ESTIMATING AND FORECASTING DEMAND

Alternative methods of estimation are considered and the problems associated with each one considered. Attention is then directed to forecasting methods, including time series and market research techniques.

METHODS OF ESTIMATION

It is clear that in principle the concepts of the demand curve and elasticity of demand are potentially of great importance for the purpose of business decision making. However, the theoretical concepts can only be of practical application if reliable quantitative estimates can be made of the level of demand and elasticity. The most fundamental distinction is between ESTIMATION, which attempts to quantify the links between the level of demand and other variables that determine it, and FORECASTING which attempts to predict the level of demand at some future date.

a) Simple estimation of arc elasticity

One of the crudest ways in which the market elasticity of demand could be estimated is by observing the quantity of a product sold before and after a price change and assuming that the two known combinations of price and quantity are points on the same demand curve. In figure below for example, if 100 units of output were sold at a price of $8 (point A) and 120 units were sold when the price fell to $6 (point B), then the elasticity of demand can be directly estimated from the standard formula.

\[ PED = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q} \]

It advantage lies in the fact that it is very simple and estimates can be made on the basis of a single price change. The disadvantage is that adjustments have to be made to compensate for speculative building up or running down of stocks in anticipation of a price change. There is no guarantee that the two-price/output combinations which are observed lie on the same demand curve. It could quite be the case that both demand and supply curves shifted in the movement from A to B.
b) **Econometric estimation**  
The second more sophisticated approach to demand estimation is through **econometrics** (the statistical analysis of economic data using techniques like simple linear regression and multiple regression which allow empirical data on demand and its determinants to be used to estimate the coefficients of a demand function).

The general form of the demand function has to be set out as:

\[ Q^d = f(P) \]

\[ Q^d = f(P_0, P_c, P_s, Y_d, T, A_0, A_c, A_s, I, C, E) \]

In this general form the equation simply states that the quantity demanded is a function of each of the determinants, without specifying any form for the relationship between the dependant variable \( Q^d \) and the independent variables \( P_0, P_c, P_s \ldots \)

If the coefficients linking the various variables with the level of demand are to be estimated a particular functional form needs to be chosen. The most common forms are the Linear Demand Function and the Exponential Demand Function.
The linear demand function can be written as follows:

\[ Q^d = a + b_1P_0 + b_2P_c + b_3P_s + b_4Y_d + b_5T + b_6A_0 + b_7A_c + b_8A_s + b_9I + b_{10}C + b_{11}E \]

If the data is available on each of the variables, and there are sufficient observations to apply the statistical technique of multiple regression then the coefficient for the intercept (a) and the coefficients showing the impact of each determinant upon the quantity demanded (b_1 to b_{11}) can be estimated. Once they have been estimated it is possible to predict the level of demand for any set of values for each of the determinants by simply inserting these values into the equation.

In the case of the linear specification of the demand curve, estimating the coefficients of the demand function does not provide a direct estimate of the elasticity of demand. Nevertheless, it is a simple process to calculate the elasticities. The definition of own price elasticity of demand can be written as:

\[ PED = \frac{\frac{dQ}{dP} \times P}{Q} \]

However, it can be seen from the demand function that:

\[ \frac{dQ}{dP} = b_1 \text{ so that } PED = b_1 \frac{P}{Q} \]

Other elasticities, including the income elasticity of demand, cross price elasticity and advertising elasticity can be calculated in the same way.

The linear specification of the demand function allows the estimation of elasticity and own price elasticity which is calculated as a result does change with different combinations of price and quantity, as is expected. However the linear form embodies the assumption that a given change in price always have the same effect on volume regardless of the level of price. In other words this means that the marginal impact of price on volume is CONSTANT. This assumption conflicts with most economic reasoning, including theories of consumer behaviour, so that alternative specifications are often used in attempting to estimate demand.
The most popular alternative to the linear form is the EXPONENTIAL FORM, which may be written as:

\[ Q^d = P_0^a P_s^b P_c^c A_0^d A_s^e A_c^f Y_d^g I^h C^i E^j \]

In this form elasticities are the exponents (the coefficients “a” to “j”) and the equation can be rewritten in linear form by taking logarithms. This gives the equation:

\[ \log Q^d = a \log P_0 + b \log P_s + c \log P_c + d \log A_0 + e \log A_s + f \log A_c + g \log Y_d + h \log I + i \log C + j \log E. \]

This equation can be estimated using the methods of multiple regression, giving direct estimates of various elasticities of demand. This is the most commonly used form of the demand function for the purposes of estimation, although it should be noted that it embodies a assumption that elasticities are constant.
STATISTICAL PROBLEMS INVOLVED IN ARRIVING AT ESTIMATES

A detailed treatment of them lies beyond the scope of what you are supposed to know, but it is useful to note them briefly.

- The method of multiple regression does not provide an exact relationship between the level of demand and each of its determinants. It simply shows the relationship that has the "best fit" to the data. In some cases that "best fit" may be very poor, in which case the equation specified explains only a small proportion of the variation in the level of demand. If this is the case, the equation will have very little value in estimating and predicting the level of demand.
- Errors of measurement
- Misspecification of the model
- The estimated values of the coefficients in the demand function are only good estimates known as Best Linear Unbiased Estimators (BLUE) if a number of quite restrictive assumptions about the behaviour of the error term (the difference between the estimate of the level of demand given by the equation and the actual value) are valid. If they are not then various corrections will need to be made, non of which are entirely satisfactory.
- There is what is known as the identification problem. If statisticians have collected a number of observations on the price of a commodity, over time, and the level of demand at each price, it is tempting to conclude that the line which provides the best fit to this set of observations is the demand curve. In figure below such a line is shown as ABC.
The portion of the demand curve between A and C is identified through shifts in the supply curve.

If $Q^d = f(P, Y, r)$ and $Q^s = f(P, Y, r)$ when we estimate the demand function we do not know whether we have estimated the demand function or the supply function as they are both explained by the same variables.
If both the supply and demand functions shift simultaneously nothing is identified.

However, such a set of observations could have arisen in a number of different ways. Certainly, if it is known that the demand curve remained in the same position (indicating that none of the factors other than price changed over the period of observation) but the supply curve shifted then the points traced out would identify the demand curve. On the other hand the same set of points could have been generated by both the demand curve and the supply curve shifting, as in the second figure above in which case the line ABC does not represent the demand curve at all. It is helpful when considering this point to appreciate that if neither the demand curve nor the supply curve shifted over the period of observation, the set of data recorded would consist of multiple observations of a single point on the diagram, P and Q remaining the same at every observation.

**Solution:** The identification problem can be solved, subject to a range of qualifications, but the solution is quite complex and requires the estimation of a model made of a number of simultaneous equations (a system of equations), rather than single equations for demand.

**FORECASTING DEMAND**
The methods discussed above build upon a theoretical model of market demand and the demand curve in order to estimate the way in which demand will respond to changes in price. The aim of such procedures is to quantify the causal links between the level of demand and its determinants.
A) **EXTRAPOLATION**

One of the simplest techniques is to assume that some aspect of past behaviour of the variable being forecast will continue to be true in future, thereby providing the basis for the prediction. At its most elementary this includes **NAÏVE METHODS** of forecasting such as the assumption that next year’s volume of sales will be equal to this year’s figure, or that next year’s growth of sales will be equal to this year’s. A slightly more sophisticated version is to identify any trends over the recent past and then extrapolate those trends forward into the future. Figure below illustrates the procedure.

Scatter points in the figure below shows the level of sales in recent time periods, and the solid line is that which provides the **BEST FIT** to those points, fitted either by the eye or by simple linear regression. The extension of that relationship into the future, marked by the dotted line, provides the forecast of sales levels for future periods. The major weakness of such methods is that they make no reference to the causal factors which determine the volume of demand, in effect assuming that time is the only determining factor which needs to be taken into account. They also assume that the relationship between time and the variable being forecast is a very simple one consisting only of a long term trend.

![Graph of Forecasting by Extrapolation](image-url)
B. **TIME SERIES ANALYSIS**

**A more sophisticated type of extrapolation is TIME SERIES ANALYSIS**, which includes a wide range of different techniques. Perhaps the best known of these techniques is the **DECOMPOSITION METHOD**. In this approach it is assumed that any time series is made up of a series of components.

- The trend (T) showing the long run changes in the variable being considered.
- Seasonal movements (S) within each year.
- Irregular movement (I) – which consists of non recurring and essentially unpredictable changes
- The textbooks usually include a fourth component consisting of **CYCLICAL MOVEMENT (C)** made up or regular contractions and expansions over periods of a few years, but the practical value of this component is much more doubtful. Its not clear whether industries really are subject to regular cyclical movements and isolating such movements from the data can involve making arbitrary judgments. It may take an economy more than 10 years to experience a downturn. So this component may not be relevant when making forecasts on an annual basis.

Whichever model is adopted, each individual observation is assumed to be made up of these components, which may be linked additively, in which case:

$$X_t = T_t + C_t + S_t + I_t$$

Where

- $X_t$ = the observation for period $t$
- $T_t$ = the trend value for period $t$
- $C_t$ = the cyclical component for period $t$
- $S_t$ = the seasonal component for period $t$
- $I_t$ = the irregular component for period $t$

Alternatively the relationship between the components could be multiplicative in which case:

$$X_t = T_t \cdot C_t \cdot S_t \cdot I_t$$

In order to use time series analysis for forecasting the raw data are divided up into their constituent components in a number of stages. This can be done in may different ways but a simple example can illustrate the basic features. In this example a cyclical component is
not included for the reasons outlined above. First the trend factor in the data is isolated, either by taking a moving average of the raw data or by fitting a straight line to the raw data by using regression analysis. The new time series that results represents the effects of the trend. If the resulting value for each time period is subtracted from the actual observation the differences represent the seasonal and irregular components taken together.

In order to separate out the seasonal components alone an average is taken of these “seasonal – plus – irregular” components for each season of the year, across the full period for which data are available. As the irregular component for each season is thereby averaged out, the results provide the seasonal component, giving the value for each season. As the seasonal components should add to zero, some adjustments of the result may be needed.

Once the trend and the seasonal components have been identified, the construction of a forecast for any future period consists of using the regression equation to calculate the trend value for the future period in question and adding in the seasonal component for the season in question.

C  BAROMETRIC FORECASTING TECHNIQUES

Time series analysis uses information about the past in order to make forecasts of the future. Barometric forecasting uses indicators of current activity in order to provide forecasts of the future. Perhaps the most common barometric technique is the use of LEADING INDICATORS. A leading indicator is a variable which known or believed to be correlated with the future behaviour of the variable for which a forecast is required. For example, if we wish to forecast the number of children who will be entering school for the first time in six years time in Zimbabwe the number of children born this year will provide a very useful leading indicator. In that example the connection between the leading indicator and the variable being forecast is very close indeed. In other cases there may be no obvious link between the indicator and the variable being forecast.

Given the importance to businessmen of being able to predict the general movements in the level of economic activity, there are a number of leading indicators that are used in the attempt to identify changes in total spending, income and employment. A number of such general indicators used are:
• New orders for machine tools
• Average hours worked in manufacturing
• Index of new business formation
• New orders for durable goods
• Orders for plant and equipment
• New building starts
• Changes in manufacturing inventories
• Industrial material prices
• Stock exchange indices
• Profit figures
• Price to unit labour cost ratios
• Increases in consumer debt
• Inflation figures

In recent years leading indicators have been shown to be useful in a number of settings. Banking crises can be predicted from a number of macroeconomic and financial measures (Hardy and Pazarbasioglu, 1999), stock predict investment, and a set of composite leading indicators has shown value in predicting inflation.
THE MARKETING APPROACH TO DEMAND MEASUREMENT

In the simple economic model of the firm, the business being modeled produces a single product for a single market, and the amount of information required on the level of demand is relatively limited. Real companies are much more complex and require a great deal more information concerning the markets in which they operate.

It is recognized that a firm needs information on different geographical markets including, local, regional, national continental and global, and for different time periods, perhaps simply short term, medium term and long term. It becomes very clear that enormous amount of information is potentially required if a firm is to be fully informed about its markets. This information may be collected in a number of different ways.

a) MARKET SURVEYS

This is used to forecast the level of demand for a product, testing buyers reactions to different product configurations and packaging and identifying the links between purchasing behaviour and other variables, like buyers age, sex, social status and income. If the aim is to estimate the level of demand, a sample of buyers is asked direct questions about their intentions with respect to purchasing the product within a specified future period. That information may be used in conjunction with other evidence about the potential market to construct an estimate of the total volume of sales. The effectiveness of this technique depends upon a number of variables.

- It depends upon the number of potential buyers. If the number is very large, only a small sample can be reached for a reasonable cost. It may be possible to construct a truly representative sample, in which case the results from that sample can be extrapolated in order to reach a forecast for the market as a whole. However, if the sample should contain an unknown bias, which can be difficult to avoid, the results will also be biased and could give misleading estimates. Market surveys are therefore of most use when the number of potential buyers is small so that a very high proportion of them can be questioned.

- The second variable that determines the usefulness of market surveys is the clarity of the buyers’ intentions. If the buyers
themselves are vague about their own intentions they will be unable to provide useful information to the market researcher. Other factors that will affect the cost effectiveness of market surveys are as follows:
- The cost of identifying and contacting buyers.
- The buyers willingness to disclose their intentions
- Buyers’ propensity to carry out their intentions.

This analysis suggests that market surveys will be of most value for industrial products, for consumer durables and for other products where buyers plan their purchases in advance. Market surveys could also be useful for new products where there is no past data on sales so that time series analysis or estimation is not possible.

b) SALES FORCE OPINION

If market surveys are inappropriate, an indirect method of forecasting buyers’ intentions is to survey the sales force. This approach is fraught with problems as the sales force may not be fully aware of changes in the firms marketing strategy. Furthermore the sales force may have the incentive to provide biased forecasts in pursuit of their own interests. They may provide deliberate under-estimates of sales in order to be given low quotas which they will be able to exceed without effort, or over - estimates in order to justify their continued employment. This is an example of the principal agent problem. It may be possible for the firm to devise methods that bring the interests of the sales force together so that the sales force has an incentive to provide accurate forecasts. Bonuses could be linked to the accuracy of forecasts, for instance, or the amount spent on advertising and promotions could be linked to the forecast level of sales in order to avoid underestimation.

The Advantages of Sales force opinion are as follows:
- The sales force is closer to customers than most groups within the firm, and may be able to spot trends first.
- The knowledge of the sales force is at a very detailed level with respect to different products, markets, distribution channels and individual customers, which may allow a more accurate forecast than a more aggregated approach.

c) EXPERT OPINION

A third approach to demand forecasting is to ask experts in the field to provide their estimates of future sales volume. Experts may include executives directly involved in the market, such as dealers,
distributors and suppliers or others whose major interest is in the forecast itself such as stockbrokers, specialist marketing consultants or officers of the trade association. Various methods exist for the construction of such forecasts. Each expert could be asked independently to provide a confidential estimate and the results could be averaged. The advantage of that approach is that there is no danger that the group of experts develop a group think mentality where their desire to be seen as loyal and conforming members of the group.

One well-known approach that seeks to avoid “group think” while allowing the experts to pool their knowledge is the Delphi technique (Rowe and Right, 1999). Each participant is asked independently to produce a forecast. Each of the forecasts with reasoning behind it is then presented as feedback to each of the participants with anonymity being maintained so that none of the participants know who is responsible for other forecasts. Each of the experts is then asked to revise their own forecasts in the light of the forecasts and reasoning of the others, and this process is repeated until consensus is reached. If the experts disagree, their opinions may not be shifted, but experience with the method suggests that the process of iteration often lead to the convergence of the different forecasts around an agreed value. The Delphi technique has been used to forecast demand in a variety of settings, including international tourism (Wright, 1998).