5 A SHORT CHAPTER ON WEBER’S LAW AND FAIR PRICE THEORY – WHAT DO THEY SAY?

Researchers and marketers alike are interested in behavioral changes of consumers to marketing actions. For instance, what would be the reaction of consumers to a quantum of price increase? In this short chapter, we investigate the claim of Kamen and Toman (1970) of having found an exception to Weber-Fechner Law.

5.1 Introduction

Weber-Fechner’s Law predicts that for a given quantum of price change consumers would take action, such as reducing consumption or shifting to other products, when the price is low as opposed to high. Applying Weber-Fechner’s Law, a price increase of Rs. 5 is highly apparent for a product (say a liter of gasoline) worth Rs. 15; however, it may escape perception if the price increase is on a base of price of Rs. 125/- per liter. Consumers are more likely to take an effort of driving 20 minutes away to save $5 on a $15 item than if the same item costs $125 (Tversky and Kahneman, 1971).

On the other hand, Fair Price Theory of Kamen and Toman (1970) posits that consumers would take action such as shifting to another (cheaper) brand or reducing consumption when the price increase is inflicted when the price is high as opposed to low. For e.g., considering any possible price of gasoline (we take the same example, as in Kamen and Toman Study) between 15c and 40c, a consumer would shift to lower brands of fuel or reduce consumption when a price increase (say a cent) is on 40c than on 15c. In fact, Kamen and Toman claim rather boldly so “… ‘fair price’ theory […] is essentially contradictory to Weber’s Law. As price levels rise, a constant price differential between brands becomes more important, rather than less important, in determining market share” (Kamen and Toman, 1970, p 27) and is heralded as seminal work by several other researchers (e.g. Oliver and Swan, 1989a). This research article routinely appears in many later studies on PPU. We, therefore, assume that the Fair Price Theory is important and worthy of a detailed review. Is Kamen and Toman’s Fair Price Theory in contradiction to Weber-Fechner’s Law?
In this chapter, first we explain Weber’s Law and the Fair Price Theory keeping in mind the problem in hand and later move to explain the differences, if any.

5.2 Weber-Fechner Law

The Weber-Fechner Law (Fechner, 1860; Monroe, 1973) describes the relationship between the physical magnitudes of stimuli and perceived intensity of and thereby responses to the stimuli. Weber was one of the first to approach the study of human response to physical stimulus in a quantitative fashion. Fechner later provided a theoretical interpretation of Weber’s findings that he simply referred to as Weber’s Law. However, later studies refer to Weber’s Law as Weber-Fechner Law.

In one of the many experiments, Weber gradually increased the weight held by a blind-folded man with a request to inform whenever he felt a change in the weight. Weber found that the smallest noticeable difference in weight was proportional to the starting value of the weight. That is, if the weight was 1 kg, an increase in a few grams will not be noticed. Rather, when the weight is increased by a certain factor, an increase in weight is perceived. If the mass is doubled, the threshold called the ‘just noticeable difference’ (JND) also doubles.

Fechner suggests that it is not possible to directly measure subjective sensation; it is to be indirectly measured using differential increments. To determine the magnitude of a sensation Fechner assumed \( dp = JND \) and that the sensed differences, being all just noticeably different, were equal and constituted a proper unit (\( p = \) magnitude of perception). The Weber’s Law is:

\[
\frac{dS}{S} = k
\]

Equation 2

There are two interesting propositions possible from the above equation.

First, let us consider \( S \) to be \( S_i \), i.e. the initial value of the stimulus, and consider additionally \( S_n \), the next higher value of the stimulus (i.e. \( S_n > S_i \) and \( dS = S_n - S_i \)). In the above equation, let us replace \( dS \) by \( (S_n - S_i) \) and \( S \) by \( S_i \). By holding \( S_i \) constant and gradually increasing \( S_n \), there will be a certain value of \( S_n \) upon which an
individual will be able to correctly discriminate between $S_i$ and $S_n$. Then, $dS$ is this perceived difference between $S_i$ and $S_n$.

Second, holding $dS$ constant, if the magnitude of $S_i$ were increased then $k$ would drop in value. Consequently, an individual will be unable to continue discriminating between $S_i$ and $S_n$.

Further, if the equation (2) is true, then it must also hold for any small increment of $p$. Therefore, $dp$:

$$dp = k \frac{dS}{S} \quad \text{Equation 3}$$

where, $dp$ is the differential change in perception, $dS$ is the differential increase in the Stimulus and $S$ is the stimulus at the starting point. ‘$k$’ is determined experimentally.

Integrating equation (2):

$$p = k \ln S + C \quad \text{Equation 4}$$

where, $C$ is the constant of integration and $\ln$ is the natural logarithm; the complete derivation of this function is in Monroe, 1973.

To determine $C$, substitute $p = 0$ or no perception, then,

$$C = -k \ln S_0 \quad \text{Equation 5}$$

where, $S_0$ is the threshold of stimulus below which there is no perception at all.

Therefore, equation (3) becomes

$$p = k \ln \frac{S}{S_0} \quad \text{Equation 6}$$

The relation between perception and stimulus is logarithmic. This relationship implies that as the stimulus varies in a geometric progression, the perception varies in
arithmetic progression. For instance, if the price is tripled (i.e., 3 x 1), the subjective perception of price (say, expensiveness) may double (i.e., 1 + 1). Again, if the price is tripled (i.e., 3x3x1), the corresponding perception may only be three times as the original value (i.e., 1 + 1+ 1). That is for multiplication of stimulus strengths, the perception only adds. Possibly, at higher values of a stimulus, a much greater differential threshold is required for perception.

Price perceptions have been known to be analogous40 to perceptual phenomena relating sensory processes to physical stimuli (Monroe, 1973; Monroe and Petrosious, 1981; Mete, B.S., 1993). The perceptual phenomena that is often seen such analogous applications are the absolute and differential thresholds. Between two thresholds – one the lower and the other the upper is the set of stimuli for which there is no response. Within the stimulus set in which responsiveness occurs the differential threshold is the minimum amount of change in a stimulus necessary to produce “just noticeable difference” or JND.

That consumers have lower and upper price thresholds within which responsiveness does not differ is empirically affirmed (Gabor and Granger, 1964). Such range may be different for different products (Fouilhe, 1970) and within a product may vary across income and social class of consumers (Sherif, 1963; Mete B.S, 1993).

According to Monroe, 1973, even in a pricing scenario, in judging differences over two levels of price, Weber-Fechner Law holds only over limited ranges. When prices approach the lower threshold, K may become considerably higher, and it also may increase for high prices. Equation (3) provides a means of experimentally determining the absolute threshold because a least squares regression relating p to logS can be fitted from data (Mete, B.S., 1993). Then the threshold is operationally defined as the stimulus value with a probability of producing a response 50% of the time (Monroe, 1973). That is, the relationship between the price and an operationally defined response is logarithmic.

Weber Fechner Law has often been cited as basis for inferences about perceived price differences (Miller, 1962; Webb, 1961 and more recently, Mete, 1993). Just as K

40 It is only ‘analogous’. There is till date no valid test of the applicability of Weber-Fechner Law to pricing; it is possible to contend that any price difference is noticeable and is in fact more in the domain of judgment and cognition, than in the domain of psychophysics.
varies over different physical stimuli and as stimuli approach minimal or high intensity, so does K vary over different products (similarly priced) (Monroe, 1973, Mete, 1993), and over divergent price levels.

Uhl (1970) postulates that perception of retail price change is a function of the magnitude of the price change. In equation (2) above, the foregoing statement refers to the magnitude of dS. In the Uhl, 1970 study, consumers correctly identified 74% of the experimentally manipulated price changes. Within that study, 5% deviations were identified 64% of the time and 15% deviations 84% of the time – leading to an inference that the larger price changes exceeded the differential price thresholds of greater numbers of respondents. Uhl, 1970 (and also Pessimier, 1961) also discovered that while perception of price changes was independent of their direction, the dominance of reaction thresholds made respondents more sensitive to price increases.

If we extend the Weber Fechner Law into a pricing scenario, a price increase of, say Rs. 5 may be perceived on a base price of Rs. 15; however, the same increase of Rs. 5 on a base of price of Rs. 125/- may escape perception\(^{41}\).

However, Kamen and Toman (1970) seem to disagree.

### 5.3 Fair Price Theory

Kamen and Toman (1970) posit a “fair price” theory, according to which consumers have some preconceived ideas about what is a fair price for a given item, and are willing to pay this price or below. That is, a fair price is the maximum price that the consumer is willing to pay\(^{42}\). When the price exceeds this amount, they become motivated to maintain it and may take any one of many courses of actions, such as move to a lesser known brand with lower price or reduce consumption. Their study is in a setting of gasoline prices of 1960’s.

In 1960’s, it appears there were two types of marketers existed in the gasoline industry: large integrated firms (referred to as Majors) and several hundred local and

\(^{41}\) It is the magnitude of the change that is of importance here. It may be confused with percentage of change. For instance, a 15% change on Rs. 125 may be perceived and a 15% change on Rs. 15 may escape perception. See Uhl, 1970 for further discussion.

\(^{42}\) Several studies operationalize the maximum price that the consumer is willing to pay for a product as the “reservation price” (e.g. Garbarino and Slonim, 2003). Fair price is usually near the lowest of the observed prices (e.g. Garbarino and Slonim, 2003; KKT, 1986a).
regional marketers (referred to as Independents) which typically charge less per gallon than others. The modal price difference between Majors and Independence is 4 cents. According to “fair price” theory, as the price of Major brand of gasoline exceeds the perceived fair price, more and more motorists will turn to the Independents. To explain further, suppose that the price difference between Majors and Independents is two cents. Fair price theory would predict that when the price of gasoline is high – for example 42 cents for Majors and 40 cents for Independents – more people would be attracted to the Independents than when the price of gasoline is low – for example, 28 cents for Majors and 26 cents for Independents. “This prediction is exactly opposite to the one inferable from Weber’s Law” (Kamen and Toman, 1970, p28).

It is important that we describe the survey / experiment conducted by Kamen and Toman in some detail to understand the maximal predictions possible from the study.

In a pilot survey that used 36 pairs of prices representing all possible combinations of six absolute price levels (for Independents) and six Major-Independent differentials:

Price levels: 15c, 20c, 25c, 30c, 35c, 40c

Price Differentials: 1c, 2c, 3c, 4c, 5c, 6c.

Each respondent was asked to consider a set of 18 pairs (from the total set of 36 pairs) and for each pair of prices (e.g. “Major Brand – 33 cents; Independent Brand – 30 cents”) the respondent to indicate whether and to what extent they would be inclined to purchase gasoline at the prices stated from a Major Independent. The rating categories and weight were:

<table>
<thead>
<tr>
<th>Rating Category</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely buy at Major</td>
<td>1</td>
</tr>
<tr>
<td>Probably buy at Major</td>
<td>2</td>
</tr>
<tr>
<td>Inclined to buy at Major</td>
<td>3</td>
</tr>
<tr>
<td>Undecided</td>
<td>4</td>
</tr>
<tr>
<td>Inclined to buy at Independent</td>
<td>5</td>
</tr>
<tr>
<td>Probably buy at Independent</td>
<td>6</td>
</tr>
<tr>
<td>Definitely but at Independent</td>
<td>7</td>
</tr>
</tbody>
</table>

Respondents were asked to think of the Major and Independent brands they use and buy most often, or if they buy no such brand(s), the brand(s) they know best. They were also asked to consider the prices in relations to the gasoline grade they most often use. It is noteworthy that there are, if the questionnaire was filled accurately and
completely, 18 responses per respondent. Questionnaires were mailed to 1400 respondents randomly drawn from a telephone directory. 15% did not own automobiles, leaving an effective sample size of 1,190. Approximately, 40 were returned by the Post Office as undeliverable to further reduce the size to 1,150. From a total of 352 respondents who did return the questionnaires, 133 were eliminated. 48 because one or questionnaire items were incomplete, and 85 because they gave identical ratings for all the price combinations, i.e. they said they would at a Major or Independent brand regardless of the price variables. The analysis is based on 219 respondents. A regression analysis revealed three significant effects: absolute Price, Price Differential and interaction between Price and Price Differential, with a high r-square of 0.864. The equation is as follows:

\[
\text{Intention} = 4.15P + 54.66D + 68.30PD - 2.75P^2 - 702.74D^2
\]

Equation 7

In the above equation in the Kamen and Toman study (1970) has no constant. The equation is only for Regular Grade Gasoline users. There is a similar equation for Premium Grade users. The \(P^2\) and \(D^2\) stand for squared values of \(P\) and \(D\) since the researchers assume Price and Price Difference may have quadratic relationship with responses.

The inference by the researchers is that as the price level of gasoline goes up, inclination to buy at Majors goes down. The significant interaction between Price and Price Difference indicates that as the price differential increased from 1c to 6c, the price level becomes more important in determining intentions. The pilot survey was followed up with a longer and more detailed study with similar prediction.

The primary inference of the researchers is that as price increases beyond a certain point, the point the researchers call as the “fair price”, any price increase appears a burden just as the proverbial last straw on the camels back, and the consumers switch. And they conclude “It seems clear, then, that Weber’s Law is not operating and that the “fair price” theory is tenable.” (Kamen and Toman, 1970, p31).
5.4 Reconciling the seeming contradictions

While we agree with Kamen and Toman’s inference that consumers do indeed profess intentions to shift to lower priced Independents when the price goes beyond a certain “fair price”, we do not agree to the researchers’ claim that they indeed have found an exception to Weber’s Law.

Before commencing the reconciliation of the predictions between Weber-Fechner Law and Fair Price Theory, we briefly recap the three essentials of Weber-Fechner Law that is relevant for reconciliation of the findings:

First is the law itself:

\[ \frac{dS}{S} = k \]  

Equation 8

Second is the set of two propositions:

1. Let us consider S to be \( S_i \), i.e. the initial value of the stimulus, and consider additionally \( S_n \), the next higher value of the stimulus (i.e. \( S_n > S_i \) and \( dS = S_n - S_i \)). In the above equation, let us replace \( dS \) by \( (S_n - S_i) \) and \( S \) by \( S_i \). By holding \( S_i \) constant and gradually increasing \( S_n \), there will be a certain value of \( S_n \) upon which an individual will be able to correctly discriminate between \( S_i \) and \( S_n \). Then, \( dS \) is this perceived difference between \( S_i \) and \( S_n \).

2. Holding \( dS \) constant, if the magnitude of \( S_i \) were increased then \( k \) would drop in value. Consequently, an individual will be unable to continue discriminating between \( S_i \) and \( S_n \).

Third is the set of two major conclusions:

1. The subjective price scale of the buyer follows logarithmic scale

2. There exists a range of acceptable prices

We now proceed to reconcile the findings. One may take care to remember that Major is a higher priced alternative than Independent.
Kamen and Toman’s (1970) study deals with prices of gasoline that has a range of plausible prices from 15c to 40c. The study does not specify whether such prices are currently prevalent or they are prices generally prevalent over a period of time. The authors do indicate that the price range has been elicited from a “period of high turbulence in gasoline pricing” (p 27). Possibly the consumer’s IRP is a band that comprises just this range. Consequently, in line with the second conclusion above, one may argue that the range of acceptable prices, i.e. the lower and the upper threshold of gasoline prices is indeed 15c and 40c respectively; consumers do have a range of acceptable prices (Gabor and Granger, 1964). Therefore, in line with Weber Fechner Law, any price change within this band may evoke no change in response while a price above the upper band of 40c may evoke a change in perception. In this sense, the conclusions of Kamen and Toman, that consumers would probably change response when the price change is inflicted when the price is higher than lower is indeed in line with Weber Fechner Law.

But, one may argue that it is difficult to consider a range of price from 15c to 40c is the threshold for gasoline. Recall, in Uhl’s (1970) study, respondents identified 74% of the price deviations, and within that study, 64% identified a 5% deviation correctly and 15% of the deviations 84% of the time. In most studies in pricing literature concerning Weber-Fechner Law, the differential thresholds are indeed small. Then, the issue is how exactly is Weber Fechner Law should be applied to data of Kamen and Toman?

Recall the core finding of Kamen and Toman (1970). According to “fair price” theory, as the price of Major brand of gasoline exceeds the perceived fair price, more and more motorists will turn to the Independents. To explain further, suppose that the price difference between Majors and Independents is two cents. Fair price theory would predict that when the price of gasoline is high – for example 42 cents for Majors and 40 cents for Independents – more people would be attracted to the Independents than when the price of gasoline is low – for example, 28 cents for Majors and 26 cents for Independents.

The example of Kamen and Toman (1970) is similar to the proposition 2 (in page 119). That is, the dS is held constant at 2c and Si is increased from 26c to
40c. If the 2c difference is assumed to produce the JND at 26c, then in line with Weber-Fechner Law, an individual may well be unable to discriminate, based on price, between Major and Independent at prices 42c and 40c respectively. On the basis of Weber-Fechner Law, as price level increases for a given price differential (say 2c), the proportion of consumers who will differentiate between the prices of Major and Independent ought to reduce.

Then the question remains, how have consumers (as per Fair Price Theory) have been able to prefer the lower priced Independent? Perhaps such preference is based on some other variable other than price.

3. Monroe, (1971) provides a framework in which price may be used as a measure of quality. Use of price as a measure of quality leads to an assumption of a positive price-demand relationship\(^{43}\). That is, given a price differential, provided all other aspects remaining constant, a higher-priced alternative may be preferred by the consumer. For a constant price differential of say 2c, as price levels increases, proportionately fewer consumers will be discriminate between prices of Major and Independent and prefer Major (which is higher-priced when compared to Independent).

In a positive price-demand relationship, one may assume a constant proportion of a set of consumers who will prefer the higher-priced alternative (i.e. the Major) and the rest will prefer the lower-priced alternative (i.e. the Independent). Some of the relevant notations are:

Let:

- \( J_i \) be the proportion of consumers that perceives a difference in the price at \( i \)th level of price (\( i = 1,2,3,\ldots,n \))

- \( K_i \) be the proportion of consumers that does not perceive a difference in the price at \( i \)th level of price; \( J_i + K_i = 1 \)

\(^{43}\) Price can also be a measure of cost. Then an inverse price-demand relationship is valid.
r be the constant proportion not perceiving a difference in the price at the \(i\)th level of price and choosing a low-priced alternative, i.e. the Independent.

(1-r) is the constant proportion not perceiving a difference in the price at the \(i\)th level of price and choosing a high-priced alternative, i.e. the Major.

As the price level goes up, in line with Weber Fechner Law, the proportion of consumers that perceived a difference in the price will reduce. Therefore, \(J_1 > J_2 > J_3 > \ldots > J_n\).

At the lowest level of price, the total proportion choosing high-priced alternative, i.e. the Major, is \(J_1 + (1-r)K_1\) and the total proportion choosing the low-priced alternative, i.e. the Independent, is \(rK_1\).

At the highest level of price, the total proportion choosing the Major is \(J_n + (1-r)K_n\) and the total proportion choosing the Independent is \(rK_n\).

Since \(K_1 < K_2 < K_3 < \ldots < K_n\), \(rK_n > rK_1\). That is, if Weber Fechner Law and a positive price-demand relationship due to quality where applicable then as the price level increases, for a constant price differential, more and more consumers will select Independent.

That is, if the both Weber Fechner Law and Fair Price Theory are to be correctly applied to the case in hand, then it can be done only if a positive price-demand or price-quality relationship is assumed. That is, consumers are inferring more quality from increasing price.

We now list some of the other aspects of the Kamen and Toman (1970) study that may be worth consideration:

1. One has to bring to attention the fact that Kamen and Toman (1970) test for preference for different price levels and price differences; Weber Fechner Law is a test of discriminability between two intensities of a stimulus.
2. Even though they do not state so, Kamen and Toman (1970) test for an inverse price-demand relationship. It has to be noted here that the results support a positive price-quality relationship.

3. Clearly, the data points of dependent variable are not independent of each other, for, each respondent provides 18 responses to the same dependent variable for each of the 18 pairs of Major-Independent combinations.

4. Total set of valid responses used in the pilot study are 219. 85 were discarded because the respondents said “they would buy at Major or Independent brand regardless of the price variables.” (p29). Perhaps this is clearly an indication of the brand power which comprises perceived quality. Thus there is some evidence even in the study to point to a positive price-quality relationship.

To conclude, we do not consider that Kamen and Toman study is a valid test of Weber Fechner Law. They test preferences and Weber Fechner Law is about discriminability. Further, Kamen and Toman have found no exception to Weber Fechner Law. The data and inference from Kamen and Toman supports Weber-Fechner Law if a positive price-quality relationship is assumed. There are pointers in the Kamen and Toman study that quality, by way of brand loyalty, is at play (though the authors have not chosen to include the variable in the study).