

# The Role of Econometrics Data Analysis Method in the Social Sciences (Education) Research

Emmanuel Kayode Ogunyinka<sup>1\*</sup> Bin Tang<sup>1,2</sup>

1. Department of Economics of Education and management, College of Education, Central China Normal University, 152 Luoyu Avenue, Wuhan, Hubei Province, China
2. Visiting Scholar of Center on Chinese Education, Teachers College, Columbia University, (New York City, NY) 525 W 120th St, New York, NY, USA  
\*kaysmart\_89@yahoo.com

## Abstract

This paper examines the role of econometrics data analysis as one the method used in the social sciences (education) to provide factual evidence. How to understand the power of these procedures, the limits to them and the implications of this in terms of standards of evidence in the social sciences (education). Early attempts at quantitative research in economics, the birth of econometrics, and the econometric model. How econometrics and Experimental Methodologies Complement One Another. The specific subjects of these studies cover virtually all parts of economic theory, macroeconomics, accounting and economics of education. It also includes the effects of public policies in all of these areas.

**Key words:** Role, Econometrics, Data Analysis, Method, Social Sciences, Research

## Introduction

Econometrics is, generally speaking, the set of statistical procedures used to estimate economics models. The procedures are used to explain and predict the levels of economics variables as well as to test hypotheses about their relationships, and the results are often used as evidence in a wide range of policy settings.

Econometrics is a rapidly developing branch of economics which, broadly speaking, aims to give empirical content to economics relations. The term 'econometrics' appears to have been first used by Pawel Ciompa as early as 1910; although it is Ragnar Frisch, one of the founders of the Econometrics Society, who should be given the credit for coining the term, and for establishing it as a subject in the sense in which it is known today (Frisch, 1936, p. 95).

Econometrics can be defined generally as 'the application of mathematics and statistical methods to the analysis of economics data', or more precisely in the words of Samuelson, Koopmans and Stone (1954), 'as the quantitative analysis of actual economics phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference' (p. 142).

Other similar descriptions of what econometrics entails can be found in the preface or the introduction to most texts in econometrics. Malinvaud (1966), for example, interprets econometrics broadly to include 'every application of mathematics or of statistical methods to the study of economics phenomena'. Christ (1966) takes the objective of econometrics to be 'the production of quantitative economics statements that either explain the behaviour of variables we have already seen, or forecast (i.e. predict) behaviour that we have not yet seen, or both'. Chow (1983) in a more recent textbook succinctly defines econometrics 'as the art and science of using statistical methods for the measurement of economics relations'. By emphasizing the quantitative aspects of economics problems, econometrics calls for a 'unification' of measurement and theory in economics. Theory without measurement, being primarily a branch of logic, can only have limited relevance for the analysis of actual economics problems. While measurement without theory, being devoid of a framework necessary for the interpretation of the statistical observations, is unlikely to result in a satisfactory explanation of the way economics forces interact with each other. Neither 'theory' nor 'measurement' on their own is sufficient to further our understanding of economic phenomena. Frisch was fully aware of the importance of such unification for the future development of economics as a whole, and it is the recognition of this fact that lies at the heart of econometrics. This view of econometrics is expounded most eloquently by Frisch (1933a) in his editorial statement and is worth quoting in full:

*'Econometrics is by no means the same as economics statistics. Nor is it identical with what we call general economic theory, although a considerable portion of this theory has a definitely quantitative character. Nor should econometrics be taken as synonymous with the application of mathematics to economics. Experience has shown that each of these three view-points, that of statistics, economics theory, and mathematics, is a necessary, but not by itself a sufficient, condition for a real understanding of the quantitative relations in modern economics*

*life. It is the unification of all three that is powerful. And it is this unification that constitutes econometrics'.*

This unification is more necessary today than at any previous stage in economics. Statistical information is currently accumulating at an unprecedented rate. But no amount of statistical information, however complete and exact, can by itself explain economic phenomena. If we are not to get lost in the overwhelming, bewildering mass of statistical data that are now becoming available, we need the guidance and help of a powerful theoretical framework. Without this no significant interpretation and coordination of our observations will be possible. Whether other founding members of the Econometrics Society shared Frisch's viewpoint with the same degree of conviction is, however, debatable, and even today there are no doubt economists who regard such a viewpoint as either ill-conceived or impractical.

#### **Early Attempts at Quantitative Research in Economics**

Empirical analysis in economics has had a long and fertile history, the origins of which can be traced at least as far back as the work of the 16th-century Political Arithmeticians such as William Petty, Gregory King and Charles Davenant. The political arithmeticians, led by Sir William Petty, were the first group to make systematic use of facts and figures in their studies. (Stone (1984) *on the origins of national income accounting*.) They were primarily interested in the practical issues of their time, ranging from problems of taxation and money to those of international trade and finance. The hallmark of their approach was undoubtedly quantitative and it was this which distinguished them from the rest of their contemporaries. Political arithmetic, according to Davenant (1698, Part I, p. 2) was 'the art of reasoning, by figures, upon things relating to government', which has a striking resemblance to what might be offered today as a description of econometrics policy analysis. Although the political arithmeticians were primarily and understandably preoccupied with statistical measurement of economic phenomena, the work of Petty, and that of King in particular, represented perhaps the first examples of a unified quantitative/theoretical approach to economics. Indeed Schumpeter in his *History of Economic Analysis* (1954) goes as far as to say that the works of the political arithmeticians 'illustrate to perfection, what Econometrics is and what Econometricians are trying to do' (p. 209).

The first attempt at quantitative economic analysis is attributed to Gregory King, who is credited with a price-quantity schedule representing the relationship between deficiencies in the corn harvest and the associated changes in corn prices. This demand schedule, commonly known as 'Gregory King's law', was published by Charles Davenant in 1699. The King data are remarkable not only because they are the first of their kind, but also because they yield a perfectly fitting cubic regression of price changes on quantity changes, as was subsequently discovered independently by Whewell (1850), Wicksteed (1889) and by Yule (1915). An interesting account of the origins and nature of 'King's law' is given in Creedy (1986).

The monumental work of Schultz, *The Theory and the Measurement of Demand* (1938), in the United States and that of Allen and Bowley, *Family Expenditure* (1935), in the United Kingdom, and the pioneering works of Lenoir (1913), Wright (1915, 1928), Working (1927), Tinbergen (1930) and Frisch (1933b) on the problem of 'identification' represented major steps towards this objective. The work of Schultz was exemplary in the way it attempted a unification of theory and measurement in demand analysis; whilst the work on identification highlighted the importance of 'structural estimation' in econometrics and was a crucial factor in the subsequent developments of econometric methods under the auspices of the Cowles Commission for Research in Economics. Early empirical research in economics was by no means confined to demand analysis.

#### **The Birth of Econometrics**

Although, as we have argued above, quantitative economic analysis is a good three centuries old, econometrics as a recognized branch of economics only began to emerge in the 1930s and the 1940s with the foundation of the Econometric Society, the Cowles Commission in the United States, and the Department of Applied Economics (DAE) under the directorship of Richard Stone in the United Kingdom. (A highly readable blow-by-blow account of the founding of the first two organizations can be found in Christ (1952, 1983), while the history of the DAE is covered in Stone, 1978.) The reasons for the lapse of more than two centuries between the pioneering work of Petty and the recognition of econometrics as a branch of economics are complex, and are best understood in conjunction with, and in the light of, histories of the development of theoretical economics, national income accounting, mathematical statistics, and computing. Such a task is clearly beyond the scope of the present paper. However, one thing is clear: given the multi-disciplinary nature of econometrics, it would have been extremely unlikely that it would have emerged as a serious branch of economics had it not been for the almost synchronous development of mathematical economics and the theories of estimation and statistical inference in the late 19th century and the early part of the 20th century.

One important aspect of econometric procedures is that they have largely developed on the assumption that the data would be generated from naturally-occurring activity, rather than from a formal experiment in which a specific treatment is to be tested in order to determine its effects. In the experiment, the effects of all factors other than the treatment of interest are intended to be removed by the process of random assignment to an experimental or control group. Econometrics procedures, on the other hand, are intended to account for all non-

random influences by explicitly incorporating them as variables in the econometrics model. Economists may be interested in how the price of natural gas influences home energy consumption, but to estimate this in an econometrics model means also including variables accounting for the weather, the size of the home, the number of occupants and their employment or school status, and other factors that influence home energy consumption.

Econometrics begins with a theory from field of study such as accounting, sociology, and economics – about how important variables are related to one another. In economics, ideas about relationships between economics variables are expressed using the mathematical concept of a function. For example, to express a relationship between income and consumption, it may be written

$$\text{CONSUMPTION} = f(\text{INCOME})$$

Which says that the level of consumption – say, the Honda Accord might be expressed as

$$Q^d = f(P, P^s, P^c, \text{INC})$$

Which says that the quantity Honda Accords demanded,  $Q^d$ , is a function  $f(P, P^s, P^c, \text{INC})$  of the price of items that are complements  $P^c$  (gasoline), and the level of income INC.

The supply of an agricultural commodity such as beef might be written as

$$Q^s = f(P, P^c, P^f)$$

Where  $Q^s$  is the quantity supplied,  $P$  is the price of beef,  $P^c$  is the price of competitive products in production (e.g., the price of hogs), and  $P^f$  is the price of factors or inputs (e.g., the price of corn) used in the production process.

Each of the above equation is a general economic model that describes how we visualize the way in which economic variables are interrelated. Economic models of this type guide our economic analysis.

How do we understand the power of these procedures, and what are the limits to them? What are the implications of this in terms of standards of evidence in the social sciences (Education)? We had liked to offer the bottom line of our discussion in advance.

It is as follows: In a world of limited research resources it is critical to understand the high cost-effectiveness of non-experimental, econometric methods. These methods complement and provide independent checks on experimental findings. It is crucial not only to continue supporting these efforts, but to continue to support the necessary infrastructure for them: the extensive data collection efforts of our censuses and surveys. For studying social policies, the tradeoff between experimental and non-experimental methods is something like this: a substantial tilt toward increased experimental research will result in better evidence in some dimensions, but far less of it because many fewer studies could be supported. The advantages of an experiment come from greater internal validity (certainty about the treatment effect) but often are offset by greatly reduced external validity and uncertainty about how to replicate the treatment. Because *econometrics methods have opposite strengths and weaknesses*, the combination of the two approaches is preferable to more exclusive reliance on either alone. Nevertheless, our concern here is to be sure that this proposition is understood: to maximize the value of social science research with a budget of any fixed size, a substantial portion of the research portfolio must continue to be allocated to non-experimental research methods like econometrics.

## The Econometric Model

*What is econometric model, and where does it come from?*

In an econometric model we must first realize that economic relations are not exact. Economic theory does not claim to be able to predict the specific behavior of any individual or firm, but rather describes the averages or systematic behavior of many individuals or firms. When studying car sales we recognize that the actual number of Hondas sold is the sum of this systematic part and a random and unpredictable component  $e$  that we will call a **random error**. Thus, an **econometric model** representing the sales of Honda Accord is

$$Q^d = f(P, P^s, P^c, \text{INC}) + e$$

The random error  $e$  accounts for the many factors that affect sales that we have omitted from this simple model, and it also reflects the intrinsic uncertainty in economic activity.

To complete the specification of the econometric model, we must also say something about the form of the algebraic relationship among our economic variables. We extend that assumption to the other variables as well, making the systematic part of the demand relation

$$f(P, P^s, P^c, \text{INC}) = \beta_1 + \beta_2 P + \beta_3 P^s + \beta_4 P^c + \beta_5 \text{INC}$$

the corresponding econometric model is

$$Q^d = \beta_1 + \beta_2 P + \beta_3 P^s + \beta_4 P^c + \beta_5 \text{INC} + e$$

The coefficients  $\beta_1, \beta_2, \dots, \beta_5$  are unknown parameters of the model that we estimate using economic data and an econometric technique. The functional form represents a hypothesis about the relationship between the variables. In any particular problem, one challenge is to determine a functional form that is compatible with economic theory and the data.

In every econometric model, whether *it is a demand equation, a supply equation, or a production function, there*

is a systematic portion and an unobservable random component. The systematic portion is the part we obtain from economic theory, and includes an assumption about the functional form. The random component represents a “noise” component, which obscures our understanding of the relationship among variables, and which we represent using the random variable  $e$ .

We use the econometric model as a basis for *statistical inference*. Using the econometric model and a sample of data, we make inferences concerning the real world, learning something in the process. The ways in which statistical inference are carried out include:

- **Estimating** economic parameters, such as elasticities, using econometric methods.
- **Predicting** economic outcomes, such as enrollment in three-year colleges in Nigeria for the next ten years.
- **Testing** economic hypotheses, such as the question of whether newspaper advertising is better than store displays for increasing sales.

*Econometrics includes all these aspects of statistical inference.*

### **The Strength in Econometrics Methods**

While econometrics can never provide absolute proof that one factor causes another, it may provide good evidence of causality when:

- (1) A statistical relationship is persuasively documented, and
- (2) Plausible theoretical explanations to explain the relationship are consistent with respect to the direction of cause and effect between the two factors.

The words “persuasive” and “plausible” are terms of judgment about which, in the end, reasonable people may disagree. Nevertheless, there is a fairly well-established set of hoops that are used to conduct and to evaluate econometrics work, and their widespread use by professionals helps to create agreement and to narrow the range of disagreement. I hope that I can convey, in a short and not too technical exposition, the flavour of this process. Consider the economics proposition that the demand for a commodity will fall as its price rises, other things being equal. Economists think that other things besides a commodity’s own price might affect the demand, like the price of substitute commodities and the general level of income. So the price proposition is tested econometrically using *multiple regression analysis* to control for the effects of the other factors. No single study is taken as the convincing proof of this fundamental proposition. But because thousands of such analyses have been done independently, on hundreds of commodities in hundreds of different communities and because these studies uniformly find that demand falls as price rises economists agree that the basic proposition is correct.

This simple description hides the great complexity of actually conducting a persuasive study. We had say that the number of serious issues to be resolved in order to do one is somewhere between dozens and a hundred, although we have never actually tried to count them. Roughly speaking, these issues might be thought of as belonging to three categories:

- (1) Matching theory and hypotheses to available data (the specification problem);
- (2) Making statistical inferences from a particular body of data (model estimation and testing); and
- (3) Drawing appropriate conclusions, including predictions and policy implications, from the estimated model.

The process of controlling for other factors is not necessarily statistical. It does involve mathematical modeling or specification: identifying a precise numerical relationship among several factors. Theory often offers guidance about these relationships: whether variables are positively or negatively related, limited possible ranges for the parameter values, that one parameter must be smaller or larger than another. But rarely does it identify precise values. Statistical procedures help us to identify these numerical relationships when they are imperfectly observed (due to other factors, disturbances that cause random deviations from the relationship). Statistical tests are used to assess the level of confidence in the relationships established under these imperfect conditions. Even when we are confident in a relationship, we may not be confident in our understanding of the underlying causal mechanism that explains it. More than one theory can be consistent with an established relationship. We may then search for new opportunities where the competing theories offer contradictory predictions in order to test further. Absent such new opportunities, we fall back on judging the plausibility of the alternative theories: perhaps one offers a consistent explanation for a wide range of similar situations, while the other is “new” and has not been tested elsewhere. In this situation, one is more likely to favour the established theory over the new one, although the truth is uncertain. This might be a good time to mention that the standard for relying upon any particular econometrics result depends on the purpose of the user. My discussion is about the standards used by professional economists themselves, evaluating for a purpose something like “what the study has contributed to knowledge”. But decision-making users, like those in the public sector who choose and shape public services, have very different standards of usability. In other cases, estimates that achieve standard statistical significance may still be far too imprecise, as when millions of Naira (Nigeria currency) of tax revenue can be affected by a very small change in the exact tax rate used.

We have tried so far to emphasize the role of theoretical guidance, and the consistency of results with it, in our brief description of factors that determine the persuasiveness of econometrics work. Confidence in econometrics results depends on far more than the reliability of the specific data and appropriateness of statistical inference methods used to analyze it in any one study. It depends heavily on understanding of and confidence in the underlying theory that has motivated the study. To a large extent, the successes of econometrics reflect the successes of economics theory.

The results of econometrics work are used routinely for decision-making in both the private and public sectors. When a large corporation faces a major investment decision like whether or not to build an expensive new plant to expand its capacity, it often uses an econometrics model to predict the state of the economy, the expected corporate sales and the likely profitability of the plant. When federal regulators try to assess whether a firm has exercised market power to illegally manipulate prices as in the Nigeria electricity crisis, econometrics work is used to distinguish whether or not the observed prices can be explained by normal competition or not. When damages due to workplace injuries are to be awarded in court cases, econometrics models are often used to establish their magnitudes. When changes in the tax code are considered like those reflecting the history of the Earned Income Tax Credit, econometrics studies are used to assess the likely changes in work effort of those affected. The list of applications is essentially endless, and the extensive use underscores the need to continue to improve and advance the state of the art.

### Issues in Econometrics

It is, of course, impossible to give in a short paper a comprehensive overview of specific econometrics issues that must be confronted in the course of an application. We have selected a very small number, in the hope that they will convey the flavour of the task.

1. Matching theory and hypotheses to available data (the specification problem).

*Specifying a functional form:* Economics theory often suggests the variables that should be included in a theorized relationship, but typically stops somewhere short of specifying the precise mathematical way that the variables are related. For example, a demand function suggests that the consumption amount  $Q$  of a normal good will increase with income  $Y$  and decrease with price  $P$ , but not necessarily the specific form. Two common functional forms that have this property are linear and log-linear, although there are of course others. Assume that we have observations on the variables, and that there are other minor factors that do not intrinsically concern us but cause small random deviations  $u$  from the theoretical relationship.

Then we could represent the two common forms:

$$Q = a + bP + cY + u \quad (b < 0, c > 0)$$

$$\ln Q = a + b \ln P + c \ln Y + u \quad (b < 0, c > 0)$$

As long as the disturbances can be assumed to be independently drawn and normally distributed, the above equation parameters  $a$ ,  $b$ , and  $c$  could be estimated by *ordinary least squares regression*. Older studies used to simply assume a specific functional form (often like one of the two above). However, modern practice is to specify a more general functional form that includes the older ones as special cases, and let the data determine the specific form. One method of doing this is to use the *Box-Cox transform*, which identifies by the maximum likelihood method a specific parameter  $\lambda$  from the range  $0$  to  $1$ , where  $0$  is the linear form and  $1$  is the log-linear form. One can also test a result like  $\lambda = .8$  to see if it is significantly different from  $1$ . The point is that a study that is sensitive to this choice of functional form issue is preferred to one that is insensitive to it.

*Omitted Variables:* To some extent, this is an available criticism of almost any econometrics study because it so easy to think of something else that would have been nice to include. An example of quite constructive criticism, however, comes from the *education* area where early econometrics efforts to explain *a child's educational progress focused on school resources only: spending per pupil, class size, teacher quality, etc.* Over time researchers learned that important omitted factors included the nature of other students in the class, the student's family background, and aspects of the student's home neighborhood. We might consider as a special case of this category the measurement problem: is the included variable selected to represent a particular influence actually representing that influence? If not, then the true variable is still omitted. What variables, for example, measure the kind of teacher quality relevant to the learning of children? Highest degree? Years of experience? Quality of undergraduate training? If a relevant variable has been excluded from the analysis, it can bias the estimated coefficients of the included variables. The direction of the bias is given by the sign of the true coefficient on the excluded variable multiplied by the sign of the correlation between the included and excluded variable. There is no bias if the excluded variable is either uncorrelated with the included ones or if its true coefficient is zero. There is not too much that one can do about omitted variables, in the sense that they are usually omitted because the appropriate observations of them are not available for the sample.

However, good practice is to do the following:

- if crucial variables are known to be missing, do not do the study on that dataset;

- offer a good discussion of possible omitted variables and the bias that they might cause; and
- most creatively, use proxy variables that are available to take the place of the variable that would otherwise be omitted.

An example of the latter is that sometimes an individual's wealth is more relevant than the current income level for certain purchases, but there are rarely good measures of this wealth. However, sometimes good proxies for wealth are available: the square footage of the home, or income data combined with demographic data like age and education.

*Structural homogeneity of the sample:* Economists often test the theory of individual behavior using observations on groups of individuals. For example, the economic theory of crime and deterrence is a theory that asserts individual choices will depend, other things equal, on the level of punishment. However, the data available to test this theory is usually based on geographic units like cities, senatorial districts, states, local councils or the country as a whole (within which crime rates, arrest rates, etc. are available); the data may or may not involve a time series. The use of these aggregated observations can cause serious bias in the parameter estimates if individuals in one region or time period behave differently than they do in another region or time period. This is a serious problem because the parameters can be biased in either direction, depending on how the true differences among regions are distributed. There will be no bias if individuals in the sample are homogeneous across regions and time. One method of testing for structural homogeneity is to use *Chow tests* to see if any of the estimated model parameters are significantly different over regions or time, and if so, corrective procedures may require additional *dummy variables* or separate estimating equations. An econometrics study that fully tests for structural homogeneity will be preferable to one that either ignores it or considers as possible controls dummy variables interacted only with the constant term.

## 2. Making statistical inferences from a particular body of data (model estimation and testing).

Once one has settled on the data and the model, numerous problems may remain before appropriate statistical inferences can be drawn. We mention very briefly three. They all have in common violations of the usual assumption for regression estimation that the error or disturbance terms will be independently and normally distributed.

*Simultaneous equations bias:* In economics, many observations of market price and quantity outcomes are thought to be jointly determined by demand and supply curves. A very simple representation of them is as follows:

$$\text{Demand} \quad Q = a + bP + cY + u_1 \quad (b < 0, c > 0)$$

$$\text{Supply} \quad Q = d + eP + fZ + u_2 \quad (e > 0, f > 0)$$

If observed  $Q$  and  $P$  are determined jointly by both equations, then how does one get an estimate of each?

If one runs ordinary least squares on the equations separately, then the variable  $P$  will not be independently distributed from  $u_1$  because  $P$  is not really exogenous; it is jointly determined by the two equations. The estimated parameter  $\hat{b}$  will be biased, and could be anywhere between  $\underline{b}$  and  $\underline{e}$  depending on the relative sizes of the variance of the errors terms  $u_1$  and  $u_2$ . In other words, one does not know if one has estimated the demand parameter, the supply parameter, or some weighted average of the two. The estimate is likely useless. This problem is very closely related to *the identification problem*, which is more generally how to identify the individual coefficients in the equations of a simultaneous equation model.

There are a variety of procedures that can be used to solve these problems. Common methods include the use of *instrumental variables*, *indirect least squares*, *two-stage least squares* and others. Again, good econometrics work will consider carefully the nature of any simultaneous equations bias, and will undertake corrective procedures appropriate for the specific case.

*Heteroskedasticity:* The standard assumptions about the error or disturbance term are not only that they are independently and normally distributed, but with constant mean and variance. The assumption of constant variance is violated when the error terms are correlated with one or more of the independent variables, e.g. the size of the errors increase with the income level in estimating a demand equation. This problem is somewhat less serious than the others mentioned in that it does not cause bias in the estimates. However, it does invalidate the usual tests of significance because it biases the variance estimates. Heteroskedasticity may be diagnosed by a variety of tests such as those suggested by Ramsey, White and Goldfeld-Quandt, and corrective procedures may involve using weighted least squares or maximum likelihood methods.

*Serial correlation:* In many time series studies, the assumption of independent errors is violated by the presence in the model of a lagged dependent variable or an expectations variable that depends upon prior history. In such cases, the error term in any one period is correlated with the error terms in the immediately preceding periods. This results in inefficient and in most cases biased estimates. The presence of serial correlation can be detected by tests like the Durbin-Watson statistic, or Durbin's  $h$ -test, or tests based on the Lagrange Multiplier principle.

Corrective procedures, if serial correlation is found, may involve transforming the data based on estimating the degree of first-order autocorrelation, or estimating the equations by using the first-differences of the sequential observations rather than their absolute levels.

3. Drawing appropriate conclusions, including predictions and policy implications, from the statistical inferences.

*Consistency with theory and prior estimates:* It is normal, once the models are estimated, to then report the consistency or inconsistency of the results with the underlying theory. For example, do the estimated parameters have the expected signs and are they statistically significant? How do the estimates compare with previous estimates reported in the literature, and what might explain any differences (many studies are undertaken because new and better data have become available, compared to older efforts)?

*Competing hypotheses:* In addition to the general checks on model consistency with theory and previous estimates, there are often other specific reasons why the model has been estimated. In some cases, the motivation behind the study is to test two alternative theories against each other to see which is more accurate. In macroeconomics, there may be Keynesian versus monetarist theories. In microeconomics, there is much current attention to what is now termed behavioral economics: the applicability of various models of limited or bounded rationality to economic decision-making. Growing attention will be paid to whether models based on conventional or behavioral theories explain actual decisions better.

When alternative theories are to be tested against one another using the same data set, the nature of the appropriate test depends on the specific source of differences between the alternative models. We will mention briefly the J-test, which is appropriate when used with two different, non-nested theories (the variables of one are not a subset of the other) to explain the level of the same dependent variable. It evaluates which model is better by asking if one model adds any significant new explanatory power to the other (and vice-versa). It essentially adds to the model being tested an additional right-hand-side variable equal to the predicted level of the dependent variable by the other model. If this new variable is significant based upon its t-statistic, then one rejects the model being tested in favour of the alternative. It is possible, however, for the results to be ambiguous: both models could be rejected, and both can be maintained.

*Policy Uses.* There are many uses covering many quite different decision-making circumstances, and it is difficult to describe general rules for high standards in such diverse circumstances. Competition is one good thought to mention. When time permits, a number of independent studies might be commissioned and then the results of each scrutinized relative to one another. This is the case in many courtrooms and regulatory proceedings, in which different sides or interest groups will present differing estimates of the consequences of some policy action like the estimated effect on prices if a merger of two entities is permitted. Even if a single econometrics study is offered as evidence for a particular policy position, it is usually desirable to have it assessed by some other independent expert. The greater the stakes, the more effort it is worth to narrow the range of uncertainty about econometrics estimates. However, we are also mindful of urgent situations in which a decision must be made quickly, where perhaps standards lower than the usual statistical ones might be of high value.

### **Econometric and Experimental Methodologies Complement One Another**

Once one recognizes that the costs prohibit us from routinely doing the "ideal" social experiment, we have several different ways of lowering costs. Some of them retain the experimental design, but move from larger to smaller social experiments and then down to laboratory experiments, with each step increasing the artificiality and reducing the generalizability of the observed decision-making. Alternatively, we can move away from the experiment but retain some of the comprehensiveness of time, place and population studied by using the non-experimental research design.

Imagine research efforts of both types that have equal (and relatively low) costs. It is not at all clear which is preferable. One must judge the extent of artificiality in the experiment against the quality and comprehensiveness of the data available for the non-experimental design. Because each method has different strengths and weaknesses, it is valuable when possible to know if the findings are consistent across them. That is, we suspect that in most cases, one learns more from doing both kinds of research than from concentrating on only one of the two approaches.

### **Conclusion**

We have tried to convey the flavour of econometrics methodology, and of the care that is required to execute such a study to high standards. Perhaps the most important aspect to understand is how closely linked to economics theory good econometrics must be. It is typically the theory that guides the preliminary specification of the model, provides the motivation for what is to be tested, and helps to evaluate the results. Once one has a theoretical model and a dataset, there is a tremendous amount of further specification and empirical diagnosis that must be done in order to end up with good estimates. Then the use of the model for hypothesis testing or prediction must be carefully done as well. Even a very good econometrics model cannot remove uncertainty

about its conclusions. That is why many policy uses of econometrics work involve the comparison of several independent studies or at least scrutiny by an independent expert. Some sensitivity to the potential policy uses of an econometrics study can produce better discussion of the study's implications and generalizability.

Some researchers think that experimental methods should always be preferred to non-experimental methods. This is not true in any world in which the budget for research has some limit to it. The strength of the experiment is its internal validity and the ability to design treatments precisely, but limited budgets can put severe limits on the external validity or the ability to generalize beyond the experimental setting. The laboratory experiment is quite unlike the real world of economics decision-making, and even very expensive social experiments have important elements of artificiality and leave as a mystery just what aspects of the treatment might be important for replication. Econometrics studies are in widespread use both in the education sector, marketplace and by government because they are a generally cost-effective research strategy and because they offer complementary strengths and weaknesses relative to the experiment. We should continue to strive to improve them and the data sources that are central to their use.

### Suggestion for further Studies

Further studies in this direction of enquiry and with larger sample and wider coverage are eagerly awaited to unravel the anomaly observed in this study and to extend the generalizability of the conclusions. By implication, cautious interpretation of the findings of this study is advocated.

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**Emmanuel Kayode Ogunyinka** studied in Ekiti State University, Ado-Ekiti, Nigeria (EKSUA) and was awarded B.Ed. First Class (Hons.) Educational Management in February 2009. He was awarded best graduating student faculty of education 2008/09 academic session. As at present, he has been called for teaching job as Graduate Assistant, Department of Educational Foundations and Management, Faculty of Education in the same University. In September 2012 he was awarded BEA (Nigeria-China) scholarships for master's programme, Economics of Education and Management, College of Education, Central China (Huazhong) Normal University, Wuhan City, Hubei Province, P.R.China.

**Bin Tang** is an Associate Professor, Department of Economics of Education and Management, College of Education, Central China Normal University, Wuhan, Hubei Province. His area of specializations are: Economics of Education, Education Econometrics and Education statistics, as at present, he is a visiting scholar of Center on Chinese Education, Teachers College, Columbia University, (New York City, NY) 525 W 120th St., New York, NY, USA.