

Choosing the Right Warranty Policy – from the Customer’s to the Manufacturer’s Point of View

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Abstract—Product warranty is a powerful marketing tool, but it always involves additional costs to the manufacturer. This paper deals with the warranty cost analysis for one type of passenger car batteries. Costs were calculated for three variants of fully renewing combination free replacement and pro-rata policy and for different warranty parameters. After choosing the price range for the product, a market research was performed to determine which warranty policy customers recognize as most favourable to them. Obtained results are guideline for the manufacturer to choose the warranty that minimizes the costs and maximizes the profit.

Index Terms—Free replacement warranty, pro-rata warranty, cost analysis, market research.

I. INTRODUCTION

Product development risk increases more and more every day [1]. One of the factors that affect this risk is product warranty. It affects the costs to the manufacturer and also to the customer [2]. From the customer’s point of view warranty has two functions – protective and informative. Warranty performs its protective function by assuring the customer that faulty products will either be repaired or replaced at no cost or at a reduced cost. Informative function of warranty means that it indirectly gives the customer an information about the product quality. From the manufacturer’s point of view warranty also has two functions – protective and promotional. Protective function is reflected in warranty terms that specify the use of the product and limited coverage or no coverage at all in the case of product misuse. Promotional function from the manufacturer’s point of view is associated with the informative function from the customer’s point of view.

Warranty is one of the key factors in the customer’s decision-making process. When choosing between several products with similar characteristics, customer will usually buy the product that provides a better warranty. This led to the competition between manufacturers in offering the better warranty to attract more customers

Warranty itself is a part of product’s logistic support, the design of which is a very complex problem [3]. Huang et al. [4] developed the model for maximization of profit for a product sold with a free replacement warranty by optimal selection of warranty period, product price and reliability. Chun and Tang [5] studied optimization of warranty price based on the producer’s and customer’s risk preferences. Optimization of two-dimensional warranty was analysed by Manna et al. [6]. In this paper a fully renewing combination

free replacement and pro-rata warranty will be considered with the objective to find the optimal policy.

II. WARRANTY COST CALCULATION

Combination free replacement and pro-rata warranty (FRW/PRW) policy is often used as a compromise between the free replacement warranty (FRW) and the pro-rata warranty (PRW). This type of warranty is comprised of two periods – a period of free replacement followed by a period of pro-rata policy. The manufacturer agrees to replace the product with a new product at no cost to the customer if it fails before w' ($w' < w$) expires, where w is warranty period length and w' is free replacement period length. If a failure occurs in the time interval from w' to w the product is replaced by the manufacturer at a fraction of the replacement cost (pro-rata cost) to the customer. Such combination has a significant promotional value to the manufacturer and at the same time provides adequate cost control for both manufacturer and customer in most cases [7,8]. This type of combination warranty policy is usually offered with non-repairable products. A more comprehensive studies on the types of warranty policies can be found in [9,10].

Warranty analysis in this paper is done for one type of passenger car batteries. This type of batteries has been on the market for 16 years and the manufacturer wanted to launch the new warranty policy along with the start of a new marketing campaign. According to the collected data from a 16 year long exploitation it is determined that the life of this type of battery follows Weibull distribution with a shape parameter $\beta = 1.63$ and a scale parameter $\eta = 4380$ days. The price per battery unit excluding the warranty cost is $c' = 82$ €. It is assumed that every failure results in a warranty claim, all warranty claims are valid and all failures are statistically independent.

Warranty cost calculation is covered in detail in [11-13]. In this paper the pro-rata cost is a linear function of time. Replacement cost to the manufacturer at time t is calculated by the following equation [7], [8],

$$C(t) = \begin{cases} c, & 0 \leq t < w', \\ kc \left(1 - \delta \frac{t - w'}{w - w'} \right), & w' \leq t < w, \\ 0, & t \geq w, \end{cases} \quad (1)$$

where c is unit price after adding the warranty cost r ($c = c' + r$), k is proportionality coefficient of c , and δ is proportionality coefficient of time of failure in the warranty

interval. For $w' = 0$ FRW/PRW policy becomes PRW policy, and for $w' = w$ FRW/PRW policy becomes FRW policy. Warranty cost per unit to the manufacturer can be calculated using the following equation [14]:

$$r = \frac{c'A}{1 - A}, \tag{2}$$

where A is calculated by

$$A = \int_0^{w'} \frac{f(t)}{(1 - F(t))^2} dt + \int_{w'}^w k \left(1 - \delta \frac{t - w'}{w - w'} \right) \cdot \frac{f(t)}{(1 - F(t))^2} dt, \tag{3}$$

where $f(t)$ and $F(t)$ are (in this case, Weibull) probability density function and cumulative distribution function, respectively. Warranty costs were calculated for the warranty period length w ranging from 1 to 6 years and the free replacement period length w' ranging from 0 to w for three different policies: the first policy with proportionality coefficients $k = 1$ and $\delta = 1$, the second with $k = 0.5$ and $\delta = 1$, and finally, the third one with $k = 1$ and $\delta = 0.5$. Table I shows the calculated unit price values after adding the warranty cost for these three policy variants.

III. MARKET RESEARCH

Manufacturer wanted to place their product in a price range from 90.5 to 92.5 €. Five policies providing the unit prices in this range were chosen for the market research. Two additional policies, the first one with the corresponding price above 92.5 €, and the second one with the corresponding price below 90.5 € were chosen as the control policies. The research was conducted on 100 subjects. Each subject was given ten minutes to rank these seven policies using a scale from 1 (least favourable to the customer) to 7 (most favourable to the customer). Seven policies that were the subject of this research are shown in Fig. 1 through warranty cost to the manufacturer as a function of time based on (1). There was figure in the questionnaire that represented the cost to the customer in an analogous way. Table II shows the results of the market research.

Policy F was ranked as best by 51% of subjects, while 43% of subjects ranked policy C as best. This means that, when choosing between seven offered policies, 51% of subjects would buy a product with policy F, and 43% would choose the policy C. Not one subject ranked policy A as best. Policy G was marked by 69% of subjects as least favourable, while policy E got the same ranking from 21% of subjects. It is interesting that policies C and F got an equal mean rank although it is obvious that policy F is better for the customer than the policy C, since policy F is comprised of policy C with an additional pro-rata period. It is also interesting that 45% of subjects considered the policy C as better than the

policy F. If control policies F and G are excluded from the analysis, 76% of subjects considered the policy E as least favourable, while 82% of them ranked the policy C as most favourable. Mean rank for policies A, B and D is in the range from 3.87 to 4.13, while policies C and E stand out, the first with the mean rank of 6.06 and the second with 2.24. Mean rank for policy A is 4.13, and for the policy E it is 2.24, even though policy A is cheaper to the manufacturer than policy E.

TABLE I: UNIT PRICE VALUES IN € AFTER ADDING THE WARRANTY COST

		$k = 1, \delta = 1$					
w [years]	w' [years]						
	0	1	2	3	4	5	6
1	82.55	83.47					
2	83.74	84.98	86.81				
3	85.51	87.06	89.26	92.14			
4	87.87	89.80	92.43	95.83	100.19		
5	90.95	93.33	96.49	100.56	105.78	112.53	
6	94.92	97.85	101.71	106.66	113.05	121.39	132.55
		$k = 0.5, \delta = 1$					
w [years]	w' [years]						
	0	1	2	3	4	5	6
1	82.27	83.47					
2	83.47	84.21	86.81				
3	83.72	85.23	88.02	92.14			
4	84.83	86.52	89.53	93.95	100.19		
5	86.24	88.12	91.39	96.17	102.91	112.53	
6	87.99	90.09	93.67	98.87	106.23	116.79	132.55
		$k = 1, \delta = 0.5$					
w [years]	w' [years]						
	0	1	2	3	4	5	6
1	83.00	83.47					
2	85.25	85.88	86.89				
3	88.70	89.53	90.68	92.14			
4	93.63	94.71	96.15	97.96	100.19		
5	100.60	102.03	103.89	106.21	109.05	112.53	
6	110.62	112.59	115.10	118.21	122.03	126.73	132.55

IV. CONCLUDING REMARKS

The choice of product price and warranty policy has to be based on the manufacturer's market position and reputation. If the manufacturer is a market monopolist, the best strategy is to choose the highest product price and offer the longest warranty period which covers the entire product lifetime, but the competition in the market restricts the product price [16]. Also, high product warranty is favourable only to the manufacturer having high credibility [17]. After choosing the product price range, manufacturer has to define the warranty policy that provides product price in that range.

This paper presents an effort to determine what warranty policy that satisfies the price range condition customers find most favourable. Although the manufacturer had the idea of introducing the FRW/PRW policy or PRW policy as its variation, customers proved not to be ready for such policy. Customers' irrational fear of paying for the product replacement is noticeable. For example, those who preferred policy C to policy F did not considered the fact that after the

free replacement period, that is, the whole warranty C period ends they will have to pay the full price for the product replacement.

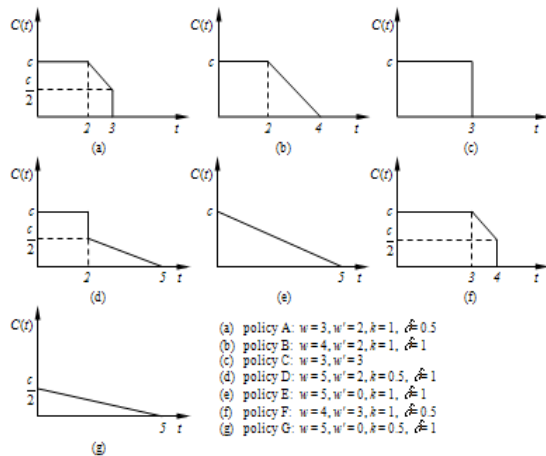


Fig. 1. Warranty cost to the manufacturer as a function of time for seven considered policies

The results of the conducted research indicate that the sole idea of paying for the replacement of a faulty product repels the majority of customers, regardless of the fact that in the end it can save their money. It must be emphasized that market research in this paper was conducted before any form of advertising campaign. Such campaign can be used to promote the FRW/PRW policy using the fact that, for the same warranty price to the manufacturer, warranty period of FRW/PRW policy is longer than that of FRW policy. However, advertising campaign and its effects are not in the scope of this paper.

This paper presented the importance of warranty returns prediction and marketing effects that choice of warranty policy can have, but most important, it pointed out current customers' point of view at warranty policies.

TABLE II: RANK FREQUENCIES, MEAN RANK AND UNIT PRICE VALUES FOR ALL SEVEN POLICIES

rank	policy						
	A	B	C	D	E	F	G
1	1	3	1	4	21	1	69
2	7	8	1	8	58	2	16
3	23	19	4	36	8	3	7
4	27	36	5	18	6	6	2
5	31	25	6	19	5	11	3
6	11	8	40	13	0	26	2
7	0	1	43	2	2	51	1
mean rank	4.13	4.00	6.06	3.87	2.24	6.06	1.64
c [€]	90.6 8	92.4 3	92.1 4	91.3 9	90.9 5	97.9 6	86.24

When it comes to FRW policy, customers express more anger in response to product failures that occur just after warranty expiration compared to product failures that occur later [18]. FRW/PRW policy could be used to avoid such negative effects since in this type of warranty policy there is no instant transition from free replacement to paying the full

price for the replacement, and such characteristic of this type of warranty policy is yet to be studied

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