ECONOMIC-ENVIRONMENTAL SYSTEMS STUDIES

by

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C E R T I F I C A T E

Certified that the thesis entitled "ECONOMIC ENVIRONMENTAL SYSTEMS STUDIES", which is being submitted by Mr. D.K. BHARGAVA for the award of the degree of Doctor of Philosophy in Electrical Engineering of the Indian Institute of Technology, Delhi, is a record of the student's own work carried out by him under our supervision and guidance.

The matter embodied in this thesis has not been submitted for the award of any other degree.

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DINESH KUMAR BHARGAVA

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* A B S T R A C T *
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The long-felt need for developing a general system theoretic frame-work for socio-economic systems incorporating dynamic, spatial and structural aspects together with predictive capabilities has resulted in the extensions and generalizations of the procedures of "Physical System Theory" so as to render them applicable to the study of systems such as economic, transportation, education and health care. The present research work aims at further generalizing the physical system theory modelling philosophy and methodology in a significant way such that they encompass multidimensional studies of economic-environmental system. Broadly speaking, there are two major parts and a minor part into which the research investigations can be divided:

Part one deals with the development of a multi-regional multi-sectoral state-space model for the national economy. The latter is viewed as comprising of m inter-dependent regions each of which consists of n inter-dependent sectors. Each sector is treated as a collection of interconnected multi-terminal components. The behavioural characteristics of each (N + 1)-terminal components are completely specified by a set of N 'terminal equations' and a 'terminal graph' with N edges. Each edge of the terminal graph is associated with a distinct

pair of complementary variables appearing in the associated terminal equations: a through variable Y, the commodity flow-rate valued in constant mometary units and an across variable X, the associated per unit price-index. The final state model is developed through a systematic procedure amenable to automatic formulation that suitably combines the component terminal equations with the interconnection constraints, the latter resulting from the system structure. In addition to subsuming the relevant models developed earlier, the present class of models has the following features that are worth noting.

Two of the most important economic aspects are the supply and demand for a commodity. Usually, the economic system models do not explicitly and adequately incorporate both of these variables as distinct entities. The present modelling construct maintains a distinction between the two by invoking the concept of inventory - its changes acting as signals for controlling the rate of production and/or associated price-index. The non-linearities existing in production and transportation are taken care of, without unduly complicating the model, by introducing additive nonlinear terms through appropriate modifications of per unit value added and transportation costs. The models, in addition to predicting the various outputs, inter-and intra-regional supplies, and the associated

price-indices can also be used to obtain the values of stock changes. The model has been empirically implemented for India both at a two region-three sector level as well as its relatively "open" counterpart at a two region-two sector level, in terms of a time-span consisting of base year 1963-64, calibration period from 60-61 to 69-70, validation period from 70-71 to 72-73 and prediction period ranging upto 80-81.

Pollution is a byproduct of regular economic activities. Obviously then, if possible, these environmental repercussions should be described and analyzed as an integral part of the traditional economic system. Part two of the present work develops a state-space model for this integrated economic-environmental system. The state variables in this extended version remain precisely the same as those in the economic counterpart. Both externalization and internalization of antipollution activities are taken into account. In absence of any relevant real life data in the context of our country, the model has been rendered operational using a suitable hypothetical example.

Technological progress can be incorporated in the system-theoretic constructs described above by introduction of suitable macro-economic production functions. The minor part of our research investigation utilizes Extended Kalman Filtering to identify the

parameters of a linear labour-capital production function suitably modified to include the technological innovations. The results are compared with similar other results obtained by using Marquardt's nonlinear regression technique.

Lastly, in conclusion, the thesis provides a critical discussion of the proposed models together with the results following there from and also outlines the scope for further work in the areas partially unscrambled by our research.

An Appendix provides a system-theoretic interpretation to the said models using the familiar block diagram representation.

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