Volume 2 • Issue 2
July 2024

IMI
BHUBANESWAR

jim.imibh.edu.in
e-ISSN: 2583-8326

IMIB Journal of Innovation and Management

e-ISSN: 2583-8326

IMIB Journal of Innovation and Management is published biannually in January and July by International Management Institute (IMI), Bhubaneswar.

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Printed and published by Nitin Bhushan, Chief Administrative Officer, International Management Institute Bhubaneswar, on behalf of International Management Institute Bhubaneswar, IDCO Plot No. 1, Gothapatna, PO: Malipada, Dist.: Khurda, Bhubaneswar 751003, India. Printed at Sai Printo Pack Pvt Ltd, A 102/4 Phase II, Okhla Industrial Area, New Delhi, Delhi 110020.

Editor-in-Chief: Ramesh Behl

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The main focus of the journal is to provide a platform to the academicians and practitioners to discuss innovations and their implications on business management and processes. It focuses on bridging the gap between academia and industry for cross fertilization of ideas leading to effective dissemination of innovative solutions in emerging areas. The journal features research papers across function areas on topics such as customer relationship management (CRM); market segmentation; supply chain management; data mining tools & techniques; block chain; artificial intelligence (AI); internet of things (IoT); customer lifetime value (CLV); economics of information technology; cloud applications; cyber security; mobile computing; geographic information systems (GIS); information systems and ethics; sustainability; green computing; digital marketing; social media; social analytics; supplier relationship management; enterprise solutions; virtualization; cognitive science; governance; entrepreneurship; design thinking; VR or augmented based learning and development; HRMS and HR score card; people analytics; automation in performance management; algorithm trading; RegTech; and FinTech.

The journal is primarily an application-oriented journal and therefore invites research papers that are based on evidence and produce findings that are implementable. The journal is impartial towards methodology used as long as it is robust and relevant.

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Aims and Scope

IMIB Journal of Innovation and Management offers a platform for interface between emerging business management problems and evolving innovative techno-management solutions. It serves as a platform for seamless integration of methodological, technological and disruptive developments, and their business applications. We publish articles which address research in technology, techniques, processes and applications in business. The journal, therefore, bridges the gap between academia and industry for cross fertilization of ideas leading to effective dissemination of developments in emerging areas.

IMIB Journal of Innovation and Management is an interdisciplinary journal in the area of business management which captures developments in technology to facilitate application in business. The journal facilitates dissemination of knowledge on shifting techno-management paradigms and maps its cascading consequences on various facets of business (Marketing, Finance, OB HR, Operations, Strategy, Entrepreneurship, etc.). We encourage research that investigates the impact of innovations on various stakeholders such as customers, vendors, partners, etc. In pursuit of this endeavor, we publish scholarly research as well as practice papers offering unique insights.

IMIB Journal of Innovation and Management

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Innovation in Healthcare Through Information Technologies: A Review

IMIB Journal of Innovation and Management
2(2) 165–178, 2024

DOI: 10.1177/jinm.241237039
jim.imibh.edu.in

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Abstract

The application of innovative information technologies in healthcare can definitely subside the present limitations of the healthcare industry through better affability and accessibility. It encompasses the use of artificial intelligence, big data, biomedical research including drug invention, medical education, innovative/robotic surgical technology, cutting-edge equipment, telemedicine, virtual consultation, online supportive platforms, etc. The present review is an attempt to identify and analyse the impact of these innovative information technologies and explore the potential scope of improvement in the Indian healthcare system. The database search was performed in Scopus, Web of Science, PubMed, ProQuest, Google Scholar and Wiley Online Library. Initially, 319 articles related to innovative digital healthcare technologies have been sourced. However, 105 articles were taken into consideration for the review due to various exclusion criteria. Through an extensive review of previously published articles, the present study concludes that undoubtedly information technologies and their applications aid providers reduce inefficiencies, increasing quality, increasing access, removing human errors, reducing costs and making diagnosis, treatment and medicine more personalised for patients. It has really improved the quality, quick and convenient healthcare system.

Keywords

Digital technologies, digital applications, healthcare, innovative, information technology (IT)

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Introduction

The report 'To Err is Human' released by the Institute of Medicine during 1999, emphasised medical errors which are alarming in terms of keeping the faith of patients in the healthcare system. According to the report, approximately 98,000 deaths per year happen due to human errors (Donaldson, 2008). This happens due to failure of intentional action to be accomplished, faulty practice or conditions that lead individuals to make mistakes to achieve the goal. The report also stated that healthcare is a decade or further behind many other high-risk industries for patients' safety purposes. Way out to the above issue has been discussed in 'Crossing the Quality Chiasm' as implementing the usage of digital technology to improve the current status of healthcare (Institute of Medicine Committee on Quality of Healthcare in America, 2001).

During the 71st World Health Assembly (held in May 2018), the member states of the World Health Organisation signed the resolution that emphasises the need to ensure that innovative digital health solutions complement and enhance existing health service delivery models, reinforced already integrated patient-centred health services, contribute to the betterment of public health and address the lack of research and evidence on the influence of digital health on public and clinical health (Le et al., 2018).

Innovative Digital Technologies in Healthcare

Health information technology (HIT) has become an integral part of the modern practice of medicine as it brings many potential benefits, accessibility and convenience for patients. Healthcare service quality depends on various aspects namely biomedical research and education, infrastructural facilities at hospitals, availability of accessible and ease of treatments, online consultation services, use of artificial intelligence (AI), robotic surgery options, telemedicine, online follow-up service, etc. The prototype may differ from country to country, however, the core principles of treatments remain the same. In this review, the researcher has included innovative technologies and their applications in the healthcare industry. Because healthcare refers to the preservation and enhancement of mental and physical health through various medical services. It encompasses a broad range of aspects including an overall system of medical care and operational aspects.

Benefits of Information Technology

The benefits of HIT include facilitating communication between healthcare providers and patients; improving medication safety, remote care (Choukou et al., 2021), telehealth (Jonnagaddala et al., 2021), telemedicine (Abd-Alrazaq et al., 2021; Galiero et al., 2020) teleconsultation service (Raffaele et al., 2020), tracking, and reporting and promoting quality of care through optimised access to and adherence to guidelines. One of the most significant roles of IT in healthcare is to reduce the risk of medication errors which simultaneously increases patient safety.

Through mediational alerts, follow-up reminders, a better patient tracking system, patients' data sources, efficacy of therapeutic intervention can be analysed. This technology not only simplifies the efforts of healthcare providers but also inspires patients to engage themselves in noticing the results of self-care treatment (Unni et al., 2021). The second section of the study provides the review summary followed by a discussion of research method—how various reviews have been collected systematically. Lastly, the author concludes with present study's limitations and suggestions for further scope.

Objectives of the Study

The primary objective of this review is to identify and enlist various technologies that marked a new journey in the history of the healthcare system. Second, to analyse how information technologies transform the healthcare system and techniques of treatment. Last, to explore the potential scope of improvement in the Indian healthcare system.

Review of Literature

As stated in the World Health Organisation's Global Strategy on Digital Health 2020–2025 report (Yaeger et al., 2019), sustainable, safe, reasonable, reliable and moral digital health ought to be an integral part of modern healthcare practices. It should be established with accessible, feasible, transparent, affordable, confidential, and scalable ideologies. The literature review is divided into two main parts namely digital technologies and digital applications.

Digital Technologies

AI, Blockchain, Big data, Wearable smart devices, Machine Learning, etc., can be defined as digital technologies which aid healthcare providers in getting rid of drawbacks of traditional methods of healthcare system.

Artificial Intelligence

A bundle of AI technologies are incorporated by healthcare industry which emphasises the simulation of human intellectual practices and also reacts like human beings through machines (Yaeger et al., 2019). Horizons of AI in healthcare industry are spread across surgical robots, robotic process automation, diagnosis and treatment application, virtual patient consultation and medication, image processing, image processing, big data analysis, predictive modelling (Rabello et al., 2022), adherence and administrative applications, networking and deep learning, voice technology, cognitive computing, language processing (Odukoya & Chui, 2013), expert system (Davenport & Kalakota, 2019), etc. Figure 1 illustrates the use of AI to promote healthcare facilities.

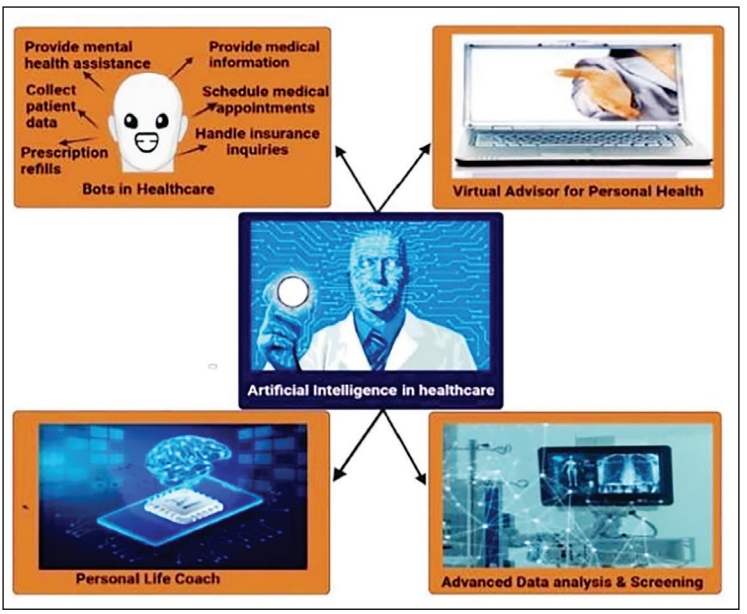

Figure 1. Attributes of Artificial Security in E-health.

Source: Tagde et al. (2021).

Integration of AI into workplace can enable better understanding and fulfilling the needs of patients with less administrative burden, in-depth analysis, unlocking the power of big-data (Chen & Decary, 2020; He et al., 2019), replacing human efforts through robotic assistance, better quality and efficiency, safety, accuracy, etc. Mostly AI tools are used in key ailment areas such as cardiology, neurology and cancer for early disease discovery, examination and appropriate treatment (Jiang et al., 2017; Park et al., 2020).

The efficacy of AI application during COVID-19 to detect the infectious and its further treatment is illustrated in Figure 2.

Blockchain

Blockchain is a scattered ledger of digital entries. It stores data in blocks which are interconnected together and form a chain (Chukwu & Garg, 2020; Sharma et al., 2022). The blocks ratify the sequence of transactions and meticulous time. Once the blocks are linked together, no records can be altered as they are now tied up in a chain. Thus, it provides a forum of accountability, safe accumulation and sharing of information on thousands of servers at publicly accessible networks.

In healthcare system, a blockchain network is used to secure the preservation and exchange of students', citizens' data and patients' data through physicians, researchers, scientists, hospitals, pharmacies and laboratories (Haleem et al.,

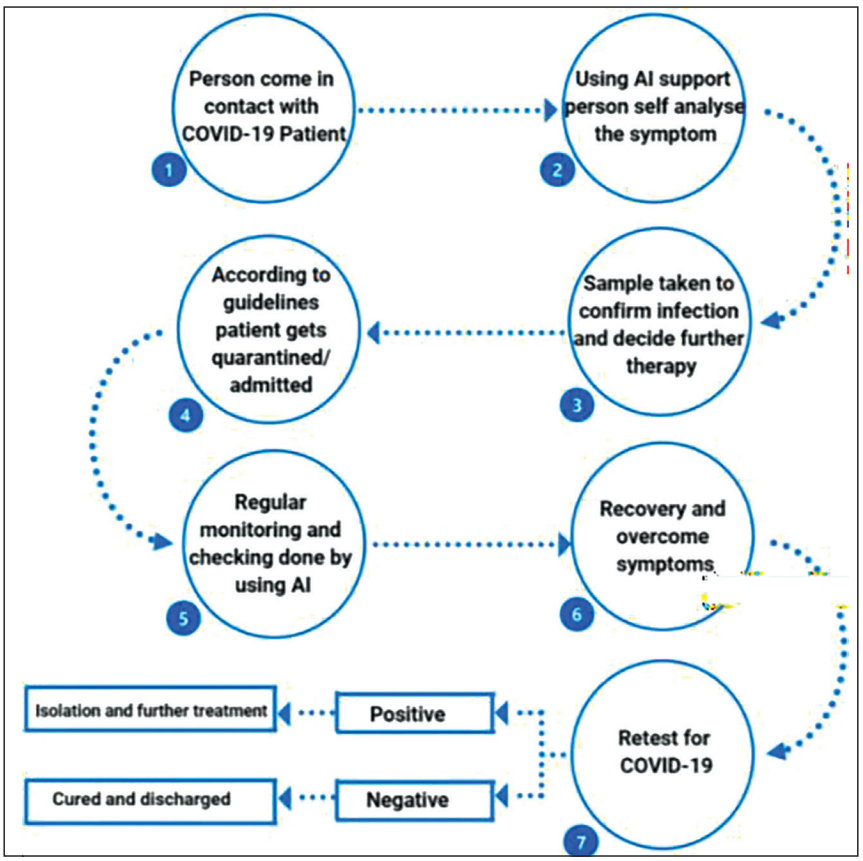

Figure 2. Efficacy of AI Application During COVID-19.

Source: Chandra et al. (2022).

2021). Concisely, Blockchain provides a platform for universal and disseminated value exchange (Dua, 2023). Pharmaceutical companies can also trace counterfeit medications through Blockchain technologies. Blockchain mitigates healthcare issues by creating a decentralised, user-centric, secure and trustlessness mechanism for record transactions (Velmovitsky et al., 2021). Hence, it is often portrayed as a technological solution to gigantic healthcare information's secure exchange (Gaynor et al., 2020). in an efficient way (WHO Report 2020–2025).

Blockchain and AI technology have proved their significance by enhancing the reach, speed, usability, etc., in various sectors. Industries like automobiles have expanded the use of AI by launching driverless vehicles. Though AI demonstrated itself as more powerful than human beings, which can execute many dynamic and cognitive functions, sometimes doctors diligently restrict the use of AI in healthcare, especially when it influences a patient's well-being.

Big Data

Big data encompasses diverse, complex and huge sets of information in quantities such as zettabytes, petabytes, terabytes, etc. Properties of big data are measured through variety, velocity, volume and veracity (Sharma et al., 2018). Sources of big data are numerous including healthcare surveillance registries, government and private hospital records and registrations (Hong et al., 2018), social media (Katsas et al., 2022), search engine databases, smart wearable technologies (Loncar-Turukalo et al., 2019), insurance company records, internet of things (IoT) sensors, smartphones (Mahajan et al., 2020), etc.

Big data are more accurate than traditional methods, can improve efficiency of health strategy, advance quality care services, assist in clinical trials, helpful in forecast modelling, address disparities and early detection of diseases (Alhajaj & Moonesar, 2023). Essentially, big data is useful in predictive analytics, machine learning, keeping electronic records, networking, healthcare intelligence, simplification of huge datasets in a meaningful way. IT providers convert this big data in an understandable way through various Hadoop tools namely Apache Hadoop, Spark, Impala, Hive, Mahout, etc. (Senbekov et al., 2020).

Smart Devices

Health consciousness has caused a paradigm shift in the inculcated use of wearable devices which monitor vital functions of the body. Two striking features of smart devices are support to pursue a healthy lifestyle and constant health monitoring data related to alarming ailment symptoms along with varied physiological parameters by metabolic system tracking. The wearable technologies not only unlock clinical data but also behavioural and self-monitored data of the patients. Hence, wearable health devices have the potential to become a promising mainstream mobile medical market for the upcoming era.

Wider likability of novel smart devices such as smart watches, smart belts, wearable blood glucose monitors mobile applications, radio frequency identification (RFID), ECG monitors, insulin pumps, etc., began with the smartphone (Madanian et al., 2019).

Digital Applications

The applications of digital health technologies including Blockchain, machine learning, and AI can be termed as hospitals, healthcare, and public health (Supriya & Chattu, 2021). This mainly includes virtual consultation and medications, that is, telemedicine, disease diagnosis, therapeutic, hierarchical treatment, machine learning algorithms used for disease prediction, further research and development, virtual surgery techniques, etc. In this review, the researcher has selected a few ordinary and general applications of digital technologies including virtual consultation, telemedicine, medical education and research (Joshi, 2010), pharmacy and logistics, social media platforms, etc.

Virtual Consultation

Although virtual consultations have been available since long, it has proved its significance during COVID-19. Virtual consultation is interchangeably used with E-consultation or teleconsultation. This technology allows health provider to consult their patients through telephone/mobile or other similar digital devices, text/image messaging, video conferencing, email, etc. (Monaghesh & Hajizadeh, 2020). This technology has given birth to E-prescription which ensures patient safety (Alotaibi & Federico, 2017; Page et al., 2021), digital patient records and telemedicine.

Virtual consultation is beneficial to both—health providers and patients. Such as enabling patients to express themselves more openly, image sharing, reducing the need for patients' accompanying persons, multi-person interaction opportunities, remote access, reducing time off work for appointments and no transport costly, etc.

Telemedicine

Telemedicine can also be termed as the usage of telecommunication technologies (Alotaibi & Federico, 2017) to provide and support healthcare when distance separates participants. This application can be one of the economical as well as efficient mean to increases reach and a convenient healthcare system. Healthcare professionals use IT for the information exchange related to diagnosis, treatment and prevention of disease, educational research and evaluation of healthcare workers, with the goal of preserving the health of population (Yaeger et al., 2019). Infrastructural facilities including internet penetration play an important role in telemedicine reach attainment (Dash et al., 2021).

The concept of telemedicine was introduced especially for the remote or rural areas where accessibility is difficult, but people witnessed its peak use during COVID-19 outbreak (Echeverría et al., 2021; Noorbakhsh et al., 2019; Rolston & Meltzer, 2015). And emergencies (Daniel et al., 2015; Kumar & Singh, 2019).

With an intention to restrict the spread of COVID-19 and remote consulting services, Indian Ministry of Health and Family Welfare has acquainted a citizen-friendly national teleconsultation service named eSanjeevani OPD aimed to deliver healthcare services to patients at their place (Masic et al., 2011). Some other examples of telemedicine services include virtual doctor consultation through E-Doctor Seva, Practo, a start-up of BIT Sindri at Dhanbad named Milo Doctor and FOREIGN OPD – The only healthcare brand in India that provides personal consultations with global medicinal experts.

Medical Education & Research

In views of OTA (Office of Technology Assessment), 'Medical technology is a set of techniques, medicines, equipment, tools and procedures used by the health professionals in providing healthcare to the individuals and systems, in which such technology is used' (Moher et al., 2010). IT can assist medical education in

various means such as in computer and technology-assisted learning, human patient simulators, virtual reality, advances in medicine, novel techniques of operating a complex disease, to facilitate student learning such as virtual surgical tutorials, etc. (Jonnagaddala et al., 2021).

Medical research can be upgraded with the assistance of information technology to uplift the health standard, to explore the simplest and the most effective way of treatment and rehabilitation.

Social Media Platform

Social media platforms remarkably changed the way patients and healthcare providers way of communicating health-related information (Gijsen et al., 2020). These platforms include various online applications such as Facebook, Twitter, YouTube, Blogger, Wikipedia, etc., and allow the users both creation and usage of content. Social media plays an important role in disseminating health-related information on online platforms. Due to internet connectivity, and extended smart phone usage, it is estimated that today approximately 3 billion users have benefitted from such applications (Hong et al., 2018). According to a report, it is estimated that worldwide, 15,220,700 contents are uploaded every minute (Gaynor et al., 2020).

Developing countries like India dealt with COVID-19 pandemic situation through frugal technological innovations like origination of ventilators at large spectrum, production of PPE kits, Dhanvantari Rath, launch of Arogya Setu mobile app, etc. (Sharma et al., 2022).

Pharmacy & Logistics

Online pharmacy also known as telepharmacy is rapidly growing area within pharmaceutical industry. Telemedicine falls under the umbrella of telepharmacy. This platform allows pharmacist to evaluate the prescription and providing the ordered medicines (Tin et al., 2018) to patients at their place without unnecessary commuting (Michele et al., 2013). The telepharmacy encompasses telephonic patient counselling, mail order, cooperative drug management, central processing, automated and remote distribution systems, medication therapy management, remote order entry, and 24/7 pharmacist counselling, etc. (Tin et al., 2018). During the COVID-19 pandemic, telepharmacy was soon recognised as a tool which could overcome so many challenges (Unni et al., 2021). including limiting the transformation of viruses, quick availability, etc.

Method

Article Sourcing

The articles were sourced from various databases namely Google Scholar, Scopus, Web of Science, PubMed, ProQuest and Wiley Online Library.

Inclusion Criteria

Initially, 319 articles related to digital healthcare technologies have been sourced. All articles were published from 2000 to till date in English language. The keywords used for present review article were digital healthcare technologies, IT in healthcare, big data, telemedicine, blockchain, remote and virtual follow-up, AI, healthcare industry progress, etc.

Exclusion Criteria

However, application of exclusion criteria reduced the size of collected articles up to 105. Exclusion criteria encompass time horizon, scalability of geographical area, purpose of the study, data collection technique, grade of innovation, short articles, wider applicability of technology, practical application including feasibility, adoptability, language barrier, etc.

As a qualitative measure, all the collected articles were critically analysed through Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist 2009 (Moher et al., 2010) and 2020 (Page et al., 2021). Which ensures that the techniques and end results of systematic reviews reported in the article are adequate, trustworthy and applicable to futuristic research. Similar to PRISMA 2009, PRISMA 2020 has a checklist of 27 items. The difference between both versions is updated and revised wording. PRISMA 2020 uses more comprehensive wording and is more helpful for all fields. It gives reviewers more report precision. Figure 4 shows a flow chart of different stages by which finally, 105 articles were considered appropriate for the review.

Discussion and Implication

Figure 3 provides a summary of digital technologies and their applications discussed in the present review. The usage of digital technology in healthcare industry can definitely improve the quality, accessibility, convenience, ease of approach and quick treatment. Innovative healthcare treatment produces a lot of benefits along with patient satisfaction but also triggers concern for providers related to patient data privacy and safety. Though the precise impact of information technology on healthcare is difficult due to various aspects and applications, it can be defined through the existing literature notifying the change in nature and principles of interactions between doctors and patients.

The innovative information technologies contributed immensely to defeating the worldwide COVID-19 pandemic (Ienca & Vayena, 2020; Javaid et al., 2020). In fact, COVID-19 outbreak has hastened the growth of information technology. At the same time, the implication of information technology in healthcare system is not an exception in terms of challenges namely data fragmentation, data lag, data privacy, digital security breaches, risk in over reliance, etc. (Mold et al., 2021; Wang et al., 2021).

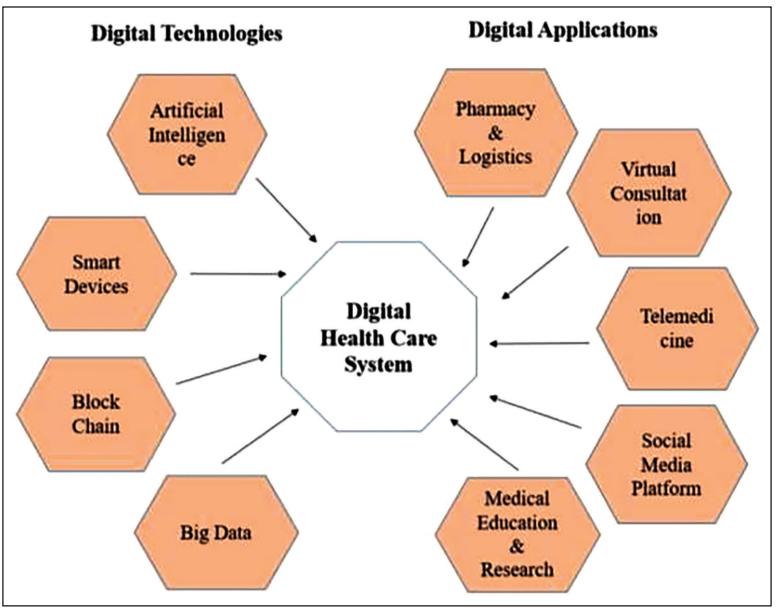

Figure 3. Summary of Digital Technologies and Applications of Digital Health Technologies.

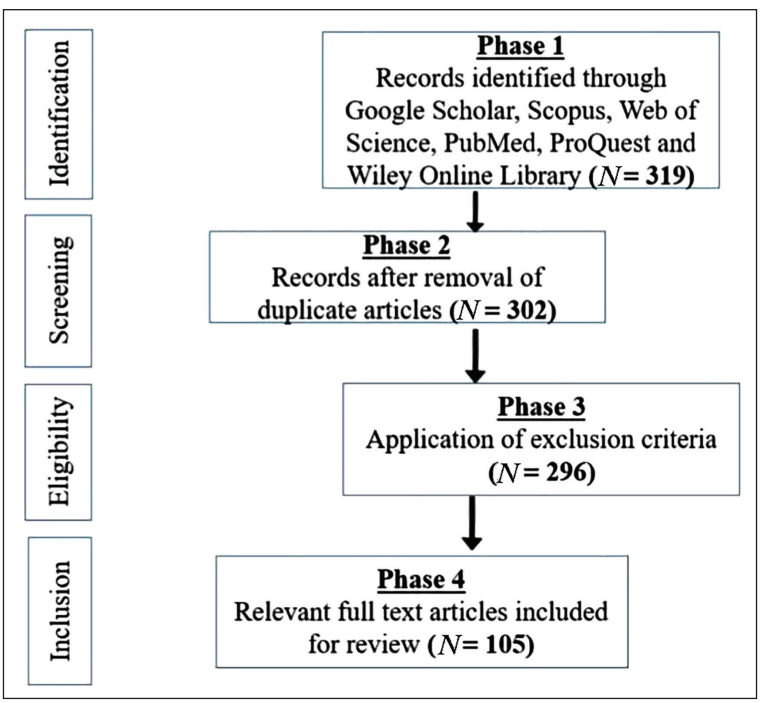

Figure 4. Flow Chart Showing Data Source Method.

Conclusion

In recent decades, information technologies in healthcare were broadly studied and applied in medical education, research, biomedicine, diagnosis and disease treatments. Moreover, such technologies became highly sought during COVID-19 pandemic. The execution of information technologies such as big data, smart devices, telemedicine, telepharmacy, AI, machine learning, blockchain, IoT, etc., and its applications can enrich the quality support with far convenient way of treatment. Since the outbreak of COVID-19, IoT gained momentum as it provides with rapid screening of patients, automatic or programmed treatment through various medical tools and devices, tele-healthcare consultation.

Based on available literature, it can be proposed that with more scientific developments, technology upgradations and the propagation of personalised health devices, information technology will enrich the daily lives of citizens. However, further exploration related to better IT applications and its implications in healthcare industry is still required.

Acknowledgement

The author is grateful to the anonymous reviewers of the journal for their extremely useful suggestions to improve the quality of the article. Usual disclaimers apply.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author received no financial support for the research, authorship and/or publication of this article.

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Article

Exploring Innovation and Public Health Priorities Within the Realm of Medical Sociology of India During COVID-19 Pandemic

IMIB Journal of Innovation and Management
2(2) 179–192, 2024

DOI: 10.1177/jinm.241242857
jim.imibh.edu.in

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Abstract

In the context of the ongoing COVID-19 pandemic, the Indian medical innovation ecosystem confronted substantial challenges in meeting the pressing healthcare requirements of the nation. These challenges demand a comprehensive examination to discern the critical issues in Indian Medical Sociology about medical innovations. The primary objective of this study is to assess the intricate interplay between the approaches employed in drug and vaccine development and their consequential effects on affordability and accessibility. Concurrently, it aims to evaluate the efficacy of the existing policy measures affecting social divisions that have emerged because the supply-driven health system has exacerbated.

A qualitative research methodology has been adopted for this inquiry, utilising thematic analysis to dissect the intricacies of the Indian medical innovation ecosystem. The study unfurls the following noteworthy discoveries that contribute to a nuanced understanding of the landscape: (a) it becomes evident that the predominant focus within the Indian medical innovation ecosystem revolves around creating affordable medical technologies and pharmaceuticals, often overshadowing the pursuit of cutting-edge advancements. (b) The strategies employed in developing drugs and vaccines exhibit a conspicuous inclination towards products that promise higher profits, subsequently giving rise to issues associated with affordability and accessibility. (c) While policy measures have been implemented with the intent of addressing the concern of affordability, their actual efficacy in ensuring equitable access to medical innovations raises

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significant doubts. (d) A discernible imbalance emerges between India's industrial and public health priorities, with economic growth overshadowing the imperative of bridging the existing social disparities.
These insights collectively underline the imperative for strategic policy interventions, a more balanced approach to development, and establishing a multi-institutional framework. These actions are essential to confront the challenges related to affordability, accessibility and the aggravated social divisions that persist within the ecosystem. The study brings out the indispensable importance of cultivating a socially responsible and all-encompassing medical innovation ecosystem, not only as a means to address the prevailing healthcare challenges but also to foster an environment that guarantees equitable access to transformative medical innovations for all segments of society.

Keywords
Medical sociology, innovation, public health, medical innovation ecosystem, public policy, access to healthcare

Introduction

The COVID-19 pandemic in India has introduced unprecedented disease prevention and management challenges. This has given rise to a multitude of obstacles in the field of medical sociology, as well as the broader healthcare industry's innovation ecosystem. Throughout history, the occurrence and resurgence of contagious diseases have posed significant concerns for developing and underdeveloped nations worldwide. Various political and economic conditions have hindered these countries' growth and attention towards medical advancements. A noteworthy example is the inadequate focus on diseases, such as 'Ebola', 'Dengue' and 'Japanese encephalitis' in India and Nepal, as well as 'Influenza' and 'Malaria' in numerous African and South Asian nations. Vaccines, drugs and medical devices for these diseases have not received attention. This disparity is evident in global instances of 'Severe Acute Respiratory Syndrome' (SARS) in 2002 and the 'Zika' virus outbreak in 2016. Diseases of this nature in impoverished nations have either been neglected or not considered priorities for development. The COVID-19 pandemic has laid bare the ill-preparedness of the world in addressing contagious disease issues, transcending the dichotomy of rich and poor.

Consequently, this situation provides a fascinating avenue for sociological exploration of the threat posed by such diseases in global societies, considering that the perception of infection risk has permeated all socioeconomic strata. Such investigations into medical sociology can be grounded in the epistemology of the contemporary organisation of innovation ecosystems. Current medical innovation systems have been shaped by the values and ethos of techno-capitalism, exerting substantial influence over governments' policy priorities. Thus, it becomes imperative to comprehend the distinctions between public health policies and medical innovations in India and the world.

Over the past four decades, there has been a remarkable progression in medical advancements, particularly in pharmaceuticals, vaccinations and medical equipment. This progress and the interplay and innovations within disciplines such as biotechnology, biomedicine, bioinformatics, genomics and synthetic biology have fueled this progress and have given rise to a new breed of competitive markets and intellectual property protection regimes fostered by collaborations between governments, academic and entrepreneurial research institutions and industries on a global scale. A consequential result of these transformative shifts has been the proliferation of Research and Development (R&D) endeavours within the healthcare domain. Private enterprises primarily drive this upsurge, thanks partly to the emergence of venture capital. However, amidst these advancements, there has been a significant fall in government funding allocated to public health initiatives. This decrease in public health funding, except for a few diseases addressed by state health departments, university divisions and specific research institutes, raises essential considerations.

Globally recognised is the significant contribution of the medical innovation ecosystem to disease control, treatment and management. Laal (2012) delineates a spectrum of innovative medicines, encompassing 'aspirin', 'insulin', 'oral contraceptives', 'penicillin', 'smart pills', 'statins', 'vaccines' and 'viagra'. Similarly, a range of technologies, including 'electrocardiography', 'electronic health records', 'laser surgery', 'magnetic resonance imaging (MRI)', 'nano-healing', 'organ transplant', 'ultrasound', 'X-ray', etc. have emerged as pivotal medical innovations in recent decades. Also, notable medical devices such as 'artificial hearts', 'artificial joints', 'bone injector drills', 'dialysis machines', 'handheld medical scanners', 'lens implants', 'robotic catheters', 'skin antennas', etc. exemplify the diverse landscape of medical innovation. Discoveries of the human genome allowed medical sciences to explore enormous possibilities that expand medical innovation's scope regarding personalised medicines, prognosis and diagnosis of high-risk diseases. Similarly, stem cell research, cancer therapies, combinational drug therapies and DNA-sequencing technologies are innovations joining the league of medical innovations that contributed to the development of the healthcare industry and had a long-lasting impact on human society.

These research and innovations have contributed to the development of drugs, vaccines and medical devices through academic-industrial collaborations. An increase in thrust to such collaborations is observed in India, but rigorous commercialisation and monopolisation of innovations from such collaborations pose vital questions for public health. It poses sociological questions about such collaborations' power dynamics, authority and political economy. For instance, who decides priorities for medical innovation? What significant contemplations require looking into the disease or components of public health of any beneficiaries? Are these collaborations, R&D and innovations adding value to society, or are they just meant to satisfy the needs of techno-capitalism? Do such innovations lead to vulnerabilities, marginality or social inequalities? Will such devices, drugs or medical innovations lead to medicalisation? If so, the burden will be borne by whom? And many more.

The biggest challenge experienced in India during the COVID-19 pandemic in the medical innovation ecosystem is achieving a balanced approach for drug and

vaccine development, controlling price and affordability. The study of existing literature suggests that such challenges must be addressed at the policy, management and administration levels. It is a known truth that returns drive R&D projects in the Indian pharma industry, as drug and vaccine development were financially costly projects with the lowest success rate. The therapeutic trajectory of drug and vaccine development predominantly revolves around high-yield products and target demographics. Nonetheless, existing literature does not fully acknowledge the social and emotional toll incurred in mitigating disease burdens, thus complicating the defense of arguments advocating for increased financial allocation toward future disease mitigation efforts. Research and Development expenditure often correlates with the projected costs of new pharmaceutical products. While various policy interventions implemented at different stages of the pandemic have ostensibly addressed the affordability of vaccines and drugs, they have not uniformly ensured enhanced access. Furthermore, certain policy measures aimed at alleviating the financial burden of R&D expenditure have fallen short of guaranteeing affordability. For instance, initiatives such as reducing or standardising value-added tax on medications, cutting or eliminating excise duties, commitments to establishing biotech parks, providing financial aid to start-ups, lifting financial caps on Foreign Direct Investments (FDIs) and fostering collaboration between academia and industry have incentivised R&D in medical innovation. However, its translation in affordability and accessibility of drugs or vaccines is still questionable.

Another challenge observed during the COVID-19 pandemic in India is about balancing Industrial (or capitalist?) and public health priorities. India's public health and drug policies are still exclusive frameworks in terms of their objectives and functions, with multiple overlapping concerns (George et al., 2018). For instance, in India, the Ministry of Chemicals and Fertilizers oversees drugs and pharmaceuticals, whereas in developed nations, drug development falls under the purview of the Health Ministry. Consequently, industrial expansion, regulatory measures and promotional initiatives related to FDIs, exports and tax incentives within the medical sector, including pharmaceutical and biopharmaceutical enterprises, are predominantly influenced by industrial and export-import economic policies rather than health-focussed social policies (Figure 1). Because of such a scenario, more thrust is observed on investment promotion and industrial or economic growth rather than focussing on bridging the social divide between the medical innovation ecosystem and society.

There exists a scarce amount of scientific literature discussing over social costs and benefits of medical innovations in India. In India, supply-driven healthcare produces results in a variety of societal divides like (a) it emasculates policy focus on the epidemiological burden of poor geographically and social sections of society; (b) the benefits of medical innovations are disturbed by and for economically better-off populations while the burden of cost in terms of clinical trials generally borne by the poverty-ridden population. In this vital context, it is urgently required to fix policy priorities for the drug industry to have formal social obligations, directing funds for more affordable cutting-edge R&D and translating these R&D investments into the public welfare of the heterogeneous population of the country through a multi-institutional framework.

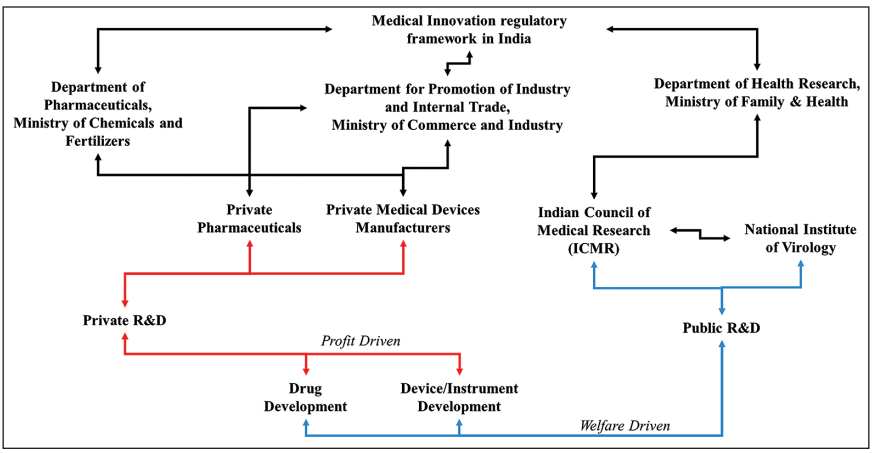

Figure 1. Regulatory Framework Observed During the COVID-19 Pandemic When India Sought Vaccines and Other Medical Innovations.

It becomes crucial to address vital research gaps that are observed in existing scientific literature and thus, the paper contributes towards grasping (a) policy measures adopted in India to address issues related to access and affordability of medical innovations in India during COVID-19 pandemic conditions; and (b) contribution of supply-driven health systems towards social divisions leading to unequal access to medical innovations.

Based on the literature survey, the research questions were formulated which is used in the next section of the paper. The following section of the article focusses on details about the study, research questions and objectives. The paper's third section comprises a qualitative analysis of the Indian medical innovation ecosystem. This analysis encompasses various thematic dimensions, including examining the roles played by different stakeholders, the emphasis on the development of affordable technologies and drugs, the challenges associated with achieving a balanced development approach and the impact of industrial and public health priorities. Interpretations are supported by incorporating pertinent literature and critical observations.

Lastly, the concluding section effectively summarises the key insights derived from the analysis and critical observations. It highlights challenges confronting the medical innovation ecosystem in India, explicitly focussing on affordability, accessibility and the need to bridge the social divide. The study underscores the necessity for policy interventions and establishing a multi-institutional framework to address these challenges effectively.

Previous Works (Literature Review)

Table 1 provides an overview of selected studies that have contributed to understanding the medical innovation ecosystem. Each study focusses on

Table 1. Major Studies Reviewed.

Authors	Year	Thematic Focus
K. Birch & D. Tyfield	2013	Theorising the bio-economy and its implications
A. Clarke et al.	2009	Biomedicalising genetic health, diseases and identities
M. E. Cooper	2011	Examining biotechnology and capitalism in the neoliberal era
V. R. Fuchs & Jr H. Sox	2001	Physicians' views on the relative importance of innovations
S. George et al.	2018	Assessing drug development in India and its responsiveness
S. Jasanoff	2004	Exploring the idiom of cooperation in scientific research
K. S. Rajan	2017	Uncovering the dynamics of value, politics and knowledge
T. Stevens & S. Newman	2019	Investigating entrepreneurial bioscience and its agendas
C. Waldby	2002	Examining the production of biovalue through tissue cultures

theoretical frameworks related to a variety of areas. These studies cumulatively contribute to the body of scientific knowledge and inform the analysis presented in the current research work.

Fuchs and Sox (2001) conducted a noteworthy study categorising 30 significant innovations in America. Among these innovations, angiotensin-converting enzyme, balloon angioplasty, inhibitors, mammography MRI and computed tomographic scanning and statins, emerged as the five most impactful on human society. Conversely, innovations such as bone marrow transplant, calcium channel blockers, conscious sedation, non-sedating antihistamines, sildenafil (Viagra), were identified as the least essential. Such categorisation of innovations raises questions because the study was conducted based on the experiences and perceptions of participants. Such studies do not satisfy questions related to the relevance of innovations to public health. Instead of judging the usefulness of innovations, one should judge innovations based on their impact or contribution to public health. Along with innovations in the medical field, medical sociology also needs to grasp conditions of social changes created by pharmaceutical and biopharmaceutical innovations that have attracted a significant amount of attention from scholars worldwide for various reasons. The studies discussed illustrate the involvement of medical sociologies in navigating epistemological shifts, examining political economy dynamics, exploring collaborative production processes and analysing impacts and consequences for access, affordability and the medicalisation of the human body and entire human society (Birch & Tyfeld, 2013; Cooper, 2011; Pandey et al., 2014; Rose, 2007; Waldby, 2002).

The commodification of science on others has influenced public health policies heavily. The commodification of science has thus impacted the research ecosystem where research and development are viewed as business Levins & Lewontin (1985). This scenario is evident from growing literature in the area of medical sociology (mostly on biopolitics and patient subjectification) and the political economy inclined towards medical innovations and biomedical technology.

The concept of biovalue, as introduced by Waldby (2002), serves to elucidate the intricate nexus between biotechnology, life sciences and capitalism. This theoretical framework draws upon Marxian theories of value and Foucauldian notions of biopolitics. Biopolitics, as conceptualised by Michel Foucault, focusses on the governance and management of populations through the regulation of their biological and social life. In the medical innovation ecosystem, biopolitics presents how power operates within the healthcare system, shaping the development and distribution of medical technologies, drugs and vaccines. One aspect where biopolitics is pertinent is understanding the prioritisation and allocation of resources within the medical innovation ecosystem. Such perceptions allow us to grasp the challenges of balancing industrial and public health priorities, where economic growth and profit-driven motives often take precedence over equitable access to healthcare innovations. This alignment with biopolitics can be observed in the tension between industrial growth, economic policies and the social obligations of the medical industry towards the larger population. The concept of biopolitics allows for a critical examination of how power relations, economic interests and political forces influence the direction and outcomes of medical innovation, potentially leading to inequalities and a social divide.

Such conceptual framework is further extended by various scholars like Rajan (2006), who illustrated how the novel know-how became the basis of medical innovations that boosted the advancements within the domain of biomedical research and how new technology emerged from such innovations pave the way for the development of a techno-capitalistic paradigm of the healthcare industry as well as affect public health policies. Birch and Tyfield (2013) presented different perceptions. The authors did subscribe to biovalue, bio capital and biopower concepts but not wholly different from the value of labour within a Marxist framework. Their central argument is that value is a mere representation of knowledge value that can be produced, reproduced, exchanged and circulated through various processes and institutions.

Despite such disagreement on 'bioconcepts', the scholars also acknowledge the power of the (bio) knowledge economy and its impact on the social deterministic model of health and well-being to biomedical reductionism and individualised care.

Interestingly, some studies attempt to apprehend the epistemic changes observed in the techno-capitalistic biomedical paradigm. These studies heavily focus on the nature of capital and its strategies of circulation, co-production, accumulation and subjectification of patients (Birch & Tyfeld, 2013; Clarke et al., 2009; Cooper, 2011; Jasanoff, 2004; Rajan, 2017; Rose, 2007; Stevens & Newman, 2019; Strasser, 2014;). Rose (2007) elaborated epistemologies of the 'molecular self', which views the body as a collective of various organs and cells

grasped as separate entities for research. He epistemologically approaches biomedicine and claims it is biomedical reductionism, which presents a shift from 'corporeal self' to 'molecular self'. Such conceptions open an avenue for a wide range of medical innovations focused on customising bodily appearance, redefining normalcy, medicalising the body, etc. Clarke et al. (2009) focussed on techno-scientific innovations organised around biomedicines that led to the biomedicalisation of society. The authors explained that biomedicalisation is a process that is consolidating, hegemonised and legitimised by the State. Increased health surveillance in the biomedical paradigm presents a shift in the healthcare approach, that is, treatment of risk, which further commodifies health, well-being and lifestyles.

About Study

The study adopts a qualitative approach, presents thematic propositions and leads to a hypothesis for further research. Thematic propositions, such as the influence of the social divide on the affordability and accessibility of drugs and vaccines, provide a foundation for further exploration. It emphasises the importance of multi-institutional collaboration to translate R&D investments into public welfare for the diverse population. The need to balance industrial growth and public health priorities is underscored, suggesting the alignment of drug policies with social needs rather than solely economic considerations. Ethical concerns regarding distributing benefits and burdens in drug development are also highlighted. The paper also suggests a hypothesis highlighting the financial burden on future disease mitigations resulting from prioritising high-profit products and target groups in drug and vaccine development. It recommends policy interventions to address affordability and accessibility issues, such as price regulation and targeted subsidies.

Research Questions

1. What are the existing policy measures to address the affordability and accessibility of medical innovations in India during the pandemic?
2. How does the supply-driven health system in India contribute to social divisions and unequal access to medical innovations?

Research Objectives

The overarching objectives of this study are fourfold—firstly, to meticulously identify and analyse the multifaceted challenges that the Indian medical innovation ecosystem encountered during the COVID-19 pandemic. Secondly, to conduct a comprehensive examination of the intricate interplay between various drug and vaccine development strategies and their direct influence on the crucial aspects of affordability and accessibility within the context of India. Thirdly, to undertake a

rigorous evaluation of the efficacy and impact of the prevailing policy measures that were implemented to address the intricacies of affordability and accessibility concerning medical innovations amidst the pandemic's turbulence. Lastly, a vital goal is to critically assess the pronounced societal divisions that have emerged as a result of the supply-driven healthcare system, delving into their far-reaching implications about the populace's access to pivotal medical innovations.

Medical Innovation Ecosystem of India During the COVID-19 Pandemic

In the context of COVID-19 in India, it is changes in both pharmaceutical and biopharmaceutical domains during the post-product patent period in India are observed. The Indian drug industry under new IPR realms observed consolidations through M&A (Mergers and Acquisitions), Out-Contracting, decentralising of production and interconnectedness with global value chains. The COVID-19 pandemic proved the powerful influence of biomedical and biopharmaceutical giants over public health policies. The surge in the expansion of research and collaboration networks, coupled with the active engagement of governments, research institutions, public sector laboratories, university departments, among others, is evident amidst the ongoing pandemic.

It is observed that despite an upsurge in income generation within the Indian pharmaceutical sector, the financial growth trajectory of multinational corporations has trailed behind that of Indian private enterprises. The private sector players in India boast substantial revenue and R&D expenditure, particularly within the realm of Indian biopharmaceuticals. Amidst the challenging landscape of the COVID-19 pandemic, the medical innovation ecosystems in India exhibit characteristics intricately intertwined with a multifaceted institutional framework, fostering the commercialisation, replication and realisation of specialised expertise. Such multifaceted institutional approach encompasses a diverse array of contributors, both domestic and international, including pharmaceutical and biopharmaceutical entities, contract organisations, research institutions, private healthcare facilities, as well as foreign and domestic venture capital investors. Moreover, state agencies such as DST, BIRAC, SAARC, etc. play pivotal roles alongside entities facilitating technology dissemination, funding and state-sponsored research bodies like the Council of Scientific and Industrial Research and the Indian Council of Medical Research. Further enriching this ecosystem are private and public research laboratories, individual and institutional entrepreneurs, bolstered by the support of media outlets, information service providers, civil society organisations, community-based volunteer groups and non-governmental organisations engaged in facilitating clinical trials, patient engagement initiatives and online pharmaceutical services. The network also extends to encompass health and wellness centers, various healthcare providers and ancillary service providers contributing indirectly to the ecosystem's vitality. This entire gamut became part of the political economy driven by the marketing strategies of corporate giants. Such marketing strategies focussed on medical and social

innovations that were further 'used' to determine and increase funding in R&D. These overwhelming politically driven fundraisings resulted in the development of products with improved investment returns. How much of these investments are translated into improving the population during a pandemic? It may have a hegemonic response.

In the domain of medical innovations ecosystems in India during the COVID-19 pandemic, a heavy focus was placed on R&D related to drugs/medicines, vaccines and medical devices. Most pharmaceuticals were inclined to branded generics, biosimilars and NCEs (new chemical entities), which was very low from 2000 to 2017. For instance, during the period spanning from 2000 to 2017, a total of 135 novel pharmaceuticals received approval for commercialisation. A substantial proportion, that is, 87% of these approved drugs were targeted towards addressing Non-communicable diseases (NCDs), while a mere 6% were designated for combating communicable diseases. Within these 6%, most drugs were meant for cancer, cardiovascular, dermatological, immunological, neurological and ophthalmological diseases (George, 2021).

Vaccine development in India during COVID-19 times has attracted not only intellectual attention but has also created a vast public hype. This domain attracted urgent focus from companies, the government and the public. Vaccine development in India's biopharmaceutical corporate giants was previously limited to infectious diseases like chikungunya, hepatitis A, influenza, Japanese encephalitis, malaria, meningitis, pertussis, typhoid, etc.

The medical innovation ecosystem was more focused on NCDs, while most international companies focussed their R&D on developing high-end drugs and medical technologies for preventing and managing communicable diseases. Conversely, publicly funded institutes of the Indian medical innovation ecosystem are more focussed on creating affordable medical technologies and drugs. Only a few organisations (including start-ups) in the private sector can be observed as paying attention to developing cutting-edge technologies and drugs that can be marketed at affordable rates. The COVID-19 pandemic has proven that the social divide and challenges to addressing priorities in the innovation ecosystem are scarcely discussed in India.

Conclusion

The study has addressed the contemporary issues and fulfilled the objectives outlined. Firstly, it identified and analysed the challenges encountered by the Indian medical innovation ecosystem during the COVID-19 pandemic. By conducting a comprehensive analysis and incorporating relevant literature, the study presented the complex issues faced by the innovation ecosystem in the medical realm, such as the need for a balanced development approach, affordability concerns and social divisions.

Secondly, the study examined the relationship between drug and vaccine development approaches and their impact on affordability and accessibility in India. By analysing the R&D scenario of the Indian pharma industry and its focus

on high-profit products, the study highlighted the implications for affordability and access to medical innovations. It addressed the financial burden of drug and vaccine development and its potential consequences for future disease mitigations.

Thirdly, the study evaluated the effectiveness of existing policy measures in addressing the affordability and accessibility of medical innovations during the pandemic. It discussed various policy measures implemented, such as reducing taxes, providing financial assistance to start-ups and linking academia with industry. The study critically examined the outcomes of these measures and their impact on ensuring affordability and accessibility, highlighting the limitations and areas for improvement.

Lastly, the study assessed the social divisions the supply-driven health system created and their implications for access to medical innovations. By emphasising the unequal distribution of benefits and burdens within the ecosystem, the study drew attention to the marginalised sections of society bearing the cost of clinical trials while the benefits primarily accrued to economically better-off populations. It underscored the need for policy priorities that promote formal social obligations, affordability, and accessibility to bridge the social divide.

Future directions will advance our understanding of the Indian medical innovation ecosystem and contribute to evidence-based policymaking. By leveraging complex methodologies and multidisciplinary approaches, researchers can unearth critical insights, propose effective strategies and foster a more inclusive and accessible healthcare system in India and beyond.

It becomes essential to explore the enduring ramifications of the pandemic on the medical innovation ecosystem and discern its impact on the priorities and strategies of stakeholders. By searching more deeply into the transformations in research and development investments, collaborations between academia and industry and the emergence of novel models for affordable and accessible medical innovations, researchers can gain comprehensive insights into the long-term effects of the pandemic. Understanding these effects will provide a foundation for future policy formulation and strategic decision-making in the healthcare sector.

A thorough evaluation of the policies implemented during the pandemic is warranted to gauge their effectiveness in addressing the affordability and accessibility of medical innovations. Such an evaluation can help identify gaps or limitations in the existing policies and offer recommendations for policy enhancements to ensure equitable access to healthcare technologies. This analysis allows researchers to contribute to evidence-based policymaking, empowering governments and healthcare authorities to optimise their strategies and interventions to benefit the wider population.

Conducting comparative analyses between the Indian medical innovation ecosystem and other countries or regions can illuminate best practices and successful models. Through in-depth case studies, researchers can explore the approaches that have effectively balanced industrial growth with public health priorities, achieved affordability in drug and vaccine development, or implemented policies that bridge social divides. This cross-country comparison will identify valuable lessons and facilitate knowledge exchange, fostering global collaboration to address the challenges medical innovation ecosystems face worldwide.

Gaining insights into the perspectives and experiences of various stakeholders within the medical innovation ecosystem is crucial. Exploring the viewpoints of healthcare professionals, industry leaders, policymakers and patients can provide a comprehensive understanding of the challenges and aspirations within the system. By integrating these perspectives, researchers can identify strategies to bridge the social divide, enhance affordability and improve access to medical innovations. This inclusive approach ensures that research outcomes align with the needs and aspirations of all stakeholders, resulting in more effective and sustainable solutions for healthcare challenges.

Lastly, investigating the adoption and diffusion of medical innovations in diverse socioeconomic contexts within India will yield valuable insights. This research can delve into the barriers and facilitators of technology uptake, identify strategies to overcome challenges and examine the impact of diffusion patterns on healthcare outcomes. Researchers can develop targeted interventions and policies to accelerate the widespread dissemination of medical innovations by unravelling the complexities of technology adoption and innovation diffusion. This, in turn, will contribute to narrowing the existing disparities in access to healthcare technologies and fostering equitable healthcare delivery across different population segments.

Recommendations

Adopting a Balanced Development Approach

The medical innovation ecosystem in India should expand the boundaries of medical advancements beyond profits. For this, it becomes imperative to balance breakthrough innovations, basic healthcare necessities and academia-industry-government collaborations. An incentivised (through tax exemptions, grants, etc.) collaborative research and development among (pharma and healthcare) industry, independent R&D units and government regulatory agencies will help to achieve a sustainable balanced development approach.

Affordability and Accessibility Concerns

A complex intertwined and intricate drug and vaccine development process holds centrality for medical innovations in India. A multifaceted approach is required at policy levels to alleviate the financial burden on the R&D of medical innovations. Such an approach should accompanied by socialist or welfare-inclined regulatory frameworks. The socialist or welfare-oriented regulatory frameworks should keep a check on the affordability and accessibility of medical innovations.

Pricing Models

A more holistic approach is required for scrutinising the pricing models of pharmaceutical products. Stricter implementation of pricing regulations would balance incentivising innovation and ensuring affordable access for all strata of society.

The Burden of Clinical Trial

The marginalised sections of the country withstanding the worst of clinical trial costs is a glaring social justice issue. This calls for a paradigm shift in policy priorities. Policies should be geared towards reducing the disparities in access to medical innovations. Incorporating strict formal social obligations into the healthcare system would ensure that the benefits of medical advancements are shared equitably across the population. This bridges the social divide and strengthens the overall fabric of healthcare accessibility.

Acknowledgements

The author is grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the paper. Usual disclaimers apply.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Article

Proposing a Solution Towards Avoiding Ecological Fallacy While Using National Culture Dimensions in Consumer Behaviour Studies

IMIB Journal of Innovation and Management
2(2) 193–207, 2024

DOI: 10.1177/ijim.231200085
jim.imibh.edu.in

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Abstract

Today web-enabled services ranging from information sharing to online purchasing of products or services have become an increasingly frequent affair. In this context, previous research has explored the nature of complex cyber transactions and the various factors, which lead to formation of perceptions about such web-based services in the consumers' minds. One important factor, which has been intriguing management researchers in this respect, is the influence of cultural values of consumers on online purchase intentions and perceptions about e-service quality. Most studies done in this context have used Hofstede's national-level culture dimensions to do an individual-level analysis of consumer behaviour, but in doing so, have encountered a methodological issue known as ecological fallacy. This study wishes to demonstrate an alternate approach for culture-specific consumer purchase behaviour research using individual-level cultural values as study variables, thus eradicating the issue of ecological fallacy.

Keywords

National culture, Online buying, ecological fallacy, e-service

Introduction

One of the most intriguing areas of contemporary research in consumer behaviour is the study of buying behaviour of consumers in an online environment (Jarvenpaa

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& Tractinsky, 1999; McKnight et al., 2002; Schlosser et al., 2006; Van der Heijden et al., 2003). The Internet provides a platform for low-cost, time-saving transactions between buyers and sellers across geographical borders, with more flexibility for shopping at convenient hours, and a greater variety to choose from (Jarvenpaa & Tractinsky, 1999). However, the online mode of business transactions is not free from its shortcomings. The greatest pitfall of online commercial transactions is the lack of trust in the consumers resulting in the reluctance of the consumers to make the actual transactions (Donthu & Yoo, 1998; Jarvenpaa & Tractinsky, 1999; Van der Heijden et al., 2003).

Studies have been conducted to develop models of e-purchase intentions and cause-effect relationships have been constructed to gain a comprehensive understanding of online purchase intentions (McKnight et al., 2002; Pavlou, 2003; Van der Heijden et al., 2003). Trust, perceived ease of use and usefulness of website design have been identified as the key influencing factors of online purchase intentions of consumers in these studies. The above dimensions have been backed by one of the most widely accepted theories in Information System (IS) literature—the Technology Acceptance Model (TAM) theory which states that the acceptance of a new technology by an end user will depend on the perceived ease of use (user-friendliness) and perceived usefulness of the technology (Koufaris, 2002; Lai & Li, 2005; Loiacano et al., 2007).

In some studies, researchers have emphasised the role of national culture dimensions on the formation of attitudes towards e-commerce websites (Donthu & Yoo, 1998; Furrer, 2000; Pavlou, 2003). Research in this domain has shown a positive relation between national-level cultural values and the perceptions of a website's quality (Donthu & Yoo, 1998; Furrer, 2000; Pavlou, 2003) in terms of perceptions of trust, ease of use and usefulness. The serious drawback of these studies is that the framework of choice for national culture used in all these studies has been unanimous—Hofstede's (2001) dimensions of national culture (Donthu & Yoo, 1998; Furrer, 2000; Pavlou, 2003). However, in doing so, these studies have incurred a methodological error known as ecological fallacy—which occurs when indicators meant to represent constructs at a different level are used as proxies for different levels of analyses.

Hofstede's (2001) framework of national culture is meant for national-level analyses, not individual-level analyses. However, several researchers have been found to use the Hofstede typology as a measure of individual-level cultural values (Donthu & Yoo, 1998; Huang & Crotts, 2019; Pavlou, 2003). This type of methodological error of measuring individual-level variables using national-level measures gives rise to a methodological shortcoming known as the ecological fallacy (Hofstede, 2001; Walker, 2021), giving an improper interpretation of the findings.

This study wished to rectify this potential mistake of the previous research models by constructing a modified model of online consumer buying behaviour by using the culture orientation framework as given by Kluckhohn and Strodtbeck which helps in measuring cultural values at an individual level (Maznevski et al., 2002; Steenkamp, 2019). Hypotheses have been proposed for empirical validation of the model.

Literature Review

Website Quality

One of the earliest attempts to develop a framework for measuring service quality was made by Parasuraman et al. (1988) through the development of the SERVQUAL model. Parasuraman et al. (1988) defined service quality as—the relative perceptual distance between customer expectations and evaluations of service experiences. In the context of internet-based services, Zeithaml et al. (2002) have defined e-service quality as the 'extent to which a website facilitates efficient and effective shopping, purchasing and delivery'. Zeithaml et al. (2002) conducted focus groups to generate the items for e-service quality. They identified 11 dimensions of e-service quality: reliability, responsiveness, access, flexibility, ease of navigation, efficiency, assurance/trust, security/privacy, price knowledge, site aesthetics, and customisation/personalisation.

Yoo and Donthu (2001) developed the SITEQUAL, a nine-item, five-point Likert-type instrument to measure e-service quality. The SITEQUAL has four dimensions—ease of use, aesthetic design, processing speed and security. The issue with these early instruments was the lack of comprehensiveness and a shift in focus from websites to Internet. A full website-focused approach to e-service quality first came into picture with the framework proposed by Loiacano et al. (2007) which they termed WEBQUAL, in tribute to its offline counterpart—SERVQUAL. Loiacano et al. (2007) came up with 12 parameters of website quality, which they further clubbed into three broad classifications in their latest ramification of the WEBQUAL model—Ease of Use, Usefulness and Entertainment. Although the WEBQUAL model is more complex than some of the simpler models discussed above, such as SITEQUAL, the reason for choosing this model was the inclusion of all the potential dimensions of web quality making it a more comprehensive instrument for quantifying quality of a website. Another reason is that WEBQUAL is gaining rapid popularity among IS and marketing researchers as a valid instrument for measuring website design quality (Loiacano et al., 2007; Tsikriktis, 2002).

Website Quality and End User Purchase Intentions

McKnight et al. (2002) developed the trust-building model (TBM) of online consumer purchasing behaviour in a study with 1,729 students from three large universities in the USA to find that several antecedent factors of website design have a significant influence on the online trust factor of consumers. Perceptions of website quality were found to positively influence the trusting perceptions of vendors and willingness to depend on the vendors. This again had a significant influence on the intention of the consumers to buy from the site. Lee and Lin (2005) surveyed 297 online consumers to investigate the relationship between customer perceptions of e-service quality and purchase intentions. The results showed that the

dimensions of website design- responsiveness, reliability and trust have a positive effect on customer satisfaction and consequently, intention to purchase.

In a study by Liu and Arnett (2000), information and service quality, system use, playfulness and system design factors of web quality were found to have significant effects on the purchase intentions of consumers. In an online platform, the consumers have to depend on the information provided by the websites to learn about the various products and services. The easier the site will allow the consumers to navigate through its contents, the more at ease the consumer will feel. According to TAM, this will create a favourable attitude towards the website.

Empirical research using the TAM framework has shown that usefulness and ease of use are two important aspects of web design, which the web developers have identified as significant determinants of web business success (Hamzah et al., 2022; Koufaris, 2002; Lai & Li, 2005). Shia et al. (2016) found a strong impact of website quality factors on customer satisfaction. In a similar vein, Napitupulu (2017) has also proven that website usability and level of service integration have significant and positive effects on users' satisfaction.

Another aspect that consumers will look into while evaluating which site is good and which site is bad, is the perception of how useful and trustworthy the information is displayed on the site. If a site can project a strong sense of trust to the end users, consumers will be more trusting to do transactions through those sites. The proposition that perceived usefulness of a website will have a positive influence on the consumer's perception of a website's quality is backed by the Transaction Cost theory, which states that entities try to reduce costs associated with economic exchange by cutting down on their search costs associated with product and price discovery, negotiation costs and settlement costs. The internet can serve as a perfect medium for reducing transaction costs by reducing all the above costs mentioned. Empirical data also supports the fact that e-commerce has the potential to reduce transaction costs compared to traditional media of transaction (Lampe et al, 2007).

A third important design element for websites that has been identified by researchers is the entertainment/playfulness factor (Koufaris, 2002; Liu & Arnett, 2000; Loiacano et al., 2007). The entertainment aspect of a website lies in the graphics, the visual display, the appearance and the special features of a website (Gligor, 2015; Koufaris, 2002). The previous research has used the flow theory (Csikszentmihalyi, 1977, as cited in Koufaris, 2002) to justify their inclusion of entertainment factors in web design parameters (Loiacano et al., 2007). The flow theory suggests that human beings can sometimes experience a state of flow, which is a cognitive state of the mind where people have a sensation of being fully immersed in a task (Ozkara et al., 2017). When people are in a flow state, they 'shift into a common mode of experience when they become absorbed in their activity' (Csikszentmihalyi, 1977; as cited in Koufaris, 2002). The main effect of this flow state is a sharpening of awareness about the task so that unnecessary thoughts and preoccupations are replaced by 'a loss of self-consciousness, by responsiveness to clear goals and unambiguous feedback, and by a sense of control over the environment' (Csikszentmihalyi, 1977; as cited in Koufaris, 2002).

From the flow theory, it may be inferred that while designing websites for e-commerce purposes, web developers must keep in mind the salient features of a

website, which can trigger a flow experience in the consumers. The empirical works done in this context support the logic proposed here (Bilgihan et al., 2014). In fact, the WEBQUAL instrument developed by Loiacano et al. (2007) captures all three important design elements of web quality—ease of use, usefulness and entertainment. The dimensions of website quality are described in Table 1.

Web-quality & National Culture: The Ecological Fallacy Issue

Culture may be defined as 'the collective programming of the mind' (Hofstede, 2001). The study of culture has its research origin in the works of anthropologists like Boas and Benedict (Sanday, 1977). The anthropological works of the early researchers have focused on culture-specific studies (Sanday, 1977) where the approach has been to spend time with the members of a society and then unveil the native's point of view (Hill, 1993; Sanday, 1977). Culture researchers have developed several frameworks to capture the construct of national culture taking the Cultural Orientation Model as the basic starting point. Some of the most prominent models of culture are Schwartz's model, Hall's model, Trompenaars'

Table 1. WEBQUAL Dimensions and Descriptions.

Higher Level Category	Dimension	Description
Ease of use	Ease of understanding	Easy to read and understand
	Intuitive operation	Easy to operate and navigate
Usefulness	Information fit to task	The information provided meets task needs and improves performance
	Tailored communication	Structured communication between buyer and seller
	Trust	Secure communication and information privacy
	Response time	Time to get a response after a query or a request
	Online completeness	Provisions for necessary transactions to be completed online
	Relative advantage	Equivalent or better than other means of interacting with the company
Entertainment	Visual appeal	The aesthetics of a website
	innovativeness	Creativity and uniqueness of design
	Emotional appeal	Emotional intensity of involvement with the website
	Consistent image	Compatibility of the website image with the image of the firm/product it is advertising

Source: Loiacano et al. (2007).

model, House et al's GLOBE framework and the most well-known of them all—Hofstede's typology of National Culture (Sent & Kroese, 2022).

The earliest model of cultural values was given by Kluckhohn and Strodtbeck (1961, Maznevski et al., 2002) who came up with the Cultural Value Orientation Framework. Kluckhohn and Strodtbeck's Value Orientation Model (Maznevski et al., 2002; Yan & Li, 2021) describes six individual cultural value dimensions, namely, relationship with nature, relationship with other people, human activities, relation with time, relationship with space and human nature (Kluckhohn & Strodtbeck, 1961). Each dimension has three continuums depending on the type of dimension.

At a much broader level of analysis, Hofstede (2001) conducted the IBM Value Survey and came up with five dimensions of culture at the national level – individualism/collectivism, power distance, masculinity/femininity, uncertainty avoidance and future goal orientation. His study has been, till to date, the most comprehensive work on national culture, and the most cited one in cross-cultural research (Donthu & Yoo, 1998; Jackson, 2020; Litvin, 2019).

However, Hofstede (2001) himself has cautioned the researchers that his measure of national culture is for a national-level comparison of cultural values and should not be used to measure its effect on individual-level perceptions. If such an attempt is made, it will cause the methodological error of ecological fallacy (Hofstede, 2001; Sajadi & Badreh, 2019). However, despite that, numerous studies have used the Hofstede typology to elucidate individual-level value perceptions (Bakir et al., 2020; Donthu & Yoo, 1998; Jarvenpaa & Tractinsky, 1999).

The ecological fallacy occurs, when, one variable in a study is measured at the individual level and another variable at the national level (Hofstede, 2001). The fallacy lies in the assumption that the national level culture dimensions are a representation of the individual level perceptions of cultural values (Triandis et al, 1995). Similar errors have been noticed in the works of Sigala and Sakellaridis (2004), and Dash et al. (2007), and criticised by Brewer and Venaik (2012). The problem with the use of Hofstede's dimensions for individual-level analysis is that it leads to apples for oranges type of comparison.

However, the fact that they have all overlooked is that they have still used the instrument to measure individual-level perceptions of values. If Hofstede's typology is to be used, the unit of analysis must be the nation, not individuals. Because of this conceptual error in the previous models of online consumer behaviour, we are proposing a refined model of online consumer purchase intention, by operationalising culture at the individual level of analysis using Kluckhohn and Strodtbeck's framework (Maznevski et al., 2002). Kluckhohn and Strodtbeck's framework (refer to Table 2) has a distinct advantage for individual-level analysis of value perceptions because it focuses on how individuals perceive that the world must operate and what do individuals perceive about the way that the world is really working.

Theoretical Framework & Research Propositions

The main relationship that this study wishes to investigate is how the cultural values of consumers influence their perceptions about the quality of web-based

Table 2. Kluckhohn & Strodtbeck's Value Orientation Framework.

Culture Dimensions	Sub Dimension 1	Sub Dimension 2	Sub Dimension 3
Relation with nature: Beliefs about the need or responsibility to control nature	Mastery: Belief that people have need or responsibility to control nature	Harmony: Belief that people should work with nature to maintain harmony or balance	Subjugation: Belief that individuals must submit to nature
Relationship with people: Beliefs about social structure	Individualistic: Belief that social structure should be arranged based on individuals	Collateral: Belief that social structure should be based on groups of individuals with relatively equal status	Lineal: Belief that social structure should be based on groups with clear and rigid hierarchical relationships
Human activities: Beliefs about appropriate goals	Being: Belief that people should concentrate on living for the moment	Becoming: Belief that individuals should strive to develop themselves into integrated whole	Doing: Belief on striving for goals and accomplishments
Relationship with time: Extent to which past, present and future influences decision	Past: In making decisions, people are principally influenced by past decisions	Present In making decisions, people are principally influenced by present decisions	Future In making decisions, people are principally influenced by future decisions
Human nature: Beliefs about good, neutral or evil human nature	Good: Belief that people are inherently good	Neutral: Belief that people are inherently neutral	Evil: Belief that people are inherently evil
Relationship with space: How do people define their relationships with others in terms of maintaining space	Public Belief that the space around someone belongs to everyone and may be used by everyone	Private Belief that the space around someone belongs to that person and cannot be used by any other person without permission	Mixed Belief that the space around someone is selectively exclusive to that person depending on the relation with the invader of the space

Source: Maznevski et al. (2002).

services and what impact such perceptions eventually have on their online purchase intention. Online consumer behaviour researchers have frequently explored the possibility of whether a cultural value system of individuals has any influence over the purchase intention of cyber consumers. The theoretical premise for such a conceptualisation is rooted in the signalling theory of communication and social identity theory of cognitive psychology.

The signalling theory (Lampe et al., 2007) states that certain signals can have different interpretations for different individuals and the consequent variation in behaviour is a manifestation of the different opinions formed by the respondents about the meaning of the signal. From the signalling theory, it can be inferred that the users will judge the quality of the websites, based on what information/signal the website is communicating to the users. This evaluation of the signals may be affected by the cultural value orientation of the consumers (Donthu & Yoo, 1998; Furrer, 2000; Pavlou, 2003).

Kluckhohn and Strodtbeck's value dimensions may have a significant impact on the linear relationship between perceptions of website quality and online purchase intentions. The theory of reasoned action (TRA) is used here to explain the logic behind the interrelationship between cultural values and perception of website quality (Fishbein, 1979). Fishbein's TRA states that 'individuals evaluate the consequences of a particular behaviour and then take actions in lieu of their evaluations'.

Another important factor which determines the degree of new technology adoption is the consumer's time perspective—especially whether they are past-oriented or future-oriented. Taking cue from the theory of time perspective, it may be argued that human beings, who believe that the past was better than the present, will think that new technologies are eliminating the good traditional shopping experiences of the past (Settle et al., 1978). These individuals will be more unwilling to accept new technologies. Similarly, individuals with a present/future time orientation will realise the benefits of online transactions because they would want to be upgraded with time and are quick to realise the future opportunities that lay ahead (Blázquez, 2014). For such individuals, the present/future time-orientation cultural value is expected to have a strong moderating effect on the web quality-purchase intention relation. Therefore, there is strong reason to believe that time orientation (past/future) may have a moderating effect on the relationship between ease of use and usefulness dimensions of web quality and purchase intention.

Research Proposition 1: The relationship between perceived usefulness of website and online purchase intention will be moderated by the time orientation cultural value of consumers.

The relationship with nature dimension of the Cultural Orientation Model is about the belief in individuals that they are the masters of the external environment and vice versa (Gaur et al., 2019). This belief may have a strong influence on the perceptions of ease use and usability categories of WEBQUAL and the consequent impact on online purchase behaviour. The more an individual values autonomy and accepts freedom of action for granted, more would be his demand for improved ease of use and usefulness of websites. Similarly, for individuals who believe in harmony/subjugation with the external environment, there will be little urge for such quality improvement. They are ready to compromise and adjust to

the website ambiguities if needed (Kim & Choi, 2005). Hence for them, ease of use and usefulness of websites will be perceived more leniently, with little demand for modifications. Hence, it is proposed that-

Research Proposition 2a: The relationship between perceived ease of use dimension of WEBQUAL and consumer's online purchase intention will be moderated by the relationship with nature orientation of consumers.

Research Proposition 2b: The relationship between perceived usefulness dimension of WEBQUAL and consumer's online purchase intention will be moderated by the relationship with nature orientation of consumers.

The consumers with individualistic values will differ from those with collateral/ lineal values in their perceptions of web quality. As per Hofstede's Individualism/ collectivism spectrum, individualists will have more need for unique features and complementary services because they will want to have customised web pages so that they have to depend less on others to achieve their goals (Miao et al., 2020). They would assess the quality of a website based on how unique it is so that individual experiences need not be a common one. For individualists, personal pleasure is also an important factor in judging a website's quality. Similarly, the collectivists will judge the quality of a website based on the ease-of-use dimensions of WEBQUAL because they want to have more people to interact at the same level of ease and to experience enjoyment with an appeal for a large base of users (Costa Pacheco et al., 2021). Based on the above logic, it is proposed that -

Research Proposition 3a: The relationship between perceived usefulness of WEBQUAL and online purchase intention will be moderated by the relationship with people value orientation of consumers.

Research Proposition 3b: The relationship between perceived ease of use dimension of WEBQUAL and online purchase intention will be moderated by the people value orientation of consumers.

Research Proposition 3c: The relationship between perceived entertainment dimension of WEBQUAL and online purchase intention will be moderated by the people value orientation of consumers.

The belief about human activities—being, becoming and doing, can also have far-reaching effects on the rating of consumers about website quality. Those with the 'being' value orientation will have less reason to improvement of website quality because they are content with the present state of web quality. Accordingly, the 'being' value orientation should have no significant impact on the relationship between overall perceived web quality and intention to purchase (Simcox, 2019).

But those with 'becoming' and 'doing' values will always want to have greater ease of use, usefulness, and entertainment from the web designs as such individuals always try to strive for improvement in their life (Franco & Meneses, 2020; Maznevski et al., 2002). Therefore, it is proposed that

Research Proposition 4a: The relationship between perceived ease of use dimension of WEBQUAL and online purchase intention will be moderated by the activity orientation of individuals.

Research Proposition 4b: The relationship between perceived usefulness of WEBQUAL and online purchase intention will be moderated by the activity orientation of individuals

Research Proposition 4c: The relationship between perceived entertainment dimension of WEBQUAL and online purchase intention will be moderated by the activity orientation of individuals

Values of personal space can also have a significant influence on consumer behaviour (Luck & Benkenstein, 2015). The consumers who value private space would want more security about their information will be less trusting about the websites and will want to have information according to their specific requirements. For consumers who believe in public/mixed space, the usefulness dimension is of less concern, and the greater concern is for the ease-of-use dimension. Accordingly, it is proposed that

Research Proposition 5a: The relationship between perceived usefulness and online purchase intention will be moderated by the value orientation about space.

Research Proposition 5b: The relationship between perceived ease of use and online purchase intention will be moderated by the value orientation about space.

Regarding the value dimension about nature of human beings, those who believe that people are necessarily good will have more positive perceptions about the trust dimension of perceived web quality, while those who believe that people are necessarily evil or a mixture of both, for them trust and security issues will be of more concern (Webster et al., 2021). Therefore, usability will be of major concern for people with a value that human beings cannot be trusted to be good all the time.

Research Proposition 6: The relationship between the usefulness dimension of WEBQUAL and online purchase intention will be positively moderated by the value about nature of human beings.

The research questions are represented in a research framework (refer to Figure 1).

Measurement of Variables

Standard indices exist for measuring each of the above constructs. Perceived ease of use, usefulness and entertainment aspects of websites may be measured using the 24-item WEBQUAL scale developed by Loiacano et al. (2002). Each sub-dimension of the WEBQUAL scale has been validated and replicated in several studies (Barnes & Vidgen, 2002; Tsikriktis, 2002). Alternatively, researchers may use the SITEQUAL scale developed by Yoo and Donthu (2001) which is a 9-item Likert scale capturing four dimensions- ease of use, aesthetic design, processing speed and security. Cultural values at the individual level may be measured using the cultural perspectives questionnaire version 4 (CPQ 4) developed by Maznevski et al. (2002) which is a 79 item 7-point Likert scale that captures four of the six dimensions of Kluchhohn and Strodtbeck—relationship with nature, relation with people, activity orientation and belief about human nature.

The constructs of space and time were not included in this scale, though we have shown through our theoretical framework how these two dimensions can influence the perceptions of website quality and consequently the online purchase intentions of consumers. Hence, we propose to integrate the two unused dimensions of space

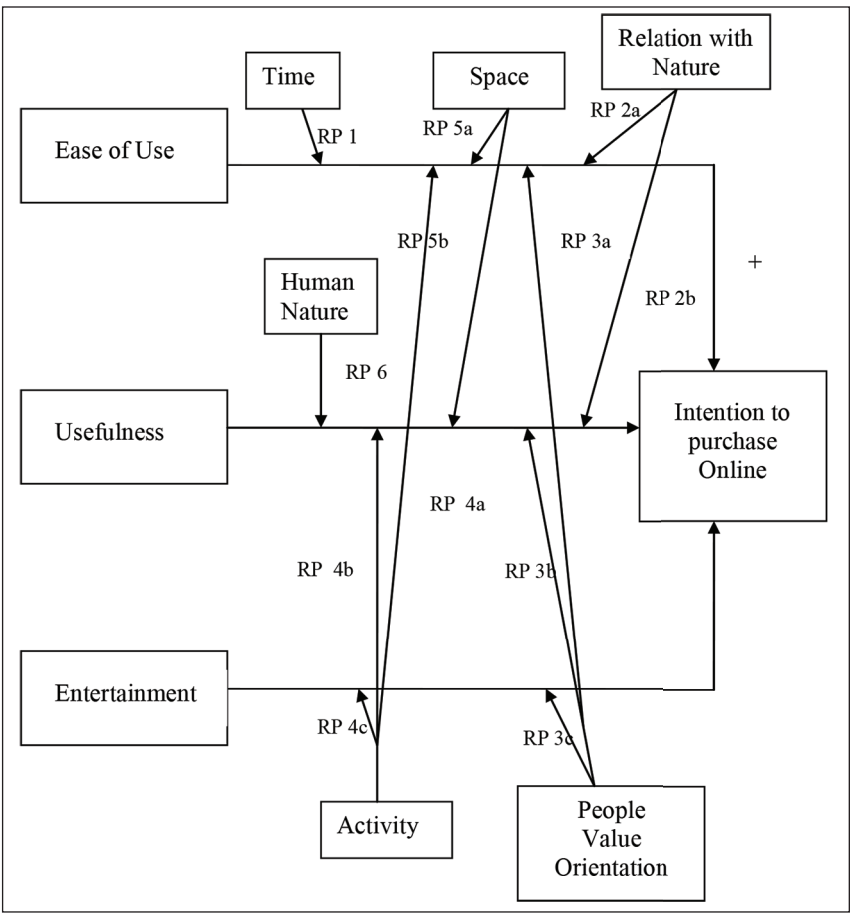

Figure 1. Proposed Theoretical Model of Culture Moderated Consumer Purchase Intention.

and time in our final questionnaire which will help us address all the major individual-level cultural value dimensions in an e-commerce context. As for our dependent variable, online purchase intention can be measured using the single-item scale used by Koufaris (2002) or the 3-item scale developed by Lai and Li (2005) to measure intention to use internet banking.

Discussions and Directions for Future Research

We hope that the framework proposed in this study may help researchers in resolving the dilemma associated with investigating the impact of cultural values on consumer online buying behaviours using within-country data instead of cross-country data. By using the cultural value framework, researchers and marketing analysts may be better able to get rid of the ecological fallacy error in understanding

the different cultural value orientations existing at an individual level and consequently develop more innovative e-commerce applications which can help in incorporating such modifications on a generalised basis (Walker, 2021).

The above framework may be extended for different e-commerce platforms such as online B-2-C transactions, internet banking and e-business websites such as e Bay and Amazon. The framework may also be extended to traditional consumer behaviour studies such as influence of consumer's cultural values on their attitude towards advertisements and promotions. More studies are required to increase the validity of the scales used to measure individual-level cultural values (Maznevski et al., 2002).

Although the above framework may seem to be slightly complicated to apply in real practice, we expect that with proper orientation towards the cultural value orientation of the target population, e-commerce businesses will be able to incorporate different cultural value cues in the design of e-commerce web pages to help improve perceived quality of the same in the minds of the users/online consumers. We suggest that such user-centric website designs will result in more favourable intentions to buy from online e-commerce transaction points by consumers. In the domain of e-commerce research, simplified models using one or two dimensions of cultural values may be used to understand specific relationships with different variables of interest such as online social networking, net banking, consumer attitude towards online advertisements and online gaming.

To illustrate further, an e-commerce-based organisation dealing in online share trading, may wish to make its customers more trusting about investing their funds with their organisations. For such organisations, the trust factor of perceived usefulness dimension of website quality will be the prime factor of concern. Such organisations can then try to understand which cultural values were dominant among their customers by conducting a survey with a reasonable sample of the customer base with the subscales of CPQ and the WEBQUAL questionnaires to find how a majority of the users felt regarding their own beliefs about privacy and trust on others and how they felt about their privacy and security while interacting with the website (De Mooij & Hofstede, 2011). Based on such findings, the management can instruct the web developers involved in designing the web pages to incorporate trust-specific messages and cultural cues to increase perceived trustfulness of the websites.

Similarly, website quality of an organisation focused on entertainment business such as online gaming, audio/video hosting, blogging or social networking will depend on all the WEBQUAL dimensions of perceived ease of use, perceived usefulness and aesthetics, as well as several dimensions of cultural values such as relationship with nature, values about activity, values about time and space and so on. In future, there is a scope for incorporating other individual-level variables such as personality, locus of control and socio-demographic variables such as computer literacy, gender and age in the above model to reach a deeper level of exhaustiveness in the proposed framework. As a logical next step, we urge fellow researchers in cross-cultural e-commerce research to further validate our model in different cultural contexts.

We have earlier mentioned that the CPQ 4 scale (Maznevski et al., 2002) needs to be extended further to include the time and space dimensions of culture. Therefore, future research should be devoted to upgrading the CPQ 4 scale- which will help us to

measure all the major dimensions of individual cultural differences (Napitupulu, 2017). On a related note, it may also be argued, that given the case of cultural relativism (Hofstede, 2001), more exploration is needed to get a more enriching understanding of the latent values embedded in native cultures. Hence, future studies should consider investigating cultural values from an exploratory perspective to add new insights to the seminal Kluchhohn and Strodtbeck (1961) cultural framework.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Article

An Approach of Normal Accounting Cycle Embedded in Three Dimensions: Steps towards Empowerment of Accounting System

IMIB Journal of Innovation and Management
2(2) 208–225, 2024

DOI: 10.1177/ijim.241235735
jim.imibh.edu.in

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Abstract

A rigorous change is required to be made in the normal accounting cycle to update and improve it. The dynamic development of the industry and transformation towards accounting 4.0 creates pressure to update six-century-old accounting and reporting systems. The main purpose of the article is to identify the need to empower normal accounting systems with three-dimensional (3D) accounting. Descriptive statistics is used for demographical and physiographical report presentation. For testing the hypotheses, the chi-square test and one-way ANOVA have been applied. It is found that the majority of respondents are in agreement for small size business and persons agree to apply a 3D accounting system to the normal accounting cycle. The 3D system is better presented than a normal accounting system; hence, normal accounting cycle should be embedded in the 3D accounting system for better performance. Several important variables have been predicted to explain the requirement of a normal accounting system embedded in the 3D accounting system by using a neural network.

Keywords

Normal accounting system, accounting 4.0, three-dimensional accounting system, empowerment, embedded

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Introduction

The field of accounting has undergone a radical transformation due to advances in science and technology. The two-dimensional entry system is no longer sufficient to meet all stakeholder needs. The standard accounting cycle needs to undergo significant modification to be updated and improved. Three-dimensional accounting (3D accounting) has taken the role of the traditional accounting method.

Businesses and organisations have switched from a two-dimensional to a 3D accounting system. Due to the damage that various financial frauds and intelligence crimes have caused to the economy, this technology is being studied all around the world. It has been shown that accounting technology advancement is necessary. Even though it occurs in developing countries, it is still in its infancy and needs greater attention. It has been questioned why poor countries were not promoting and using green logistics practices (Maurya, 2023).

With the advancement of blockchain technology (BCT), a different concept known as triple-entry accounting (TEA) has regained popularity. In a study by Yuji Ijiri from 1989, the term 'triple-entry accounting system' first arose. Later, it was expanded (Gröblacher & Mizdraković, 2019).

Blockchain is a recent technology with potential uses in numerous industries. It has built a name for itself in the financial world using cryptocurrencies. BCT has only seldom been implemented in reality, despite the applications in many industries that its security, resilience, interoperability and dependability have promised. The decision-making process for integrating with this new technology and implementing blockchain is now being conducted among the stakeholders. This article discusses how corporations and individuals can adapt, incorporate and assimilate new technologies. It uses principles that have been created in this area (Dua, 2022).

For the first time, double-entry bookkeeping was combined with breakthroughs in financial encryption, such as the Signed Receipt. TEA is what it was named (Grigg, 2005).

An example of a proposal for a shared transaction record (and thus for 3D accounting) is triple-entry bookkeeping. To come to a consensus on the information in the shared record, it uses triple-signed receipts (Ibaez et al., 2020). TEA is one of the most creative ideas to emerge in recent years (Vadasi et al., 2021).

BCT makes it simpler to record transactions and manage assets in a firm network by enabling a distributed impermanent ledger. Accounting programme deals with the transfer of asset ownership and the maintenance of an accurate financial ledger. This article does a genealogical analysis of shared ledger systems and tracks the development of Resource–Event–Agent (REA), TEA and BCT to clear up any misunderstandings (Kwilinski, 2019).

The article is further divided into eight sections.

The second section elaborates on the previous knowledge on the topic. A summary of single-entry and double-entry bookkeeping systems has been provided. Mainly, the author focuses on identifying the research gap through a review of the literature. Third section explains the journey of three dimensions of

accounting and fourth section discusses the need for a normal accounting cycle embedded in three dimensions. These sections depict how 3D accounting has become the need of the hour. The approaches applied by them from 1975 to 2005 continue to go on. It depicts the relationship among REA, *TEA* and *BCT*. Also, normal accounting for recording procedures and income statement and position statements have been presented by applying blockchain through charts.

The fifth section describes the objectives of the article to identify the need to embed three dimensions of accounting in the normal accounting cycle and to explore the change that the 3D accounting would bring in the empowerment of accounting to its users.

The next section explains the research design, methodology and statistical tools to test the hypothesis. Then it is elaborated through discussion on the application of artificial neural networks (ANNs) for the prediction of important variables for normal accounting to embed in a 3D accounting system. The study has been concluded in the last section.

Review of Literature

A thorough mapping of the literature is necessary to comprehend the present research gaps. Based on the literature assessment, an attempt has been made to determine whether triple entry is necessary with regard to BCT. With the use of distributed ledger technology and blockchain, 'TEA' is a novel approach to accounting. Using this strategy, business transactions are stored and recorded as a third entry on the blockchain. In order to create a solid foundation for the discipline and application of triple-entry bookkeeping and accounting, it emphasises the necessity of the Fifth Industrial Revolution in accounting (Noble et al., 2022) and shows how it might potentially address a number of challenges (Sunder, 2018).

It is anticipated that this third entry will provide a transparent, reliable and unchangeable system. The latest accounting technology can prevent financial and accounting crimes such as financial statement manipulation, accounting record falsification and fraudulent banking transactions. It also has an impact on fraudulent practises (Mahtani, 2022). BCT is a type of accounting software (Demirkan et al., 2020). It deals with the ownership transfer of assets and the upkeep of an accurate financial ledger (Peprah et al., 2022).

The use of triple-entry bookkeeping in a correct and thorough manner can significantly decrease errors, lower internal fraud and enhance the operational effectiveness of educational institutions (Mahaini et al., 2022) and investigate possible solutions for some of the issues identified with small size of businesses (Kuruppu et al., 2022).

According to Supriadi (2020), as BCT reduces the cost of ledger maintenance and reconciliation, it has the potential to enhance the accounting profession. Applications for financial technology, decentralised finance and distributed ledger technology can make it easier to integrate AISs and ERP systems and provide major gains in productivity, efficiency and security (Faccia & Petratos, 2021). It produces impenetrable accounting systems for demanding users. It not only

reduces costs by providing accurate and well-supported accounting, but it also enables far stronger governance, which has a favourable effect on future requirements for public and corporate accounting (Grigg, 2005). Triple-entry bookkeeping contributes to transparency, future reference, reconciliation, assurance and auditing (Gröblacher & Mizdraković, 2019). Using the blockchain protocol, TEA offers a novel concept called 'π-account' that allows users to visualise and analyse accounting book journal entries to obtain a complete picture of blockchain-based economic activity (Chen et al., 2021). Blockchain is a technology that combines a number of innovative elements, including a distributed note-taking and storage system, a consensus algorithm, smart contracts and asymmetric encryption to guarantee network security, visibility and transparency (Dutta et al., 2020). The most reliable and consistent platforms for BCT are accounting systems like Quorum, Sap Hana and Ethereum. Blockchain platforms are also thought to be the most appropriate, safe and robust platforms (Sharma et al., 2022).

It had been highlighted that proper accounting was done based on double entries. Double entry remained unchallenged for more than 700 years. Only in late 1900 and early 2000, some eminent accounting researchers like Yuji Ijiri and William E McCarthy came up with ideas that address the loopholes in double entry and suggested better alternatives like the 'TEA' and 'REA' and ' BCT' concepts. Due to high costs, small and medium enterprises could not adopt these techniques with useful features. Now the following research questions come to mind.

A. What is the journey of three dimensions of accounting?
B. What is the need and potential of the three dimensions of accounting?
C. How to make the accounting reporting system more proper with optimum use of the right time, right place and the right person?
D. How can normal accounting be more reliable and immutable?
E. Would it be possible to use a 3D application with a normal cycle of accounting?

Research Gap

Most of the article explains the advantages of triple-entry (3D) bookkeeping system that triple-entry-based undistributed ledger and BCT-based accounting system are immutable with its unique feature and are up to the mark in the era of industry 4.0 and have potential for industry 5.0. It is also clear that these technology-based accounting systems have their shortcomings like being costly and complex to understand and adopt by small entrepreneurs. Now, the problem arises whether it is possible to adopt the 3D accounting system for small entrepreneurs with less investments and small size of business? It is not discussed in any paper so far. The author focuses on making it possible to take advantages of this advanced featured technology for small-sized business. Double-accounting-based normal accounting cycle is adopted to maintain accounting by small businesses. Thus, there is a requirement to merge this technology into the normal cycle of accounting in a simplified manner to understand and make it affordable for all types of businesses regardless of their size. Not much work has been done

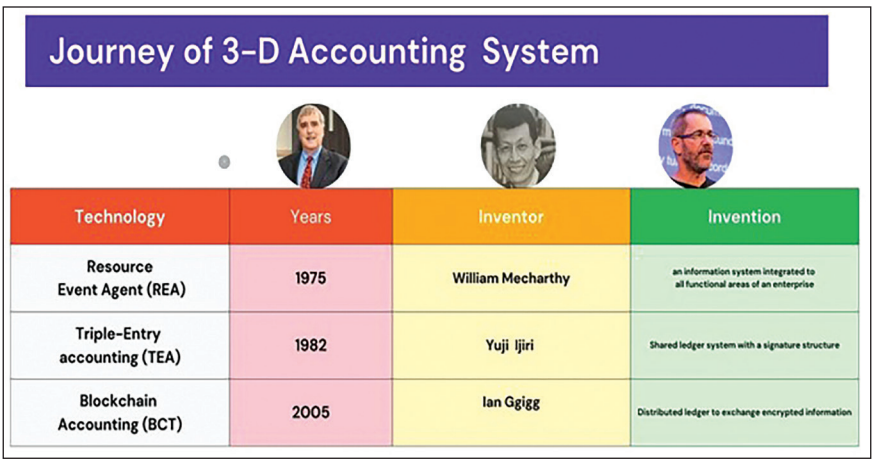

Figure 1. Journey of 3D Accounting System.

in this area so far. The study would be unique for a small size business that avail the advantages of embedded accounting systems.

Journey of Three Dimensions of Accounting

TEA is a step ahead of the two-dimensional accounting system (traditional double-entry accounting), one that will relieve the bookkeepers and companies from tedious troubleshooting and help remove the mistrust, frauds, or manipulations faced by them (Figure 1).

Resource–Event–Agent (REA) by William E McCarthy

REA is a model presented for re-engineering accounting systems in the time of machine learning. TEA is, in part, a historical by-product of the REA accounting framework designed by McCarthy, while parallels between TEA and the REA framework have been noted (Ijir, 1986).

Resource–Event–Agent (REA), Triple-Entry Accounting (TEA) and Blockchain Accounting (BCT)

Triple-Entry Accounting (TEA) by Yuri Ijiri.

The existing double-entry accounting system was expanded, and an arbitrary third dimension was added to call it triple-entry bookkeeping. Therefore, the third dimension of double-entry bookkeeping must be logically deducible from the current two dimensions (the debit and the credit) to satisfy the essential criteria for a solution to the double-entry problem.

Blockchain Accounting (BCT).

Blockchain is a network of peers that hashes records into a continuous chain of hash-based proof of work to timestamp them, creating a record that cannot be modified unless repeating the proof of work.

Relationship and Working of REA, TEA and BCT.

Blockchain is a decentralised general ledger that other associated parties use. A distributed database with a structured set of blocks can be compared to a blockchain, where each committed block is immutable.

Steps have already been taken in the direction of improvement by many contributors like William McCarthy, Yuri Ijiri and Ian Grigg.

Due to the shortcoming of the double-entry system, BCT is preferred in accounting and financial reporting. This article conducts a genealogical analysis of shared ledger systems, in particular, tracing the development of REA, TEA and blockchain (Ibañez et al., n.d.) (Figure 2).

Need of Normal Accounting Cycle Embedded in Three Dimensions

A normal accounting cycle is a normal system of recording transactions, posting, analysing and communicating. It manages business's records to keep track of income, expenses and other financial activities and is used to create reports. The format of the transaction on the immutable ledger has been presented in Figure 3.

The figure discloses that it becomes more convenient to record the transaction in details by using transaction id, sender & receiver details, quantity, type of product, date, signature, and most important the unique ID the hash value.

Figure 4 presents the format of an income statement with the application of three layers or 3D accounting statements.

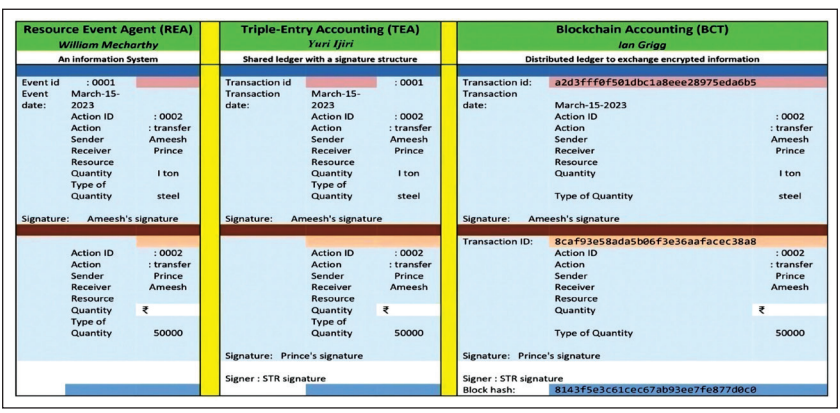

Figure 2. Working of REA, TEA and BCT.

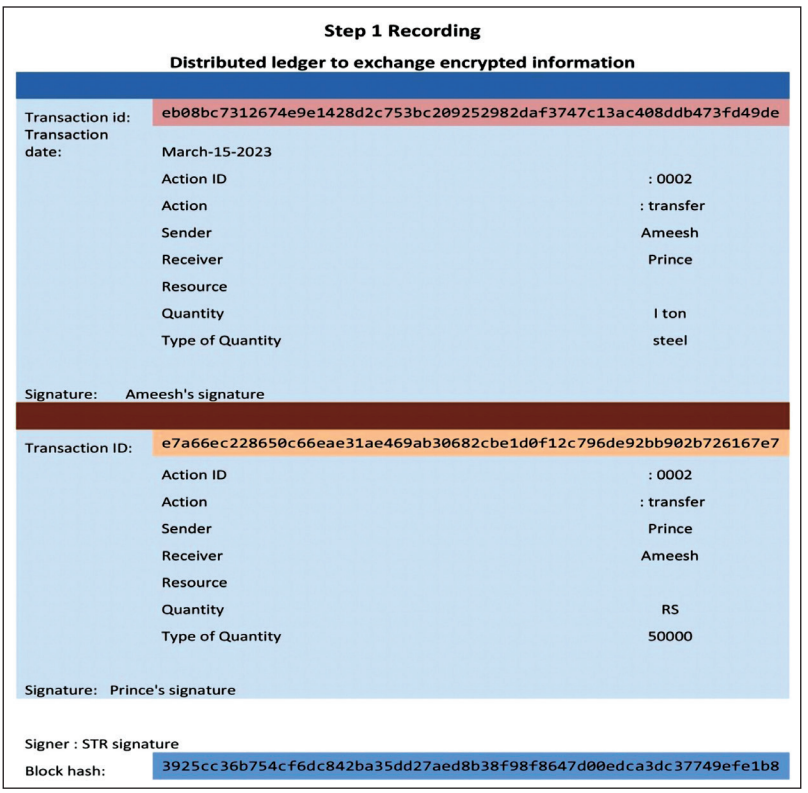

Figure 3. Recording Procedures with Three Layers of Accounting.

Figure 5 presents the format of the position statement with the application of three layers or 3D accounting statements. The hash value has been generated for every entry. The main purpose of financial reporting has always been to provide information for the main stakeholders (Mizdrakovic, 2021).

Objective of the Study

The aim of this article is to present and measure the relationship among the evolution of three dimensions of accounting systems: REA, TEA and BCT. The purpose of the study is to explore whether *there* is a need to embed three dimensions of accounting in the normal accounting cycle. The objective of the article is to explore the change that three dimensions of accounting would bring in the empowerment of accounting to its users also.

Rationale of the Studies/ Theoretical Framework

In light of the evolving nature of time and technology, it is vital to adapt new strategies to current financial statements and financial reporting objectives. A 3D accounting

Step 2
(As preparing Income Statement in Normal Accounting Cycle) Recording

Transaction id:
e27e3a46628d12fdaaa93608da5df16a
Transaction date: March-31-2023

Books of Ameesh

Trading & Profit & Loss Account

Date	Particulars	Hash Value	Amount	Date	Particulars	Hash Value	Amount
				31-03-2023	**By Sales**	f2924477835d74d546d59cdaac96b672	50000
31-03-2023	To Gross Profit C/d	1fcdb2725a6590049e04c2415a1b8cc7	100000	31-03-2023	By Closing Stock	5851f7ae73f93c3375d2565f76f456fd	50000
			100000				100000

Transaction id:
Transaction date:

Books of Prince

Trading & Profit & Loss Account

Date	Particulars	Hash Value	Amount	Date	Particulars	Hash Value	Amount
31-03-2023	**To Purchase**	e78db5dbb2c98505f31f902144838fde	50000	31-03-2023	By Closing Stock	5328296e3ae22643245fe6a01c7e9576	50000
31-03-2023	To Gross Profit C/d	e77c46c3cf82a60170bb97b9a8176f3e	0				

Figure 4. Income Statement in Normal Accounting Cycle.

Chart 5 Example of Position Statement in Normal Accounting Cycle

Step 3
(As preparing Position Statement in Normal Accounting Cycle) Recording

Transaction id:	5acd3c81bc2eb0e69a8c381a35468a86	
Transaction date:	March-31-20231	
Balance Sheet		
Particulars	**Hash Value**	**Amount**
Equity and Liabilities		
Capital		
Reserve		
Profit & Loss A/c	c91e3a4ad53b15a3c5846f54755eac6a	100000
Sundry Creditors		
		100000
Assets		
Property, Plant & Equipment		
Land & Building		
Machinery		
Current Assets		
Inventory	571e4c477e1c93c1b3528d0a03059ca2	50000
Debtors		
Cash and bank	c9ccb98fba0173b7a98636b2ca6a3812	50000
		100000

Source - Prepared by the author

Figure 5. Example of Position Statement in Normal Accounting Cycle.

system has replaced the two-dimensional one used by businesses and companies. The shortcomings of the double-entry system led to the development of the triple-entry system. This technique has been investigated globally due to the harm that numerous financial frauds and intelligence crimes have done to the economy. To empower accounting, the article focuses on implementing a new decentralised ledger and 3D accounting system integrated with the normal accounting cycle.

Research Methodology

Sampling Design and Statistical Technique

Data collected for the study are primary. A structured questionnaire was prepared to obtain the opinion of accountants and auditors of different natures (small, medium and large size) of businesses. For further study, the questionnaire was sent to 200 professionals but only 126 duly filled responses were received. The questionnaire is segregated into two parts; one is based on opinion towards the implementation of a 3D accounting system, and the second for demographic questions like age, gender, education, nature of business, and so on. Questions have been framed on a 5-point Likert scale. The respondents were asked to implement 3D accounting system to embed the normal accounting cycle.

Hypotheses

***H*1:** There is no significant difference among the opinion of respondents regarding the need of 3D accounting systems in the normal accounting cycle and their demographical information.

***H*2:** There is no significant difference in the opinion of respondents regarding the need for the embedment of a 3D accounting system in the normal accounting cycle.

Further, data have been analysed in two steps. Descriptive statistics used for demographical and physiographical report presentation. For testing the hypotheses, the chi-square test and one-way ANOVA have been applied. Also, the neural network has been used to assess the model's suitability and predict the key elements needed for the integration of 3D into the standard accounting system.

Result and Discussion

Demographic information such as age, gender, nature of work and qualification of respondents has been presented in Table 1.

Tables 1 and 2 present the descriptive statistics for demographical variables and other variables presenting the application of 3D accounting along with the

Table 1. Descriptive Statistics of Demographical Variables.

Demographical Variables	Mean	Std. Deviation	Variance	Skewness
Age	1.2937	.45725	.209	.917
Gender	1.2381	.42762	.183	1.245
Nature of working and qualification	1.6667	.80994	.656	.683
Experience	1.3571	.63830	.407	1.585
Need of embedment to 3D	1.2381	.54301	.295	.100

Table 2. Descriptive Statistics of Variables Presenting Application of 3D Accounting.

Variables presenting application of 3D accounting	Mean	Std. Deviation	Variance	Skewness	Sign.
More transparency	3.3492	1.13361	1.285	–0.087	.865
Automation and time saving	3.4048	1.14667	1.315	–0.329	.947
More transparency	3.4048	1.11124	1.235	–0.289	.455
More authentic and trustworthy	3.4127	1.18841	1.412	–0.298	.140
Long-term sustainable	3.5159	1.17122	1.372	–0.373	.105
Hash value makes it immutable	3.4683	1.19121	1.419	–0.313	.644
Distributed ledger	3.4127	1.1262	1.268	–0.223	.616
Improvement in traditional accounting	3.4683	1.31262	1.723	–0.232	.357
Fast and vast disclosure	3.5	0.86487	0.748	–0.264	.715
Good in supply chain management	3.381	0.76793	0.59	–0.883	.315
Better reporting	2.4127	0.63586	0.404	–0.614	.260
Immutable and forever	3.5317	0.85498	0.731	–0.412	.319
Good governance with no error	3.4365	0.95076	0.904	–0.468	.128

Levene test result of homogeneity. Respondents were offered specific skills related to knowing which feature of 3D is more important. The question 'Hash value makes it immutable' has the highest mean value and the mean value varies between 2.5 and 3.5. It is found that the variance ranged between 0.5 and 1.72. The value of C V is also very low which shows that there is little variation in responses of respondents. The highest agreement (1.419) was for 'Hash value makes it immutable' and the least agreement (0.59) was for 'Good in supply chain management'. Values of C V were low indicating consistency in responses.

Results of the Levene test show that *p* values for both types of demographic variables along with all statements have been found more than .05. This shows that the data distribution is homogeneous and hence parametric tests are to be used. To test the hypothesis, one-way ANOVA has been applied.

Table 3 reflects the demographical presentation of respondents. The study focused on analysing the requirement of 3D accounting system whether the opinion of respondents has been varied with its demographical status. The interest and intention are reflected in the demographic characteristics of 126 respondents. The majority of respondents are male (76.2%), between the age of 35 years (70.6 %).

Table 3. Demographic Status.

Age	Frequency	%	Gender	Frequency	%
Below 35	89	70.6	Male	96	76.2
More than 35	37	29.4	Female	30	23.8
Total	126	100.0	Total	126	100.0
Nature of working and qualification	Frequency	%	Need of embedment to 3D	Frequency	%
Small	69	54.8	Neutral	7	5.6
Medium	30	23.8	Yes	82	65.1
Large	27	21.4	Not needed	37	29.4
Total	126	100.0	Total	126	100.0

Table 4. Chi-square Tests.

	Value	*df*	Asymp. Sig. (2-sided)
Pearson chi-square	10.403[a]	4	.034
Likelihood ratio	12.750	4	.013
Linear-by-linear Association	1.034	1	.309

Source: SPSS output.

The respondents who indulged in small businesses were 54.8%; those with middle size businesses were 23.8% and the remaining (21.4%) had large size businesses.

***H_1*:** There is no significant difference among the opinion of respondents regarding the embedment of 3D accounting systems in the normal accounting cycle and their demographical information.

The opinion that 3D accounting system needs embedment has been segregated into three criteria: first, those who have a positive opinion of it, second, those who have a negative opinion, and third, those who are neutral.

There were three demographic factors, the effect of which could be tested—gender, age, and *nature of working and qualification*. To test the significant difference between demographics and respondents' opinions towards the embedment of a 3D accounting system, a chi-square test has been applied.

While testing the hypotheses based on gender, none of the items was found to have significantly different opinions. Similarly, age was also not found to have a significant association between respondents' opinions. Hence, gender-wise and age-wise hypotheses results have not been presented. It was concluded that there is no significant difference among the opinion of respondents based on gender and age.

Table 4 presents the results of the chi-square test for opinion. Their opinion has been tested with their nature of work; it is found that the chi-Square test statistic was significantly associated, as the *p* value is less than 0.05. There is a significant

difference in the overall opinion of respondents on their business size, that is, small, medium and large.

It can be concluded that respondents' opinion differs significantly regarding the need for a 3D accounting system and the opinion of the respondent is significantly different based on the size of the business. The majority of respondents are in agreement for small size business persons agreeing to apply 3D accounting system to the normal accounting cycle. It may be due to loopholes in traditional systems like manipulation of financial data presentation.

***H_2*:** There is no significant difference in the opinion of respondents regarding the need for the embedment of a 3D accounting system in the normal accounting cycle Table 5 ANOVA.

Since the data are normal and homogenous, one-way ANOVA has been applied to test the hypothesis. All the statements have been framed to know the opinion of respondents and there is no significant difference in the opinion of respondents on the need to empower normal accounting cycle and it should be embedded in the *3D accounting system*. It means a normal accounting system is equivalent to a 3D accounting system and there is no need to embed it. *P* values for all the changes are less than .00 and thus null hypothesis is rejected for all the changes at a 5% level of significance. The 3D accounting system is better presented than the normal accounting system; hence, it should be embedded in the 3D accounting system for better performance.

Application of ANN for Prediction of Important Variables for Normal Accounting to Embed in 3D Accounting System

Every ANN starts with an artificial neuron as its fundamental building piece. Its structure and features were inspired by the biological neuron, the fundamental

Table 5. ANOVA

Variables	Symbol	*F*	Sig.
Distributed ledger	FB1	8.572	0.000
More transparency	FB2	6.708	0.002
Automation and time saving	FB3	3.963	0.021
Save time and resources	FB4	7.547	0.001
More authentic and trustworthy	FB5	4.346	0.015
Long-term Sustainable	FB6	7.901	0.001
Hash value makes it immutable	FB7	3.877	0.023
Improvement in traditional accounting	FB8	4.164	0.018
Fast and vast disclosure	FB9	11.487	0.000
Good in management	FB10	5.104	0.007
Better reporting	FB11	3.003	0.053
Immutable and forever	FB12	8.309	0.000
Good governance with no error	FB13	9.381	0.000

unit of biological neural networks (systems) that include the brain, spinal cord and peripheral ganglia. Similar to a biological neural network, an ANN is a mathematical model that attempts to imitate its structure and functions. A simple mathematical model (function) known as an artificial neuron serves as the fundamental building block of every ANN.

The neural network has been used to assess the model's suitability and predict the key elements needed for the integration of 3D into the standard accounting system.

Multilayer Perceptron

The productivity of basins is attempted to be measured using an ANN. Using SPSS 21 in the Windows XP environment, the neural network approach has been used to validate the analysis of the effects of various oil production components. The results of the analysis are given in Table 6.

Table 6's summary of case processing reveals that 47.6 cases are assigned to the training sample, and 31% is used to test the sample which is used to validate the model. 21.4% of the data been allocated as a holdout cases. Like the human brain, data must be trained. Fresh holdout instances will be subject to the real test.

Table 7 provides details on the network. It explains how work is done. Input, hidden and output layers make up its three working layers. It demonstrates that 13 units are operating in the input layer, 2 units in the hidden layer and 3 units in the output layer.

Information on the network is shown in Figure 6. It explains how work is done. Input, hidden and output layers make up its three working layers. It is an entire connected graph with input, a hidden layer and output. The replies or dependent variables are contained in the output layer. There are a few secret units that operate each output unit. Once more, the particular type of operation depends in part on the network type and in part on user-controllable requirements.

The importance of each predictor or independent variable, which in turn impacts the shape of the neural network, is computed in the picture to offer the sensitivity analysis. The combined training and testing samples served as the basis for the analysis.

Table 6. Case Processing Summary.

		N	%
Sample	Training	60	47.6
	Testing	39	31.0
	Holdout	27	21.4
Valid		126	100.0
Excluded		0	
Total		126	

Source: SPSS output.

Table 7. Network Information.

Input layer	Covariates	1	Distributed ledger
		2	More transparency
		3	Automation and time saving
		4	More transparency
		5	More authentic and trustworthy
		6	Long-term Sustainable
		7	Hash value make it immutable
		8	Improvement in traditional accounting
		9	Fast and vast disclosure
		10	Good in supply- chain management
		11	Better reporting
		12	Immutable and forever
		13	Good governance with no error
	Number of units[a]		13
	Rescaling method for covariates		Standardised
Hidden layer(s)	Number of hidden layers		1
	Number of units in hidden layer 1[a]		2
	Activation function		Hyperbolic tangent
Output layer	Dependent variables	1	Need of embedded to 3D
	Number of units		3
	Activation function		Softmax
	Error function		Cross-entropy

Source: SPSS output.

Note: [a]Excluding the bias unit.

Each predictor or variable's relevance and normalised importance are shown in Figure 7. It is crucial to note that sensitivity analysis requires a lot of calculation time and money if there are a lot of predictors or instances. A measure of an independent variable's relevance is how much the predicted value of the network model shifts for various values of the independent variable. When stated as a percentage, normalised importance is calculated by dividing the importance value by the biggest importance value.

More authenticity and trustworthiness, good governance with no error, hash value that makes it immutable, improvement in traditional accounting, saving time and resources, and fast and vast disclosure are found to be the most important

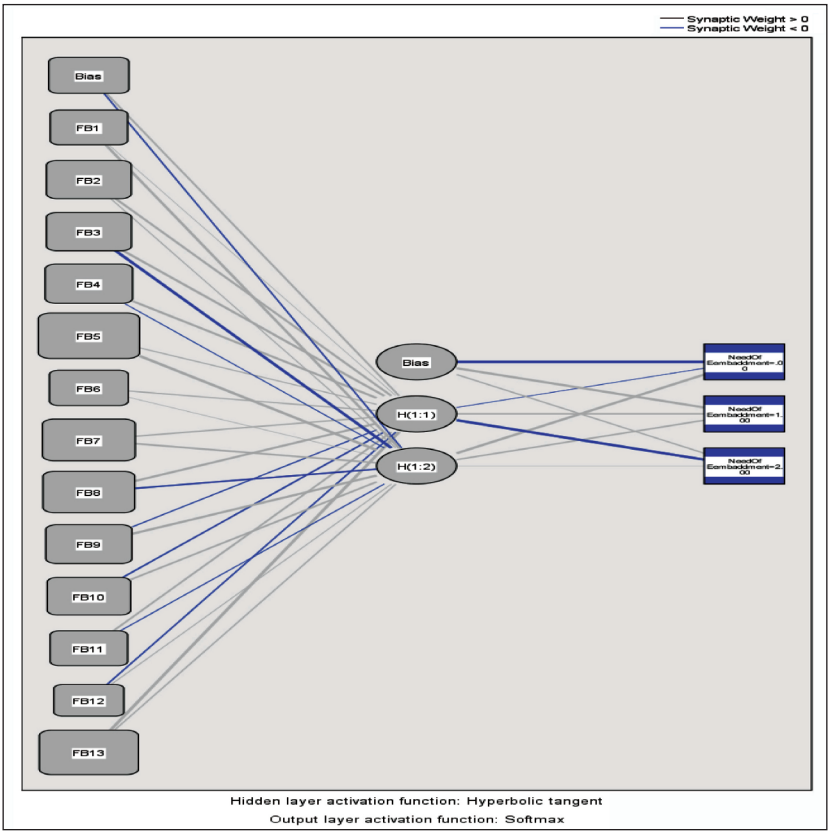

Figure 6. Prediction of Influenced Factor to Empower Normal Accounting Cycle.

Source: SPSS.

variables to explain the requirement of a normal accounting system embedded in the 3D accounting system.

Managerial Implications

This explanation will help practitioners to understand and analyse the adoption of blockchain technology in togetherness of normal accounting cycle for small and medium enterprises, and for academicians, it will act as the base to develop new approach of tradition accounting embedded to blockchain accounting .This study would prove useful for them and for academician for further research. This article would be usefulness to decision-makers by providing understanding about blockchain technology and its adoption. Academia will find utility of blockchain technology embedded to normal accounting cycle.

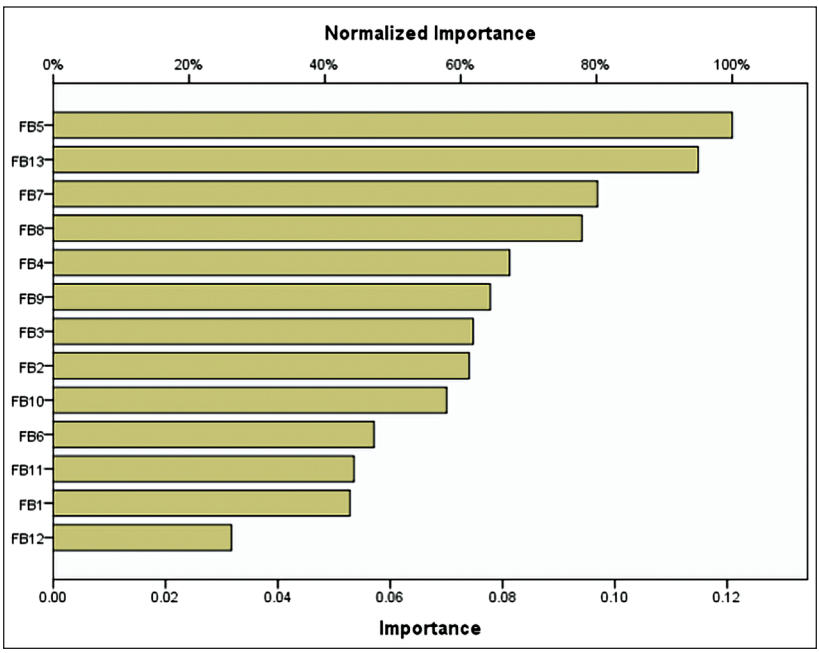

Figure 7. Normalizes Importance (Extracted from SPSS).

Source: SPSS.

Limitations/Future Research

This article provides an approach of togetherness of traditional vs. techno-oriented accounting and reporting system. It is a starting point to be familiar with blockchain to be embedded to normal accounting. Small and medium businesses have limited resources and thus less adoption power of technology that makes their work complex and leads to possibility of errors and frauds.

Conclusion

In this acco-tech and disruptive technologies era, TEA is becoming more prevalent worldwide. The bookkeeping and accounting method has evolved and been impacted by every phase of the economy. The introduction of technology has altered the way how businesses function today. The triple-entry bookkeeping system was updated as a result of the introduction of blockchain technology.

Here, the triangle-related component is covered. The 3D accounting is an addition to double entry which is consisting of the entries for debit and credit recorded. Instead of using a double-entry system, a triple-entry system is used for the movement of cash or currency equivalents. The term was expanded by

adopting a novel notion of a third entry that corresponds to 3D accounting to increase the dependability of the conventional double-entry accounting system.

It can be concluded that respondents' opinion differs significantly regarding the need for a 3D accounting system and the opinion of the respondent is significantly different based on both the demographical information like the size of the business and psychological information like features of the 3D accounting system. All the characteristics of 3D accounting have been framed to know the variation in the opinion of respondents. It is found that there is no significant difference in the opinion of respondents on the need to empower the normal accounting cycle and it should be embedded in the *3D accounting system*. This accounting system is better presented than a normal accounting system; hence, it should be embedded in the 3D accounting system for better performance.

Acknowledgement

The author is grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the article. Usual disclaimers apply.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author received no financial support for the research, authorship and/or publication of this article.

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Article

Cronbach's Alpha: Genesis, Issues and Alternatives

IMIB Journal of Innovation and Management
2(2) 226–242, 2024

DOI: 10.1177/ijim.241234970
jim.imibh.edu.in

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Abstract

The most widely used metric for assessing a scale's reliability is Cronbach's alpha. Since its introduction in 1951 by Lee Cronbach, it has evolved into the accepted benchmark for scale reliability. A quick search for 'Cronbach's alpha' in Google Scholar yields more than 8 hundred thousand results. By any measure, this is enormous, and the usage of alpha appears to be present in practically every domain of academics. The fact that alpha has been so successful is surprising, as researchers have consistently criticised and have pointed out a plethora of problems with it. For instance, is that Cronbach never suggested alpha as a reliability metric—rather he proposed alpha as an alternative measure for equivalency in a test-retest context. Another issue Cronbach never suggested the lower bound of 0.70 as a benchmark of reliability. However, the lower bound of 0.70 has become the holy grail of scale reliability. Alpha continues to lead all measures of scale reliability despite its numerous issues. This article examines the history of alpha, its derivations based on classical test theory, and its limitations. It then suggests three alternative measures, along with software procedures to calculate them: alpha with confidence interval, omega and greatest lower bound. The purpose of this article is to enable researchers to have a better idea about the limitations of Cronbach's alpha, and to make them aware of other measures of reliability which are available. It is hoped that this article will help researchers report better and more accurate reliability measures in their research works alongside the alpha.

Keywords

Reliability, scale development, Cronbach's alpha, McDonald's omega, greatest lower bound

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Introduction

Measurement is an integral part of the modern world, but its origins can be traced back to the barter system. Before a farmer could agree to barter his produce, he needed to establish a common ground on which the exchange could take place. Fortunately, in the natural sciences, measurement systems evolved at a rapid pace and were accepted worldwide. However, developing measurement systems in the social sciences proved to be more difficult as social scientists were forced to measure abstract concepts. For example, measuring '*happiness'* is not as easy as asking how happy you are? Social, economic, legal and other factors determine the meaning of happiness. Despite these issues, it became necessary to measure these abstract concepts, to provide accurate information for decision-making in various fields. This requirement for measuring items that were not directly observable led to a huge interest in the development and validation of such scales in psychology and related fields.

For some reason, Cronbach's alpha has become the standard on which the reliability of such measurements is judged. However, to quote the famous author, '*The numerous citations to my article by no means indicate that the person who cited it had read it'* (Cronbach & Shavelson, 2004). Such a strong criticism from the author has not dented the image of alpha, and it continues to be cited with aplomb by researchers worldwide.

This article examines the evolution of Cronbach's alpha, the limitations associated with its use, and a few alternative approaches. In part two, we provide a concise overview of the reliability measures before alpha. Part three covers the classical test theory (CTT), whereas part four focuses on the derivation of alpha. Part five covers the concerns related to alpha, while part six explores three alternatives to alpha: alpha with confidence intervals (CIs), McDonald's omega and the greatest lower bound (GLB). Part seven employs a readily accessible data set to illustrate the computation of different options. This work aims to enhance scholars' comprehension of the issues involved with Cronbach's alpha, while also stimulating consideration of alternative metrics.

Reliability Measures Before Alpha

Reliability has been one of the main concerns of researchers for a long time; however, reliability is not easily determined in the real world. To accurately demonstrate the reliability of a scale it is necessary to replicate the scale on two or more similar populations and compare the results. This is easier said than done as the subject may not be available for subsequent testing. The problem was first investigated by Spearman who proposed the *split-half* approach (Brown, 1910; Spearman, 1910). The approach, more commonly known as the Spearman–Brown procedure was the standard for testing reliability for the next 40 years (Cronbach, 1951).

The split-half method was criticised due to its inability to provide a single coefficient value for the test result. The coefficient value depended on the randomness of the split and thus made it extremely confusing for the researchers to identify a single measure of reliability. Kuder and Richardson (1937) proposed

a series of coefficient measures, one of which (KR20) was adopted by many researchers. Another criticism levied against the split-half method was that it was unclear what it was measuring (Goodenough, 1936).

Cronbach's proposed the idea of stability and equivalence in place of reliability (Cronbach, 1947). According to him an identical re-test after a certain amount of time indicates how stable the scores are over time and therefore should be called the coefficient of stability. On the other hand, the correlation between two forms of a test given at the same time represents equivalence and therefore should be called the coefficient of equivalence. Cronbach (1951) makes it quite clear that the coefficient alpha is a measure of equivalence.

One thing to note is that when Cronbach's formulated coefficient alpha, he did not base his derivation on CTT simply because CTT was propounded much later by Novick (1966). A detailed reading of the original article reveals that alpha was developed not to test scale reliability but to understand relationships between 'similar' test forms using correlations. This led to various interpretations of alpha and gradually it started to be used as a measure of reliability (Sijtsma, 2008).

A Brief Deviation into CTT

For the sake of understanding a discussion on CCT is provided. CTT assumes that each scale item has been administered an infinitely large number of times and the scores of such administration are available and observable. Let us denote this observable score using $\boldsymbol{X_{pi}}$ for the person $\boldsymbol{p}$ observed at the period $\boldsymbol{i}$. The average of all such observable scores is the true score of the scale item and is denoted by $\boldsymbol{T_p}$. CTT assumes that the true score is consistent and any variation which is seen or recorded occurs due to random measurement errors denoted by $\boldsymbol{e_{pi}}$. Hence, the observed score is comprised of the true score and the error component as follows $\boldsymbol{X_{pi} = T_p + e_{pi}}$. This indicates that the variance of the individuals observed score consist of the variance of the true score and the variance of the error component $\boldsymbol{s^2_{Xi} = s^2_T + s^2_{ei}}$ under the assumption of $\boldsymbol{cov(T, e_i) = 0}$ and $\boldsymbol{cov(e_i, e_j) = 0}$.

This provides sufficient information to define reliability under CTT. If there is low variability between the observed scores from one test to another, it would mean that the error component is low. This would indicate that the correlation between the observed score and the true score is high. On the other hand, if the observed scores change substantially from one test to another; that would imply that the error is substantial and therefore the correlation between the observed score and true score would be low. Reliability under CTT is defined as the square of the correlation, in the population, between observed and true scores. In a more formal sense, reliability can be defined as the proportion of true score variance to total variance $\boldsymbol{(s^2_T / s^2_{Xi})}$.

Assumptions about the true score, their variances and their relationship with the error terms define the four basic measurement models in CTT. These models are summarised in Table 1 with $\boldsymbol{b}$ and $\boldsymbol{d}$ being real numbers not equal to zero. Cronbach's alpha is presented under the tau-equivalence conditions of CTT.

Another term that is related, but conceptually different, is *internal consistency* which is concerned with the homogeneity of the items within a scale. According to CTT, the relationships among the measured items are logically connected to the scale and to each other. Given that the scale is designed to capture a similar set of phenomena (e.g., job satisfaction) we can think that the measurement items used to capture 'job satisfaction' correlate strongly to the scale and, hence, by assumptions of CTT, to each other. We cannot determine whether the measured items are strongly correlated to the true scale item (as it is an unobservable latent variable), but we can measure the correlations between the measurement items. In other words, a scale is *internally consistent* provided that the measurement items are highly correlated to each other. Researchers need to be clear on the difference between reliability and internal consistency as both measure conceptually different things.

Derivation of Cronbach's Alpha

In this section, a simplified version of the derivation of alpha based on the book by DeVillis (2003) is presented. Let us consider that a scale item $\boldsymbol{Y}$ which is made up of $\boldsymbol{X}_1, \boldsymbol{X}_2, \boldsymbol{X}_3, \ldots, \boldsymbol{X}_k$ measurement items. The covariance matrix ($\boldsymbol{C}$) for the measurement items can be written as

$$\boldsymbol{C} = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \cdots & \sigma_{1k} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \cdots & \sigma_{2k} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \cdots & \sigma_{3k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \sigma_{n3} & \cdots & \sigma_{kk} \end{bmatrix} \quad (1)$$

The diagonal elements of the matrix are the variances ($\sigma_{ii} = \sigma_i^2$) and the off-diagonal are the covariances. Each variance contains information regarding the variation of only one measured item and the covariances contain information about the variation of two of the measured items. Now as the covariances represent the communal (or joint) variation; all non-communal variation is represented by

Table 1. The Four Measurement Models of CTT.

Measurement Model	True Score	Variance	Error Terms
Parallel	$T_i = T_j$	Var (T_i) = Var (T_j)	Var (E_i) = Var (E_j)
Tau equivalence	$T_i = T_j$	Var (T_i) = Var (T_j)	Var $(E_i) \neq$ Var (E_j)
Essentially tau equivalence	$T_i = T_j + d$	Var (T_i) = Var (T_j)	Var $(E_i) \neq$ Var (E_j)
Congeneric	$T_i = bT_j + d$	Var $(T_i) \neq$ Var (T_j)	Var $(E_i) \neq$ Var (E_j)

Source: Warrens (2016).

the variances. Summing up all the elements of the matrix would give us the total variance present in the scale item Y, under the assumption of equal weights of the items (Nunnally, 1978).

Alpha is defined as the proportion of the total variance that is attributable to a common source. Let σ_Y^2 denote the sum of all the elements of the matrix $\boldsymbol{C}$ and let $\sum \sigma_i^2$ represent the sum of all the diagonal elements of matrix $\boldsymbol{C}$, then we can represent the ratio of non-communal variation to total variation as

$$\frac{\sum \sigma_i^2}{\sigma_Y^2}$$

And we can express the ratio of communal variation to total variation as follows:

$$1-\left(\frac{\sum \sigma_i^2}{\sigma_Y^2}\right) \tag{2}$$

Equation (2) captures the essence of Cronbach's alpha, however it suffers from a problem. Let us assume that a scale is made up of five perfectly correlated items. Then it should result in *perfect reliability*. In other words, Equation (2) should have the value of 1. But this would not be so as the correlation matrix will have a total of 25 entries, all equalling 1. The sum of the diagonals would be 5 and the sum of the matrix would be 25 and hence the value of Equation (2) would be $1-(5/25)=0.80$. This happens because the total number of elements in the covariance matrix is $\boldsymbol{k}^2$ and the number of elements on the diagonal are only $\boldsymbol{k}$ leaving $\left(\boldsymbol{k}^2-\boldsymbol{k}\right)$ off-diagonal elements. In Equation (2) the numerator is based on $\left(\boldsymbol{k}^2-\boldsymbol{k}\right)$ values while the denominator is based on $\boldsymbol{k}^2$ values. To counteract for these differences in a number of terms, we multiply the formula by $\boldsymbol{k}^2/\left(\boldsymbol{k}^2-\boldsymbol{k}\right)$ or equivalently by $\boldsymbol{k}/\left(\boldsymbol{k}-1\right)$ thereby arriving at the formula for alpha:

$$\alpha=\frac{k}{k-1}\left(1-\frac{\sum \sigma_i^2}{\sigma_Y^2}\right) \tag{3}$$

If we assume that $\overline{\boldsymbol{v}}$ is the average variance, then $\sum \sigma_i^2=\boldsymbol{k}\,\overline{\boldsymbol{v}}$. Similarly, σ_Y^2 is the sum of all the elements in the matrix $\boldsymbol{C}$ and if we assume that $\overline{\boldsymbol{c}}$ is the average covariance then $\sigma_Y^2=\boldsymbol{k}\,\overline{\boldsymbol{v}}+\left(\boldsymbol{k}^2-\boldsymbol{k}\right)\overline{\boldsymbol{c}}$. Substituting them in Equation (3) we get:

$$\alpha=\frac{k}{k-1}\left(1-\frac{k\,\overline{v}}{k\,\overline{v}+\left(k^2-k\right)\overline{c}}\right) \tag{4}$$

which on simplification gives:

$$\alpha=\frac{k\,\overline{c}}{\overline{v}+\left(k-1\right)\overline{c}} \tag{5}$$

The formula in Equation (5) is based on unstandardised (raw) scores. To convert it to standardised scores, we need to recall that in a correlation matrix all the diagonal values equal 1; hence the average variance would also be one. The off-diagonal elements represent the correlations and hence the average covariance could be replaced by $\bar{r}$ or the average intra-item correlation. This gives us the *standardized alpha* formula as

$$\alpha = \frac{k\,\bar{r}}{1+(k-1)\bar{r}} \tag{6}$$

Issues with Cronbach's Alpha

Despite its frequent use, Cronbach's alpha has been criticised heavily by many researchers. One set of criticisms comes from the assumptions that are used to derive alpha (McNeish, 2017).

Issues Arising from Assumptions

Assumption of Tau-equivalence. One of the requirements for Cronbach's alpha is the assumption of *tau-equivalence* which states that all the measurement items scale contribute equally to the construction of the scale. Any social researcher can easily see that such an assumption is impractical in the real world. Almost all the scales that are used in the real world are *congeneric*, meaning that the measured items contribute to the latent variable but with different importance (Raykov, 1997). Being a *tau-equivalent* measure means that alpha is not an exact measure of reliability but a lower bound provided that the errors are reasonably uncorrelated (Sijtsma, 2008).

Assumption of Normality and Continuous Items. One of the things to note in the derivation of alpha is that it is based on observed covariances and correlations between items. Statistical software estimates alpha using Pearson's covariance matrix—which is known to be calculated on continuous data (Gadermann et al., 2012). On the other hand, the measurement items used to create the scales are usually interval or ordinal scales. This means that the covariance matrix so calculated would be biased downwards. This leads to lower alpha values because the relationships between the items would appear smaller than they are. The use of polychoric correlation is recommended for the calculation of alpha under such circumstances (McNeish, 2017). Another assumption is that of normality of the error terms and the true score. Cronbach's alpha assumes that the error terms and the measurement items are normally distributed; but often empirical data shows non-normality and correlated errors. This means that Cronbach's alpha does not reflect true reliability. Studies in the area have given mixed results—some arguing that Cronbach's alpha is robust to deviations from non-normality (Zimmerman et al., 1993) while others argue it is susceptible to non-normality (Sheng & Sheng, 2012).

Assumption of Uncorrelated Error Terms. Another major requirement of the derivation of Cronbach's alpha is that the error terms of the measurement items be uncorrelated to each other. Correlation of errors can arise due to several reasons like the order of measurement, respondent fatigue or the unforeseen multidimensionality of a scale. When errors are correlated, it is mostly found that they are correlated positively. This leads to an overestimation of Cronbach's alpha (Gessaroli & Folske, 2002). While some of the errors can be minimised by randomising the test items, others are difficult to identify during the conceptualisation and data collection phase.

Assumption of Unidimensionality. Many researchers tend to believe that large alpha values indicate unidimensionality, or that the measurement items measure a single latent construct. But in real life, even pre-validated scales can show multidimensionality when used in a socio-economic context outside of the environment in which they were constructed. Multidimensionality comes to light when data is being analysed using factor analysis techniques and by that time it may be too late to reconstruct a new scale. Another confusion that occurs is that many researchers tend to believe that unidimensionality and internal consistency are the same—which is untrue. Internal consistency is defined as the interrelatedness of a set of items while unidimensionality is the degree to which items measure the same latent construct (Schmitt, 1996). Green et al. (1977) have pointed out that internal consistency is necessary but not sufficient for demonstrating unidimensionality. This means that large alpha values do not necessarily guarantee that the measurement items measure a single latent construct. It is possible that high values of alpha may be measuring the internal consistency of the construct and not unidimensionality.

Other Related Issues

Besides the above, there are other issues related to alpha. One of the most common beliefs is that alpha values greater than 0.70 provide excellent reliability. Cronbach (1951) never proposed any cut-off values for alpha. The value of $\alpha = \mathbf{0.70}$ seems to come from the work of Nunnally and Bernstein (1994). Over a period, this has become the standard benchmark over which all scale reliability is judged. In fact, many researchers have pointed out that there is no universal minimum acceptable reliability value for alpha. Any acceptable value depends on the type of application and what is being measured (Bonett & Wright, 2015).

Another issue that arises with alpha is that of the bounds. It can be seen from Equation (6) that when $\bar{r} = \mathbf{0}$, the value of $\alpha = \mathbf{0}$ and when $\bar{r} = \mathbf{1}$ the value of $\alpha = \mathbf{1}$. The extremely high value of alpha tends to indicate that the items on the scale are highly correlated. This could indicate issues of unidimensionality or problems of multicollinearity with scale items. As such it is recommended that alpha values >0.90 should be viewed with extreme caution. On the other hand, when $\bar{r} < \mathbf{0}$ the formula does not give a lower bound.

In his original article Cronbach (1951) had demonstrated that alpha is the average of all possible split-half coefficients which could be calculated using the

Spearman–Brown formula. This result positioned alpha as the expectation of split-half reliability values. This has led to the growing belief that alpha is a point estimate of reliability and as such it is sufficient to establish reliability. However, the reported value of alpha is the sample value (statistic) and contains sampling errors. Hence the reported value of alpha may not correctly reflect the reliability of the scale in question. It is always advisable to report a CI to give a better perspective to reliability (Bonett & Wright, 2015).

With so much criticism of alpha floating around it is surprising that it remains one of the most reported methods for reliability. In fact, many researchers conclude that the popularity of Cronbach's alpha is due to inertia—reviewers and publishers look for alpha to give some sort of legitimacy to scale items. This was supported by the empirical work done by Hoekstra et al. (2019) in which they found that 74% researchers reported alpha because it was a common practice in the area while 53% reported it because the journal demanded it. In the same study, about 79% of the researchers mentioned that they consider 0.70 or more as a desirable level of alpha. Only about 20% of them suggested that the values be either a range of values or context-dependent.

Alternative to Alpha

Many alternatives to alpha have been proposed since then. It is not the intent to review all the alternatives; but a few of the most common ones are discussed here.

Alpha with CI

The problem with alpha is that researchers tend to report it as a point estimate. In statistics, a point estimate is considered the best guess estimate of the unknown population parameter. However, in the case of alpha, this is not the case as it clearly is a sample statistic and hence can be significantly biased. Interval estimation is a natural way of incorporating precision in statistical summary. One way of doing it is to use 'bootstrapping' using software like R and MATLAB. CI reporting is also present in SPSS and will be discussed in the seventh section. Dunn et al. (2014) have strongly recommended that alpha be always reported with the CI.

McDonald's Omega

Another measure that has been regularly proposed is omega (McDonald, 1999). The ω_t coefficient—which is *congeneric* in nature—uses the factorial analysis framework for estimating reliability and is expressed as

$$\omega_t = \frac{\left(\sum \lambda_j\right)^2}{\left[\left(\sum \lambda_j\right)^2 + \sum\left(1-\lambda_j^2\right)\right]} \tag{7}$$

where λ_j is the loading of item j and λ_j^2 is the communality of the item j. Now $\left(1-\lambda_j^2\right)$ can be thought of as the uniqueness of the item j and if we replace the same with Ψ then the formula reduces to

$$\omega_t = \frac{\left(\sum \lambda_j\right)^2}{\left[\left(\sum \lambda_j\right)^2 + \sum \Psi\right]} \tag{8}$$

As the ω_t coefficient makes use of the factor loadings it tends to correct one of the key drawbacks of alpha—that is of unidimensionality. Under the condition of tau-equivalence, when the factor loadings are equal or extremely close to each other, it reduces to alpha. On the other hand, when the assumptions of tau-equivalence are violated then ω_t corrects the underestimation bias of alpha (Dunn et al., 2014). Various other studies have also found ω_t to be one of the the best alternatives for estimating reliability (Revelle & Zinbarg, 2008; Zinbarg et al., 2005; Zinbarg et al., 2006).

Another variant of omega was proposed by McDonald (1999) and is known as hierarchical omega (ω_h). It is used when errors in the measured items are correlated; or when there is more than one latent dimension present in the scale. ω_h, calculates the contribution of each dimension to the total variance and corrects for the overestimation bias in multidimensional data. Under unidimensionality, ω_t and ω_h are identical. Most statistical software report ω_t under the assumption that scale is unidimensional.

Greatest Lower Bound

The final measure that is discussed is known as the *GLB* (Woodhouse & Jackson, 1977). Under the assumptions of CTT and a single administration of the scale, the covariance matrix of observed scores ($\boldsymbol{C_Y}$) is decomposed into the sum of the covariance matrix of true scores ($\boldsymbol{C_T}$)and the error covariance matrix ($\boldsymbol{C_E}$). The error covariance matrix ($\boldsymbol{C_E}$) is diagonal with error variances on the main diagonal and off-diagonal are all zeros as per the assumptions of CTT. All three matrices are assumed to be positive semi-definite; that is, they have only positive eigenvalues. Then the GLB is defined as

$$GLB = 1 - \frac{trace\left(C_E\right)}{\sigma_Y^2} \tag{9}$$

GLB represents the smallest possible reliability given the observed covariance matrix under the restriction that the sum of error variances is maximised. For a single-scale administration, true reliability is in the interval [GLB, 1]. However, if the scale administration can be repeated then GLB would provide a point estimate. The biggest problem in computing GLB is finding the trace of $\boldsymbol{C_E}$ and various algorithms have been proposed for calculating the trace of $\boldsymbol{C_E}$. One of the most

popular methods is that of GLB algebraic (GLB_A) (Moltner & Revelle, 2015). The GLB_A algorithm is the most faithful to the original definition of GLB and has the added advantage of introducing a weight vector which weighs the items by their importance. Studies have demonstrated that GLB_A tends to produce better results than alpha and omega (Wilcox et al., 2014).

Finding the Alternatives

Given the drawbacks of Cronbach's alpha and the availability of alternatives it is surprising that alpha is the most reported reliability coefficient. In many cases, researchers tend to report alpha values as generated by the software without giving much thought to the appropriateness of the scale. This is because they tend to use 'standardized' scales which they assume would be equally applicable in a context outside of the origin of the development of the scales (Maurya et al., 2023; Rao & Lakkol, 2023).

In this section, we demonstrate how to calculate the measures using SPSS and R statistical software. The data set used is '*staffsurvey.sav*' (Pallant, 2016).[1] The data set is a part of the staff survey held at Australian universities and has 10 questions on a five-point scale. These questions are scored on agreement and importance. In the SPSS data set q1a represents the score of statement 1 on agreement and q1im represents the score on importance. The analysis is done on the agreement responses only.

Using SPSS to Generate CI for Alpha

To generate the CI for alpha we need to use the menu sequence **Analyze → Scale → Reliability Analysis** . This opens the RELIABILITY ANALYSIS dialogue box. On the bottom right we have the **Model** drop-down selector which allows us to select Alpha, Split-Half, Gutmann (all lambda's), parallel and strict-parallel modes. On the top right is the **statistics** button. Clicking on this button brings up the RELIABILITY ANALYSIS: STATISTICS dialog box. Next, we need to click on the **Intraclass Correlation Coefficient** and select the CI. Figure 1 shows the steps in detail. Now we click on **continue** and finally on the **OK** button to run the analysis. The output from SPSS is shown in Table 2.

The single measure intraclass correlation is the average intra-item correlation and the average measure intraclass correlation is the alpha value along with the 95% CI. The 95% CI has the value of [0.824, 0.865] which suggests that these set of items provides excellent reliability.

Using R and the psych Package

In the R ecosystem, the package psych (Revelle, 2023) provides a useful addition to the repertoire for the calculation of various reliability measures. The same data set was analysed using the psych package and the results are presented below. The code is provided in Annexure A.

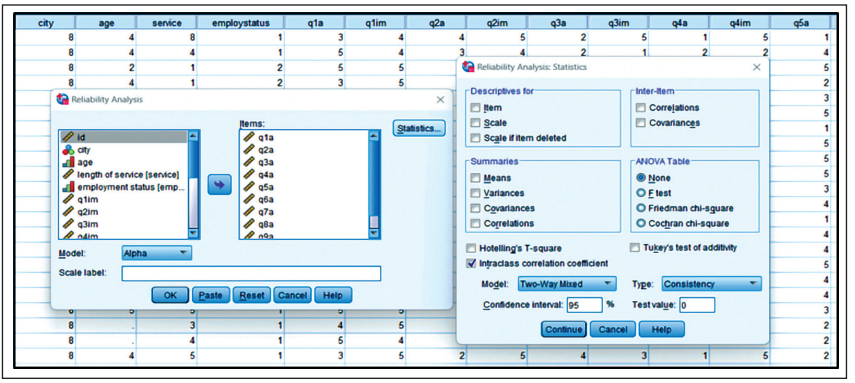

Figure 1. How to Calculate Alpha Confidence Intervals in SPSS.

Source: The snapshot is taken by the author in IBM SPSS Statistics version 21.

Table 2. Intraclass Correlation Coefficient Table as Generated by SPSS.

	Intra-class Correlation	95% Confidence Interval		*F* Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single measures	0.354	0.319	0.391	6.474	490	4,410	0.000
Average measures	0.846	0.824	0.865	6.474	490	4,410	0.000

Source: Computed from the staffsurvey.sav data set by the author.

The alpha() command reports raw alpha, standardised alpha, Guttman's λ_6, the average value of intraclass correlations and other statistics. It also provides the 95% CI of alpha using the older Feldt et al. (1987) and the newer Iacobucci and Duhachek (2003) methodology.

Based on the output of alpha it may be concluded that the items used in the scale are extremely reliable. However, when we run the omega() command the software reports 'omega total (ω_t)' and omega hierarchical (ω_h) along with a bunch of other statistics. As omega is based on a factor analysis framework it also produces a graph showing an estimated number of factors along with the interrelations between the various scale items. Table 3 provides the output of the omega command.

The output shows the alpha value, Guttman's λ_6 and the omega hierarchical, omega hierarchical asymptotic and omega total values. Table 3 provides a completely different take on the outputs of Table 4—as the values are calculated using multiple random splits. The lower bound of alpha is 0.55 which automatically makes the scale a suspect even though the upper bound and the estimated values

Table 3. Output for the Omega Command.

	Lower	Estimate	Upper
omega_h	0.21	0.58	0.63
alpha	0.55	0.84	0.85
omega_tot	0.76	0.88	0.87
G6	0.73	0.85	0.85
omega_lim	0.30	0.66	0.77

Source: Computed from the staffsurvey.sav data set by the author.

Table 4. 95% Confidence Boundaries of Alpha.

	Lower	Alpha	Upper
Feldt	0.82	0.84	0.87
Duhachek	0.82	0.84	0.87

Source: Computed from the staffsurvey.sav data set by the author.

are consistent with Table 4. The omega_tot values seem excellent; but the omega_h and omega_lim values are extremely problematic.

Scale development in social sciences is majorly based on the assumption that the items in the scale measure a single latent variable. However, the internal structure of the scale is not taken into consideration. Omega uses the Schmid–Leiman transformation to identify the unidimensionality of the scale (Schmid & Leiman, 1957). Figure 2 shows the graphical output for the scale items.

The pictorial output of omega shows that there is a 'third order factor' denoted by **g** and there are three second order factors namely **F1**, **F2** and **F3**. Another interesting thing to note is that **g** relies on eight measured variables. **F2** seems not to be correlated with any of the measured variables while the bulk of measured variables load on **F1**. Item q8a loads negatively on **F1** and either is a reversed measurement (in which case it needs to be corrected) or it is not a part of the measurement indicating that it may be needed to be dropped from the analysis. Thus, the omega analysis provides a deeper insight into the scale development process. Readers attempting to replicate the analysis should note that as the splits are random (n.iter = 10) they may get slightly different figures.

GLB_A calculation requires the covariance matrix and the covariance matrix can be used in the **glb.algebriac()** command to get the values. The function does not check for positive semi-definiteness of the covariance matrix. In case of empirical matrices with small sample sizes, calculated values of GLB_A may be strongly biased upwards. Table 5 provides the output of GLB.

GLB represents the smallest possible reliability given the observed covariance matrix under the restriction that the sum of error variances is maximised. For a single-scale administration, true reliability is in the interval [GLB, 1]. Variable q4a, q5a and q9a may seem problematic as their estimates are greater than 1. Similarly, q1a and q8a can also be a cause of concern due to their low estimates.

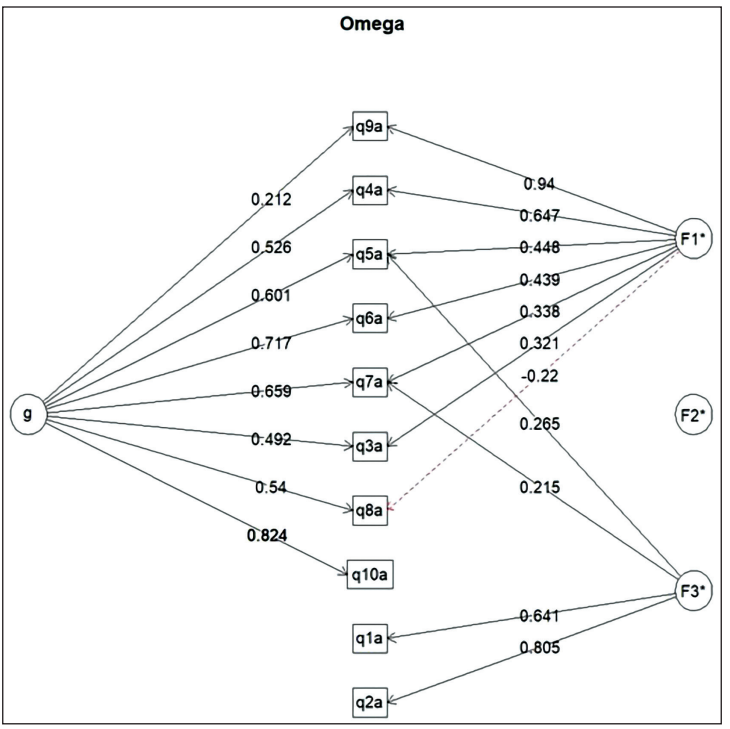

Figure 2. The Omega Factor Analysis Output (sl = TRUE).

Source: Computed from the staffsurvey.sav data set by the author.

Table 5. Output of the glb.algebraic() Command.

	GLB Estimate
glb [overall]	0.9037
q1a	0.2268
q2a	0.4799
q3a	0.5964
q4a	1.2833
q5a	1.0136
q6a	0.7004
q7a	0.5950
q8a	0.2333
q9a	1.0654
q10a	0.7102

Source: Computed from the staffsurvey.sav data set by the author.

In this section, we have calculated alpha, omega and GLB. Based on alpha we may have concluded that the scale is a robust scale but analysis with omega and GLB tends to indicate issues with the items and consequently the scale development process.

Summary

This article does not criticise Cronbach's alpha or claim to encompass all reliability calculations and reporting methods. The reliability literature is broad and over a century old. Due to the widespread use of alpha in social science and the lack of understanding surrounding it, this article aims to educate researchers about the various problems and associated issues with alpha and provide them with easy-to-calculate alternatives that provide deeper insights into reliability. It is suggested that researchers should use two or more different metrics to better comprehend the reliability of scales. With the passage of time, it has become necessary to use and report better measures of reliability social science literature.

Annexure A: Code for Analysis

```
## Install the necessary packages.
install.packages("psych", dependencies = TRUE)
install.packages("psychTools", dependencies = TRUE)
install.packages("foreign", dependencies = TRUE)
install.packages("tidyr", dependencies = TRUE)

## Load the packages and make it available to R
library(psych)
library(psychTools)
library(foreign)
library(tidyr)

## Read in the SPSS File using a dialog box.
spssdb <- file.choose()
myData <- read.spss(spssdb, use.value.labels = FALSE, to.data.frame = TRUE,
use.missings = FALSE)

## See whether the data set was read in correctly. The dim() command should give
## the output as 536 30 indicating 536 rows and 30 columns
head(myData)
dim(myData)

## Drop all rows with NA or missing values
myData2 <- myData %>%
drop_na()

## myData2 should have 330 rows and 30 variables
dim(myData2)

## Copy all the column variables which have "agreement scores" to a new dataframe
## The new dataframe should have 330 rows and 10 columns
newDf <-myData2[, c(6, 8, 10, 12, 14, 16, 18, 20, 22, 24)]
dim(newDf)
```

```
## Calculate Alpha
alpha(newDf, use = "complete", impute = "mean", check.keys = TRUE)
print(alpha.ci(.84, 330, p.val=.05, n.var = 10))

## Calculate Omega
omega(newDf, n.iter = 10, digits = 4, sl = TRUE)

## Convert the dataframe to a covariance matrix and calculate the GLB
covMatrix <- cov(newDf)
glb.algebraic(covMatrix)
```

Acknowledgement

The author is grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the article. Usual disclaimers apply.

Declaration of Conflicting Interest

The author declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author received no financial support for the research, authorship and/or publication of this article.

Note

1. Available from http://spss.allenandunwin.com.s3-website-ap-southeast-2.amazonaws.com/data-files.html.

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Article

Relationship of ESG Scores with Firm Performance: A Study of Indian Listed Companies

IMIB Journal of Innovation and Management
2(2) 243–255, 2024

DOI: 10.1177/jinm.241242865
jim.imibh.edu.in

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Abstract

This study seeks to explore whether there is a substantial correlation between corporations' ESG (Environmental, Social and Governance) ratings and their profitability, specifically return on assets (ROA). It aims to determine whether this correlation is positive, negative or neutral in nature. The research methodology involved an investigation of companies listed on the BSE500 stock index, analysing their ESG ratings for the years 2020 and 2021. The final dataset encompassed 148 companies, resulting in 296 observations for the two years, sourced from the Ace equity database. Panel regression analysis was employed to assess the link between ESG ratings (the independent variable) and ROA (the dependent variable), while also considering financial leverage and firm size as control factors. The results revealed a statistically significant negative linkage between ESG ratings and firm performance, as indicated by ROA, at a 5% significance level. The negative relation between ESG scores and firm performance (ROA) could be attributed to several factors. Organisations that prefer ESG initiatives often incur additional costs in areas like environmental compliance and employee welfare, which can temporarily reduce profitability. Moreover, ESG-conscious firms may make long-term investments that take time to generate returns, impacting short-term ROA. Additionally, stringent ESG standards may deter certain investors or customers, affecting revenue. However, over the long run, robust ESG practices can enhance sustainability and resilience, potentially leading to improved performance and risk mitigation.

Keywords

ESG, ROA, penal regression, listed companies

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Introduction

The three components of Environmental, Social and Governance (ESG) used to evaluate the sustainability of an organisation in today's world investor prefers to invest in those companies that are indulged in valuable business practices that have a positive effect on the world. ESG considerations have gained substantial significance in recent times. Strong ESG practices help businesses to stand out and be ethical and can lead to the good long-term financial performance of an organisation. The European Union and the United States are putting pressure on their developing counterparts to pay attention to their obligation towards the diverse sources of their support. As an illustration, the US Securities and Exchange Commission recommended requiring climate-related disclosure in 2021 to address climate change (KPMG, 2021).

ESG Practices in India

In India, the Ministry of Corporate Affairs 2011 issued voluntary guidelines on social, environmental and economic duties of business (NVGs). India's Government, marked the beginning of ESG reporting practices, driven through the goal of aligning investment with ESG themes. ESG Programmes have become widely recognised in recent years. In India, SEBI (Securities Exchange Board of India) mandates for top 1,000 listed firms to disclose information regarding sustainability in the sustainability report in May 2021. This was a massive change in India towards ESG practices. This is a noticeable change from the previous BRR (Business Responsibility Report) Policy regime. This disclosure requirement will be in effect from FY 2022–2023 and this is seen as footfall towards conducting sustainability reporting up to standard with the requirement for financial reporting (SEBI 2021). In light of this context, it is of academic interest to investigate whether there is any proof that sustainability disclosure (ESG) influences the long-term financial performance of Indian-listed companies, thereby supporting the wisdom of SEBI's initiative on Indian ESG regarding the framework. This study examines the relationship between the financial performance of the Indian listed companies (BSE 500) and Environment Social and Governance score individually and the total ESG score.

About the Study

We will examine the factors that contribute to the connection between ESG performance and financial returns. We will delve into ESG's aspects and how they might impact a company's financial results. The penal regression model is used in this analysis. The results of this research indicate that no significant correlation between ESG scores and firm performance at a 5% significance level.

These results imply that there is a misalignment between the business's overall plan and its ESG practices. Efforts for ESG may not influence a company's overall financial performance if they are poorly integrated with other business operations and are only implemented just to satisfy regulatory requirements. Our goal is not

to discredit the importance of ESG but to offer a nuanced perspective that recognises the intricate interplay between these factors. By identifying when ESG and financial performance might be inversely related, we aim to provide valuable insights for shaping corporate strategies, investment choices and policy decisions. Moreover, our work seeks to stimulate a broader discussion about the delicate equilibrium companies must find between ethical responsibilities and financial goals, promoting more informed and responsible corporate practices in our constantly evolving global environment.

Review of Literature

ESG is becoming an emerging concept for businesses as well as for researchers. During the period of review of the literature, in our research, we came across studies demonstrating positive, negative and neutral connections between ESG disclosure scores and a company's financial performance.

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Chelawat and Trivedi (2016) and Friede et al. (2015) pointed out that good corporate ESG practices help to enhance the financial performance of the company, while Bodhanwala and Bodhanwala (2022) pointed out that in the tourism industry, different factors affect how well a company does financially and how much it is worth. These factors are like different aspects or characteristics, and each one has a unique influence on how successful a tourism company is and how much it is valued by investors. Doing well in terms of corporate ESG performance can improve a company's financial performance when you look at both its financial statements and its value in the stock market (Thaker & Dalal, 2019). When they look at how individual companies perform in terms of ESG factors, the findings are a bit mixed. However, when they consider all the results together, it does support the proposition that firms emphasising strong ESG standards generally achieve better financial outcomes than those lacking such commitments (Ahmad et al., 2021). Sharing information about a company's ESG practices boosts its performance, even when it considers its competitive advantage (Mohammad & Wasiuzzaman, 2021). However, some research claims that there is no, or merely a weak association, between ESG disclosure and financial performance. ESGP (ESG performance) positively affects return on assets (ROA), but it does not have any influence on Tobin's Q. They break down ESGP into its three parts, governance performance has the most significant impact on financial performance compared to environmental and social performance (Velte, 2017).

ESG has a notably positive impact on performance overall. But when they look at each ESG aspect separately, they see some differences. Environmental disclosure boosts ROA and Tobin's Q, while corporate social responsibility (CSR) disclosure has a negative effect on all three models. On the other hand, corporate governance disclosure negatively impacts ROA and return on equity (ROE) but has a positive influence on Tobin's Q (Buallay, 2019). There is a notable adverse connection between a company's environmental score and its ROA and return on capital employed (ROCE). However, only the social score demonstrates a

significant unfavourable link with ROE. Consider the combined score of ESG, it also exhibits a negative and substantial relationship with both ROA and ROCE (Jyoti & Khanna, 2021). The study's title is 'A Factor Approach to the Performance of ESG Leaders and Laggards'. Research Letters in Finance 44. Most of them primarily accept that ESG leaders are superior to their ESG laggard equivalents in terms of performance. ESG disclosure had a favourable impact on a firm's performance indicators.

The study by Alareeni and Hamdan (2020) found a negative correlation between environmental (EVN) and CSR disclosure and both ROA and ROE. At this point, it has to be mentioned that there are just a few studies that look at how ESG variables affect financial performance in the context of listed companies in India. As an example, Bodhanwala and Bodhanwala (2018), Chelawat and Trivedi (2016), Dalal and Thaker (2019), Jha and Rangarajan (2020) and Jyoti and Khanna (2021). Each of the above research has concentrated upon data from the 2010s, demonstrating the previously indicated increasing sensitivity of the topic from an Indian perspective. The majority of this research also supports the fact that ESG disclosures have a generally beneficial influence on the financial performance of Indian companies, despite the research done by Jha and Rangarajan (2020). 'An examination on the Causal Linkage between Corporate Sustainability Performance and Corporate Financial Performance in the Indian Context.' Jyoti and Khanna (2021) and the *Asian Journal of Sustainability* and *Social Responsibility* provide contradictory information.

Theoretical Framework

Stakeholder Theory

According to the stakeholder theory, a company's long-term success depends on how well it manages its relationships with all the people or groups that are affected by its actions, not just its shareholders. These stakeholders can be individuals or groups who either benefit from or are harmed by what the company does. Based on this theory, when a company engages in ESG activities, it can improve its performance in the market. For instance, if employees are happy and loyal, they will work more effectively. Satisfaction of customers will lead to staying loyal, and content suppliers may offer discounts. All of these positive outcomes increase the company's goodwill and that leads to better financial outcomes and sustainability. Research by Jo and Harjoto (2012), as well as Ghoul et al. (2017), supports the idea that ESG engagement has a positive impact on a company's performance. This is because ESG activities can help resolve conflicts between managers and stakeholders. In essence, actively pursuing ESG initiatives is not only essential for protecting a company's financial health but also for increasing the value of its shares. The stakeholder-focussed theory argues that using ESG practices can help companies perform better financially. Within this theory, there's an idea called the 'conflict-resolution hypothesis', which suggests that when companies practice ESG, it can help resolve disagreements between managers and people who are not investors in the company (Freeman, 1984).

Agency Theory

The relationship between ESG principles and agency theory lies in their shared goal of promoting responsible corporate behaviour and aligning the interests of shareholders and company executives. ESG factors offer a framework for assessing a company's performance and sustainability in key areas, including its environmental impact, social responsibility and governance practices. By incorporating ESG considerations into decision-making and reporting, companies can enhance transparency, accountability and stakeholder engagement. This, in turn, helps mitigate the principal-agent problem at the heart of agency theory, as it encourages executives to act in the long-term interests of shareholders and stakeholders, reducing agency costs and fostering a more ethical and sustainable corporate culture.

Following Jensen and Meckling's agency theory from 1976, we can suggest that involving ESG activities creates a conflict of interest between company managers and shareholders. According to this theory, spending on ESG initiatives is not in the shareholders' best interest because it means using company funds that could otherwise contribute to profit. There are at least three ways that agency problems related to ESG activities can show up. First, managers might use company resources for their gain when they engage in ESG activities. They could do ESG stuff for personal benefit or spend excessively to boost their reputation as responsible citizens, all at the expense of shareholders. This perspective sees ESG engagement as a waste of company resources, which ultimately harms company performance (Brown et al., 2006). Second, ESG activities might force companies to give up more profitable projects. Corporate social actions come with financial costs that come from the company's capital and resources, putting it at a disadvantage compared to less socially active firms (Barnea & Rubin, 2010). Third, there's the argument of managerial opportunism, where managers use company resources for ESG activities to divert attention from poor financial performance. This is often referred to as 'window dressing'. ESG activities are carried out to gain positive publicity and cover up weak financial results (Allouche & Laroche, 2005; Schuler & Cording, 2006).

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The Objective of the Study

To investigate the association between the business's financial performance (listed companies) in India and the different governance, social and environmental factors parameters and total ESG score.

Hypothesis Formulation

H_1: Financial performance of Indian listed companies positively associated with ESG score.

H_2: Financial performance of Indian listed companies positively associated with environment score.

H_3: Financial performance of Indian listed companies positively associated with social score.
H_4: Financial performance of Indian listed companies positively associated with governance score.

Research Methodology

In the review of the literature, studies used secondary data to investigate the association between ESG scores and the financial performance of Indian companies. In previous studies, mostly the data was extracted from the Bloomberg database to obtain ESG Score. Despite other studies, the present study employed ESG data from the CRISIL (an Indian analytics firm offering risks and policy advising services as well as ratings and research) ESG Database to support the study's proposed hypothesis. All necessary financial data is obtained using the ACE Equity database. 'CRISIL Published the ESG score of 225 Indian companies in 2021 based data availability in the annual reports of companies for 2020 and the next data published in 2022 of 586 companies on the basis of information available in the annual reports of companies 2021 financial year. A total of 201 companies are shortlisted for which the ESG score data is available for both years'. Despite this, depending on the accessibility of financial data in the ACE Equity database, 148 listed Indian firms make up our final sample for the research. Because not all listed companies provide data regarding their ESG performance, this is the reason behind the small sample size.

Dependent and Independent Variable

ROA is taken as the dependent variable. ROA is calculated as net income divided by the total assets. The main independent variable used to assess ESG performance is the overall ESG score and its individual components. According to Ting et al. (2020), the ESG score is a representation of how well businesses adhere to ESG principles. The existing literature (Alsayegh et al., 2020; Arayssi, 2020; Hasan et al., 2021) frequently uses the Bloomberg ESG score to assess the sustainability of a company. The base of this research, in contrast to this, is the ESG score developed by CRISIL in 2022 to measure the ESG performance of Indian enterprises. The complicated methodology used by CRISIL to generate ESG ratings is extensive. All elements of the environment have been examined including greenhouse gas emissions, usage of energy, pollution and waste, consumption of water and the utilisation of land. The social factors are the reach and accessibility, vendor and customer involvement, workplace and product safety, communities and society, accessibility and workforce diversity have all been evaluated. The efficiency and its independence of the company's board, concentration of ownership, managerial record of performance, shareholder connections and rules regarding transparency and statements are some of the factors examined while evaluating the governance standards. With the exception of the governance requirements, all of these challenges are pertinent across

diverse industries. As a result, ratings are determined by considering how important a certain issue is to a particular industry. In addition, only after taking into thought the fines or penalties for breaking the appropriate regulations are the particular environmental (E), social (S) and governance (G) ratings determined. Overall Environment, Social and Governance components are each given weights of 35%, 25% and 40%, respectively, to indicate the relative weights of each element and to calculate the final ESG score. On a scale of 0–100, 100 indicates the highest accomplishment and 0 the worst. Some variables that have to be controlled are determined and covered by this research in accordance with the literature on ESG and business performance. Firm size, net sale growth and firm leverage are taken as controlled factors according to previous literature leverage is determined by calculating the ratio of secured loans to shareholder funds, as indicated in several studies (Alsayegh et al., 2020; Bodhanwala & Bodhanwala, 2018; Hasan et al., 2021; Ruan & Liu, 2021; Ting et al., 2020; and various others) (Net Sales (Current period)) − Net Sales (Previous period))/Net Sales (Previous period) × 100 to calculate the net sales increase percentage.

Descriptive

Univariate descriptive statistics were generated to look at how the experiment distribution of the study's variables. The results are shown in Table 1. The sample of listed Indian companies provided more ESG data than the minimal quantity mandated by CRISIL, with an average ESG score of 56.19. The median value for each ESG indicator reveals that social disclosure is the second-highest at 67.59 and that it is followed by disclosure of governance issues. The three ESG variables have a wide range of values, ranging from around 20%–81%, but the disclosure regarding environmental matters is notably lower, mean at 46.09, indicating that certain companies provide minimal ESG information, while others are more forthcoming. As for leverage, the wide range underscores that some businesses rely heavily on loan financing within their capital structure, while others operate entirely without debt.

Table 1. Summary Statistics Using the Observations.

Variable	Mean	Median	SD	Min	Max
ESG score	57.7	57.0	7.54	40.0	79.0
Evs score	48.9	48.0	12.8	22.0	86.0
Social score	54.7	56.0	8.01	29.0	71.0
Gov. score	67.2	68.0	7.84	40.0	83.0
ROA	7.44	6.49	8.89	−30.4	54.4
Total assets	3.77e + 004	3.41e + 003	1.33e + 005	25.8	1.16e + 006
Net sales growth	1.33	0.274	39.6	−99.1	418.
Total debt equity	0.556	0.0521	1.88	0.000	21.7

Table 2. Correlation Matrix.

Variable	ROA	Env. Score	Social Score	Gov. Score	ESG Score	Size	Net Sale Growth	Leverage (Debt to Equity)
ROA	1.00							
Env. score	−0.0058	1.00						
Social score	0.0828	0.5903	1.00					
Gov. score	−0.0483	0.3241	0.1981	1.00				
ESG score	0.0014	0.8822	0.6850	0.6641	1.00			
Size (total asset)	−0.1909	0.0245	−0.0300	−0.0043	0.0054	1.00		
Net sale growth	0.1560	0.0007	0.0545	−0.1588	−0.0506	0.1339	1.00	
Leverage (debt/equity)	−0.2371	0.0538	−0.0338	−0.0059	0.0178	0.2283	−0.0297	1.00

Note: *Statistically significant at 5% (two-tailed test).

The range of sales increase is −99.1% to 229%. This implies that both companies with significantly negative and positive sales growth are included in our sample Univariate analysis of ROA indicates a mix of profitable and unprofitable companies within the group. Univariate descriptive statistics were conducted to explore the empirical distribution of the study's variables, with the results presented in Table 2. Notably, the Indian companies in the sample exhibit a higher level of ESG disclosure compared to the average required by CRISIL, as evidenced by an average overall ESG score of 57.7.

The mean value for each ESG indicator shows that social disclosure comes in second with a score of 67.2, followed by transparency on governance issues. However, with a mean of 48.9. The level of disclosure concerning environmental issues is significantly inconsistent. Similarly, the extent of information provided across all three ESG components varies widely, spanning from approximately 22%–86%. This indicates that certain companies disclose minimal ESG data, while others are more transparent. Moreover, based on this range, some firms have a greater reliance on loan capital within their capital structures, while others operate with no debt whatsoever. Our sample includes businesses with both negative and very strong sales growth, as indicated by the fact that the range of sales growth is from −99.1 to 418. Both successful and loss-making companies may be seen in the sample, according to the univariate statistics of ROA.

The matrix analysis shows a notable positive correlation among the ESG factors. Furthermore, a positive relationship has been identified between a company's size and its environmental and social ratings.

Large-sized businesses are heavily leveraged, as seen by the strong correlation between leverage and company size. However, there is no observable relationship between growth in sales and any other variable. While substantial coefficients of correlation are frequently reported, their strength is often not particularly great, which can lead to serious multicollinearity issues.

Table 3. Random Effects (GLS), Using 296 Observations Included 148 Cross-sectional Units.

Variables	Coefficient	Std Error	z	*p* Value
Const	7.25505	5.72582	1.267	.2051
Evs score	−0.0658396	0.142963	−0.4605	.6451
Social score	0.0705564	0.117030	0.6029	.5466
Gov. score	−0.0832522	0.168054	−0.4954	.6203
ESG score	0.102647	0.368278	0.2787	.7805
Total assets	−1.16848e-05	4.50056e-06	−2.596	.0094***
Net sales growth	0.0384221	0.0114012	3.370	.0008***
Total/debt equity	−0.729716	0.257749	−2.831	.0046***
F Statistics (*F* Test)	2.16e-13	SD Dependent Var		8.890160
R-squared	0.111707	SE of regression		8.472710
Log-likelihood	−1048.971	Akaike criterion		2113.943
Schwarz criterion	2143.466	Hannan-Quinn		2125.763

Notes: Time-series length = 2, *** $p < 0.001$ (significance level).

Dependent variable: ROA.

Model 1

$$\text{ROA} = \beta_0 \text{ESG} + \beta_1 + \beta_2 \text{SIZE} + \beta_3 \text{Lev} + \beta_4 \text{SG} \quad (1)$$

$$\text{ROA} = \beta_0 + \beta_1 \text{ENV} + \beta_2 \text{SIZE} + \beta_3 \text{Lev} + \beta_4 \text{SG} \quad (2)$$

$$\text{ROA} = \beta_0 + \beta_1 \text{Social} + \beta_2 \text{SIZE} + \beta_3 \text{Lev} + \beta_4 \text{SG} \quad (3)$$

$$\text{ROA} = \beta_0 + \beta_1 \text{ Gov.} + \beta_2 \text{SIZE} + \beta_3 \text{Lev} + \beta_4 \text{SG} \quad (4)$$

Cross-sectional and time-series data represent the study's sample. As a result, it was determined that the panel data regression model was the best model for analysing the data. In this analysis, balanced panel data for the years 2020 and 2021 were employed. When the null and alternative hypotheses were present, a test for different group intercepts was used to examine the first assumption of panel data analysis concerning heterogeneity in data:

H_0: The group has an intercept (homogeneity).
H_1: Group heterogeneity (no common intercept).

The results are shown in Table 3.

A value of $p < .05$ (1.83243e-11) rejects the null hypothesis since it clearly shows how the data is heterogeneous. In tests for panel data regression when there

is heterogeneity, parameters were estimated using fixed-effect and random-effect models to explain individual effects. It is required to establish which of the random and fixed models is statistically more suitable for the study after the panel data regression analysis is implied, and the panel regression analysis should be repeated. Which model is valid is determined using the Hausman test. The following are the Hausman test hypotheses.

H_0: A random effect exists.

When $p > .05$, which is the result of the Hausman test, H_0 is accepted, which equals (0.952297), indicating that the model is fit for the random effect. When the p value is less than .05 (2.16e-13), the model's fitness is evaluated using the F test. ESG score, environment score, social score, governance score, size of the firm, leverage and net sales growth are all jointly affecting firm performance (ROA), which indicates the model is fit.

According to the results of the analyses, the hypotheses are interpreted following:

H_1: Financial performance of Indian listed companies positively associated with ESG score.

The total ESG score has a negative effect on dependent variables (ROA). The H_1 hypothesis was rejected because $p > .05$ (0.6203) significant level. It means the total ESG score did not impact the company's financial performance (Alareeni & Hamdan, 2020; Jyoti & Khanna, 2021).

H_2: Financial performance of Indian listed companies positively associated with environment score.

Environment disclosure has a negative impact on the dependent variable ROA. The H_2 hypothesis is rejected because the results show $p > .05$ (0.6451). Results declare that an Increase in the environment score did not lead to an increase in the company's financial performance (Alareeni & Hamdan, 2020; Buallay 2019; Jyoti & Khanna, 2021).

H_3: Financial performance of Indian listed companies positively associated with the social score.

Environment disclosure has a negative impact on the dependent variable ROA. The H_3 hypothesis is rejected because the results show $p > .05$ (0.5466). Results declare that an increase in social score did not lead to an increase in the company's financial performance (Alareeni & Hamdan, 2020; Buallay 2019; Jyoti & Khanna, 2021).

H_4: Financial performance of Indian listed companies positively associated with governance score.

Environment disclosure has a negative impact on the dependent variable ROA. The H_4 hypothesis is rejected because the results show $p > .05$ (0.6203). Results declare that an increase in governance score did not lead to an increase in the company's financial performance (Alareeni & Hamdan, 2020; Buallay 2019; Jyoti & Khanna, 2021).

Conclusion

The study's findings indicate that ESG scores for sustainability do not have an impact on a company's financial success. Overall, these findings suggest that the relationship between ESG and firm performance is multifaceted, and a one-size-fits-all approach may not be applicable. While ESG initiatives are important for ethical and sustainability reasons, their impact on financial performance may vary depending on how they are implemented and managed within a company. Furthermore, the pressure to meet ESG expectations from stakeholders, including investors, customers and regulators, can lead to rushed decisions and inadequate planning, potentially resulting in financial setbacks. Companies must be cautious not to compromise their financial stability in the pursuit of ESG goals. It is essential for organisations to carefully consider the trade-offs and potential agency conflicts associated with ESG engagement and strive for a balanced approach that aligns with both ethical and financial goals.

Implications of Study

- ESG practices may not yet have the same value in the Indian market as other considerations. Which could be the reason for the lack of significance in the relationship. If so, an organisation's efforts in connection to ESG objectives/practices will not result in improved financial performance.
- The findings might indicate a misalignment between the business's overall plan and its ESG practices. ESG efforts may not improve a company's overall financial performance if they are poorly integrated with other business operations and instead are implemented merely to satisfy regulatory or disclosure requirements.
- Some investors might consider ESG efforts to be a burden or a distraction. Investors may think that ESG initiatives are useless or even harmful. As a result, they might be hesitant to provide financial support for these types of initiatives, which would cause funding to shift to businesses that place less emphasis on ESG.

Limitations of the Study

1. A small sample size has been taken in the study which may lead to inappropriate results. Only two financial year's data were taken due to the lack of availability of data on the CRISIL website.
2. ROA is considered the only measure of the financial performance of the company. Further studies can be conducted by taking another financial performance measure.

3. The study focusses on listed Indian companies. Consequently, the findings cannot be applied to all forms of businesses.

Acknowledgements

The authors are grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the article.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The first Author Priyanka Devi thankful for the financial support provided by Ministry of Social Justice and Empowerment, Government of India.

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Article

Perception of Farmers as Investors Towards Various Investment Avenues: An Empirical Analysis

IMIB Journal of Innovation and Management
2(2) 256–271, 2024

DOI: 10.1177/ijim.241240877
jim.imibh.edu.in

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Abstract

Farmers are among the many small investors in India who may save money and invest in various avenues. It is yet to be determined how farmers and 'the agrarians' in India perceive different investment opportunities. The present study fills this gap in the investment avenues literature. Surveys and interviews were used to gather primary data, and secondary data sources comprised of journal papers, books and articles. The reliability of the scale and the internal consistency of the variables were evaluated using Cronbach's alpha. The study employed one-way analysis of variance and rank correlation to assess its goals. The findings of the study show that significant deciding variables for choosing an investment include money, safety, time, trust and risk preferences. The results also highlighted the fact that older, higher-earning farmers and agrarians prefer investing only in bank deposits and postal savings accounts for reasons of safety and security. The findings of the study will help develop an investing tool that meets the needs of the national economy, financial institutions, the government and certain groups like farmers and agrarians while also being appropriate for them.

Keywords

Investment avenues, farmer's investing perception, risk factor, decision-making

Introduction

Financial markets are essential to a nation's economic growth. They speed up investment activity in the nation by moving scarce resources from savers to

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borrowers (Rao & Lakkol, 2023; Senthilkumar, 2017; Sharma et al., 2023; Shilpa, 2022; Velmurugan et al., 2015). Investment is a serious topic and not a game that may significantly influence investor's future well-being (Ikhar, 2014; Sharma et al., 2023; Shilpa, 2022). Investing in real estate, buying of house, life insurance, bonds, and postal savings are all examples of investments that can be made even if the individual does not choose specific assets like stock (Krishnamoorthi, 2009). The potential return and risk are two qualities that any investment has in common (Ikhar, 2014; Rao & Lakkol, 2023).

A nation's capital formation is facilitated by a well-organised financial system that is set up with wise laws and skilful investment channels, paving the way for the nation's economic progress. The world's seventh-largest economy, India, is the finest illustration of this. The country's largest industry is agriculture. The foundation of the Indian economy is agriculture. About 15% of India's GDP is made up of agriculture and related sectors, which employ two-thirds of the country's people. Indian farmers have a strong propensity for saving and investing. Agricultural produce and its sale are the sources of income for rural agrarian investors. Rural farmers' agricultural income is uncertain as a result of natural or man-made disasters. But at the moment, India is experiencing an increase in agricultural production, better technological deployment, augmented corporate earnings, surplus disposable income, higher levels of per capita income, low dependency ratios, etc., which is leading to higher levels of consumption and more room for savings. It is important to look at how these rural individuals save and invest money since their financial decisions are so important. The country's financial markets will profit significantly if the farmers and rural investors are able to identify and use a financial product that satisfies their specific needs and unique criteria. To promote industrialisation, which would lead to India's economic success, it is essential to attract farmer income and direct it correctly into the financial system. Agricultural financial products are utterly unknown to the large majority of people who work in agriculture across the world (Anbarasu et al., 2011; Priya & Gayathri, 2019; Shilpa, 2022). Therefore, the primary focus of this study is on farmers' perceptions of their investments.

Numerous studies have examined how urban and rural investors perceive various investment options and prospects (Deb & Singh, 2018; Naveed et al., 2020; Verma, 2018) along with the factors that impact their investment-related decisions, such as their level of awareness and other demographic and socio-economic factors (Ghodake & Khedkar, 2020; Paramashivaiah & Ramya, 2014; Senthilkumar, 2017). A good amount of research has been done to find out what influences individual investors' investment behaviour, but the investment behaviour and investment avenues available to rural people, particularly farmers, remain untouched by the research and academic community as the farmers' standard of living has not increased since they find it difficult to save money or invest it in a variety of investment opportunities. The investment view of farmers or rural residents whose primary source of income is from sales of agricultural output has received little to no investigation, if any. Thus, there is a dearth of significant research in the relevant literature that focuses on the investing choices and behaviours of rural farmers and other agrarian individuals. Thus, the current

study makes an empirical attempt to investigate how farmers perceive different investment opportunities and avenues. Additionally, as an unexplored market for Indian investment industry, it seeks to identify prospective factors and potential elements that influence the investment behaviour of farmers and agricultural investors. The farmers' well-being rests in more consistent and greater income development, which may influence their investment patterns. Consequently, the rationale for researching the investment opportunities and avenues open to farmers and their investment behaviour is challenging.

Finally, the rest of this paper is structured as follows. The following section provides an overview of the literature on the examined topic that motivates the present study's research questions. The third section deals with the objectives of the study, and the fourth section highlights the rationale of the study. In the fifth section, the study presents the stepwise methodology employed, and the sampling frame. Next, in the sixth section, the data analysis and results are detailed. Then, the seventh section presents the findings and discussion. In the end, the article concludes discussing the key findings, implications and future research agendas.

Review of Literature

The literature reviewed below aims to illustrate how different investors see distinct investment opportunities. Singh and Chander's (2006) analysis revealed that the majority of investors rely on their investment decisions in significant part on the advice of experts and financial advisers. Mittal and Dhade (2007) showed that service class prefer to invest in equity and mutual funds, while, business owners prefer debentures and bonds, housewives prefer real estate and gold, professionals prefer investing in postal deposits and derivatives, and students generally prefer equity and derivatives for investment. Research studies by Mittal and Vyas (2008) and Krishnamoorthi (2009) indicate that an investor's choice of investments is significantly influenced by demographic parameters, such as age, income, education level and marital status. The primary concerns of investors with mutual funds, according to Gupta and Jain (2008), are volatility, price manipulation, brokers' poor behaviour and corporate leaders' poor management.

According to Kumar and Vikkraman (2010), for a safe investment, investing in gold after banks is the most preferred option, however, the investors choose to invest in insurance for security reasons. Anbarasu et al. (2011) indicated that the investor's lack of awareness and information about the various investment options available significantly influence their investment decision. Even though bank deposit plans offer high returns, Pati and Shome (2011) discovered that individuals prefer protected mediums of savings to unsecured ones. Aggarwal and Rani (2011) revealed that investors, regardless of age, income level, job title or educational background, would wish to secure their future by purchasing an insurance policy. According to research by Patel and Patel (2012), investors do not like traditional investment alternatives due to their low returns. Nonetheless, gold investments are popular among female investors. However, Bhatt and Bhatt's (2012) investigation indicates that due to the decreased risk, investors of all

income levels and classifications choose investing in bank and postal deposits. Simultaneously, educated and affluent groups prefer investing in real estate, equity shares, mutual funds, insurance and commodities. According to Umamaheswari and Kumar (2014), for safety and liquidity, the majority of investors choose fixed deposits with banks, followed by gold, Unit Trust of India (UTI) units, non-government firm's fixed deposits, mutual funds, stock shares and debentures. In their 2013 study, Bairagi and Rastogi looked at investors' buying habits and knowledge of various types of investments. The study results revealed the effects of an individual's age, education, employment and income level on investments.

It is also clear from the aforementioned research that the majority of investors prioritise safety and security for their assets first, followed by a desire to maximise returns (Priya & Gayathri, 2019; Rao & Lakkol, 2023; Senthilkumar, 2017; Sharma et al., 2023; Shilpa, 2022; Velmurugan et al., 2015). The literature assessment conducted for the present study on the attitudes of farmers and rural agricultural investors towards different investment opportunities reveals that the biggest influence is dependent on the choices made by all investors. However, no significant attempt is made to identify the critical factors responsible for investment decision-making, their relative importance and particularly how they are related and influenced by the demographic factors. Further, considering the various investment avenues available in the Indian context, the existing literature has not explicitly addressed the investment behaviour/perception of farmers or agrarian individuals as potential investors. Thus, it is evident from the literature that understanding the behaviour and perception of rural individuals, especially farmers towards investment options and choices has not been given adequate attention by the research and academic community. Reportedly, there is no noteworthy research available in the existing body of literature that emphasises on rural farmers/agrarian individuals' investment behaviour and the options available to them. Thus, the goal of the current study is to ascertain how farmers perceive different investment opportunities.

Research Aims and Objectives

The current study is largely concerned with the difficulties farmers have while investing, their innate ability to save, the routes they like, and the many variables impacting their view of saving and investing, or the option of various investment avenues. In light of the high-income volatility and unpredictability, the present study aims to answer a few questions: What are the motivational sources that drives farmers' investment decisions? What are the factors that influence their investment intentions? What is the pattern of their investment? What are their preferred investment options? What factors are responsible for the investment behaviour of farmers?

It sets specific objectives to understand how farmers feel about different investment opportunities. To understand the farmers' goals for investing and saving. The present study aims to assess farmers' level of investing knowledge and to identify the factors that affect their choice of investments. It comprehends

how farmers view various investment opportunities and their current investing behaviour. It makes an effort to identify the pertinent factors impacting the investor's choice or preference order among several investment avenues. Finally, it identifies and suggests if necessary, the strategies to improve the farmers' investment decision-making.

Rationale of the Study

Agrarians, or farmers, are the backbone of society. The study of their investing behaviour is extremely important for a number of reasons. First, due to the unpredictable nature of their income and the agricultural nature of their labour, it has become vital to understand their investment behaviour. Second, financial institutions need to be able to interpret a lot of issues that the academic community has not yet been able to provide answers for. Farmers are unique among groups due to the extreme fluctuations in their income. Therefore, it is imperative to carry out an investigation that delves into their investing patterns and the investment opportunities that suit them. Third, from the standpoint of policymakers, it is also critical to understand the investment behaviour of farmers in order to anticipate future investment behaviour and comprehend the dynamics of how uncertainty affects their decision-making. Therefore, as the aforementioned considerations provide us with good reason to investigate farmers' investment behaviour, this study focuses on determining the likely impact of a variety of factors, including psychological, behavioural and socio-demographic characteristics, on investment decisions and the investment avenues available to them. With this objective, the present study aims to bridge the gap in knowledge that has been overlooked in the current literature.

Research Methodology

A single cross-sectional descriptive study employing survey methods was conducted. In the study, a variety of farmers were taken into account. To determine and explain the properties and associations of the variables of interest in a scenario, descriptive research was conducted. The study sought to identify the many aspects that affect farmers' and other agrarians' preferences for investments as well as how their degree of awareness affects that choice.

Through the use of direct interviewing, a two-part structured questionnaire was created and given to the respondents. The demographic profile in the first section includes both open-ended and closed-ended questions. The questionnaire's second section asks questions on respondents' perceptions of various investment opportunities. To maximise response rates, the questionnaire was made available in both Hindi and English. Moreover, this allows to reply in the native language, which ensures the validity of the study. The present study made use of both primary and secondary data for the analysis. Target respondents (farmers from the target demographic) were surveyed for primary data, while papers, magazines and publications were used to gather secondary data. The data collection method

employed was convenience sampling and to some extent snowball approach was followed, and the data was nearly clustered. Individuals served as the unit of analysis.

The respondents belonged to rural areas in central Uttar Pradesh. The sample size was determined statistically based on a 95% confidence level to ensure accurate results and adequate representation of the population. Around 100 units were chosen from each district on a pro-rata basis to meet the 600 sample unit target. However, at the end, the village head's reference was used to select the 30 sampling units from each village. A total of 600 individuals were reached. Despite this, only 513 respondents were deemed eligible for the study.

Data Analysis and Results

The statistical analysis results and their interpretation are discussed in the following section.

For analysis, a sample of 513 respondents from the entire population was taken into account. The analysis and statistical testing (descriptive analysis, one-way analysis of variance [ANOVA] and rank correlation) were carried out using IBM SPSS 20 version software.

Reliability Analysis

Cronbach's alpha test was used to determine the reliability of the questionnaire, which had elements consisting of awareness of investment avenues and instruments, future investment avenues and investment decision-making factors. Cronbach's alpha was estimated at 0.782. This demonstrates that the items' internal consistency is rather high.

The descriptive analysis results show that the respondents have enough land for farming, but the revenue from farming is inadequate. The farmers' spending patterns reveal that spending on food is their top priority, coming in first with the lowest mean value, followed by housing, health and land preservation spending in second, third and fourth place, respectively. The farmer's spending on durable goods comes last on his list of priorities.

One-Way ANOVA

According to Table 1, respondents' ages have an impact on how aware they are of different investment options. With a p value of $0.000 < 0.05$ at the 5% level of significance and an F value of 13.13, 66.94, 47.00, 7.08, 53.19, 40.80, 57.77, 31.32, 66.40, 9.21, 150.93, 53.15, 39.2, 45.98, 37.97 and 53.8, respectively, there appears to be a significant relationship between age and all investment options. With an F value of 150.93.66.40, 9.21, 150.93, 53.15, 39.2, 45.98, 37.97 and 53.8, respectively, age has a stronger impact on respondents' awareness of investing in government bonds.

Table 1. Results of ANOVA Test for Comparing the Demographic Variables of the Farmers and Awareness About Investment Avenues.

		Age	Gender	Edu	Occ.	Income
		Sig.	Sig.	Sig.	Sig.	Sig.
Aware-Livestock	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-Chit funds	Across groups	.002	.000	.000	.202	.000
	Within groups					
	Total					
Aware-POS	Across groups	.000	.000	.002	.509	.000
	Within groups					
	Total					
Aware-Coop PIGMI	Across groups	.000	.001	.000	.000	.000
	Within groups					
	Total					
Aware-Bank deposits	Across groups	.000	.000	.000	.069	.000
	Within groups					
	Total					
Aware-Com deposits	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-Insurance	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-PF	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-Real estate	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-Precious metals	Across groups	.005	.000	.000	.003	.000
	Within groups					
	Total					
Aware-Govt bonds	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					

(Table 1 continued)

(Table 1 continued)

		Age	Gender	Edu	Occ.	Income
		Sig.	Sig.	Sig.	Sig.	Sig.
Aware-Debentures	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-IPO	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-Sec market	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Aware-MF	Across groups	.000	.000		.000	.000
	Within groups					
	Total					
Aware-Derivatives	Across groups	.000	.000		.000	.000
	Within groups					
	Total					

The gender of the respondents influences their level of knowledge about different investment options, it can be deduced from Table 1. With a p value of $0.000 < 0.05$ at the 5% level of significance and an F value of 13.13, 66.94, 47.00, 7.08, 53.19, 40.80, 57.77, 31.32, 66.40, 9.21, 150.93, 53.15, 39.2, 45.98, 37.97 and 53.8, respectively, there appears to be a significant relationship between age and all investment options. With an F value of 150.93, gender had a stronger impact on respondents' awareness of government bond investments. According to the aforementioned table, respondents' levels of education have an impact on how aware they are of different investment options. With a p value of $0.000 < 0.05$ at the 5% level of significance and an F value of 31.17, 16.6, 4.44, 5.30, 20.90, 72.99, 45.40, 106.56, 42.48, 26.43, 56.87, 112.065, 85.48, 70.38, 70.96 and 83.89, respectively, there appears to be a significant link between age and all investment possibilities. With an F value of 112.065, education level had a stronger impact on respondents' awareness of investments in debt securities.

The social status of the respondents significantly influence their knowledge of the various options, this can be inferred from Table 1 with a p value less than .05 at a level of significance of 5%. With p values of .20, .50 and .069, respectively, there is no correlation between social status and knowledge of investment choices like chit funds, postal savings and bank deposits. According to Table 1, there exists a significant relationship between the farmers' occupation and their awareness of different investment options, as the observed p value is less than .05 at a level of significance of 5%. On government bonds, the F value is the highest at 99.21.

The age of the respondents determines the channels used to make investment decisions, including family, spouse, friends, electronic and print media, awareness campaigns, opinion leaders and financial experts, according to Table 2. The *p* value for all investment decision-making modes is $0.000 < 0.05$. So, we conclude that there is a connection. The family has the greatest *F* value at 103.6. Thus, it follows that family members are consulted for decisions by people of all ages.

The gender of the respondents determines the channels used to make investment decisions, according to Table 2. All investment decision-making modalities have *p* values that are less than .05. So, we conclude that there is a connection. With 207.7, a financial consultant has the highest *F* value. Since $p = .128 > .05$, there is no correlation between gender and opinion leader as a method of making investment decisions. It can be deduced from the above table that the respondents'

Table 2. Results of ANOVA Test for Comparing the Demographic Variables of the Farmers and Their Influence on Investment Decisions.

		Age	Gender	Edu	Occ.	Income
		Sig	Sig.	Sig.	Sig.	Sig.
Influ_Fam	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Influ_Spouse	Across groups	.000	.035	.000	.000	.000
	Within groups					
	Total					
Influ_Fri	Across groups	.000	.000	.000	.000	.001
	Within groups					
	Total					
Influ_Emedia	Across groups	.000	.001	.000	.000	.000
	Within groups					
	Total					
Influ_Pmedia	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Influ_Aprgs	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Influ_Lead	Across groups	.000	.128	.000	.000	.000
	Within groups					
	Total					
Influ_FC	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					

educational background affects the channels they utilise to make investment decisions. The *p* value for all investment decision-making modes is 0.000 < 0.05. So, we conclude that there is a connection. With 161.07 and 144.9 respectively, the opinion leaders and electronic media had the highest *F* values, demonstrating that educated respondents frequently seek the advice of experts and read online media viewpoints while making investment decisions.

It can be deduced from Table 2 that the respondents' social position affects the channels they utilise to make investment decisions. The *p* value for all investment decision-making modes is 0.000 < 0.05. So, we conclude that there is a connection. The *F* value for spouse and electronic media is the greatest, with 651.3 and 104.2, respectively, plainly showing that spouses' social position impacts respondents' investment decisions. The employment of the respondents determines the channels used to make investment decisions, according to the above table. The *p* value for all investment decision-making modes is 0.000 < 0.05. So, we conclude that there is a connection. The responder certainly consults financial experts when making investment decisions, as shown by the *F* value for financial consultants, which is the highest at 59.3. From the above table, it can be deduced that the respondents' tax planning and assessment affect the ways in which they make investment decisions. The *p* value for all investment decision-making modalities is 0.000 < 0.05. So, we draw the conclusion that there is a relationship. The *F* value for financial experts is the greatest at 57.4, clearly showing that respondents who fall under the tax bracket seek their assistance.

The age and gender of the respondents affects the limitations on savings, such as insufficient income, numerous family needs, risk of capital loss, lack of awareness, lack of information, seasonality of agricultural operations, procedural complexities, unusable savings avenues, lack of trust in investment avenues, insufficient formal financial institutions, instability of produce prices and traditional mindset, as shown in Table 3. A *p* value of 0.000 < 0.05 at the 5% level of significance is displayed for each restriction. With a high *F* value of 137.68, the respondents' traditional mindset proves to be a significant impediment. In case of respondents' gender, according to Table 3, a *p* value of 0.000 < 0.05 at the 5% level of significance is displayed for each constraint. However, it does not affect saving restrictions like insufficient income and various family requirements, which had *p* values of .94 and .64, respectively, larger than .05.

Table 3 demonstrates how the respondents' educational background affects the limitations on savings. A *p* value of 0.000 < 0.05 at the 5% level of significance is displayed for each restriction. The responders' lack of knowledge is a significant obstacle with a high *F* value of 208. The occupation of the respondents is shown in Table 3 to have an impact on the limitations on savings. A *p* value of 0.000 < 0.05 at the 5% level of significance is displayed for each constraint. The most significant factor is traditional thinking, with an *F* value of 106.53.

The annual income of the respondents, as shown in Table 3, affects the limitations on savings. A *p* value of 0.000 < 0.05 at the 5% level of significance is displayed for each constraint. The respondents' lack of knowledge is a significant obstacle with a high *F* value of 177.3.

Table 3. Results of ANOVA Test for Comparing the Demographic Variables of the Farmers and Constraints of Savings.

ANOVA						
		Age	Gender	Edu	Occ.	Income
		Sig.	Sig.	Sig.	Sig.	Sig.
Cons_Ininc	Across groups	.000	.648	.000	.000	.000
	Within groups					
	Total					
Cons_Fneeds	Across groups	.000	.946	.000	.000	.000
	Within groups					
	Total					
Cons_RCL	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_LoA	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_LoI	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_SAO	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_PC	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_USA	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_LoT	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_IFFI	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_IPP	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					
Cons_TM	Across groups	.000	.000	.000	.000	.000
	Within groups					
	Total					

Table 4. Ranks of Investment Avenues Are Preferred by the Farmers.

Investment Avenues	Mean Rank
Livestock	1.2
Chit funds	1.3
Bank deposits	1.9
Post office savings	2.3
Real estate	4.0
Precious metals	4.1
PIGMI of cooperative	6.0
Insurance	7.3
Provident fund	7.4
Company deposits	8.0
Government bonds	10.0
Debentures	10.0
IPO	13.0
Secondary markets	13.1
Mutual funds	13.2
Derivatives	15.0

According to one-way ANOVA, there is a strong correlation between the farmers' demographic characteristics, including age, gender, educational attainment, occupation, income level and their knowledge of available investment opportunities along with the factors that affect their investment decisions and potential future investments. It demonstrates how important demographic factors for farmers play in shaping their investing behaviour.

Rank Correlations

According to the rank correlation, farmers prefer investing in livestock above other types of investments, including chit funds, bank deposits and post office savings. It is quite obvious that farmers choose risk-free investing opportunities. The final resort for investments with a high mean score of 13, 13, 1 and 15, respectively, are regarded to be initial public offerings (IPOs), secondary markets, mutual funds and derivatives.

Findings and Discussion

Due to their inconsistent income and the dearth of new information accessible in rural areas, farmers and agricultural individual investors sometimes find themselves unable to make rational judgments. The study's findings show that the majority of respondents spend the bulk of their income on accommodation and

food to survive daily. Independent of their respective demographic factors, farmers face a variety of obstacles to saving, including low income, a large number of family needs, the risk of capital loss, lack of awareness, a lack of information, the seasonal nature of agricultural operations, procedural difficulties, unusable savings options, a lack of trust in investment options, a lack of formal financial institutions, unstable produce prices and a traditional mindset. Farmers' traditional mindsets and a lack of information are the main obstacles to their savings and investings.

The study's findings show that demographic factors have a major impact on farmers' perceptions and investment choices. Furthermore, regardless of their age or gender, respondents' investing decisions are primarily impacted by their family, spouse, friends, the media (print and electronic), awareness campaigns and financial counsellors. The survey also found that educated respondents occasionally consult financial professionals and take into account online media opinions when making investing decisions. Farmers with stronger saving tendencies are compelled to save as a precaution since agricultural revenue is uncertain and vulnerable to large swings due to many factors, including monsoons, price fluctuations, demand variations, etc. Nonetheless, the positive intention to invest in various instruments, the potential of fulfilling the financial objective to cover future needs, and the financial risk inclination of farmers and agrarian rural investors all play a role in characterising their investment behaviour. This will also help with the development of strategies to ensure that the return on their investment portfolio matches their level of certainty about their finances. The empirical findings show that people who were more financially prepared were more inclined to make investments. The findings indicate that farmers with good business expertise and experience are better able to employ financial instruments and professional advice when making decisions. The financial service providers and financial institutions may thus take a closer look at these factors to gain a better understanding of the farmers' investment patterns and to direct them accordingly, which would be advantageous to both parties. Governments and policymakers could design financial instruments to entice farmers' savings and investment decisions, which will lead to industrialisation and result in the economic prosperity of the country if they have a comprehensive understanding of the savings and investments made by farmers through this study.

Conclusion

The present study aims to uncover the potential elements that influence the investing behaviour of farmers and agricultural investors, a market niche that has yet to be fully explored in India. However, the outcomes can be implied across the globe to all the farmer's community and agricultural rural investors having similar income conditions and the information accessibility.

The present study and its findings will serve as a roadmap for creating and introducing more specialised financial products. The results of this study shed light on information that financial product and service marketers may utilise to get a firm foothold in the current competitive environment.

According to the results, farmers' conventional mindsets and a lack of information are the two main obstacles preventing them from saving and investing. The government and financial institutions should launch financial literacy initiatives to help farmers make wise investment choices in light of this. The research would be useful for determining how demographic factors affect investment choices and would also serve as a wake-up call for financial service organisations and businesses to devise suitable strategies so that all investment outlets have a successful reach. According to the results, farmers prefer investing in PIGMI of cooperatives over IPOs, secondary market instruments, mutual funds, ULIPs, and derivatives and also in livestock, bank deposits, postal savings, insurance policies, provident funds and government bonds. Such a tendency will limit the nation's economic growth until these savings are invested in the financial markets, which will lead to industrialisation. It is time for the government and financial institutions to launch initiatives to promote financial literacy to help farmers make prudent investment choices.

Managerial/Practical Implications

The current study adds to the body of literature in two ways. First off, as far as is known, this is one of the few first research of its kind that focuses on farmers' investing behaviour. Second, it differs from previous studies in that it additionally examines the impact of demographic characteristics along with the investment behaviour of farmers. Additionally, the research adds to the expanding body of knowledge about farmers' investment strategies in both established and emerging markets.

The findings and suggestions will assist farmers in making more informed investment decisions and will act as a wake-up call for enterprises, financial service providers and the government to develop strategies that are suitable for rural areas, particularly considering farmers, in order to maximise the potential of all investment opportunities. Governments are recommended to launch 'investor awareness' programs to help investors in rural and agricultural regions have a better technical grasp of financial products and how the financial markets operate overall.

Limitations and Future Research Directions

Although the current study tried very hard and accurately to accomplish the aforementioned goal, there are some restrictions. The study's primary time constraint prevented it from being completed, and it solely focused on farmers in northern India. In the future, the study can be extended to different parts of the country and emerging economies, so that the results can be generalised and more coherent policies can be framed. For better understanding, future studies can also consider the role of investor personality and cultural dimensions. Only 513 people were included in the sample for the initial data collection, which may not accurately represent the views of the general public. Further, in future studies,

robust methodologies capturing intricate details can be employed along with complimentary data analysis techniques so that the results can be verified and made robust.

Acknowledgement

The authors are grateful to the anonymous referees of the journal for their constructive suggestions to improve the quality of the paper. Usual disclaimers apply.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Article

The Big Bank Scam: Failure of Corporate Governance

IMIB Journal of Innovation and Management
2(2) 272–285, 2024

DOI: 10.1177/ijim.241237348
jim.imibh.edu.in

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Abstract

The case deliberates the series of events exposing serious shortcomings in corporate governance and risk management practices of one of India's oldest and most venerable financial institutions but also cast a glaring spotlight on various unfathomable issues of corporate governance such as weak institutionalisation of whistleblowing mechanism, ethical lapses and regulatory oversight within the banking sector. The case provides an opportunity to understand the key components of corporate governance structure and consequences of poor corporate governance. The case highlights the responsibility of the board of directors and audit committee and discusses the changes required in the corporate governance structure necessary to ensure that such incidents do not take place. The case attempts to unearth the weaknesses in the bank's internal processes that led to a scam of this magnitude and why it remained ongoing and undetected for several years. We found that there is a need for banks to leverage the latest advancements in technology to upgrade their internal functions and processes and make them more accountable and transparent. Further, it also opens the debate on whether public sector banks and other financial institutions should be guided solely by the profit maximisation motive, or they also meet their social obligations.

Keywords

Banking fraud, corporate governance, whistleblower, internal risk and control, India

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Introduction

The flow of international capital has a profound impact on economic growth, working its magic through direct and indirect channels. When foreign capital flows into a country, it brings a financial windfall, easing the financial constraints that often hinder businesses. This injection of resources encourages domestic investment, creating a ripple effect that ultimately fuels economic growth. Numerous studies, such as those by Bekaert et al. (2005), Edison et al. (2002) and Kose et al. (2009) have sung the praises of these direct connections between international capital and economic prosperity. However, there's more to the story. International capital also acts as a catalyst for financial development, particularly in banking and equity markets. This financial evolution, in turn, contributes to economic growth. It's a bit like the engine that drives the economic locomotive. Financial development and its impact on economic growth have been a hot topic among scholars and policymakers for years. While earlier studies, led by luminaries like King and Levine (1993) and Rajan and Zingales (1998), painted a rosy picture of financial development's positive influence, recent research has added a dash of complexity to the narrative. Studies by Aizenman et al. (2015), Berkes (2012), Cecchetti and Kharroubi (2012), Cournède and Denk (2015), Law and Singh (2014) and Sahay et al. (2015) have raised questions about non-linear relationships and generated mixed results.

In the annals of financial misconduct and corporate malfeasance, few scandals have reverberated as profoundly as the Punjab National Bank (PNB) scandal involving the enigmatic jeweller, Nirav Modi. This case serves as a comprehensive examination of one of India's most notorious financial debacles, a seismic event that sent shockwaves through the nation's banking industry and left an indelible mark on the global financial landscape. The PNB scandal, which burst into the public consciousness in early 2018, not only exposed serious shortcomings in the internal controls and risk management practices of one of India's oldest and most venerable financial institutions but also cast a glaring spotlight on issues of corporate governance, ethical lapses and regulatory oversight within the banking sector.

As we embark on this journey of inquiry and analysis, this case will delve into the intricate details of the PNB scandal. We will explore its origins, unravel the complex web of fraudulent transactions, and examine the far-reaching consequences that continue to shape the banking industry and regulatory landscape. Moreover, we will reflect on the lessons learned and the reforms enacted in the wake of this scandal, aiming to glean insights that can fortify the resilience and integrity of financial systems both in India and around the world.

The PNB scandal stands as a stark reminder of the critical need for transparency, accountability and ethical conduct within the realm of finance. It serves as a cautionary tale for financial institutions, regulators and the public at large, underscoring the ever-present risks of financial impropriety and the imperative of maintaining the highest standards of governance and integrity.

In a startling revelation, PNB, India's leading public sector bank, account for a massive scam of $1.77 billion in one of its branches in Mumbai. This revelation

shattered PNB's image as it ranked 191st among the Top 1000 World Banks in 2017 by The Banker, London. The scam sent shockwaves through the financial world, emphasising the need for accountability and vigilance. PNB's name became a cautionary tale, serving as a reminder of the fragility of the system and the allure of illicit gains. The aftermath of this incident would redefine the bank's future (Narayan, 2018). In a grievance presented to India's esteemed investigative agency, the Central Bureau of Investigation (CBI), a bank conveyed that Nirav Modi and affiliated entities had engaged in a clandestine alliance with its own officials. The purpose of this collusion was to obtain guarantees or Letters of Undertaking (LoUs), enabling them to secure buyer's credit from foreign banks. The bank further asserted that these activities were part of a fraudulent scheme. As per CBI's charge sheet, the fraud was coined by Nirav Modi, a famous diamond trader, with the help of his wife Ami Modi, Uncle Mehul Choksi and brother-in-law Nishal Modi. All of them were partners in several other companies, like M/s Stellar Diamonds, M/s Diamond R US and M/s Solar Exports. The charge sheet implicated officials and employees of the PNB, in collaborating with the individuals to facilitate the fraudulent acts. PNB contended that the scam, originally believed to revolve around diamond trading, was unrelated to its intended purpose. Subsequently, it came to light that the fraudulent activities extended beyond PNB and encompassed other financial institutions, such as State Bank of India, Allahabad Bank. Axis Bank and Union Bank. Multiple Indian investigating agencies are looking into this fraud now (Modi, 2018).

Studying financial scams like the PNB scam involving Nirav Modi is important for several reasons, each of which contributes to a broader understanding of financial markets, regulatory frameworks and the risks associated with financial institutions. Studying financial scams like the PNB scam involving Nirav Modi serves as a cautionary tale and provides insights that can be used to strengthen the financial system, protect investors and prevent future fraudulent activities. It underscores the importance of robust regulation, effective law enforcement and public awareness in maintaining the integrity of financial markets. The case highlights the significance of the financial scam in terms of its impact on public trust in the banking system, making it relevant and engaging. The case outlines the primary objectives of the case study, which include uncovering weaknesses in internal processes, investigating employee involvement and exploring regulatory and auditor oversights. The case raises thought-provoking questions about the role of technology in upgrading internal bank processes and the balance between profit maximisation and social obligations for financial institutions.

Subject Area

The case study covers the subject areas of corporate governance, fraud and investigations. This study is also relevant for the students to understand teaching aspects of business ethics.

Student Level/Applicability

This case study is designed exclusively for the purpose of education and does not aim to portray the effectiveness of managerial decision-making. It serves as a comprehensive exploration of special investigation techniques and methodologies while highlighting weaknesses in governance and internal controls.

Literature Review

The research insights drawn from these diverse studies shed light on crucial aspects of the financial and banking sectors. Pradhan and Kumar (2022) findings underscore a persistent link between stock market development and bank-centred financial progress, emphasising the positive influence of banks, savings and per capita real GDP on stock market growth over both short and long horizons. Petkovski and Kjosevski's (2014) empirical investigation reveals the nuanced relationship between banking sector development and economic growth, with credit to the private sector and interest rates displaying negative correlations, while a higher ratio of quasi-money contributes to stronger economic growth. Chilumuri's (2013) study highlights the structured approach and transparency in governance at the State Bank of India, emphasising the importance of regular board meetings and transparent documentation in enhancing operational efficiency. Finally, Zaman et al. (2014) research underscores the policy imperative of reducing information asymmetry and enhancing corporate governance in Pakistan's banking sector, with the potential to improve overall financial performance. These insights collectively emphasise the multifaceted nature of financial and banking sector dynamics and the critical role of effective governance, transparency and strategic policies in driving economic growth and performance.

A study by Menaga et al. (2023) is to conduct a comprehensive analysis of corporate governance practices within family-owned firms through a review of academic literature. It employs bibliometric analysis and visualisation tools to identify key trends and contributors in the field, highlighting a focus on the USA and the impact of family ownership on firm performance. The study also underscores areas that have received less attention in research, such as corporate strategy and governance in family businesses, providing valuable insights for future research. Another study by Duhoon and Singh (2023) is to investigate the relationship between consumers' perceptions of corporate social responsibility (CSR) initiatives and brand loyalty. It combines theories from Carroll's CSR pyramid and Ovidiu's brand loyalty model. Through a survey of Indian-listed FMCG sectors during the COVID-19 pandemic, the study gathers 450 valid responses and finds that CSR positively influences brand loyalty, particularly in terms of legal and ethical responsibilities. The research suggests that marketing strategies like event marketing and customer loyalty programs can enhance CSR initiatives and lead to increased customer satisfaction and repeat purchases.

Research Methodology

The research methodology employed in the case is premised on specific paradigms of unobtrusive research techniques, including conceptual and document analysis. Unobtrusive research refers to methods of collecting data/information which do not interfere with the subjects under study (because these methods are not obtrusive). In the context of this case, unobtrusive research was necessary to collect data without interacting with the subjects. Data analysis is explored through an in-depth analysis of the case that demonstrates the extent of fraud and corruption and the lack of ethical conduct in a renowned public sector bank in India.

Banking Industry in India: Unforeseen Bumps on the Road to Growth

Following a prolonged period of economic slowdown, global economic growth experienced an acceleration to 3.1% in 2017 (Global Economic Prospects, June 2018: The Turning of the Tide). Emerging economies like India displayed improved performance, largely due to structural changes implemented in recent years. Indian banks have been at the forefront of redefining their business operations by enhancing corporate governance standards, ensuring both compliance and implementing very strict risk and credit processes. These kinds of initiatives are important for the overall growth and development in the Indian banking sector. However, the banking sector of India facing significant challenges in these years, particularly concerning the mounting stressed assets. This issue has been especially prominent among public sector banks. Additionally, the banking sector has been marred by a series of scandals involving collusion among employees, which has adversely affected the credibility of these financial institutions. These incidents have cast a shadow on the overall trust and reliability associated with the banking industry in India.

Panjab National Bank: Genesis

PNB, an offshoot of the Swadeshi Movement was founded in 1894 by the leaders of the Swadeshi Movement in India with the great persuasion that if India had to grow and flourish after independence, it should have its financial establishment where people can bank upon. So, the bank started its operations on 12 April 1895 in Lahore, which is a part of Pakistan today. The first board of seven directors from different communities of India. The board consists of great patriots like Lala Lajpat Rai, Lala Harkishan Lal, Mr E C Jessawala, Babu Kali Prasono Roy and Bakshi Jaishi Ram, Sardar Dyal Singh Majithia and Lala Dholan Dass. Thus, an ethnically diversified board with a few Hindus along with a Bengali, a Sikh and a Parsi, joined hands together to start a Swadeshi bank with Rs. 2 lakhs of authorised share capital and only nine members as staff.

The Unfolding of the Scam: The Modus Operandi

Nirav Modi approached PNB seeking funds to facilitate the import of diamonds for his high-end collection. Typically, banks issue a Letter of Undertaking (LOU) to clients, outlining a specified credit limit. This allows the client to obtain short-term loans from foreign branches of other banks to make payments to their overseas suppliers in foreign currency. In the event of the client's failure to repay the amount in the Letter of Undertaking (LOU), it is the responsibility of the issuer bank to fulfil the commitment. However, in this case, an alarming irregularity emerged as the issuance of LOUs was not properly maintained by the core banking system of PNB's. This failure to document the LOUs was a direct violation of the guidelines established by the Reserve Bank of India (RBI). According to RBI regulations, buyer's credit for gem imports should have a maximum duration of 90 days from the date of shipment. However, due to the absence of accurate records, it became apparent that this prescribed time limit had been exceeded, further deepening the complexity of the situation (George, 2018).

The issuance of Letters of Undertaking (LOUs) followed a distinct procedure utilising the mechanism called the Society for Worldwide Interbank Financial Telecommunication (SWIFT). It was conducted as an independent process, separate from the bank's primary technology platform. These LOUs were duly authorised and served as valid instruments. Based on the validity of these LOUs, few Indian and foreign banks abroad extended short-run buyers' credit in foreign currencies to the designated recipients. This credit provided the beneficiaries with the ability to make payments for their imports in foreign currency. By doing so, it effectively reduced the exposure to exchange rate fluctuations, safeguarding against potential risks in this regard (Rao, 2018).

In January 2018, Nirav Modi's partnered firms contacted the Brady House branch of PNB and asked for the credit once again. During the discussions, bank officials insisted on a 100% cash margin for the credit. However, the group argued that they had previously received cash without any margin requirement. As a result, eight Letters of Undertaking (LOUs) were issued, with a total value of ₹2,800 million (S$56 million). These LOUs were set to mature and require payment on 25 January 2018. They were issued against two Indian banks, that is, Allahabad Bank and Axis Bank at their Hong Kong branches. On 14 February 2018, PNB made a public disclosure to the stock exchanges, revealing that the fraudulent amount involved in the case was ₹11,394 crore. The bank also cautioned that this amount had the potential to increase further as investigations progressed, indicating the seriousness and scale of the fraudulent activities (Narayan, 2018).

The Aftermath

PNB filed a complaint with the RBI on 29 January 2018, regarding fraudulent activities involving the Modi group firms and subsequently lodged an FIR (First Investigation Report) with CBI. As a result, RBI issued a lookout notice against Nirav Modi on 4 February 2018. Three days later, PNB filed another complaint with the RBI against Gitanjali Group companies, promoted by Mehul Choksi, for

₹65 crore worth of LOU liabilities. On 9 February 2018, an FIR was filed against these companies with the CBI. On 13 February 2018, PNB registered a fresh FIR with the CBI and filed a complaint with the Enforcement Directorate (ED). The next day, the bank informed the stock exchanges about the scam. Immediately, the ED conducted raids at 17 locations and attached properties worth ₹5,100 crore. The passports of Modi and Choksi were suspended by The Ministry of External Affairs while the CBI sought Interpol's assistance. On 17 February 2018, a former PNB employee, allegedly a key figure in the fraud, was arrested by the CBI. Two other employees were also arrested in connection with the fraud. In response to the incident, on 23 February 2018, the ICAI (Institute of Chartered Accountants of India), functioning under the Ministry of Corporate Affairs, established a committee to investigate the factors leading to the fraud and propose corrective measures. On the money laundering grounds, a red corner notice had been issued by Interpol against Nirav Modi, on 2 June 2018. Twenty-three days later, the ED was seeking Nirav Modi's extradition from a special court in Mumbai. On 3 August 2018, UK authorities are requested by the Indian government for the custody of Nirav Modi. After a wait of five months, on 27 December 2018, UK officials confirmed that Nirav Modi was residing in their country (Chronology of Nirav Modi's Case, 2019).

On 14 August 2018, the government dismissed Usha Ananthasubramanian from her position as Allahabad Bank MD and CEO. Ananthasubramanian had previously served as the of PNB's MD and CEO was named in the CBI charge sheet for her alleged involvement in the Rs. 140-billion fraud through fake Letters of Undertaking (LoUs) in collaboration with certain PNB employees. She was accused of failing to exercise proper control over PNB's operations during her tenure as managing director, which allowed the fraud to take place through the misuse of the international payment gateway SWIFT at the Brady House branch of PNB. Ananthasubramanian had held leadership positions in PNB during two separate periods. Having held the position of bank head between August 2015 and May 2017, later she transferred to Allahabad Bank. Prior to that, she worked as an executive director at PNB between July 2011 and November 2013 (Gakaar, 2017). On 1 October 2018, the ED acted by attaching assets worth Rs. 637 crores belonging to Nirav Modi and his family. These assets were in India as well as four other countries (Garg, 2018). Additionally, on 6 March 2019, the RBI fined at least 19 lenders, including prominent banks like ICICI Bank and SBI, for failing to comply with its guidelines on the use of the global payment network SWIFT, which had been misused by the perpetrators of the fraud. Senior officials of Allahabad Bank, Axis Bank and Bank of India were interrogated by CBI as part of its investigation into the scam. Arundhati Bhattacharya, the former chairman of SBI and the current chairman of SWIFT India, emphasised in an interview that maintaining vigilance and suspicion is crucial for preventing fraud, as it is when trust levels are high that people become vulnerable. She highlighted the need for bankers to remain focused and attentive to prevent such incidents. Nirav Modi was taken into custody on 19 March 2019 and held at Wandsworth prison in southwest London in response to a request by the ED for his extradition to India.

Market Reactions

In June 2017, a few months before the fraud was detected, the bank launched 'Mission Parivartan' as a transformational exercise, highlighting the 10 most important areas to enhance profitability productivity and efficiency in the making of 'Future Ready Bank'. As of 31 March 2018, the bank had over 80 million customers, 6,938 branches, with 9,668 ATMs as declared in its annual report 2017–2018 and claimed that it reached the milestones of Rs. 10 trillion from domestic business operations. For the financial year, the operating profit was Rs. 10,294 crores. During the last quarter of FY 2018, the bank clocked a profit of Rs. 343.40 crore. Its CASA (current account and savings account) deposits have increased to Rs. 263,247 crores. Operating profit for FY18 stood at rupees 10,294 crores. The cost of funds has been reduced from 4.60% in FY 2017 to 4.31% in FY 2018. The Bank's gross Non-Performing Asset (NPA) has increased to Rs. 86,620 crores as compared to the previous financial year' figure of Rs. 55,370 crores as of 31 March 2017. In the financial year 2018, the bank recorded a significant net loss of Rs. 12,283 crores. This loss was primarily attributed to several factors, including the need to create higher provisions for NPAs, mark-to-market losses in the treasury portfolio, and provisions related to the fraud that took place. These combined elements placed a substantial burden on the bank's financial performance during that period. The creation of provisions for NPAs, losses in the treasury portfolio due to market fluctuations, and the need for provisions to address the impact of the fraud were the primary contributors to the reported net loss (for more details see the PNB Annual Report, 2017–2018 available at https://www.pnbindia.in/document/annual-report/PNB%20Annual%20Report%202017-18%20(Full%20Version).pdf). The profit and loss account of the company is self-explanatory in exhibiting the effect of scam (see Annexure 1).

From the MD and CEO's Desk that is part of the annual report, 2017–2018 of the banks, the incumbent managing director and CEO, Mr Sunil Mehta wrote a message while addressing the shareholders that,

> The occurrence at the Mumbai branch of Brady House was an unfortunate incident that occurred due to the actions of a small number of employees in that specific branch. Once the incident was brought to attention, the Bank promptly responded by notifying regulatory authorities and law enforcement agencies. Additionally, they informed their fellow bankers about the situation and to initiate suitable internal measures to avoid similar kind of frauds in the future.

The last three consecutive quarters after the Rs. 14,000 crore one-off was tumultuous for the PNB. During the fiscal year 2018–2019, PNB encountered challenging financial results. The PNB recorded a net loss of Rs. 940 crores in the first quarter and a net loss of Rs. 4,532 crores in the second quarter. However, there was a significant improvement in the third quarter, as PNB posted a net profit of Rs. 247 crores for the period ending on 31 December 2018.

The bank's positive performance in the third quarter was attributed to aggressive recoveries and a substantial reduction in NPA slippages. The bank's efforts in recovering bad loans and the effective management of NPAs contributed to the

improved financial outcome. These results indicate that PNB made progress in mitigating losses and stabilising its financial position, showcasing the bank's commitment to recovering and managing its loan portfolio. (Business Line, Page1, Volume 26, Number 31 dated 6 February 2019). Sunil Mehta, Managing Director and CEO, PNB quoted in his interview to Business Line that,

> After facing a significant setback, we have successfully recovered and regained our strength. The isolated incident involving a substantial amount (Rs. 14,000 crore) was undoubtedly the most challenging phase in the bank's history. However, we have now fully accounted for and addressed the impact of this incident. We have made provisions covering the entire amount, ensuring that the financial repercussions have been appropriately absorbed.

PNB lost 9.8% soon after the fraudulent transactions were reported by the bank. The Nifty PSU Bank index lost 4.8%, and the Nifty Bank index declined 1.4%. Amid heavy sell-off by the Investors and negative sentiment further damaged to the PNB counter. The movement in the share prices of the bank from the month of February 2018 to the month of April 2019 is exhibited in Annexure 2.

> PNB is expected to face ongoing challenges with its capital position, which may result in limited loan growth. Additionally, other operational metrics are likely to exhibit weakness. However, it is worth noting that PNB demonstrated notable recovery and upgrades in FY19, which are crucial for improving asset quality ratios and enhancing earnings in FY20. These efforts are vital for the bank's overall performance and financial well-being.

Prabhudas Lilladher, a brokerage firm, said in a report published in Economic Times on 26 June 2019.

The Red Flags: Governance Issues at The Bank

The PNB episode, which has unfolded over several years, has exposed various vulnerabilities within the bank. In an interview with CNBC-TV18, the PNB fraud was commented by Raghuram Rajan, former RBI governor, stating that any policy implementation has both positive and negative consequences. He emphasised the need to thoroughly investigate how the PNB scam occurred and identify the lapses that allowed it to take place. Rajan also raised questions about the appointment of board members at PNB and the role they played in enabling the scam. He highlighted the importance of serious consideration for governance initiatives for public sector banks. Rajan further stated that if the RBI had been aware of the fraudulent activities at the time, it would have taken decisive action to prevent them. He described the PNB scam as something that occurred outside the usual reporting and oversight mechanisms. Since February 2018, Nirav Modi and the other individuals implicated in the scam have been wanted by both the Interpol and the judicial authorities of India. They are facing a range of charges, like corruption, criminal conspiracy, cheating, criminal breach of trust and dishonesty

along with money laundering. These serious allegations highlight the gravity of their alleged involvement in fraudulent activities. The pursuit of justice continues as authorities work to apprehend and bring these individuals to face the legal consequences of their actions.

Whistleblowing played a critical role in shedding light on the PNB scam involving Nirav Modi. In this high-profile case, whistleblowing was notably absent, which contributed to the prolonged duration of the fraud and its massive financial impact. Whistleblowers are individuals who report illegal or unethical activities within an organisation, and they can play a crucial role in uncovering fraud, corruption, and misconduct (Mehrotra et al. 2019). Had there been a whistleblower within PNB or one of the other organisations involved, they could have potentially alerted authorities or internal investigators to the irregularities much earlier. This could have led to a quicker response and prevented the scam from escalating to the extent that it did. Whistleblowers often provide vital information that can trigger investigations, internal audits, or regulatory actions. In the context of the PNB scam, a whistleblower could have exposed the issuance of fraudulent letters of undertaking (LoUs) and other irregularities in the banking system, prompting immediate corrective action. Additionally, the threat of whistleblowers can serve as a deterrent to potential wrongdoers within an organisation, promoting a culture of transparency and ethical behaviour.

This scam raises questions on the effectiveness of the system and puts the various parties accountable for such fraud under the scanner. It reflects a weak institutionalisation of the whistleblowing mechanism as this scam was under the earth for more than seven years and surprisingly, only after exposed by a whistle-blower.

The failure of regulators and auditors to detect irregularities in the PNB scandal involving Nirav Modi can be attributed to a range of factors. First, the complex financial transactions orchestrated by Nirav Modi, including fraudulent letters of undertaking (LoUs) and intricate banking channels across multiple countries, created a web of confusion that made it challenging for oversight bodies to uncover the irregularities. Additionally, collusion and insider involvement within PNB played a significant role, as some employees were complicit in issuing fraudulent LoUs. This insider collusion further complicated detection efforts. Lack of transparency in Modi's financial reporting, manipulation of records, and the presentation of fake documents to auditors added to the challenge. Weak internal controls within PNB, coupled with the cross-border nature of the scam, contributed to the failure. Regulatory oversight limitations, innovative fraud techniques, and the absence of whistleblower reports all played a role, highlighting the need for stronger regulatory measures, improved internal controls and better international cooperation to prevent such incidents in the future.

It is imperative to investigate the specific procedures that were compromised and identify how a small number of employees, in collaboration with clients, were able to manipulate such substantial sums of money without triggering any suspicion or detection measures. This investigation should focus on identifying the loopholes or weaknesses in the existing internal controls and oversight mechanisms that allowed this illicit activity to persist undetected for an extended

period. It should also examine any potential collusion, negligence or lack of monitoring that may have enabled the employees and clients to maintain control over the funds without raising any red flags. By thoroughly examining these aspects, the investigation can provide insights into the shortcomings in the bank's systems and protocols, allowing for necessary improvements and implementation of stricter measures to prevent similar incidents from occurring in the future. Does this scam expose the vulnerability of the Indian Banking system? Was such a scam even possible without the connivance of a large group of people? How did PNB fraud remain undetected?

Suggestions and Implications

The PNB scandal involving Nirav Modi offered several vital lessons for the financial sector and regulatory authorities. First, it emphasised the critical need for robust internal controls within financial institutions to detect and prevent fraud. PNB's failure to uncover the fraudulent transactions for an extended period revealed weaknesses in its internal auditing and oversight mechanisms. Second, effective risk management and due diligence are essential in averting such scams. Financial institutions must continuously assess and manage operational, credit and compliance risks, especially with significant customers. Third, transparent, and timely reporting of irregularities is crucial to maintaining investor and depositor confidence. The delay in PNB's disclosure eroded trust and highlighted the importance of adhering to reporting guidelines. Fourth, regulatory authorities must maintain vigilance and rigorous oversight to prevent fraud and enforce compliance. Collaboration between banks and law enforcement agencies, protection for whistleblowers, international cooperation, public awareness and prioritising ethical banking practices round out the key lessons from this scandal, serving as a cautionary tale for the financial industry's integrity and stability.

Balancing profit maximisation with social responsibilities poses a nuanced challenge for financial institutions. These organisations are inherently profit-driven, striving to generate returns for shareholders and ensure their financial stability. However, they also bear a substantial ethical and social responsibility, given their pivotal role in shaping economic and societal dynamics. Profitability is essential for attracting investors, maintaining competitiveness and facilitating economic growth through financial services provision. Nonetheless, financial institutions must acknowledge the profound social implications of their actions, including wealth inequality and environmental impact. To navigate this complex terrain, they can adopt strategies such as ethical investments, financial inclusion initiatives, transparent reporting, regulatory compliance, community engagement, long-term perspective and stakeholder engagement. Striking the right balance not only safeguards their reputation but also contributes positively to the well-being of the communities they serve, aligning profit motives with social responsibility for sustained success.

Conclusion

The present study on corporate governance failures like the PNB scandal has provided several important conclusions and insights as follows. This study emphasises the significance of robust internal controls within financial institutions and calls for more stringent mechanisms to detect and prevent fraudulent activities. The study underscores the importance of effective regulatory oversight, advocating for stronger regulatory frameworks and more proactive supervision. Additionally, the study has highlighted the role of insider collusion in such failures, necessitating mechanisms to identify and address insider threats and collusion. Cross-border risks in financial irregularities are recognised, emphasising the need for international cooperation in investigations. Encouraging whistleblowing and reporting of suspicious activities is crucial. The study also emphasises the need to foster a culture of transparency and protect whistleblowers. Weaknesses in audit and accounting practices are identified and leading to recommendations for more rigorous standards. Corporate governance reforms, risk assessments and global impact considerations. Lastly, the importance of customer protection and restitution in cases of financial fraud is underlined, calling for improved regulatory and legal frameworks.

Acknowledgement

The authors are grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the article. Usual disclaimers apply.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

This research work is funded by ICSSR. F. No. G-10/2017-18/ICSSR/RP. Dated 23-11-2018.

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Article

Factor Identification for the Procurement of Raw Material in Food Processing Industry

IMIB Journal of Innovation and Management
2(2) 286–298, 2024

DOI: 10.1177/ijim.241234969
jim.imibh.edu.in

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Abstract

Procuring raw materials (RM) is essential in the supply chain (SC), particularly in the current business landscape where organisations actively seek innovative ideas to cut costs and maintain competitiveness. The procurement operation enables these organisations to navigate through increasing cost pressures. Within SC logistics, the procurement of RM faces numerous obstacles and complexities. To address these challenges and propose potential solutions, examining the specific issues that impact the procurement of RM in the Food Processing Industry (FPI) is necessary. Therefore, this article explores the challenges affecting the procurement process. The authors also provided recommendations for mitigating the identified challenges. This study utilises interpretive structural model methodology, a qualitative and interpretive approach that produces solutions for complicated issues through discussions based on the structural mapping of intricate relationships between elements to look at and analyse the challenges that affect the procurement process. A systematic review of the existing literature provides a comprehensive understanding of these challenges. The study found that challenges in contract and procurement, infrastructure and transportation, technology, govt regulations, quality and safety standards, etc., are the factors that constitute severe challenges and affect the growth of FPI. Data were collected from only those working in Indian companies or multinational companies operating in India. Every step of the process, starting

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from the development of the questionnaire to the data collection itself, is carried out with a focus on the Indian perspective. Addressing these problems and obstacles will yield advantages for decision-makers and stakeholders, including farmers, manufacturers, customers and consumer Food Business Organisations. It will enhance their comprehension of the current situation, identify issues and confront challenges, thereby facilitating improved planning and management strategies.

Keywords

Inbound logistics, Food Processing Industry, raw material, supply chain management, challenges, ISM

Introduction

With the rise of worldwide patterns and a fiercely competitive market, collaboration within supply chain (SC) has become essential for achieving successful procurement and efficient operational practices, mainly when dealing with perishable goods. Effective SC planning is of utmost importance within the agricultural and food industry as it facilitates the integration of intricate networks consisting of farmers, suppliers, demand and supply. This integration aims to connect with end consumers efficiently and improve overall operational efficiency (Agarwal, 2017). India's Food Processing Industry (FPI) is a crucial link between its industry and agriculture, generating valuable linkages and synergies (Prakash, 2018).

India is the largest producer of vegetables like okra and ginger and fruits like bananas and mangoes and the second largest producer of vegetables such as onion, potato, cauliflower and cabbage. According to Raut et al. (2019), India ranks second in fruit and vegetables cultivation. However, despite impressive production, India's significant challenge is the substantial loss and damage of food products, estimated to be around 25%–30%. These losses primarily occur due to a lack of transportation and distribution facilities, cold storage facilities, temperature-controlled trucks, lack of technology and regulations related to quality and other practices. In 2015, the annual value of losses of primary agricultural produce at the national level was ₹ 92,651 crores (Verma 2022).

Literature Review

Procurement plays a crucial role in inbound logistics, impacting the entire SC. It represents a significant opportunity for cost reduction by addressing productivity factors and streamlining the procurement process. The knowledge about the structure of reasons is necessary for long-term solutions (Faix, 2022). Resolving challenges within the procurement process contributes to smoother operations. This helps reduce costs and contributes to maintaining and enhancing the quality of perishable products. Due to perishability and less shelf life, these products require appropriate transportation, handling and storage infrastructure. The SC

Table 1. Twelve Critical Factors Under the Four Categories.

Category	Factors	Challenges
Contract and procurement	F1	Multiple suppliers and intermediaries
	F2	Contract management
	F3	Pressure due to environmental regulations
Infrastructure and transportation	F4	Asset management
	F5	Location of supplier
	F6	Preference in location
Technology	F7	Assimilation of technology among vendors
	F8	Integration of vendors with information system
	F9	Uniform level of commitment with supplier to sustainability
Quality and govt regulation	F10	Regulatory compliance
	F11	Regulation about protection of produces/farmer
	F12	Regulation for sustainability

suffers from considerable inefficiency and faces numerous issues, prompting the authors to identify the challenges that affect the procurement of raw material (RM) for the FPI. However, the procurement process is filled with various challenges, and addressing these challenges is crucial for smooth and efficient procurement and related operations in FPI. After a literature review and discussions with industry professionals, several significant challenges have been identified that substantially impact the procurement process and the overall industry growth. Twelve critical factors under the four categories that affect RM procurement in FPI were identified and listed in Table 1.

Multiple Suppliers and Intermediaries

Using many suppliers and intermediaries in the SC has several difficulties and complications for organisations. It might take a lot of time and resources to monitor the performance of numerous suppliers, ensure that quality and delivery requirements are met and negotiate contracts with each of them. Different suppliers' RMs of varying quality can impair overall product uniformity and result in lower-quality products. Furthermore, relying on several suppliers can raise procurement prices, reduce the buyer's bargaining power and increase SC risk. Coordination and communication with numerous providers can make finding quick and practical solutions to problems more difficult (Amorim et al., 2016; Bourquard et al., 2022; Kamble & Raut, 2019; Kanani, 2019; Singh & Akoijam, 2020).

Using intermediaries in the FPI's RM procurement process has several downsides and difficulties. First, intermediaries incur additional expenses, which raises the cost of RM for food producers and drives up consumer prices. Second,

there may be concerns with quality control because intermediaries might uphold different standards than the original suppliers, which could affect the general quality of the product. The employment of intermediaries can also lead to uneven supply and delayed deliveries, slowing manufacturing and creating inefficiencies. Additionally, food processors might have fewer customisation possibilities and less control over the purchasing procedure. A lack of openness in the handling and procuring of RM might harm the reputation of the finished foods (Agarwal, 2017; Kamble & Raut, 2019; Negi & Anand, 2015). Finally, because they rely on intermediaries, food processors are vulnerable to changes in the market and SC disruptions.

Contract Management

Effective contract management is essential for efficient operations and financial success in the FPI. However, several difficulties make the process difficult. Lack of clarity in contract conditions, which causes disagreements and delays, is one of the main problems. Furthermore, rigid contracts make it difficult for food processors to adjust to market shifts, which results in RM shortages or surpluses. Misunderstandings and quality issues might be further exacerbated by poor communication with suppliers. Furthermore, exploring new sourcing opportunities and suppliers is difficult due to constrained supplier pools and rigorous contract requirements, which could result in increased costs or inputs of worse quality. Additionally, the industry's ongoing growth needs flexibility for innovation (Abebe et al., 2013; Agarwal, 2017; Bahinipati, 2014; Kamble & Raut, 2019; Kanani & Buvik, 2018; Reiner et al., 2014). However, agreements that limit the adoption of new RM or sourcing techniques can make it challenging to keep up with consumer trends and miss chances for product innovation.

Pressure Due to Environmental Regulations

Environmental rules have a variety of effects on RM procurement for food processors. They result in higher costs since new technology and sustainable practices are required, and they also make some resources less accessible in designated environmental zones. The complicated regulatory environment presents compliance problems requiring significant paperwork and auditing, which can lead to delays and inefficiencies. Penalties and legal proceedings are potential consequences of non-compliance. Thus, procurement strategies should be cautious. Additionally, the stringent restrictions may put businesses that cannot achieve sustainability standards at a competitive disadvantage, reducing their market share (Prakash, 2018).

Asset Management

Managing RM and inventory might present several difficulties. Production delays or shortages may result from the lack of visibility into inventory levels. A lack of

stock or too much inventory due to inaccurate forecasting can tie up capital. Bad supplier relationships might bring on delays in receiving critical materials. Production delays are another effect of ineffective procurement procedures. Production plans can be disrupted, and shortages might result from inadequate inventory and faulty demand projections. Partnerships are strained by poor supplier connections, which makes it harder to get vital RM. Inadequate asset management may lead to quality control issues, endangering the safety of the final product. Ineffective inventory management and storage practices may lead to higher costs. Ineffective risk management can expose businesses to financial losses and SC disruptions.

Location of Supplier

The Food Business Organisation (FBO) may face several difficulties while acquiring RM from far-off providers. First, higher transportation costs could result in higher total and product costs. Second, lengthier lead times could throw off production plans and make inventory management more challenging. Perishable commodities are also susceptible to spoiling during protracted transportation, which could result in losses. Misunderstandings and delays in procurement might result from communication problems brought on by language limitations or time zone discrepancies (Amorim et al., 2016; Dhanorkar et al., 2015; Kanani, 2019). Lastly, the industry's operations and dependability may be impacted by the industry's restricted availability and SC weaknesses.

Preference in Location

In the FPI, choosing particular sites can have several effects. The first effect on overall procurement costs is that it can lead to higher shipping costs and longer lead times for sourcing RM. Second, lacking local RM can make obtaining necessary resources challenging, increasing prices or using pricey imported components. Seasonal variations can also interfere with the reliable supply of some RM, which will impact production (Dhanorkar et al., 2015; Kanani, 2019). Customer dissatisfaction may also result from challenges in maintaining the quality and consistency of RM.

Assimilation of Technology Among Vendors

The adoption of new technology by vendors in the FPI has several effects on how RM is purchased. It might result in vendor fusion, giving fewer suppliers more negotiating leverage and raising RM prices. It could be challenging for food processors to locate suppliers who can match their unique requirements due to the standardisation of specifications. The need for traceability is expanding, which makes it challenging to determine where RM comes from. Additionally, the use of new technologies may lead to a rise in the demand for particular RM, a decrease in diversification, dependence on specific suppliers and a decreased ability of the

procurement process to adjust to market changes. These elements could affect the effectiveness and consistency of RM sourcing for food processors (Bahinipati, 2014; Makweba Ruteri & Xu, 2009; Raut et al., 2019; Simayan Pati, 2011; Singh et al., 2022; Singh & Akoijam, 2020).

Integration of Vendors with Information System

There are several issues and factors to consider when integrating vendors into the information system of an FBO. First, there could be problems with data compatibility, which would delay getting RM and mess up production timelines. System security flaws may reveal confidential information, providing rivals an advantage or resulting in product recalls. Vendor lock-in could happen, making switching suppliers difficult and impacting the supply of RM. Successfully managing orders and tracking shipments may be challenging due to the process's complexity. Integration might also reduce the range of available suppliers and foster reliance on technology, which could disrupt the procurement process. The standardised system may be inefficient when dealing with particular supplier requirements due to a lack of flexibility and modification. Reduced direct communication with suppliers can make it more challenging to work together and solve problems, impacting quality control and price discussions (Negi & Anand, 2015; Prajogo & Olhager, 2012; Siddh et al., 2015; Simayan Pati, 2011; Singh & Akoijam, 2020). Additionally, integrating vendors might make companies more susceptible to cyberattacks, compromising supplier and procurement data.

Uniform Level of Commitment with Supplier to Sustainability

Uniform sustainability requirements can have both beneficial and harmful effects on the FBO. While it encourages ethical behaviour, it can also present businesses with restrictions and difficulties. First, requiring suppliers to adhere to strict sustainability criteria may make a smaller pool of suppliers available, making it harder to find specific products and higher prices. Sustainable business practices may also be more expensive, which affects the procurement process. Additionally, if a supplier has problems, the entire SC could be affected, leading to shortages and hurting production (Abebe et al., 2013; Esham & Usami, 2006; Grimm et al., 2014; Negi & Anand, 2015; Singh & Akoijam, 2020; Suryaningrat, 2016). Moreover, a shared commitment to sustainability may result in geographical restrictions, increased prices and innovative restraints.

Regulatory Compliance

Regulations about sustainability and regulatory compliance can significantly impact how food processors purchase their RM. Due to the additional resources needed to achieve requirements, longer procurement lead times and a smaller pool of suppliers, compliance with laws can raise costs. Additionally, firms run a higher liability risk for utilising non-compliant RM, which could result in legal action

and harm to their brand. In extreme circumstances, some companies can decide to avoid a market altogether. On the other hand, sustainability restrictions may restrict the supply of some RM, increasing costs and complicating the SC (Negi & Anand, 2015; Palani & Apdhul, 2016). Geographical limitations and limited supplier possibilities may have an even more significant impact on the purchasing process for food processors.

Regulation About the Protection of Produces/Farmer

Regulations in the FPI can significantly impact the availability and pricing of RM. They might result in more significant agricultural production expenses for farmers, raising the cost of RM and making it harder for food processors to remain profitable. Furthermore, strict regulations may reduce RM availability since some farmers may find it challenging to meet the standards, creating shortages in the market. Interruptions in traditional farming may impact the supply of particular RM practices brought on by legislative changes. At the same time, barriers to the entrance for new producers may further limit the options accessible to food processors. Additionally, adhering to administrative requirements may result in time-consuming procedures for both farms and food processors, reducing the effectiveness of RM sourcing (Negi & Anand, 2015; Palani & Apdhul, 2016; Rais et al., 2013; Simayan Pati, 2011).

Regulation for Sustainability

Regulations about sustainability provide food processors with several difficulties while sourcing raw ingredients. First, compliance might raise expenses because of investments in new technologies or procedures. Second, limiting the use or sourcing to particular areas may decrease the supply of RM and increase costs. These regulations' intricacy increases bureaucracy and paperwork, which makes procurement more challenging and expensive. The regulatory environment continuously changes, which adds to the uncertainty and delays (Bahinipati, 2014; Kanani, 2019; Palani & Apdhul, 2016; Rais et al., 2013). It becomes more costly to meet strict sustainability criteria, which impacts budget-constrained smaller enterprises. Limited supply and probable shortages may occur, which would increase competition and pricing. SC modifications required to shift to sustainable practices result in brief disruptions. Furthermore, navigating worldwide standards and certifications is difficult due to compliance constraints and trade ramifications, which impact purchasing decisions (Prakash, 2018; Siddh et al., 2017).

Objective of Study

Procurement is part of inbound logistics and is laden with significant issues due to various factors. By overcoming these challenges, decision-makers and stakeholders, including farmers, suppliers and FBOs, can optimally plan and manage their operations.

Therefore, the present study has been conducted with the objective of 'Factor identification for the procurement of raw material in the Food Processing Industry'. The knowledge about the structure of reasons is necessary for long-term solutions.

Methodology

An interpretive structural model (ISM) was created to clearly understand the connections between the many challenges in the procurement of RM. ISM is a qualitative and interpretive approach that produces solutions for complicated issues through discussions based on the structural mapping of intricate relationships between elements to look at and analyse the challenges that affect the procurement process. A systematic review of the existing literature provides a comprehensive understanding of these challenges.

Development of Structural Self-interaction Matrix (SSIM)

Based on the literature review, 12 critical factors under the four categories that affect the RM procurement in FPI were identified as the first step of ISM. With the help of expert opinions, SSIM was developed. The group of seven people with an average experience was involved in brainstorming sessions. To develop this SSIM, the four symbols V, A, X and O were used, and SSIM was formed between the 12 factors. As indicated in Table 2, these factors were labelled F1–F12 in order. The SSIM matrix is available in Table 3. The conventional meaning of V, A, X and O is mentioned in Table 4 by taking i and j as two factors.

An **ISM** builds a conceptual framework. A framework is a structure between the variables. Two types of frameworks are created: (a) Theoretical—Relation between the variables is envisaged from theory; it may include one or more theories. (b) Conceptual—Conceptual framework is the proposed relationship between the variables.

ISM for Challenges in RM Procurement

ISM is an approach applied in this study to categorise the difficulties based on their driving and dependent power and to find inter-relationships among the RM procurement challenges for the FPI. ISM is a practical methodology for structuring complex problems with the movement of RM procurement. In other words, the better the input to ISM is prepared, the better the result and representation. The input to the algorithm needs to be well-defined to provide the user with a clear grasp of all challenges that need to be assessed. In conclusion, when using the procedure, a moderated process is more accurate than an evaluation based solely on paper surveys.

ISM is a qualitative and interpretive methodology that develops answers to complicated issues through discussions based on the structural mapping of complex interactions between elements (Malone, 1975; Sage, 1977; Watson,

Table 2. Literature Review.

Category	Factors	Challenges	References
Contract and procurement	F1	Multiple suppliers and intermediaries	Amorim et al. (2016), Bourquard et al. (2022), Kamble and Raut (2019), Kanani (2019), Singh and Akoijam (2020) Agarwal (2017), Kamble and Raut (2019), Negi and Anand (2015)
	F2	Contract management	Abebe et al. (2013), Agarwal (2017), Bahinipati (2014), Kamble and Raut (2019), Kanani and Buvik (2018), Reiner et al. (2014)
	F3	Pressure due to environmental regulations	Prakash (2018)
Infrastructure and transportation	F4	Asset management	
	F5	Location of vendors	Amorim et al. (2016), Dhanorkar et al. (2015), Kanani (2019)
	F6	Preference in location	Dhanorkar et al. (2015), Kanani (2019)
Technology	F7	Assimilation of technology among vendors	Bahinipati (2014), Makweba Ruteri and Xu (2009), Raut et al. (2019), Simayan Pati (2011), Singh et al. (2022), Singh and Akoijam (2020)
	F8	Integration of vendors with information system	Agarwal (2017), Bahinipati (2014), Kamble and Raut (2019), Negi and Anand (2015), Prajogo and Olhager (2012), Siddh et al. (2015), Simayan Pati (2011), Singh and Akoijam (2020)
	F9	Uniform level of commitment with supplier to sustainability	Abebe et al. (2013), Esham and Usami (2006), Grimm et al. (2014), Negi and Anand (2015), Singh and Akoijam (2020), Suryaningrat (2016)
Quality and govt regulation	F10	Regulatory compliance	Negi and Anand (2015), Palani and Apdhul (2016), Rais et al. (2013), Simayan Pati (2011)
	F11	Regulation about protection of produces/ farmer	Bahinipati (2014), Kanani (2019), Palani and Apdhul (2016), Rais et al. (2013)
	F12	Regulation for sustainability	Prakash (2018), Siddh et al. (2017), Mishra (2022)

Table 3. SSIM for Factors that Create Challenges in RM Procurement.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
F1	–	X	A	X	X	X	A	A	X	A	A	A
F2		–	O	X	X	A	V	A	V	A	V	V
F3			–	O	O	V	V	V	V	O	A	X
F4				–	O	O	A	O	O	A	O	O
F5					–	X	X	O	X	X	A	A
F6						–	X	X	X	X	O	X
F7							–	X	X	A	O	A
F8								–	X	A	A	X
F9									–	X	X	X
F10										–	X	X
F11											–	X
F12												

Table 4. Meaning of Symbols Used in SSIM.

Symbol	Meaning
V	'i' affects 'j', but 'j' does not effects 'i'
A	'i' does not affect 'j', but 'j' affects 'i'
X	'i' and 'j' both affect each other
O	neither 'i' effect 'j' nor 'j' effects 'i'

1978). An element structure emerges inside the ISM environment depending on the relation that explains how the elements are connected . The method helps discover and arrange the intricate connections among system parts so that the effects on the components may be examined. Using directed graphs (digraph), modelling transforms the object system into a clear and representative system. In addition to the structural interpretation, the object system is also interpreted in terms of its content, which involves adding context (information) to the digraphs. The 'fundamental structural model' is the object system mapped as digraphs. The final result of the content expansion is an 'interpretive structural model'.

We have used the ISM approach to problems in RM procurement based on the nomenclature described in the preceding subsections, prior research and chosen theories.

Steps involved in ISM methodology

The following are the different ISM method steps:

Selection of Elements Relevant to the Problem.

Identifying components relevant to the issue is an excellent place to start. Primary research (survey, group problem solving) or secondary research methods can accomplish this.

Establishing Contextual Relation Type.

The contextual relation must be clearly expressed as a potential expression of the relationship among the elements. Many relationships exist, including comparative, influence, neutral and temporal (Warfield, 1978).

Construction of SSIM by Pairwise Comparison.

The most challenging and complex phase of construction of ISM. The participants in this step must choose the pairwise relationship between the components. While considering the contextual relationship for each element, whether there is a relationship between any two sub-elements (i and j) and the direction in which the relationship runs is questioned. One of four symbols indicates how the components i and j relate to one another.

Future Course of Research and Conclusion

This research can be used for imperial testing about challenges in procurement for FPI. Another extension of the research can be the development of interrelationships among different challenges of procurement for FPI. This research can also be utilised for policy development of food processing reforms at the managerial theatre. This research is helpful by providing the challenges impacting the inbound SC of the FPI. Decision makers for Food SC and FPI can use this work to smooth the process. This research can also be utilised for simulations as input of Food SC.

This research listed the challenges for the food procurement industry and summarised them in the context of research works citing them.

Acknowledgement

The authors are grateful to editor/s and the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the article. Usual disclaimers apply.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Commentary

All India Institute of Medical Sciences (AIIMS), Delhi: Cyberattack Puts Digitalisation Under Scanner

IMIB Journal of Innovation and Management
2(2) 299–306, 2024

DOI: 10.1177/ijim.24124091 1
jim.imibh.edu.in

Priyanka Gandhi[1] and Sonal Pahwa[2]

Abstract

'I Dream of a Digital India where cyber security becomes an integral part of National Security'—Narendra Modi
Fulling this dream one as to realise the fact
'Cyber Security is not easy. But it comes down to three basic principles—PROTECT, DETECT AND RESPOND as early as possible'—Advent from AIIMS Case
The All India Institute of Medical Sciences (AIIMS), a top public medical research facility and hospital with headquarters in New Delhi, India, announced a sophisticated cyber-incident on its servers on 23 November 2022. Several patient care services were rendered unavailable as a result of the incident, including registration, admission, billing and discharge. Several news sources claim that this cyber event, which affected the e-services of the AIIMS (New Delhi) starting at 7:00 a.m. on 23 November 2022, was of the ransomware variety. The testing runs of the e-hospital server were successful, and the majority of the lost data had been recovered during the previous few days, according to AIIMS authorities' confirmation on 6 December 2022. The case provides background on the healthcare industry and a brief analysis of the incident, along with the measures taken to prevent such attacks in the future.

Keywords

Digitalisation, healthcare, AIIMS, cyberattack

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Position in the Course

IT application and security in business, cybersecurity at undergraduate and postgraduate levels.

Teaching Objectives

1. To empathise the learner with the behaviour that must be adopted while using cyber technology.
2. To develop the learner capability to identify, analyse and remediate computer security breaches.
3. To get insight to the contingency plan for protecting the data online.
4. To emphasise the need to enhance the cybersecurity protection measures and the conduct of regular cyber audits.

Introduction

Industry Overview

The healthcare system in India is primarily provided by public-sector and private-sector facilities. The public healthcare system is managed by the government and aims to provide healthcare for all. This includes government-funded large super-specialty and multi-specialty hospitals located in Tier I and Tier II cities with all the medical facilities and infrastructure. In addition to this, district and tehsil-level hospitals provide medical services to the people in towns, and at the village level, primary healthcare centres provide services in remote areas. The private sector provides services on a chargeable basis and caters to the demands of people who either pay themselves or have some health insurance (Klecun, 2016).

According to NITI Aayog (2019), the healthcare industry is an emerging and ever-growing industry. With advancements in technology in the last couple of decades, substantial efforts have been made to support healthcare practices with information and communication technologies. Modern healthcare delivery models incorporate tech-savvy medical infrastructure along with patient-centric services for monitoring and sharing health-related data. For accurate and early diagnosis, there is a requirement to increase health data utilisation by implementing technologies like machine learning, data analytics and artificial intelligence (Gandhi, 2022).

There has been an exponential growth in healthcare infrastructure in the last couple of decades in India. Indian healthcare markets and assets have grown substantially with technological advancements. Revised government policies are boosting many medical institutes, and the government is encouraging medical colleges to be on par with international standards (Saxena et al., 2020, Saxena & Mayank, 2021).

As per industry trends, the entire focus of healthcare delivery is on creating a patient-centric, holistic environment rather than being just disease-centric. The change in approach is because most of the health issues being faced by people today are due to poor lifestyles and eating habits. Science has proven that health disorders are also connected with an individual's behaviour, preferences and topographical location. The health data required for the patient-centric approach is not easily

available. Some critical information can be accessed only by compiling multiple datasets, which are maintained separately by different healthcare providers, and sometimes complete treatment records are missing, resulting in incorrect diagnoses and poor lines of treatment. The quality of such data is questionable for analysis purposes. As a result of modernisation and the use of technology in our daily lives, many lifestyle-related diseases such as diabetes, high blood pressure, cholesterol and liver problems caused by overconsumption of alcohol have replaced communicable diseases. Their management requires customised healthcare and treatment plans with a focus on self-care (Fullman et al., 2018).

According to best practices, health data should be kept confidential to prevent its misuse. Some of the popular techniques to ensure privacy are generalisation, anonymisation, role-based access control, perturbation and encryption.

Background of Organisation

AIIMS was established as an outcome of the health survey and development committee, chaired by Sir Joseph Bhore. In 1946, for India's development, Sir Bhore had already endorsed that a national-level medical centre should be established with the aim of fulfilling the requirement of qualified and competent medical manpower that would serve the nation's growing healthcare demands.

The foundation stone of AIIMS was laid in 1952, as a substantial grant was received under the Colombo Plan from New Zealand. In 1956, AIIMS was established as an autonomous institute via an Act of Parliament with the aim of functioning as the centre of excellence in healthcare delivery and education. It was a huge task to develop clinical and teaching faculties for undergraduate and postgraduate medical education in India and organise and manage the highest order of training facilities in all branches of medicine. As per the Act, AIIMS has comprehensive facilities for patient care, teaching, and research and imparts teaching programmes in medical and paramedical specialties at postgraduate and undergraduate levels (Sharma & Singh, 2018).

Many disadvantaged Indian citizens and people from neighbouring countries benefit from the world-class healthcare services rendered by AIIMS. Its premises are always crowded by patients, the majority of whom cannot afford good-quality treatment anywhere else. The high reputation of AIIMS brings hope to thousands of patients who come here on a daily basis after trying all the possible remedies. Currently, AIIMS is an empire of medical facilities with over 1,500 beds spread across the hospital, including the Cardiothoracic Centre, Dr Rajendra Prasad Centre for Ophthalmic Sciences, Neurosciences Centre, Institute Rotary Centre Hospital and De-addiction Centre. This entire set of facilities serves about 1.5 million OPD and 80,000 IPD patients per year. The number of surgeries performed at AIIMS is over 100,000 every year.

In today's technology-driven environment, data privacy and security are of paramount importance. With a significant amount of healthcare data available for analysis and prediction, maintaining the privacy of individual patients' health data requires lots of effort. At AIIMS, healthcare data security is a big challenge because of the huge numbers of outpatients and inpatients.

Cyber Threat Around the World

As per the combination of data from three major cybersecurity authorities, namely the National Cyber Security Index (NCSI), which is updated on a live basis, the Global Cybersecurity Index (GCI) and the Cybersecurity Exposure Index (CEI), the mean average of the NCSI, GCI and CEI's total scores is used to compute the cyber safety score.

From Table 1, the list of top 10 lowest risk countries for cyber threats is generated based on cyber threat criteria.

Table 1. Top 10 Lowest Risk Countries for Cyber Threats.

Country	National Cyber Security Index (NCSI)	Global Cybersecurity Index (GCI) 2020	Cybersecurity Exposure Index (CEI) 2020*	Cyber-Safety Score (Mean Average of NCSI and GCI)
Belgium	94.81	96.25	81.00	90.69
Finland	85.71	95.78	89.00	90.16
Spain	88.31	98.52	79.00	88.61
Denmark	84.42	92.60	88.30	88.44
Germany	90.91	97.41	75.90	88.07
Lithuania	93.51	97.93	70.30	87.25
France	84.42	97.60	77.20	86.41
Sweden	84.42	94.55	79.00	85.99
UK	77.92	99.54	79.30	85.59
Portugal	89.61	97.32	69.70	85.54

Source: https://seon.io/resources/global-cybercrime-report/

Table 2. Top 10 Highest Risk Countries for Cyber Threat.

Country	National Cyber Security Index (NCSI)	Global Cybersecurity Index (GCI) 2020	Cybersecurity Exposure Index (CEI) 2020*	Cyber-Safety Score (Mean Average of NCSI and GCI)
Afghanistan	11.69	5.20	0.00	5.63
Myanmar	10.39	36.41	9.00	18.60
Namibia	15.58	11.47	32.10	19.72
Libya	10.39	28.78	20.70	19.96
Honduras	22.08	2.20	39.70	21.33
Cambodia	15.58	19.12	29.70	21.47
Mongolia	18.18	26.20	26.20	23.53
Ethiopia	32.47	27.74	13.40	24.54
Venezuela	28.57	27.06	19.30	24.98
Nocaragua	29.87	9.00	40.00	26.29

Source: https://seon.io/resources/global-cybercrime-report/

From Table 2, the list of topTop 10 highest risk countries for cyber threat generated based on cyber threat indexes.

Based on the data available, it is very important to analyse and protect the cybersecurity in India

Cyberattack: AIIMS

'I Dream of a Digital India where cyber security becomes an integral part of National Security'—Narendra Modi

Fulling this dream one as to realise the fact

'Cyber Security is not easy. But it comes down to three basic principles – PROTECT, DETECT AND RESPOND as early as possible'—Advent from AIIMS Case.

Digitisation that is 'secure and sustainable' is essential for the Indian economy to take the lead on the world stage. The experience of India with regard to the fundamental changes in governance and socio-economic growth has led to the creation of the digital revolution. Digital India is growing sustainably thanks to the effective use of computing technology, extensive internet access and reliable networking in areas like digital literacy, financial inclusion, rural development and e-governance. However, the use of digital tools in conjunction with sustainable measures has significantly increased the dangers and attacks. The increase in cybercrime in recent years has had a significant impact on the long-term expansion of the digital economy (Gandhi & Tandon, 2019, 2021).

As the incident quoted in the Indian Express Newspaper dated 8 June 2022,

Chinese hackers launched a ransomware attack on the servers of the AIIMS, the premier medical institute in Delhi. The hack against AIIMS, Delhi, occurred on 23 November and the Delhi Police then filed a complaint of extortion and cyber terrorism on 25 November. It further stated that five of the 100 physical servers had been successfully breached by hackers. Hackers were able to breach 5 physical servers from a pool of 100, which included 40 physical and 60 virtual servers. Because of this ransomware attack that occurred last month, the confidential medical information of millions of patients at AIIMS Delhi was in danger. After this event, the case was handled by a special unit of the Delhi Police in December. According to the investigations, two emails' IP addresses that were discovered in the headers of files that the hackers had encrypted were from Hong Kong and the Henan province of China.

> The senders, according to sources, utilised the email service provider ProtonMail. The top cybersecurity organisation in the nation, the Indian Computer Emergency Response Team (CERT-In), discovered that the hackers used two ProtonMail web addresses, 'dog2398' and 'mouse63209'. According to the sources, CERT-In and Interpol were used to send the encoded web files to these two ProtonMail IDs during the investigation. After further analysis, they discovered that 'dog2398' and 'mouse63209' were created in Hong Kong during the initial first week of November. They also discovered that Henan Province in China sent another encrypted file. Additionally, sources claimed that three ransomware infections—Wammacry, Mimikatz and Trojan—had been found on the targeted servers.

CERT-In, Delhi Cybercrime Special Cell, Indian Cybercrime Coordination Centre, Intelligence Bureau, CBI and National Investigation Agency are all looking into the ransomware incident that may have exposed the records of nearly four crore patients (Liu et al., 2021). The event was examined by the CERT. According to an early investigation, servers were penetrated by unknown threat actors in the AIIMS information technology network as a result of faulty network segmentation, which led to operational interruptions owing to the non-functionality of essential applications, the author added. The complete data for online hospital services has been restored on new servers after being recovered from a backup server that was unaffected. After two weeks following the cyberattack, the majority of the capabilities of the online hospital application, including new patient registration, appointments, new admissions, discharge work, etc., have been restored.

Future Outlook

Counter plan: Created by the Computer Emergency Response Team (Rehman et al., 2022; Saini, 2021).

1. To combat cyberattacks and cyberterrorism, CERT-In had developed a Cyber Crisis Management Plan that was to be adopted by all of the ministries and departments of the union and state governments, as well as their organisations and critical sectors.
2. To inform health sector entities about the most recent cybersecurity risks, CERT-In has sent special advice to the Ministry of Health and Family Welfare on security practices to improve the resilience of health sector entities. Cybersecurity incidents must be tracked and monitored by CERT-In.
3. In August 2022, 'India Ransomware Report H1-2022' was released, detailing the most recent ransomware attacker strategies as well as incident response and mitigation techniques.
4. AIIMS, Delhi, took immediate action to improve security, including endpoint hardening, strict firewall policies and network segmentation to secure all of the institute's data.

A committee was formed to propose a data privacy framework to be implemented for the health industry.

- The legislation must be adaptable and take into account newly developed technologies.
- Both public and private sector organisations must abide by the law.
- Any data processing should be accountable to the entities managing the data.
- Data processing and analysis must be kept to a minimum.
- A strong statutory authority should be in charge of enforcing the data protection framework.

More Recommendations

1. It is very essential to do proper identification of attributes affecting cybersecurity in India, and the framework and policy must be in accordance with these attributes.
2. The cybersecurity policy must be adaptive, evolving and tailored to meet new problems and requirements.
3. While adapting and framing any cybersecurity initiative, it is very essential to involve all stakeholders' participation, and the government could be the driving force behind the implementation.
4. An effective study of other nations' cyber protection initiatives can help our country in framing and implementing cyber initiatives in India.
5. Any nation's cyberspace cannot be safeguarded without a complete policy for all aspects of cybersecurity. If all governments agree on fundamental principles and implement a global cybersecurity strategy, cyberspace can become a safer place.
6. Extensive and immediate implementation of blockchain and other technologies has the capability to change the cybersecurity domain (Dua, 2023).

Acknowledgement

The authors are grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the paper. Usual disclaimers apply.

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