

Adaptive Build Your Own (ABYO): An Alternative Approach to Feature Level Valuation

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A key objective of product design research is the estimation of the value individual respondents place on potential feature levels. Most approaches use advanced statistical methods to infer these values from respondents' choices across multiple sets of fully-configured product alternatives. These methods include Sawtooth Software's popular Choice-Based Conjoint or CBC. A recent extension of this method is the "adaptive" CBC (ACBC) described by Richard Johnson and Bryan Orme (2007). The ACBC method combines the traditional CBC technique with a traditional "build-your-own" (BYO) approach as described by David Bakken and his co-authors in a series of papers (2001, 2003, and 2006). IN ACBC, the BYO section occurs before the CBC section in order to align the sets of products shown the respondent so that they are closer to his or her "ideal" point. Between the BYO and CBC sections, Johnson and Orme also include a screening section which is used to help identify "must haves" and "unacceptables." The authors conclude by listing reasons why they "... believe that the Adaptive CBC (ACBC) method for collecting data provides several improvements over conventional CBC." To summarize:

- ACBC is more interesting and engaging for the respondents
- ACBC produces better predictions of choice shares for holdout sets
- ACBC is superior when samples are small

Moreover, Johnson and Orme found that the relative worth of the sections was, in rank order, 1) BYO, 2) Screening, and 3) Choice Tasks." (2007, p. 11, fn. 2).

Bakken et al. have produced three papers describing their findings using the BYO approach. In each of these papers the respondent goes through one build-your-own exercise, which makes the estimation of utility values for features and price difficult. In their very first paper in 2001, it is speculated that this problem may be overcome through replicated build your own questions. As far as we know, there isn't a fourth paper where this idea is explored¹.

These conclusions for ACBC and traditional BYO have motivated this paper. For the last seven years International Planning & Research (IPR) has used a technique in our Marketor™ toolkit that we call Adaptive Build Your Own (ABYO). The primary objective of AByo is the estimation of the value (or utility) individual respondents hold for a variety of feature levels in a product. As many researchers have noted, asking the respondent this question directly ("how much are you willing to pay for X?") is unnatural. While bargaining between buyers and sellers sometimes is present, most consumers make selections by "taking or leaving" when confronted with a price. Economists typically hypothesize that a consumer acts as if he compares a product's price (P) with his own personal "willingness to pay" (WTP) for the product, which can be thought of as opportunity cost of not having the product (Varian, 2001). Behavior is assumed to be rational - the customer purchases the product if its price is

less than the opportunity cost of not having the product (i.e. $P < WTP$, with the difference between WTP and P being the consumer's surplus or net gain). Both P and WTP are dollar amounts, though WTP is not observable and is unique for each person.

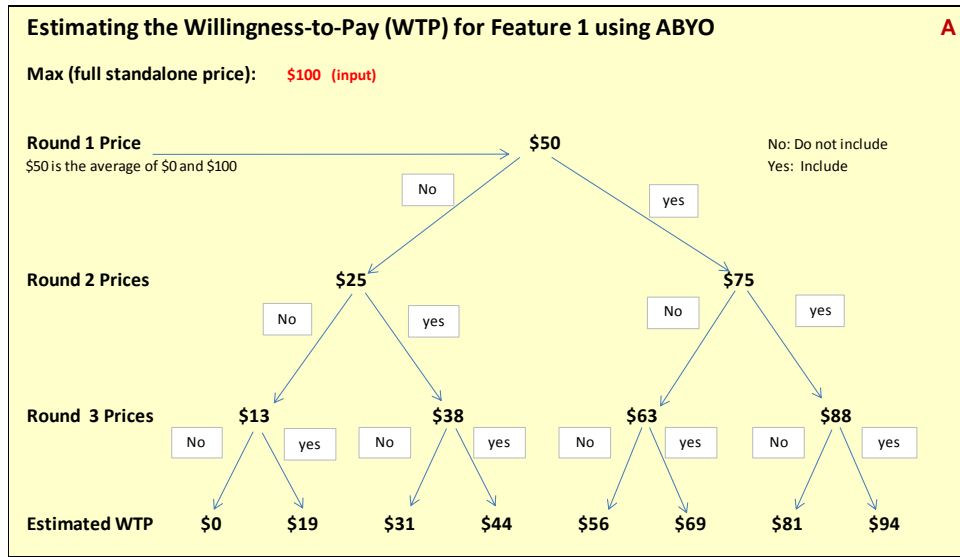
IPR's ABYO technique described in this paper provides a method for estimating the dollar WTP for each feature level evaluated by each respondent in a BYO-type survey in which the respondent completes multiple BYO exercises². This technique does not require sophisticated estimation routines, such as hierarchical Bayes, and can be easily understood by users of the technique. Moreover, as noted by Johnson and Orme (2007, p. 22), "There is good reason to believe that respondents are more careful and provide better answers to the BYO section of the questionnaire than to the more repetitive and complex considerations of products profiled on many attributes simultaneously." The ABYO technique that we will describe is more complex than the single-pass BYO in ACBC in that it requires the respondent to complete three (or four) BYO tasks, but this number of tasks is much fewer than the standard 12-16 (or more) monotonous tasks required by the ACBC or CBC techniques. In fact, in open-ended feedback from respondents at the end of our surveys, we often read that they enjoyed the BYO task, leading us to believe that the revealed preference data is of relatively high quality.

The Simple Case

Consider a basic product that has several binary upgrade features that can be either "included" or "not included" in the configured product. For simplicity and without loss of generality assume that the cost (including a profit) to the producer of including any one of the features in the product is \$50. If "mass customization" was costless to the producer, then he could simply have each customer configure his own product with the costs of the features each set at \$50. Some customers will configure the product to have very few features, spending little more than the basic product's cost. Others might configure more expensive feature-rich versions of the product. In many cases, however, mass customization is extremely costly for the producer and this "build your own" selling approach is not feasible. Thus the producer will need to decide how many different product configurations (or bundles of features) at what prices are needed to maximize its profit. However, the combinations and prices are virtually infinite. Preference research is called to the rescue. Here's how ABYO works.

Take one of the features that cost the producer \$50. It is likely that some customers value this feature very highly and would include it in the product if they were given the option. In other words, their $WTP > \$50$. But by how much? The reverse is true for other customers who would not include the feature because their $WTP < \$50$. But again, by how much? First consider those who would reject the feature at \$50. They are implying that they value the feature at less than \$50. Thus we ask these respondents to do a second round BYO with this feature's price set at less than \$50 since little would be learned if this feature was priced more than \$50 in round two. In the absence of any other information about these rejecters other than that their WTP is between \$0 and \$50, it can be easily shown that the "binary chop" value of \$25 should be used for the feature's second round price. For those who accept the feature in round 2 at \$25, but who rejected it at \$50, then it can be inferred that their WTP is between \$25 and \$50. For round 3 we thus again compute the binary chop value of \$37.50 for these rejecters-accepters. If they accept at \$37.50 and we stop at round three, we estimate their WTP to be \$43.75, which is the midpoint between the rejected price of \$50 and the highest accepted price of \$37.50. For rejecters-accepters-rejecters, we estimate their WTP to be \$31.25. For those who accept the feature at \$50 in round 1, there isn't a natural upper bound to their WTP (like the natural \$0 for the lower bound), so one must be set arbitrarily. In our own work we typically set the upper bound at two times the cost, or \$100 in this example. Under this assumption the binary chop for first round accepters is \$75 and the process proceeds as above. Figure 1 illustrates this adaptive binary chop pricing process:

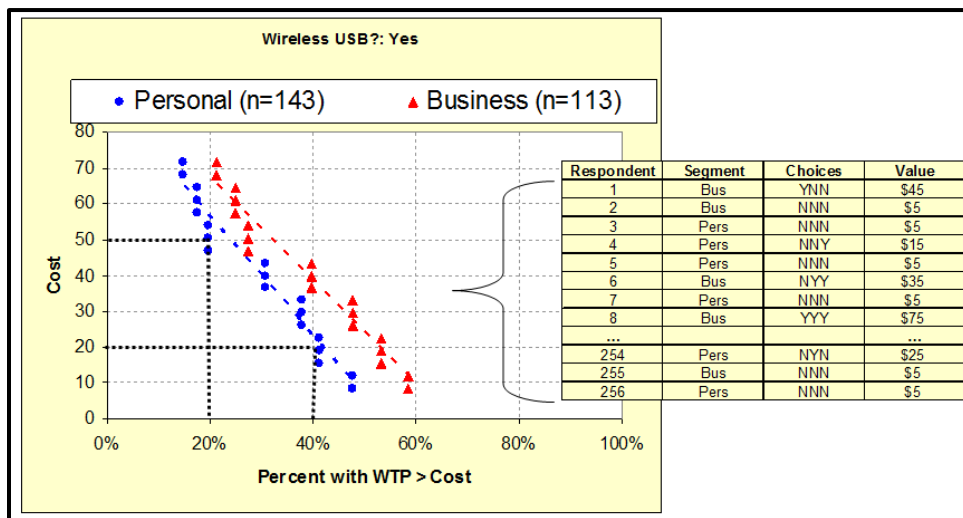
Figure 1 – ABYO Pricing for Binary Feature



With three BYO rounds using the binary chop adaptive pricing routine, each respondent’s WTP is estimated to be one of eight values between \$0 and \$100. (Instead of estimating the WTP at \$6.25 for someone who rejects the feature priced at \$50, \$25, and \$12, we typically set his WTP to \$0, as shown in the Figure 1.)

Aggregating survey results for groups of respondents, we can identify demand curves that display the normal downward slope. Feature price elasticity is easily estimated. Figure 2 shows an example of the demand curve for a Wireless USB from a printer study we completed several years ago using the binary chop BYO methodology. It is clear in the figure that a Wireless USB is more highly valued by business users than by personal users.

Figure 2 – ABYO Demand Curve for Binary Feature

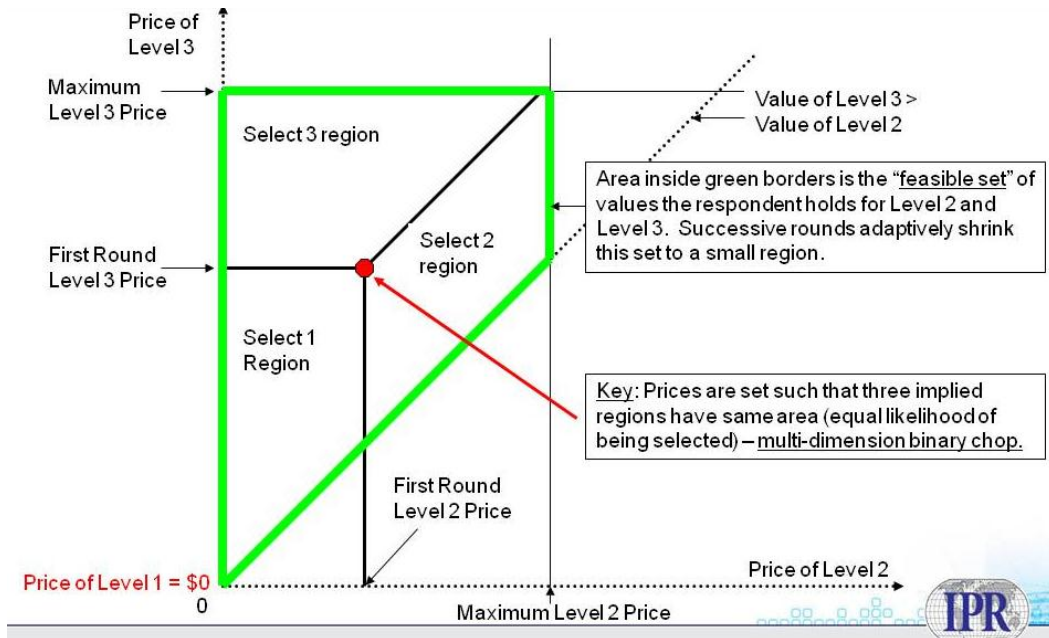


The More Complicated Case

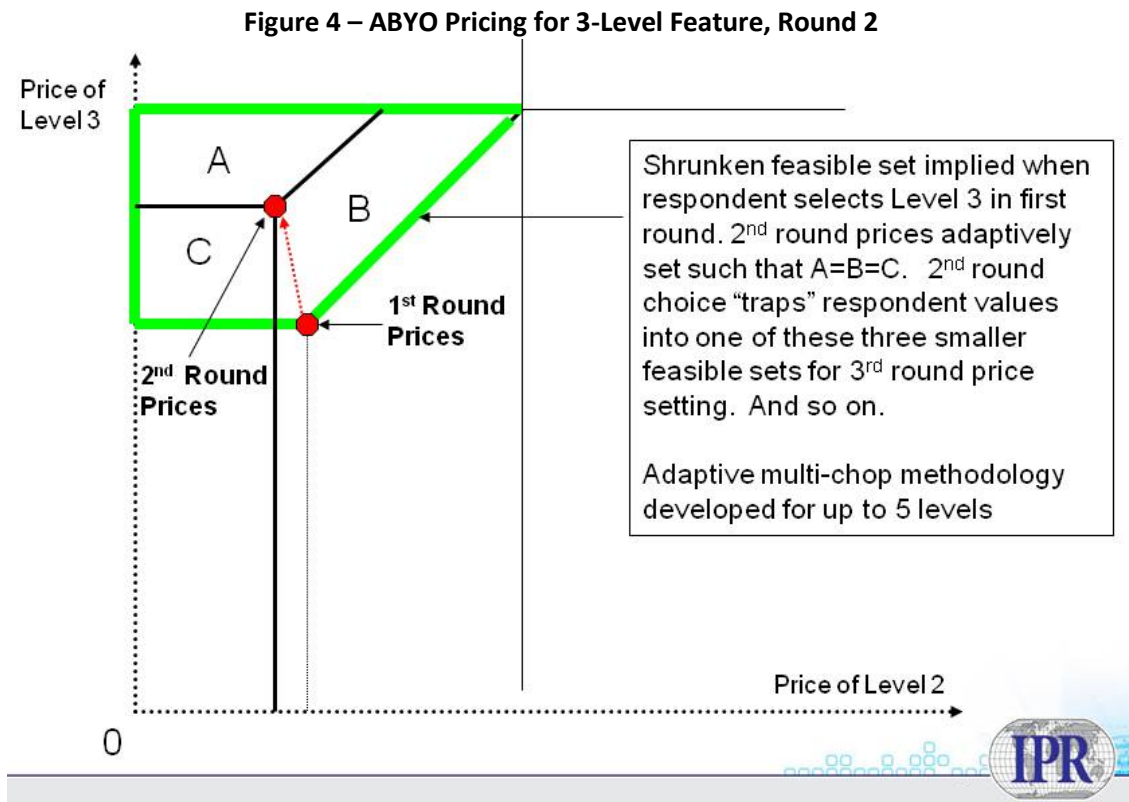
Aside from the setting of the arbitrary upper bound (\$100 in the above example), the adaptive process using the binary chop for include-exclude features is straightforward and easily understood by our clients of ABYO. Our adaptive methodology, which we call multi-chop, extends to features that have up to five naturally-ranked levels. (Below we discuss how levels that do not have a natural ranking from high to low can be handled.) For an intuitive understanding, we shall focus on a feature that has three levels: Level 1 (don't include), Level 2 (basic), and Level 3 (enhanced). Level 1 always has a value of \$0 and we assume that the value of Level 2 is less than the value of Level 3. We must specify the upper price bounds for Level 2 and Level 3. In the simple case described above, the binary chop always divides the remaining "playing field" in half. In this three-level example using multi-chop, the initial set of prices divides the feasible set of WTP pairs (WTP2, WTP3) into three equal-sized regions, as shown in Figure 3. The feasible set itself is the green trapezoid, bounded by the maximum values for the WTPs for Level 2 and Level 3, and the 45 degree line. Above the 45 degree line are all the pairs where $WTP3 > WTP2$, a requirement of the natural ranking of the levels.

The determination of the multi-chop red point in the chart depends on how the three regions are defined. We use microeconomic logic. Consider region 1. This would be the implied feasible set of WTPs if the respondent selected Level 1 in round 1. His choice implies that $WTP2 < P2(1)$ and $WTP3 < P3(1)$, where $P_i(j)$ is the price for Level i in round j . Consider region 3. This would be the implied feasible set if the respondent selected Level 3 in round 1: $WTP3 > P3(1)$ and $(WTP3 - P3(1)) > (WTP2 - P2(1))$. This latter inequality, shown in the diagram as the black 45 degree line extending northeast from the red initial price point, is slightly tricky. It says that the net value of Level 3 ($WTP3 - P3(1)$) is greater than the net value of Level 2 ($WTP2 - P2(1)$). The net value of both Levels 2 and 3 might both be positive, but Level 3 would be selected if it had the higher of the two positive net values. Finally, if Level 2 is selected, then we have $WTP2 > P2(1)$ and $(WTP3 - P3(1)) < (WTP2 - P2(1))$, shown as region 2. As with binary chop, if we have no information about where in the feasible set the WTP pair resides, the most efficient starting point is the one that results in the three regions having the same probability of resulting after the round 1 selection. In other words, round 1 pricing should be chosen such that areas of regions 1, 2, and 3 are equalized. The same logic holds more than three feature levels.

Figure 3 – ABYO Pricing for 3-Level Feature, Round 1



The second round process for multi-chop works in a similar manner. Once first round selections have been made, the feasible set has been shrunk. The second round prices are set so that the resulting three possible feasible set areas (A,B,C) are again equalized after the round 2 choice is made. Figure 4 is an example:



The adaptive multi-chop process continues for the third round of prices. If the survey stops at this point, the WTP values estimated for the respondents are the same as what the fourth round multi-chop prices would have been. When three BYO rounds are used in a study, the initial feasible set is divided into 27 (3^3) equal-sized regions containing the respondent’s implied WTP pair for Level 2 and Level 3. With four BYO rounds, there are 81 even smaller equal-sized regions that “trap” the WTP pair.

Dealing with Feature Levels that are not Naturally Ranked

The above methodology assumes that feature levels have a natural ranking that holds for all respondents. When this is not the case, we include a ranking task for the relevant features prior to the ABYO exercise. Figure 5 shows an example using brand. The first round prices shown in Figure 5 are computed using the multi-chop method described above and with each level value maximum assumed to be \$50.

Figure 5 – ABYO for Features without Natural Ranking

Before configuration rounds respondents were asked to rank brands:

Please rank the following multifunction printer brands in terms of your preference, where #1 is your most preferred brand and #6 is your least preferred brand?

6	Brother
1	Canon
2	Epson
3	Hewlett-Packard
4	Kodak
5	Lexmark

Most preferred choice (Canon) is shown as the most expensive brand, lowest ranked brand was dropped.

These rankings used to display brands in the configuration rounds:

Brand (More Info)	Price
<input type="radio"/> Lexmark	\$0
<input type="radio"/> Kodak	+\$10
<input type="radio"/> HP	+\$20
<input type="radio"/> Epson	+\$31
<input type="radio"/> Canon	+\$40

Figure 6 shows an illustration of adaptive pricing between rounds 1 and 2 for two 2-level features and one 4-level feature:

Figure 6 – ABYO Screen Example for Binary and Multiple Level Features

Round 1 selections	Round 2 – prices adjust to 1 st round choice
<p>CONNECTIVITY OPTIONS (WIRED USB INCLUDED)</p> <p>Wired Ethernet Only? (More Info)</p> <p><input type="radio"/> No \$0</p> <p><input checked="" type="radio"/> Yes +\$10</p> <hr/> <p>Wifi Ethernet? (More Info)</p> <p><input checked="" type="radio"/> No \$0</p> <p><input type="radio"/> Yes +\$20</p>	<p>CONNECTIVITY OPTIONS (WIRED USB INCLUDED)</p> <p>Wired Ethernet Only? (More Info)</p> <p><input type="radio"/> No \$0</p> <p><input type="radio"/> Yes +\$15 ↑</p> <hr/> <p>Wifi Ethernet? (More Info)</p> <p><input type="radio"/> No \$0</p> <p><input type="radio"/> Yes +\$10 ↓</p>
<p>How prices adjust with more than 2 options</p>	
<p>Print speeds for photo (More Info)</p> <p><input type="radio"/> 60 seconds \$0</p> <p><input type="radio"/> 40 seconds +\$4</p> <p><input checked="" type="radio"/> 20 seconds +\$11</p> <p><input type="radio"/> 10 seconds +\$26</p>	<p>Print speeds for photo (More Info)</p> <p><input type="radio"/> 60 seconds \$0</p> <p><input type="radio"/> 40 seconds +\$4</p> <p><input type="radio"/> 20 seconds +\$16 ↑</p> <p><input type="radio"/> 10 seconds +\$24 ↓</p>

ABYO Choice Screen

Many different configuration screens have been used for BYO. Figure 7 shows a sample of one of our screens. Sometimes we will ask the respondent what price range they plan to spend for their product and then either force them or encourage them to stay relatively close to this range as they configure their product.

Figure 7 – Sample ABYO Screen

Please carefully review each of the following components. Select an option for each component that best meets your needs.

PRINTING SPEED AND QUALITY

Prints speeds (black/color) for plain paper (More Info)

- 5 ppm \$0
- 10 ppm +\$4
- 20 ppm +\$10
- 30 ppm +\$19
- 40 ppm +\$40

Print speeds for photo (More Info)

- 60 seconds \$0
- 40 seconds +\$4
- 20 seconds +\$11
- 10 seconds ...

Print quality (More Info)

- Good Text with Good Photo
- Great Text with Good Photo
- Good Text with Great Photo
- Great Text with Great Photo +\$41

PRINTER FEATURES

Paper feed (More Info)

- Rear in only \$0
- Rear in and front in +\$4
- Front in only +\$12

Paper tray capacity (More Info)

- 50 pages \$0

Feature List

Feature	Base Price
Prints speeds (black/color) for plain paper (Go)	10 ppm +\$4
Print speeds for photo (Go)	20 seconds +\$11
Print quality (Go)	
Paper feed (Go)	
Paper tray capacity (Go)	
Automatic double-sided printing? (Go)	
Automatic document feeder (ADF)? (Go)	
Automatic double-sided copying? (Go)	
Dedicated photo paper tray? (Go)	
CD/DVD printing? (Go)	
Additional paper tray? (Go)	
Digital camera memory card slot? (Go)	
Digital-ICE photos (scratch / dust removal)? (Go)	
Legal size scanning? (Go)	
Fax included? (Go)	
LCD preview monitor size (Go)	
Touch screen for LCD? (Go)	
Wired Ethernet Only? (Go)	
Adjusted Price	\$90

Round: 1 of 3
Extra Cost -- Reduced Cost

Next Last

Move to Next Round

base price

configured price, constrained to be between \$150 and \$450

features to decide on

• Good text - general inkjet quality text that is less sharp than a laser printer;
 • Great text - crisp text comparable to a laser printer;
 • Good photo - quality similar to what you get from retail store, uses 4 ink colors;
 • Great photo - quality comparable to a professional photo lab, uses 6 ink colors

Three rounds with adapting costs, we have also used four rounds for more precision

Simulating Choice and the ABYO Simulator

IPR has conducted numerous surveys using the ABYO technique with sample sizes ranging from 150 to over 5000. The output is a database of willingness-to-pay values. That is, the adaptive aspect of the ABYO task enables us to calculate each respondent's WTP for each feature included in the study; these respondent-level values do not require the use of hierarchical Bayes or other complex methods. To summarize, the ABYO individual choice logic used to motivate the adaptive configuration screens is simple: the respondent selects the feature level with highest net value (WTP_i-P_i), including i=1. This same winner-take-all logic is used for the assumed choice between alternative product configurations. Figure 8 shows a hypothetical database of binary feature level WTPs for a group of respondents:

Figure 8 – ABYO Feature Value / WTP Database

Respondent WTPs: Derived from ABYO survey **B**

Respondent #	...					
	1	2	3	4	5	50
Feature 1	\$94	\$56	-	\$19	\$69	\$44
Feature 2	\$38	-	\$13	\$6	-	\$31
Feature 3	\$50	-	-	\$6	\$19	\$13
Feature 4	\$25	\$44	\$6	\$19	\$94	\$38
Feature 5	\$19	-	\$6	\$38	\$44	\$75
Feature 6	-	\$94	\$6	\$88	\$44	\$94
Feature 7	\$19	\$50	\$13	\$94	-	\$50
...						
Feature 23	\$6	-	\$19	\$19	-	\$38
Feature 24	\$75	\$50	-	\$88	\$44	\$75
Feature 25	\$69	-	-	\$94	\$25	\$81

And Figure 9 shows the choice logic for a respondent 1. He is assumed to sum up the values of the features in each of the two configurations and subtract their prices to obtain the net value of each. His assumed selection rule is as above: He selects the product with the highest net value (or selects “none” if both are negative).

Figure 9 – ABYO Assumed Individual Choice Logic

Individual Selection Logic: Respondent 1 C					
	WTP Derived from Survey	Configuration A		Configuration B	
		Features	WTPs	Features	WTPs
Feature 1	\$94	Include	\$94		-
Feature 2	\$38		-	Include	\$38
Feature 3	\$50		-	Include	\$50
Feature 4	\$25	Include	\$25	Include	\$25
Feature 5	\$19	Include	\$19		-
Feature 6	-		-	Include	-
Feature 7	\$19		-	Include	\$19
...					
Feature 23	\$6	Include	\$6		-
Feature 24	\$75		-	Include	\$75
Feature 25	\$69	Include	\$69		-
Gross Value (Sum of WTPs)			\$213		\$207
Price			\$79		\$179
Net Value (WTP less Price)			\$134		\$28
Choice (Highest Net Value*):		A			
* None, if both negative					

Finally, the aggregate simulator shown in Figure 10 is derived by summing the individual respondent choices. Respondents can be weighted, grouped into segments, etc.

Figure 10 – ABYO Aggregate Logic

IPR ABYO Simulator - 50 Respondents D							
		Configuration		None	Total	Input	
		A	B			Fixed Cost	Unit Cost
Feature 1	1	Include	1			\$100	\$3
Feature 2	1		1			\$150	\$3
Feature 3	1		1			\$75	\$3
Feature 4	1	Include	1			\$250	\$3
Feature 5	1	Include				\$300	\$3
Feature 6	1		1			\$100	\$3
Feature 7	1		1			\$200	\$3
...							
Feature 23	1	Include				\$75	\$3
Feature 24	1		1			\$500	\$3
Feature 25	1	Include				\$250	\$3
Prices		\$79	\$179				
Respondents Choosing:		27	19	4	50		
Share of Choice		54%	38%	8%	100%		
Revenue		\$2,133	\$3,401		\$5,534	<-Objective	
Fixed Cost		\$975	\$1,275		\$2,250		
Unit Cost		\$405	\$342		\$747		
Total Cost		\$1,380	\$1,617		\$2,997		
Profit		\$753	\$1,784		\$2,537	<- objective if costs included	
Optimization Problem: Find A and B Configurations and Prices that Maximizes Profit							

The simulator in Figure 10 is designed to help the producer determine the configurations and the prices of his two products, given fixed costs for the products and fixed and unit costs for the features. The objective is total profit. This is a difficult optimization problem since the objective function is non-smooth and the decision variables are both continuous (prices) and discrete (features). We have found that OptQuest, an optimization tool offered by OpTek Systems, Inc. is a powerful tool that is of great utility for complex ABYO problems that exceed the capabilities of Excel's Solver Add-In and even Frontline Systems Inc. licensed version of OptQuest, which we also use. We have extended this basic structure to include up to nine product configurations, a variety of constraints on the number of features in each configuration, price ranges, competition, and several other factors. Figure 11 is an example of an actual Excel-based ABYO simulator, with results disguised to protect our client:

Figure 11 – Example of ABYO Simulator

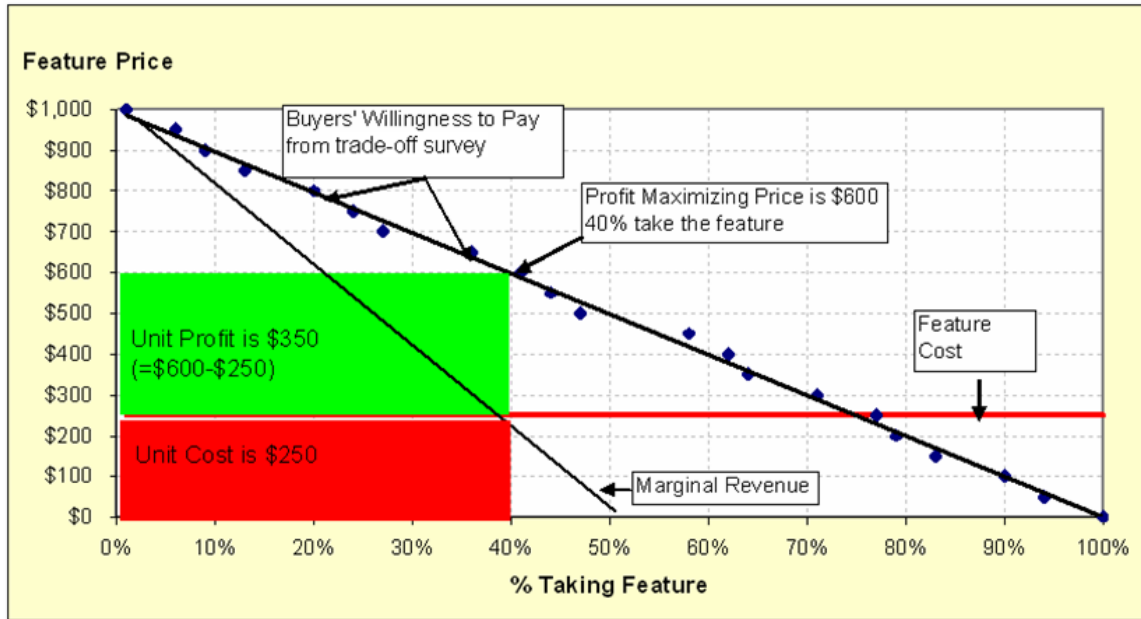
	A	B	C	D	E	F	G	H	I		
1	U.S. & Europe MFP Design Model										
2	Prepared by International Planning & Research			<input checked="" type="checkbox"/> US	<input checked="" type="checkbox"/> FR	<input checked="" type="checkbox"/> Personal	Click box to select scenario			<input type="radio"/> Unweighted	
3			<input checked="" type="checkbox"/> LK	<input checked="" type="checkbox"/> GR	<input checked="" type="checkbox"/> Business	Optimize No cost constraint	#1 Optimize	#3 Optimize Business	#5 Optimize Europe	#9 Optimize Eur. Bus	<input checked="" type="radio"/> Weighted
4	Feature	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6	None	Total		
5	Feature A	ppm	ppm	ppm	ppm	ppm	ppm				
6	Feature B	seconds	seconds	seconds	seconds	seconds	seconds				
7	Feature C	Good Text / Great Photo	Good Text / Good Photo	Great Text / Great Photo	Good Text / Great Photo	Great Text / Good Photo	Good Text / Good Photo				
8	Feature D	Front in only	Front in only	Rear in and front in	Front in only	Front in only	Rear in only				
9	Feature E	pages	pages	pages	pages	pages	pages				
10	Feature F	No	No	Yes	Yes	Yes	Yes				
11	Feature G	Yes, sheet capacity	Yes, sheet capacity	Yes, sheet capacity	Yes, sheet capacity	Yes, sheet capacity	No				
12	Feature H	No	No	Yes (requires ADF)	No	No	No				
13	Feature I	Yes, sheets	Yes, sheets	No	Yes, sheets	Yes, sheets	Yes, sheets				
17	Feature J	Yes	No	No	No	No	No				
18	Feature K	Yes (req. mem card slot)	Yes (req. mem card slot)	Yes (req. mem card slot)	Yes (req. mem card slot)	Yes (req. mem card slot)	Yes (req. mem card slot)				
19	Feature L	Yes	Yes	Yes	Yes	Yes	Yes				
24	Feature M	No	No	No	No	No	No				
25	Feature N	Yes	Yes	Yes	Yes	Yes	Yes				
26	Feature O	Yes, with 3.5" LCD	No, use buttons	No, use buttons	No, use buttons	No, use buttons	No, use buttons				
37	Feature P	No	Yes	No	No	No	No				
38	Brand										
39	Price	\$	\$	\$	\$	\$	\$				
40											
41	Number Selecting	22	126	165	402	78	6	242	1042		
42	Share	2%	12%	16%	39%	8%	1%	23%	100%		

Extensions

Most recently we have built a BYO option into the simulator itself. This allows us to simulate (and optimize) the product marketing decision that includes both fully configured products and a build-your-own option. Dell uses this hybrid selling model, for example. The customer faces a tradeoff between less expensive fully-configured models which don't exactly match his preferences vs. more expensive self-configured models.

Several years ago we developed another interesting application for ABYO in a study for a homebuilder, where the objective was to determine which options should be offered (countertop type, number of bathrooms, size of deck, etc.) and how should they be priced. This work, which we have subsequently learned is the focus of menu-based conjoint or MBC summarized by Bryan Orme (2010), is interesting because the home builder often doesn't reveal the price of the options to the buyer before the buyer has decided to purchase. Once the purchase decision has been made, the buyer must purchase the options exclusively from the builder if he wants to include the cost of the options in his mortgage. Thus the builder has some monopoly pricing power with respect to these options. We can estimate the price elasticity of each option. The prices for inelastic options relative to marginal costs should be higher than the prices of elastic options relative to their costs. Figure 12 shows a simple chart showing profit-maximizing option prices.

Figure 12 – Using ABYO to Maximize Feature Pricing



Summary

The trend toward incorporating BYO in choice research is understandable. Respondents appear to enjoy the technique, confirming Orme’s comment noted previously. This may be because they have more active involvement in revealing their preferences compared with fully configured product choice. At IPR, we don’t see the degradation in response quality like we do with monotonous conjoint or discrete choice screens. Using adaptive feature pricing techniques in ABYO results in estimates of feature level willingness to pay values that can easily be incorporated into simulators without complex estimation procedures. This survey-modeling structure has the advantage of being well understood by users of this technique. We have successfully completed projects with as many 40 features and over 100 feature levels.

Footnotes

1. Orme (2010) describe menu-based choice (MBC) research, a build-your-own approach that includes multiple rounds where feature prices are varied over a number of choice or “design” rounds. Unlike the adaptive approach described in this paper, the MBC rounds adhere to the non-adaptive experimental design standards used in CBC.
2. The adaptive build-your-own methodology described in this paper is in the same family as the adaptive technique described in Toubia et al. (2003). As opposed to the BYO approach discussed in this paper, Toubia et al. focused on the paired comparison method of preference revelation. The task they set for themselves is to solve for the optimal within-respondent adaptive paired comparison sequence that shrinks the feasible set of part-worths as rapidly as possible.

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