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ABSTRACT

Statement of the Research Problem

Natural Resources denote those naturally occurring resources, environmental and ecological systems that are valuable to mankind or could be useful under feasible technological, economic and social circumstances (Bhattacharya 2013). They are critical inputs to production, consumption and survival of life in all its forms and serve as a link between an economy and environment. A decline in their quality, availability, or productivity can generate resource scarcity and cause a reduction in economic well-being. Limited quantity of resources as a constraint to growth has been debated since the classical era and continues to be a significant research question for environmental economists and natural scientists alike. Existing empirical tests utilize diverse resources, time frames, estimation techniques and varied assumptions. Due to this diversity their results remain case and context specific and can't be generalized. In case of developing countries, such as India, scarcity is virtually unexplored. Furthermore India's dependence on resources (such as land; croplands, forests, agricultural produce; minerals, etc) can lead to overexploitation, concentrated utilization & depletion. This generates a need to determine the exact state of scarcity in the Indian economy and ensure that resources are being utilized with no higher opportunity cost. In this context the present study seeks to examine, analyze and determine whether scarcity trends have played a dominant role in the Indian economy for metal and land resources.

Research Methodology

The present study selects land and metal resources. For metals an economic indicator (Real Prices) is used and for land a physical indicator (Land-Use within and across sectors) is employed. For metals resources selection corresponds to Skinner (1982) & Anderson's (1985) classification of Geochemical Scarcity & Geochemical Abundance. Data from 1958 - 2012 were collected from the Indian Minerals Yearbook, Indian Bureau of Mines. Land use data from 1950 to 2012 were collected from Land Use Statistics, Directorate of Economic and Statistics.

To address the issue of resource scarcity from a model-based perspective Unobserved Components Models (along with Structural Break Tests and Compound Growth Rate) were estimated. The UCM is formulated in the state space form (SSF) and mandates an explicit formulation of stochastically time-varying terms to arrest the dynamics of the response series. It is estimated via the Kalman Filter. The Kalman Filter is an algorithm that utilizes a series of measurements including statistical noise and inaccuracies to generate estimates of unknown variables. These tend to be more precise than those based on a single measurement alone. This approach allows the inclusion of multiple state equations to mutually account for the dynamics of the data. These include uncertainties stemming from asymmetric information (related to stocks, economic and probable reserves, alternative technology and demand), impact of short term fluctuations which circumvents overestimation (or underestimation) of the data in the short and medium term and trend disruptions. Generally, such an

approach can be exhaustive in terms of parameters, but due to the imposition of restrictions the proposed models remain parsimonious. Finally it provides a theoretical framework that can be used to test the results against historical data and provide useful insights into data patterns.

Results

The parameter vector of the measurement and transitory equations in UCM contains variances of all disturbance terms (hyperparameters), damping coefficients, cycle frequencies and regression coefficients. The hyperparameters estimate the speed at which the unobserved terms evolve inter-temporally and their impact on the one step ahead error variance. Smaller variances indicate a higher stability while larger variances indicate that the term is more random. The results are presented sequentially.

Metal Resources - Model **c**omparison shows that models with stochastic components, breaks and cycles outperform the deterministic ones. For all metals the parameter estimates showed that the level and slope terms were positive indicating a rising trend. The identified interventions were instrumental in influencing the trend. These capture specific events of economic consequence and indicate periods when metal markets were disrupted by economic activities and not due to a sudden fall in reserves or depletion of existing resource stocks. For all resources there are short term deviations which involve a high measure of arbitrariness causing the timing, periodicity and amplitude of the cycles to exhibit stochastic properties. These are transient in nature and do not arise in response to scarcity. The q-ratio establishes that maximum volatility (in relative terms) is attributable to the cyclical terms. Their high amplitude can incorrectly lead to overestimation (or underestimation) of resource scarcity in the short term. To conclude the utilization of real prices as scarcity indicators asserts that in the long run prices will rise to indicate growing scarcity and vice versa (Fisher 1979). However the present results establish that price dynamics are attributable to separate structural components casting a doubt on the above premise.

Land Resources - Model selection criteria show that for all land classes models with stochastic components outperform the deterministic ones confirming inter temporal fluctuations. There has been a constant addition of land to the Non-Agricultural sector (NAS) however for the Agricultural sector (AGRI) land-use is a declining function of time. Towards the end of the sample period the rate of decrease reduces to an almost constant drift. In case of the Ecological sector (ECO) the trend is stochastic and land use declined from 1964 to 2009. However post 1980 the decline has been meager and since 2010 an increase has been documented. Intra-sectoral estimates document an increase for land under Forest use. The rise till 1970 coincides with the increase in reporting area and social forestry programs. In contrast, the other components of ECO **[**Miscellaneous trees (MISC), Barren & un-culturable land (UES) and Permanent pasture PERM)] exhibit decline in land use. For MISC and PERM the decline is pronounced till 1975 post which the movement of land from the sectors has been negligible. For Culturable wasteland (CULT) the slope is negative and most of the decline was achieved from 1950 to 1974. The trend for Fallow lands (FAL) shows that post 1971 more land is remaining uncultivated for more than 5 years. Net Sown Area (NSA) exhibits increase in land use however most of the gains were achieved till 1970s and from 1997 to 2004 the trend turns negative. To conclude while inter-sectoral analysis establishes rising scarcity in the AGRI the intra-sectoral analysis highlights declining land use in ECO. Further, examination of the decomposed components exhibit that the decline in the components of the ECO and AGRI coincide with a rise in NAS.