VOLUME - 12, ISSUE - 10, OCTOBER - 2023 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper | Information Technology

AN EXPLORATORY STUDY ON THE ADVANCEMENT OF COMPUTER SCIENCE IN ACHIEVING SOPHISTICATED ECONOMETRIC MODELLING TECHNIQUES, RESULTING IN RELEVANCE OF GOVERNMENT POLICY MEASURES IN INDIA.

Raghav Aggarwal

ABSTRACT The paper researches the use of advanced computer science in helping developing economies like India to achieve macroeconomic goals that have been elusive for a lengthy period. This technology could be effectively used in econometric modelling techniques to help policy makers in framing effective measures to achieve the country's goals. **Research Question:** The paper will attempt to analyze the importance of computerized technology in the use of econometric modelling. How important would these techniques be in analyzing primary data that the government puts up on various portals? Econometric modelling has become an extremely valuable tool in studying the dependent and independent variables in all spheres of the economy. The government is keen to get the right figures such that correct policy measures can be adopted. How far has the Indian economy achieved the above and what are the steps ahead are some of the questions that would be attempted during the research.

KEYWORDS : Artificial Intelligence, Machine learning, Econometric modelling, Statistics, Macroeconomic goals, Indian economy

INTRODUCTION

As science, and especially computer science, has developed rapidly, technology has spread to new fields like artificial intelligence, computing, and quantum computing. Besides this, there are fields like robotics and cyber security which have also witnessed an unprecedented development.

Artificial intelligence has specifically reached a point where it is used in every sphere. The latest computer science technology trends in 2023 are

- Artificial intelligence (AI) and Machine Learning (ML)
- Virtual Reality (VR) and Augmented Reality (AR)
- Robotics and Automation
- Three-dimensional (3D) printing

These technologies have the potential to revolutionize the way work is done, helping with communication and interaction. AI is the broader concept of enabling a machine or system to sense, reason, act, or adapt like a human. ML is an application of AI that allows machines to extract knowledge from data and learn from it in an autonomous fashion. It is often said that an intelligent computer uses AI to think like a human, but to perform tasks on its own, while Machine Learning is the way a computer system develops its intelligence.

The way this is achieved is to attempt to program the computer according to 'human reasoning.' This means the use of a 'neural network' which is a series of algorithms that are modelled like the human brain.

In all the above, the development, research and technology that has been developed is phenomenal. The primary aim is to mimic the human brain with a machine. Once this is done, the other factors like AI and ML will follow naturally.

Definition

AI and ML are the latest discoveries of science whereby ML is a subset of AI that allows a machine to automatically learn from past data without any explicit program. ML is an application of AI indicating the close relationship and connection between the two. They are not the same, but they are connected.

Computer Science Technology

This technology is extremely vast. It includes algorithms which are required for software, and the way the software interacts with the hardware. This involves the study of computational information and automation. The field is closely related to computer programming. Besides this, there are human computer interaction, operating systems, and the latest being artificial intelligence and machine learning to synthesize goal-oriented processes such as problem solving, decision making to name a few. AI and ML being the latest in the discovery of computer technology. It is necessary to understand them more closely.

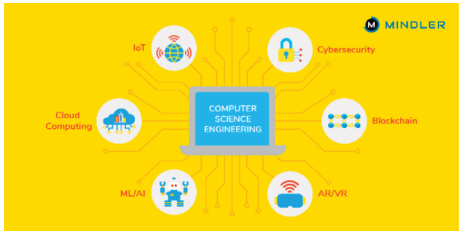

Figure 1
Source: https://www.mindler.com/blog/new-trends-computer-science-engineering/

Artificial Intelligence

AI is a wide-ranging tool that enables people to rethink how to integrate information, analyze data, and use the resulting insights to improve decision-making, transforming every lifestyle. The aim is to get the most out of AI, but to still protect human lives.

AI is a common term, but the exact definition is elusive. It is used as a tool in finance, national security, healthcare, criminal justice, transportation, smart cities as well as achieving elusive macroeconomic goals for the economy. It also aims at addressing issues like data access problems, algorithmic bias, AI ethics and transparency, and legal liability for AI decisions.

Figure 2: Depiction of AI
Source: https://www.jpost.com/business-and-innovation/tech-and-start-ups/article-719001

The nine steps that are important for maximization of AI benefits are

1. Encourage greater data access for researchers without compromising users' personal privacy.
2. To promote new models of digital education and AI workforce development so employees have the necessary skills needed to work with this technology.
3. To create a governmental AI advisory committee for various policy recommendations.
4. To regulate broad AI principles rather than specific algorithms.
5. Important to understand bias complaints and address them such that AI does not replicate historic injustice, unfairness, or discrimination in data or algorithms.
6. Important to penalize malicious AI behavior and promote cybersecurity.

AI is referred to 'as machines that respond to stimulations consistent with traditional responses from humans given the human capacity for compilation, judgement and intention.' Researchers Shubendu and Vijay have defined these systems as 'Decisions which normally require human level of expertise.' This means that machines will anticipate problems and deep issues as they come up because they operate in an intentional, intelligent, and adaptive manner.

AI algorithms are designed to make decisions using real time data. The difference between AI and passive machines is that passive machines use mechanical or predetermined responses. They combine information from a variety of sources, analyze the material instantly, and act on the insights derived from the data. As storage systems have improved, processing and analysis of such data have reached a high degree of sophistication.

AI systems are adaptable as they can learn as well as adapt while making decisions. The real-life situation of AI being used is in cars where advanced algorithm sensors and cameras incorporate experience in current operations. They use dashboards and visual displays to present information in real time, so that human drivers can make sense of ongoing traffic and vehicular conditions. In the case of fully automatic vehicles, advanced systems incorporated in AI completely control the car or truck and make all navigational decisions.

Machine Learning

This means that machines learn algorithms such as

- supervised
- Unsupervised
- semi supervised
- reinforcement learning

Machine learning algorithms can be applied to enhance the intelligence and capabilities of an application. These are then further used in various real-world applications such as projects undertaken by the government to achieve macro goals. Extracting insights from the data intelligently in the relevant domain is a part of the system that comes under ML. ML provides systems with the ability to learn and enhance experience automatically without being specifically programmed.

The effectiveness and efficiency of an ML solution depends on the nature and characteristics of data, and the performance of the learning algorithms. In the case of machine learning, regression, data clustering, feature engineering, dimensionality reduction, association rule learning, and reinforcement learning techniques exist to effectively build data driven systems. The challenge is to select a proper learning algorithm that is suitable for the target application. It is important to understand the principles of various ML technology such that they can be applied to the relevant application area.

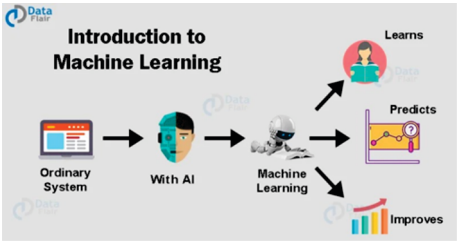

Figure 3: Synchronization of AI and ML
Source: https://data-flair.training/blogs/wp-content/uploads/sites/2/2017/07/what-is-machine-learning.jpg

Econometric Modelling

These are statistical models used in econometrics. The model specifies the statistical relationship between various economic quantities pertaining to a particular economic phenomenon. They are constructed from economic data with the help of techniques of statistical inferences. These models are based on economic theories which assume optimizing behavior.

There are two branches of econometrics:

- Theoretical econometrics
- Applied econometrics

The first one is concerned with methods, properties, and ways in which new theories can be applied to reality. The second one is applying the theory that exists to the data that is provided by an economy. The type of data that is used could be cross-sectional data, time series data, pooled cross-sectional data, and longitudinal data

$$y_{1t} = \alpha_{10} + \sum_{g=2}^{G} \beta_{1g} y_{gt} + \sum_{j=1}^{K} \alpha_{1j} z_{tj} + \eta_{1t},$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$y_{gt} = \alpha_{g0} + \sum_{g''=1;\ g\neq g'}^{G} \beta_{gg'} y_{g''t} + \sum_{j=1}^{K} \alpha_{gj} z_{tj} + \eta_{gt},$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$y_{Gt} = \alpha_{G0} + \sum_{g=1}^{G-1} \beta_{Gg} y_{gt} + \sum_{j=1}^{K} \alpha_{Gj} z_{tj} + \eta_{Gt}.$$

Figure 4: Sample Of Econometric Modelling
Source: https://www.oreilly.com/library/view/micro-econometrics-in-business/9781119096801/c02.xhtml

Normally the econometric models are observations on pricing and quantity and the data that is used could be time series or cross-section or some combination of the two. The equations are normally estimated from the data and are derived from first order conditions from an optimizing problem like Profit maximization. The data on behavior (purchases of goods) is then used to infer the underlying structure of technology and tastes.

These models establish sustainable relationships that are both supported by data as well as easily interpreted from economic theory. The range of modelling for different situations require the use of binary data sets, multiple regression and cointegrated systems.

Macroeconomic Goals Of The Indian Economy

The major macroeconomic goals of the Indian Economy can be specified as:

- Reduction in unemployment
- High Gross Domestic Product (GDP) growth
- Reduction in poverty
- Reduction in inequalities of income
- Price stability

Even after 75 years of independence, India is still lacking with respect to reduction in poverty, unemployment, and income. Inspite of GDP growth settling at close to 7% per annum, this has not trickled down to the poor and marginalized sections of the economy. Resulting in growth primarily settling at the top 10-20% of the population leading to an increase in the inequality levels. The government then, must make a concerted effort by developing several types of support measures in the form of targeted initiatives like the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), various 'BIMA AYOJANs,' Public Distribution Systems (PDS). But for the economy to achieve some type of equitable growth, it is essential that the income levels of the lowest 30% of the population start increasing. The way this could be achieved is to work on a 'trickle-up' approach. Policies directed at increasing incomes of the marginalized sections in the agricultural sector would go a long way in increasing incomes in the economy as close to 45% of the workforce is dependent on the agriculture sector. It is important to encourage medium, small, and micro enterprises (MSMEs) in this sector such that it can create employment potential as well as some extent of urbanization in the rural areas. If this is attempted, then migration to the urban areas will reduce and pressure on the urban infrastructure will be manageable.

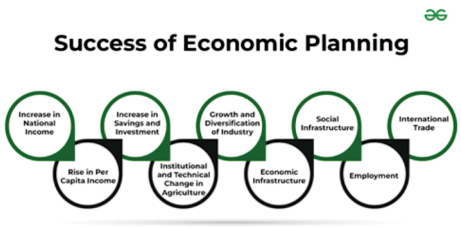

Figure 5: Goals To Be Achieved To Economic Planning
https://www.geeksforgeeks.org/evaluation-achievements-and-failures-of-economic-planning-till-1991/

Use of Statistics Since 1990 in Policy Making

Statistics help economists understand problems with production, distribution, and consumption. Macroeconomic policy for which statistics is a tool exists to provide stable economic environment which is conducive in fostering strong and sustainable economic growth, resulting in the creation of jobs, wealth, and improved living standards. Statistics are used to predict the future and determine the probability that a specific event will occur and are also used to analyze data that is collected from census estimations as well as samples that are available in between censuses.

Census estimation takes place once in ten years and for the balance time representative samples are used to give direction to economists on the type of policy decisions that must be undertaken.

The year 1990 in India was used as a benchmark as this was considered an important year for the introduction of the second major set of reforms after independence. Statistics indicated that there was deceleration in growth, price inflation was at 12.1% high, fiscal deficit was high, demand management was essential, and a reduction in the growth of money supply was important for improving the health of the economy.

All these estimates were statistically analyzed from the National Sample Survey (NSS) and NSSO (National Sample Survey Office) Data. The NSS data has been a major benchmark for various aggregates of the economy. It came into existence in the year 1950 and over the years has expanded its geographic coverage and the scope of its enquiries. It is only in the later decades that additional four categories were added

- Household survey on socio-economic subjects
- Surveys on land holding, livestock, and agriculture
- Establishment survey and enterprise survey
- Village survey

Besides this, especially after 1990, the NSS started conducting ad hoc surveys and pilot enquiries for methodological studies such as surveys on small-medium irrigation projects, rural electrification, railway travel, employment-unemployment activities, construction activities, living condition of tribals.

As the need and requirement to achieve major goals are becoming increasingly imperative, in the past years a huge priority has been attached by regular users of NSS data on

- Survey Subjects
- Extent of standardization

There are constraints with respect to limited resources as well as finance which has resulted in multi-subject integrated survey systems. Where several subjects of enquiry may not be necessarily closely related, they are simultaneously taken up in a single survey operation to optimize the use of resources that may affect the economy. This is attempted for operational convenience for researchers as well as to obtain a better analysis of the survey. In every survey, the definition of the term is indicated, and if there is any change in the definition, it is adequately highlighted. This becomes important for comparison of various figures over space and over time.

Econometric modelling is the next step which is used by researchers and statisticians in discovering the critical areas that must be addressed on an urgent basis by the government.

Given the exhaustive availability of statistical data, both by the government as well as private sources like the Center for Managing the Indian Economy (CMIE), most statisticians try and use two to three resource bases to arrive at a result.

It is only after it has been adequately collaborated from many sources is the decision then made on the path that policy makers have to follow.

For all the above, regression equations, null hypothesis, R statistics, Stata are some of the software that is used for forecasting from raw data collected through various agencies.

Figure 6: Importance Of Econometric Modelling In Policy Making
Source: https://medium.com/analytics-vidhya/machine-learning-or-econometrics-5127c1c2dc53

Recent Developments Of Computer Technology And Econometric Modelling With Respect To The Indian Economy.

Government of India has a macro-consistent framework to target some of the core macroeconomic variables (GDP, inflation, current account deficit, etc.) These targets are set for short term, medium term, and long term and along with it, there are important policy simulations for alternative policy options.

Macroeconomic models were used extensively in most of the 5-year plans till the 5-year plan structure was abandoned and NITI Aayog became the alternate body.

Each institution has their own macroeconomic models, some of which are in the public domain.

The government brings out inflation and GDP forecast every two/three month. These are periodically placed in the public domain by both the central bank, ministry of finance and various private national and international bodies.

The research on macroeconomic models was started by the planning commission with some collaboration with the Indian statistical institute. Subsequently, Klein and Tinbergen discovered models have expanded their reach for developing economies like India.

Indian Council for Social and Scientific Research (ICSSR) was the first to support institutionalization of a macro model under the leadership of Prof. A.L. Nagar. Subsequently, in the 70s and 80s, Institute of Economic Growth (IEG), Delhi School of Economics (DSE), Reserve Bank of India (RBI), Indian Statistical Institute (ISI), National Council of Applied Economic Research (NCAER), National Institute of Public Finance and Policy (NIPFP), Indira Gandhi Institute of Development Research (IGIDR), were recognized as modelling centers.

Most of the models in India followed the Klein-Goldberger tradition. Few models focused on Leontief tradition. As the planning commission was the major client, the evolution of macro models has coincided with the data availability, theoretical framework, and software. In the 80s, the Hiren Sarkar – Lance Taylor model and the Krishnamurthy-Pandit model were used.

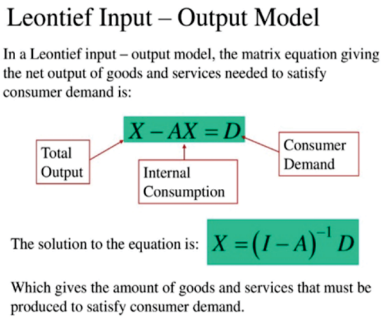

Figure 7: Leontief Input-Output Model
Source: https://slideplayer.com/slide/14261178/

There are many examples of econometric building, but the disadvantage is that models go out of date extremely fast. Database gets revised, new kinds of econometric models come into being, resulting at times in behavioral changes. Thus, any model needs to be constantly upgraded to be useful.

There is a need to focus on long-term analysis and long-term tradeoffs. The main emphasis should be on the database, which is the weakest in the Asia-pacific region. The modelling exercise needs to link the goals with ways through which revenues can be mobilized. As AI technology has taken over the world, it is important to use the same in predicting macroeconomic aggregates for the economy.

The dynamic nexus between fiscal deficit, money supply, inflation and output has led to the understanding of the importance of fiscal stimulus to money supply. Many companies are using the capability theory framework to understand the way AI firms in India are building skills, organizing, and utilizing research and resources. AI technology is being used in finance. The application of this technology in the social sector will impact a range of development and governance outcomes such as law enforcement, improvement in health and education, utilization of natural resources. India is in a position in carving out a niche in the global eco system deploying AI applications that focus on the social sector. The government of India should have an active role in creating institutions that enable constructive collaboration between the government and the AI ecosystems. This requires encouragement of private sectors to innovate and thrive, under the guidance of the government. At the same time, encouraging public-private partnership to innovate and thrive.

Equations	Theoretical model	Empirical model
(1) Consumption	$C = C(i,Y)$	$C = \alpha_0 + \alpha_1 W + \alpha_2 \Pi + \alpha_3 A + \alpha_4 C_{-1} + (L_H)_{-1} + N_p$
(2) Investment	$I = I(i,Y)$	$I = \beta_0 + \beta 1(Y_G)_{-1} - \beta_2 K_{-1} + \beta_3 (L_2)_{-1}$
(3) Liquidity preference	$\mathbf{M}/p = (M(i, Y)$	(a) households: $L_1 = \chi_0 + \chi_1(W+\Pi+A) + \chi_2(i_t - 2.0)^{-2}{}_3$ (b) business sector: $L2 = \phi_0 + \phi_1 (W_1) - \delta_2 i_S - \delta_3(p - p_{-1}) + \delta_4(L_2)_{-1}$
(4) Labor demand	$N^D = N^D (w/p, Y)$	$W_1 = - \phi_1 + \phi_2(Y + T + D - W_2) + \phi_3(Y + T + D - W_2)_{-1} + \phi_4(t\text{-}1929)$
(5) Labor supply	$N^S = N^S (w/p, Y)$	$N^S = \mathbf{N}$
(6) Wage adjustment	$\frac{dw}{dt} = f(N^S - N^D)$	$w - w_{-1} = \varepsilon_0 - \varepsilon_1 (N - N_e - N_E - N_F) + \varepsilon_2(p_{-1} - p_{-2}) \varepsilon_3(t - 1929)$

Figure 8: Klein Goldberg Model
Source: https://www.semanticscholar.org/paper/From-the-Keynesian-Revolution-to-the-Model%3A-Klein-Vroey-Malgrange/e781944f192ec2bc082faef4da2fe8a107a98b6a

Figure 9: Nagar Sahab
Source: https://profnagar.wordpress.com/

Lacuna In The Above Adoption Of Technology

The basic lacuna with respect to the use of AI technology in paving the path of growth for the Indian economy is with respect to the type of raw data that is required to anticipate the final statistic outcomes. Statistics in the Indian economy is gathered every decade through a population census and the subsequent years from sample statistics. The population census paints the true picture of the economy, and it is this raw data which can be effectively and beneficially used for the growth of the economy. Any set of data can always be corroborated through various means and through other sources. This is done to authenticate the data. The problem arises when the population census does not occur in the required framework of time and due to any problems, that arise in the collection of data. Once these issues are ironed out, technology can play an unbiased role in finalizing policy measures that would help the Indian economy.

CONCLUSION

Today's world is one of dependence on AI and ML. There is no part of the world that does not depend on this technology right from medical science to socio-economic issues to advanced use of science in space exploration, airports and other infrastructure facilities present in the economy. As the Science is an unbiased view of human thought process and intelligence, it is important to use this facility in achieving macroeconomic goals that are extremely imperative for a developing economy like India. India in its 77th year of independence requires the use of such technology to uplift the marginalized sections and use its demographic dividend effectively. The government of India should actively use this technology in taking India towards a developed path.

REFERENCES

1. Bickley, S. J., Chan, H. F., & Torgler, B. (2022). Artificial intelligence in the field of economics. Scientometrics, 127(4), 2055–2084. https://doi.org/10.1007/s11192-022-04294-w
2. Brookings. Kedia, M., & Sekhani, R. (2021). Potential Impact of Artificial Intelligence on the Indian Economy. IARIW.
3. Estrada, M. a. R. (2023). How can artificial intelligence (AI) help in economic modelling? Social Science Research Network. https://doi.org/10.2139/ssrn.4479194
4. Gries, T., & Naudé, W. (2022). Modelling artificial intelligence in economics. Journal for Labour Market Research, 56(1). https://doi.org/10.1186/s12651-022-00319-2
5. Kathuria, R., & Kedia, M. (2020). IMPLICATIONS OF AI ON THE INDIAN ECONOMY. Icrier.
6. Marwala, T. (2013). Economic modeling using artificial intelligence methods. In Advanced information and knowledge processing. https://doi.org/10.1007/978-1-4471-5010-7
7. Qin, Y., Zhang, X., Wang, X., & Škare, M. (2023). Artificial Intelligence and Economic Development: An Evolutionary investigation and Systematic review. Journal of the Knowledge Economy. https://doi.org/10.1007/s13132-023-01183-2
8. Sarker, I. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions. Springer Link.
9. West, D. (2018). How artificial intelligence is transforming the world.
10. Widman, L. E., & Loparo, K. A. (1990). Artificial intelligence, simulation, and modeling. Interfaces, 20(2), 48–66. https://doi.org/10.1287/inte.20.2.48