1 Introduction– Econometrics

1. DEFINITION AND SCOPE OF ECONOMETRICS

Econometrics deals with the measurement of economic relationships. The term 'econometrics' is formed from two words of Greek origin, *oukovouia* (economy), and *uetpov* (measure).

There are alternative definitions of econometrics, which identify the various characteristics of the science of econometrics. Thus, econometrics can be defined as that branch of economics concerned with the empirical estimation of economic relationships.

In the words of Ragnar Frisch, the first editor of econometrica (*Vol.* 1, *No.* 1, 1983), '*the mutual penetration of quantitative economic theory and statistical observation is the essence of econometrics.*'

Econometrics is a combination of economic theory, mathematical economics and statistics, but it is completely distinct from each one of these three branches of science.

Econometrics may be considered as the integration of economics, mathematics and statistics for the purpose of providing numerical values for the parameters of economic relationships (for example, elasticity's, propensities, marginal value) and verifying economic theories. It is a special type of economic analysis and research in which the general economic theory, formulated in mathematical terms, is combined with empirical measurement of economic phenomena.

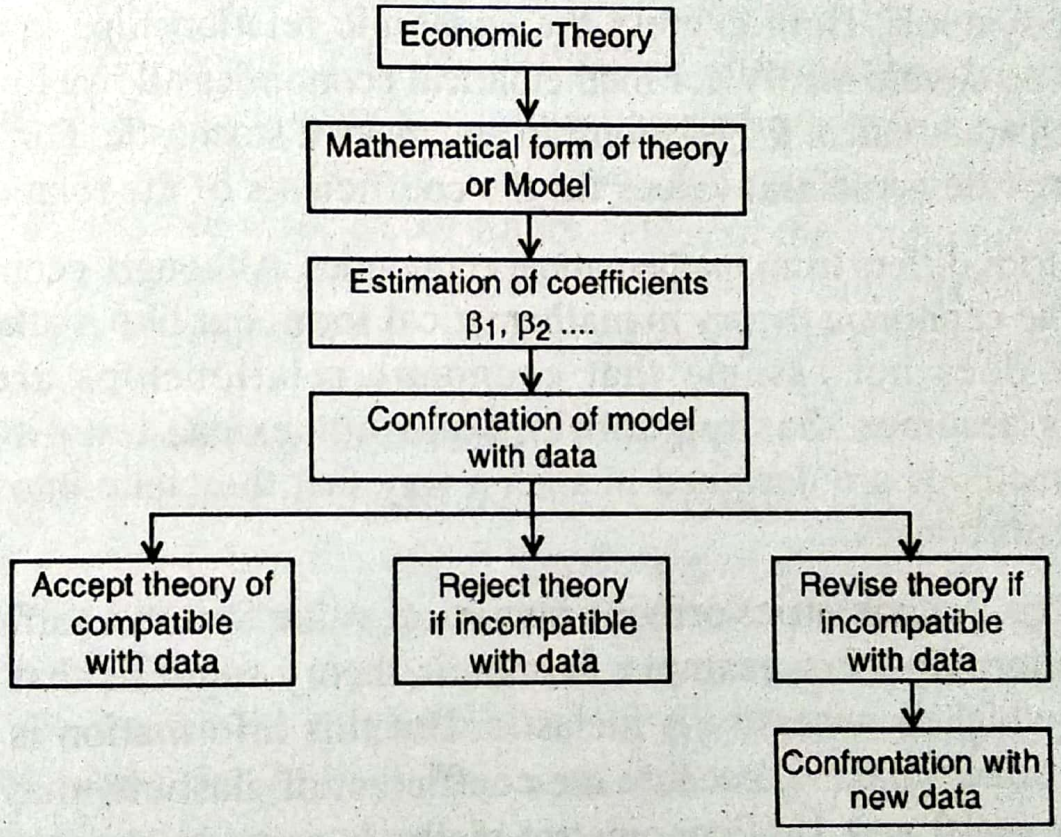

Fig. 1. Procedure for testing a theory

3. GOALS OF ECONOMETRICS

We can distinguish three main goals of econometrics : 1. analysis, *i.e.*, testing of economic theory ; 2. policy making, *i.e.*, supplying numerical estimates of the coefficients of economic relationships, which may be then used for decision making ; 3. forecasting, *i.e.*, using the numerical estimates of the coefficients in order to forecast the future values of the economic magnitudes. Of course, these goals are not mutually exclusive. Successful econometric applications should really include some combination of all three aims.

1. Analysis : Testing Economic Theory

In the earlier stages of the development of economic theory economists formulated the basic principles of the functioning of the economic system using verbal exposition and applying a deductive procedure. The earlier economic theories started from a set of observations concerning the behaviour of individuals as consumers or producers. Some basic assumptions were set regarding the motivation of individual economic units. Thus in demand theory it was assumed that the consumer aims at the maximization of his satisfaction (utility) from the expenditure of his income, given the prices of the commodities. Similarly, producers were assumed to be motivated by maximization of their

profits. From these assumptions the economists by pure logical reasoning derived some general conclusions (laws) concerning the working processes of the economic system. Economic theories thus developed in an abstract level were not tested against economic reality. In other words, no attempt was made to examine whether the theories explained adequately the actual economic behaviour of individuals.

Econometrics aims primarily at the verification of economic theories. In this case, we say that the purpose of the research is analysis, *i.e.*, obtaining empirical evidence to test the explanatory power of economic theories, to decide how well they explain the observed behaviour of the economic units. Today any theory regardless of its elegance in exposition or its sound logical consistency cannot be established and generally accepted without some empirical testing. Therefore, Econometrics is the science of estimation and testing.

2. Policy making : Obtaining Numerical Estimates of the Coefficients of Economic Relationships for Policy Simulations

In many cases, we apply the various econometric techniques in order to obtain reliable estimates of the individual coefficients of the economic relationships from which we may evaluate elasticities or other parameters of economic theory (multipliers, technical coefficients of production, marginal costs, marginal revenues, *etc.*). The knowledge of the numerical value of these coefficients is very important for the decisions of firms as well as for the formulation of the economic policy of the government. It helps to compare the effects of alternative policy decisions.

For example, the decision of the government about devaluing the currency will depend to a great extent on the numerical value of the marginal propensity to import, as well as on the numerical values of the price elasticities of exports and imports. If the sum of price elasticities of exports and imports is less than one in absolute value, the devaluation will not help in eliminating the deficit in the balance of payments.

Similarly, the price elasticity of demand for a product is less than one (inelastic demand), it does not pay the manufacturer to decrease its price, because his receipts would be reduced.

In a competitive market with linear demand and supply curves of the usual type (downward-sloping demand and upward-sloping), the government should not impose a specific excise tax (per unit of output) if its aim is to curb price increases, because such a tax would raise the price, although less than the amount of the tax per unit, ceteris paribus.

Such examples show how important is the knowledge of the numerical values of the coefficients of the economic relationships. Econometrics can provide such numerical estimates and has become an essential tool for the formulation of sound economic policies.

3. Forecasting the Future Values of Economic Magnitudes

In formulating policy decisions it is essential to forecast the value of the economic magnitudes. Such forecasts will enable the policy-maker to judge whether it is necessary to take any measures in order to influence the relevant economic variables.

For example, suppose that the government wants to decide its employment policy. It is necessary to know what is the current situation of employment as well as what the level of unemployment will be say, in five years' time, if no measure whatsoever is taken by the government. With econometric techniques we may obtain such an estimate of the level of unemployment. If this level is too low, the government will take appropriate measures to avoid its occurrence. If the forecast value of employment is higher than the expected labour force, the government must take different measures in order to avoid inflation.

Forecasting is becoming increasingly important both for the regulation of developed economies as well as for the planning of the economic development of developing countries.

2 Methodology of Econometrics

Econometrics is concerned with the measurement of economic variables. Starting from the relationships of economic theory; econometric research generally proceed along the following lines :

1. Specification : Specification of mathematical equations to describe the relationships between economic variables as proposed by economic theory.

2. Collection of data : Mathematical designs, methods and procedures based on statistical theory to obtain representative samples from the real world.

3. Estimation : Development of methods of estimating the parameters of the specified relationships described in estimation.

4. Verification : Development of statistical method to test the validity of theory by using estimated parameters.

5. Application : Development of methods for economic forecasts or policy implications based on the estimated parameters.

The requirements and the possible errors in the above steps may be described through the following chart.[1]

Step 1 : *Specification* :

Requirements : Specifying relationships based on economic theories (or) maintained hypothesis.

Possible errors : Relevant explanatory variable(s) are not included; irrelevant explanatory variable(s) included; specification bias & under-identification.

Step 2 : *Statistical designs* to obtain data :

Data : Time series, Cross section and Panel data.

Step 3 : *Estimation* :

Requirements : Estimators possess following properties :

(*i*) Linearity (*ii*) Unbiasedness, (*iii*) Minimum variance (*iv*) Consistency, (*v*) Efficiency, and (*vi*) Sufficiency.

Possible errors : Autocorrelation, Heteroscedasticity, and Multicollinearity.

Step 4 : *Verification* :

Requirements : Economic interpretation of the results obtained in Step 3.

Evaluation of economic theory or hypothesis.

Possible errors : Wrong and irrelevant tests evolved to verify the validity of the hypothesis.

Step 5 : *Forecasting*

Requirements : The ultimate goal of econometrics is to obtain predictions.

Possible errors : Biased forecasts; when forecasts are used for policy purposes they lead to losses in welfare of the society.

Let us discuss the steps involved in econometric research one by one in detail.

1. STAGE I : SPECIFICATION OF THE MODEL

The first stage in an econometric study is the specification of the model. The specification of econometric model is based on economic theory and on any available information relating to the phenomenon being studied. Thus the specification of the model presupposes knowledge of economic theory as well as familiarity with the particular phenomenon being studied. The econometrician must know the general laws of economic theory, and furthermore the researcher must gather any other information relevant of the particular characteristics of the relationships as well as studies already published on the subject by other research works. Therefore, the first stage of econometric research involves the following determinants :

(*i*) the dependent and independent (endogenous and exogenous variables) factors to be included in the model.

(*ii*) the theoretical expectation about the sign and the magnitude of the coefficient of the parameters of the model.

(*iii*) the mathematical form of the model *i.e.*, number of equations, linear or non-linear form of the equations etc.

For example, suppose that the econometrician wants to study the demand for a product. The first source of information is law of demand, which determined the demand for any commodity is determined by the price of the commodity, price of its substitutes, income of the consumer, taste and preferences of the consumer. With this information the demand function may be written in the following form :

$$D_x = f(P_x, P_s, Y, T)$$

where D_x = quantity demanded of commodity X.

P_x = price of the commodity X

P_s = price of substitutes of X

Y = income of the consumer

T = taste and preferences of the consumer

From the above sources of information the econometrician will be able to make a list of other variables, which might influence the dependent variable demand. Studies already published in the same field may provide additional knowledge about the factors determining the dependent factor demand. Apart from the above four factors, the demand for a commodity is affected by other factors like the taxation, distribution of income, credit policy of the government, the income in the previous years (lagged income). However, the number of variables included in the model depends upon the purpose of the research. The less important factors are included in the introduction of random variable by *u*. The assumption and the reasons for including the random variable *u* is discussed in the forthcoming chapter.

The next determinant in the first stage is the size and magnitude of the parameters of the model. Let us take the same example, demand function for a commodity X.

$$D_x = \beta_0 + \beta_1 P_x + \beta_2 P_s + \beta_3 Y + \beta_4 T + u$$

The expected sign and magnitudes of the parameters β_1, β_2, β_3, β_4, according to the theory are as follows :

The parameter β_1 is expected to be negative; the parameter β_3 related to the variable Y is expected to appear with the positive sign, since income and quantity demanded are positively related, except in the case of inferior goods.

The parameter β_2 of the variable P_s is expected to have a positive sign if commodity is a substitute of commodity X, and a negative sign if the two commodities are complementary. The β's are either elasticities, propensities or other marginal magnitudes of economic theory, or are components of these parameters.

As another example let us examine the simple version of the consumption function which states that consumption (C) depends on the level of income (Y).

$$C = \beta_0 + \beta_1 Y + u$$

In this function, the coefficient β_1 is the marginal propensity to consume and should be positive with a value less than unity ($0 < MPC < 1$), while the constant intercept (β_0) of the function is expected to be positive. The meaning of this positive constant is that even when income is zero, consumption will assume a positive value *i.e.*, people will spend past savings, will borrow or find other means for covering their needs.

Thus the number of variables to be initially included in the model depends on the nature of the economic phenomenon being studied, while the number of variables which will finally be retained in the model depends on whether the parameter estimated related to the variables pass the economic, statistical and econometric criteria, which we will discuss below.

The economic theory does not explicitly state the mathematical form of economic relationships, and it does not explicitly state whether a particular phenomenon should be studied with a single equation model or with a multi-equation model. It is the econometrician who must decide whether the phenomenon being studied can be adequately described by a single equation or by a system of simultaneous equations.

2. STAGE II : COLLECTION OF DATA AND ESTIMATION OF THE MODEL

The success of any econometric analysis ultimately depends on the availability of the appropriate data. It is, therefore, essential that we spend some time discussing the nature, source and limitations of the data that one may encounter in empirical analysis.

Types of Data :

There are three types of data that are generally available for empirical research.

1. Time series data
2. Cross-section data.
3. Pooled data.

Let us discuss each one with suitable examples.

1. *Time series data* : Data on one or more variables collected over the period of time is called time series data. In other words, values of one or more variables for several time periods pertaining to a single economic entity are given such a data set is called time series data. The time periods are generally consecutive (and without gaps) and at equally spaced intervals which might be a week, a month, a quarter, a year or any other period. The entity to which the data pertain might be a household, a group, a firm, an industry or an entire economy. For example, the values of aggregate consumption and disposable income for the Indian Economy from 1960-61 to 2001-02.

The data refer to individual households or firms they are called 'micro-data'. When they are to larger groups such as an economy they are called 'macro-data'.

2. *Cross-section data* : The data on one or more variables collected at one point of time is called cross- section data. For example, the share prices, dividends and retained earnings for several firms in an industry for a single year. The data might refer to a point in time-end of the financial year, end of business week, *etc.*, or a period of time.

3. ***Pooled data*** : The combination of time series and cross-section data are called pooled data. For example, annual sales of 25 firms in an industry for 25 years. Panel data, also called longitudinal or Micropanel data, are kind of pooled data. In this, data on the same set of entities are collected over time at periodic intervals. An example of this is the panel of nearly 7000 households maintained by the Market Research Wing of the Textile Committee. The purchases of textiles by these households are recorded month by month and a compilation of these records is published in the form of panel data.

The next step involved in the estimation of the model is the examination of the identification condition of the function. Identification is the problem of model formulation. There are some rules by means of which we may establish identification of the coefficients of a function.

After formulating a model, one should see whether the variables are not highly correlated. Because, most of the economic variables are correlated and they tend to change simultaneously during different phases of economic activity. Thus a certain degree of multicollinearity is inherent in the economic variables due to the growth and technological progress. If the degree of multi-collinearity is high the estimated coefficient will be inefficient.

The last step in estimating the coefficient of the model is the choice of the appropriate econometric technique. To estimate the coefficients of the economic relationships two techniques can be applied, they are, Single equation techniques and Simultaneous equation techniques. The single equation techniques are applied to one equation at a time whereas, simultaneous equation techniques are applied to all the equations of a system at once and give estimates of the coefficients of all the functions simultaneously.

3. STAGE III : EVALUATION OF THE COEFFICIENTS OF THE MODEL

The next stage in an econometric research is testing the reliability of the results. The verification of the parameters is related to decide whether the estimates are theoretically meaningful and statistically significant. There are three criteria to test the reliability of the estimates. *Firstly*, economic a priori criteria, which are determined by economic theory. *Secondly*, statistical criteria, determined by statistical theory. *Thirdly*, econometric criteria, determined by econometric theory. Let us discuss the above criteria one by one.

1. Economic 'A Priori' Criteria

An a priori criterion is determined by economic theory and refers to the sign and magnitude of the parameters of economic relationships. The coefficients of the economic variables represent elasticities, marginal values, propensities, multipliers, *etc.* For example, let us examine Keynesian theory of

liquidity preference, which states that the demand for money is determined by the level of income and the rate of interest. Keynesian theory of liquidity preference may be expressed in the form of mathematical equation.

$$D_m = \beta_0 + \beta_1 Y + \beta_2 r + u$$

where D_m = demand for money
Y = level of income
r = rate of interest
u = random variable

On the basis of theory of liquidity preference the apriori criteria states that the sign of β_1 is expected to be positive and the sign of β_2 is expected to be negative. If the estimates of the parameters turn up with signs or size not confirming to economic theory, they should be rejected unless there is a good reason to believe that in the particular case the principles of economic theory do not hold. In such cases, the reasons for accepting the estimates with the wrong sign and magnitude must be stated early.

2. Statistical Criteria

This criteria is said to be the first order test. These are determined by statistical theory and include correlation coefficient and the standard error test. The standard error of the estimates is a measure of the dispersion of the estimates around the true parameter. The larger the standard error of a parameter the less reliable it is, and if the standard error is small the parameter is more reliable. The square of the correlation coefficient shows the percentage of the total variation of the dependent variable being explained by the changes of the explanatory variables. It is a measure of the extent to which the explanatory variables are responsible in the dependent variable of the relationships. However, the statistical criteria are secondary to the apriori criteria.

3. Econometric Criteria

An econometric criterion is a second order test. It determined the reliability of statistical criteria. This test helps us to determine, whether the estimates have the desirable properties of linearity, unbiasedness, consistency, *etc.* If the assumption of the econometric method applied by the researcher are not satisfied, the estimates cease to possess some of the desirable properties. To test the validity of the assumption of non-auto correlated disturbances, Durbin Watson -d- statistic may be used. It is an econometric criterion used in the evaluation of the results of the estimates.

Therefore, it is clear that the evaluation of the results obtained from the estimation of the model is complex procedure. The econometrician must use

the entire above three criteria—economic, statistic, econometric, before accepting or rejecting the estimates.

4. STAGE IV : FORECASTING POWER OF THE MODEL

Last stage of econometric research is forecasting. It is one of the main objectives of econometric research. Forecasting is closely related to policy choice. One way of establishing the forecasting power of the model is to use the estimates of the model for a period not included in the sample. For example, if we know the population in 2005 with accurate coefficients, with the help of an estimated equation, the probable population in 2015 can be forecast. Sometimes, the forecasting power of the model may be poor. The reasons may be (*i*) the values of the explanatory variables used in the forecast may not be accurate. (*ii*) The estimates of the coefficients may be incorrect due to deficiencies of the sample data. There are different test procedures to test the significance of the forecasting power of the model.

5. THEORETICAL AND APPLIED ECONOMETRICS

Econometrics may be divided into two broad categories : theoretical econometrics and applied econometrics. Theoretical econometrics is concerned with the development of appropriate methods for measuring economic relationships specified by econometric models. In this aspect, econometrics mostly depends on mathematical statistics. For example, one of the tools that are used extensively is the method of least squares. It is concerned with the assumptions of the theoretical method, its properties, and what happens to these properties when one or more of the assumptions of the method are not fulfilled.

Applied econometrics is concerned with the application of econometric methods derived from theoretical econometrics to solve specific economics problems (theories). In applied econometrics, we use the tools of theoretical econometrics to study some special fields of economics, such as the consumption function, investment, production function, demand function, supply function, *etc.*

EXERCISE

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