TRIBHUVAN UNIVERSITY JOURNAL
VOL. XVI, JUNE 1993

The use of Quantitative Tools in Economics: Best Alternative*

[1] Neelam Kumar Sharma

Economics, a social science, dealing with the production and distribution of physical goods and services which ultimately aims at material prosperity of a country. It was known as 'political economy' earlier and still many people prefer to say 'political economy' instead of economics.

Adam Smith was a pioneer who had segregated the diluted economic science from political science and he filtered the purity of economic science by providing concise concepts and own definition, he was followed by J.B. Say, J.S. Mill, F.A. Walker, Marshall, Cannan, Pigou, L. Robbins and so on. Almost all classical as well as neo-classicial economists had contributed a lot to the theoretical interpretations of economics. "Most economics Journals (look very much alike when it comes to mathematical discourse) from roughly 1987 to 1924. During that period journals rarely devoted more than five percent of their pages to mathematical discourse, and no journal does the proportion of mathematical pages ventured 'beyond one standard deviation of zero (Basu, 1992)".. However from ancient times economists had tried to support their ideas with facts and figures. During the days of the historical school, it was a burning problem whether the study should be based on data or on some presupposed law. No doubt, Prof. Irving Fisher, first of all, developed his quantity theory of money with the help of data. But his predessors had also been using their technique. Prof. Oskar Lange attempts at a quantitative approach to the laws (relations) of which economic theories speak, by means of statistical methods (Singh, Parashar, Singh, 1984). Thus some sort of selective quantitative tools were being used very earlier too. "The Economic Journal (may appear somewhat aberrant) with respect to the five percent ceiling until one notices that in this period 39 percent of its total mathematical pages are accounted for by a single author: Francis Ysidro Edgeworth, one of the editors of

---

* The author is thankful to Kamal Dhungel, Central Department of Economics, Mahendra Joshi, CEDA and R.P. Chaudhary, Tri Chandra Campus for their suggestions and cooperation.

1 *Mr. Sharma is a Lecturer in Economics, Research Division, TU, Kirtipur.*

that journal from 1891 until his death in 1926.... when it came to mathematical expression, even a crusading editor could not make all that much difference." says Prof. Philip Mirowski who conducted the survey. This was the first "rupture" in economic thought (Basu, 1992)". Therefore mathematical concepts frequently appeared in the literature of economics first. The meaning of and notation for a function of one and of many variables, the equation of a straight line and a few other simple relationships, the definitions and elementary rules of manipulation of exponents and a matter of notation - the Σ (sigma) representation of a sum. All of these concepts appear frequently in the literature of economics and occur later in the book (Baumol, 1990)".

The use of quantitative tools in economics was just on the surface before 1930s' worldwide economic depression. The sophisticated quantitative tools were found to be extensively used in economics after economic depression of 1930s when many physical scientists turned to economists. "By a fervent desire to apply the scientific method to the social betterment of mankind, came an unprecedented wave of trained scientists and engineers into economics. The roll call is stunning, and included Regnar Frisch, Tjalling Koopmans, Jan Tinbergent, Maurice Aelais, Kenneth Arrow and host of others. For the first time, noted mathematicians such as John von Neumanu, Griffith Evans, Harrod Thayer Davis, Edwin Bidwell Wilson and other were induced to turn their attention. However briefly to economics. "why did I leave physics at the end of 1933 ?" the Dutch scientist turned economist Tjalling Koopmans, asked this question to himself at a talk he gave in 1979 to the American Physical Association. "In the depth of the world wide economic depression, he felt that the physical sciences were far ahead of the social and economic sciences. What had held me back was the completely different mostly verbal and to me almost indigestible style of writings in the social sciences. Then I leart from a friend that there was a field called mathematical economics, and that Jan Timbergent a former student of Faul Ehrenfest, had left physics to devote himself to economics (Basu, 1992)".

Quantitative tools are so extensively used that "when we turn to the pages of a standard international journal about economics, we will hardly find any article without some sort of mathematical notations and derivations··· The use of quntitative techniques has geared its tempo mainly after fifties. Many economic theories are developed in mathematical terms by Anglo American economists like Hicks, Samuelson, Hansen, Harrod, Domar, Leontief, Koopmans, Barna, Baumol, Dorfman, Duesenberry, Solow, Phillips, Turvey, Klein, Goodwin and many others (Koirala, Agrawal, 1988)".

Quantitative technique maintains quantitative relationship among economic variables and expressed in the form of equations with specified numerical coefficients. According to Prof. Carl F. christ those equations must have some desirable characteristics. These equations may have relevance simplicity. Theoretical plausibility, explanatory ability (Singh, Parashar, Singh, 1984). Thus quantitative methods could be summarized as a specific method which could analyse the general theories of economic science appropriately and exactly. "Mathematics is a systematically developed language and logical to proceed to get the precise result ··· If we can codify the language of economics into the language of mathematics, the already developed logical operation of mathematics can be borrowed without much difficulty. This is what the present time economists have done. That is mathematical economics is merely an approach to economic analysis, it should not and does not differ fundamentally from the non-mathematical approach to economic analysis (Koirala, Agrawal, 1988)".

Quantitative tools are not separable from economics "Prof. Marshall, the renowned economists, observed that "Statistics are the straw out of which I like every other economist has to make bricks ···· Statistics play such an important role in the field of economics that in 1926, R.A. Fisher complained of the painful misapprehension that statistics is a branch of economics. In recent years econometrics, which comprises the application of statistical methods to the theoretical economic methods, is widely used in economic research (Gupta, 1976)".

OBJECTIVE

The objective of this paper is to identify and underline the different areas of economic science that have commonly using quantitative tool, books, journals, research reports, seminar papers and other relevant documents into consideration.

COMMON AREAS

i) Micro Economics:

Price elasticity of demand EP $= \frac{-\Delta q}{\Delta p} \cdot \frac{p}{q}$

For the constant elastic curve q = a p - b, the derivative dq/dp becomes - a b P - b - 1, then EP = abP - b - 1

p/q = - abP - b/q = - b since q = a P - b (watson, 1986)

Elasticity of supply ES = $\frac{p}{q} \cdot \frac{dq}{dp} = b\frac{p}{aq}$

Cross elasticity of demand E x Py = $\frac{dqx}{dpy} \cdot \frac{Py}{qx}$

Income elasticity of demand

Ey = c/q A curvilinear income demand functions with constant elasticity can be written q = ayc. The value of Ey is then C. (watson, 1986).

Consumer's surples

$_0\int^{q_o}_o f(q)\, dq$ - Poqo.

Producer's surplus = Poqo - $\int^{qo} g(q)\, dq$.

(Dhungel, 1992).

Maximization of utility (IC)

Total utility is maximized when the ratio of the marginal utilities is equal to the ratio of the price i.e.

$$\frac{\frac{\sigma q}{\sigma x}}{\frac{\sigma q}{\sigma y}} = \frac{-\lambda px}{-\lambda py}$$, λ is the larrange multiplier.

(Assuming U = ϕ (x , y) to a constraint relationship

f (x, y) = o with third function G (x, y) = ϕ (x, y +) λf (x - y)

(Watson 1986)

Next simple method $\frac{f1}{p1} = \frac{f2}{p2}$ (f1 & f2 are marginal utilities of q1 and q2 and p1, p2 prices (Singh, Para shar, singh, 1984)

Maximization of profits

Profits are maximized at the output whose MR = MC i.e. at qo where $\frac{dR(q0)}{dq} = \frac{dc(qo)}{dq}$

The second order conditions = $\frac{d^2R(q)}{dq^2} - \frac{d^2c}{dq^2} < O$

$\frac{d^2 R(q)}{d q^2} < \frac{d^2c(q)}{dq^2}$ (R = Revenue; c = Total cost)

Isoquants

The marginal rate of technical sustitution between labour and capital is equal to the ratio of their marginal productivities i.e. $\frac{fc}{fL} = \frac{dc}{dL}$ (L = labour and C = capital)

C - D production function $q = klac^{1-a}$ (k and a positive constants).

Short run cost functions

If C = TC & Q = quantity: The cost function

$TC = a + bq + cq^2$ (a, b, c, constants)

For MC, first derivative $MC = \frac{dtc}{dq} = b + 2Cq.$

For AC, $\frac{a}{q} + b + cq.$

Revenue TR = PXQ; $MR = \frac{dTR}{dq}$; $AR = \frac{TR}{q}$

ii) Macro Economics:

Income determination

$C = C (y - BT - B - PW)$

$= C (y - w - B) = C (y)$

$W = BT (y) + Pw (y) = w (y)$

$B = E - D = E (y) - D [(E (y)]$

$= B (y)$

$I = \bar{I}, G = \bar{G}$

Our simple income equation finally becomes

$Y = C [y - w (y) - B (y)] + \bar{G} + \bar{I}$

(C = consumption: I = income; BT = Business taxes; personal taxes or with drawals; w = withdrawals

E = net corporate saving; ...... = corporate earnings; D = Dividents; I = net investment and G = Government expenditures).

Hypotheses (1) Consumption is a function of Income [C = C (y)]

(2) Investment may provisionally be taken, at any one time, as a constant $[I = \bar{I}]$ (Samuelson, 1948).

Acceleration principle

$Ct = Kt - Kt\text{-}1 \equiv (Ot\text{-}Ot\text{-}1) / Ct \equiv Kt - Kt - 1 = \alpha\,(ot - ot - 1)$

Ct = Output of capital goods

Kt-Kt-1 = Increase in stock of capital goods.

α (ot-ot-1) = Increase in final output times the accelerator.

The symbols have the following meanings:

C = current output of capital equipment employed by the firm to make a net increase in its capital stock. In what follows this is referred to simply as output. K = The firm's stock of capital equipment. O = The firms output of finished products referred to as final output.

α = The accelerator or the coefficient of acceleration. This is the ratio between the current increase in the stock of capital equipment and the current increase in the flow of final output produced with that equipment. The accelerator is assumed to be constant, t, t-1 etc. time periods (Knox, 1952).

Interactions between multiplier and acceleration

The national income at time t, yt, can be written as the sum of three components: (1) governmental expenditure, It, (2) consumption expenditure, ct, and (3) induced private investment, It.

$y_t = g_t + c_t + It$. But according to Hansen assumptions $c_t = \alpha\, yt - 1$; $It = \beta\,[c_t - c_t - 1] = \alpha\,\beta\, y_{t-1} - \alpha\, by_{t-2}$

Therefore, our national income can be rewritten

$$yt = 1 + \alpha\,[1 - \beta]\, y_{t-1} - \alpha\beta\; Y_{t-2}$$

(Samuelson, 1939).

National Income Accounting

$$C + S\,T + R\,pf \equiv GNP \equiv C + I + G + (X - M) \text{ (Four sector)}$$

$$APC = \frac{c}{y} = \frac{Ca}{y} + C\,;\ APS = \frac{S}{y} = \frac{Sa}{y} + S;\ MPC = \frac{\Delta C}{\Delta Y};\ MPS = \frac{\Delta S}{\Delta Y}$$ (Shapiro, 1982)

iii) Monetary Economics:

Quantity theory of Money

$Mv + M_1V_1 = PT$ (Fisher)

$M= KPT$ (Cambridge)

$M = f(P/y, 1/p.\ dp/dt, rb, re, w, u)$ (Friedman).

$HPM = Cr + RRr + ERr/1 + Cr \times M; MS = 1 + Cr/Cr + RRr + ERr \times H.$

DISCUSSIONS

The classical economic theories are simply based on the static analysis that the classicists have assumed full employment in the economy. In such a condition,the economy attains equilibrium at any point of time. Many classicists have used the mathematical model based on the full employment assumption. Let us take a very simple example of demand and supply i.e.

$qd = a + bp$; $qs = a + bp$ where qd = quantity dewanded at a point of time and qs = quantity supplied at a point of time. For equilibrium $qd = qs$

$\therefore a + bp = \alpha + \beta P$

or, $bp - \beta p = - a + \alpha$

$P(b - \beta) = a - \alpha$

$\therefore\ \bar{p} = \frac{a - \alpha}{b - \beta}$

Thus $\bar{p}$ indicates the equilibrium price at a point of time. Later many economist used quantitative tools like derivative, differentiation, integration, vectors, matrix etc. for the interpretations of economic theories. For example Prof. Marshall used some quantitative tools in his analysis, likewise Domar has used dynamic model in his growth theory. Kuznet has used various mathematical tools to analyse income determination such as measures of inequalities etc. in 1955.

Moreover growth theories could never be interpreted without mathematical tools and models. A new model of economic growth given by Nicholos Kaldor and James Mirrlees in 1962 and technical change and the aggregate production function by Robert Solow in 1957, Horrow and Domar growth models, Kaldor model of distribution, Meade's neoclassical model of economic growth all have used very sophisticated mathematical tools. "The elements of macro-dynamic theory show up the need for using differential and difference equations and for the description of oscillatory variations by means of complex variables and vectors. On this basis can be developed some fairly elaborate trade cycle theories leading to the vital problem of economic regulations. The methods of linear programming and decision making has application to the theory of firm and the consumer. A great deal of vector and matrix algebra has relevance in the theory of games and many other economic problems. (Koirala, Agrawal, 1988)".

The empirical studies drawn by various economists with the help of statistical tools have significantly contributed a lot to come up with exact mathematical models. For example, Keynes has used following linear model. $C = f(y)$

Where C is consumption and Y is disposable income. Thus the Keynes ultimately follows with $C = a + by$.

The latest addition of quantitative tools in economics are "quality analysis of consumption and production (including shepherd's lemma), the Ramsay-Boiteaux theorem on quasi-optimol pricing under a budget constraint, properties of quasiconcave utility functions and their relationship to ordinal theory, and the deswitching debate in the cambridge cambridge controversy (Baumol, 1990)".

CONCLUSION

Quantitative tools are analytic tools of optimization. It is commonly used for demand, production, firms, games and decisions theories. Similarly quantitative tools are being widely used in the areas of general equilibrium, welfare and distribution. So far the validity of quantitative tools are concerned, R.A. Fisher a renowned economist even has extremely levelled statistics as a part of economics.

It is not possible to depict the specific economic areas where quantitative tools occupies an effective role. Particularly the integration of theoretical and empirical analysis should have developed simultaneously. However, the beauty and flow of economics as a beauty description should not hampered by the complicated unnecessary, and irrelevant mathematical tools.

REFERENCES CITED

Baumol, william J., (1990), Economic Theory and Operations Analysis, Fourth Edition, Prentice Hall of India Pvt. Limited, New Delhi, 110001.

Dhungel, Kamal R., (1992), *Mathematics and Statistics for Economics.* Sarita Prakashan

Lahuri Tola, Varanasi.

Gupta, S.P., (1976), Statistical Methods. Nineth Edition, S. Chand & Sons, 4792/22. Daryaganj, New Delhi.

Jhingan, M.L., (1985), Macroeconomic Theory. Vani Educational Books, Vikas Publishing House Pvt. Limited, Ansari Road, New Delhi 110002.

Koirala, G.P: Agrawal, G.N., (1988), The use and significance of mathematics and statistics in Economics: A case of curriculum in Economics at T.U. seminar paper, Central Department of Economics, Kirtipur.

Muller, M.G.,, (ed.) (1988), Readings in Macroeconomics. Second Edition, surjeet Publi Publications, Kamla Nagar, Delhi 7.

Pranab Basu, (1992), How mathematics saved economics. The Times of India, Business Column.

Shapiro, Edward, (1989), Macroeconomic Analysis. Fifth Edition, Galgotia Publication Pvt. Limited, Ansari Road, Daryanganj, New Delhi.

Singh, Parashar, Singh, (1984), Econometrics and Mathematical Economics . S. Chand & Company Pvt. Limited, Ram Nagar, New Delhi-110055.

Watson/Getz, (1986), Price Theory and its Uses. Fifth Edition, Khosla Publishing House, New Delhi.