's side. Consequently, there is high chance for the buyer to accept the price setting and to make the deal done.

Finally, the path of the pricing and negotiation decision is [F_{Y1}-A_{Y1}-$C_H M_H$ or $C_L M_H$]. This result coincides with domain experts' expectation and final decisions after discussions on the research results.

5. CONCLUSIONS

This study develops a decision tree analysis (DTA) model for app developers to plan their pricing decisions by considering interactive bargaining with their business customers and interrelated consequences among the sequential decisions. To tackle with challenges of estimating probabilities precisely in existing studies, alternatively the proposed DTA model is embedded with the minimax regret evaluation rather than expected value calculation. Results from one case with real settings suggest decisions for app developers' benefit and to make business dealt which also shows the viability of the proposed model to help set reasonable pricing contracts. The future research should be done on the sensitivity analysis of the uncertain parameter settings.

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