

Quantifying e-governance efficacy towards Indian–EU strategic dialogue

Quantifying e-governance

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Vivek Soni

School of International Studies, Jawaharlal Nehru University, New Delhi, India

Rashmi Anand

Department of E-Governance and Information and Communication Technology, Indian Institute of Public Administration, New Delhi, India

Prasanta Kumar Dey

Department of Operations and Information Management, Aston Business School, Aston University, Birmingham, UK

Ambika Prasad Dash

Department of Administration and Management, Noida International University, Noida, India, and

Devinder Kumar Banwet

Department of Management Studies, Indian Institute of Technology, New Delhi, India

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Abstract

Purpose – The purpose of this research paper is to assess efficacy of e-governance implementation, influenced under the Indian-EU (European Union – EU) strategic dialogue. For the same purpose, this study aims to analyse and measure penetration level of information and communication technology (ICT) applications across ten select gross domestic product-dependent sectors (gross domestic product – GDP) in Indian economy.

Design/methodology/approach – Multi-criteria decision-making (MCDM) approach of PROMETHEE, using its partial and complete versions in fuzzy environment, is applied. The approach assesses e-governance efficacy in various sectors, which is chosen based on their contribution to GDP, where criteria values are assigned by expert opinions, feedback is received and lessons are learnt from training and initiatives taken under the Digital India programme launched by the Government of India. These criteria related to IT policy implementation, cyber security breaches, IT infrastructure development initiatives in select sectors are identified. Later, sectors outranking results have been highlighted using both fuzzy set theory along with PROMETHEE (F-PROMETHEE) and its visual application.

The paper inspires from implementation of digital single market strategy of EU to support Indian economy in promoting and creating sustainable architecture of e-governance. The work reported in this research paper, also inspired by flagship programme on Digital India launched by GoI and supported by national administrative society of India where study influenced one of the co-author to carry out the detailed PhD work in the important area of information security, management and e-governance. Authors acknowledge each of the entity and professional engaged in the study. Moreover, the authors would also like to thank anonymous reviewers and EIC of the esteemed TGPPP for their valuable and constructive comments, all of which significantly improved the quality of the paper to the order of the possible publication.



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Findings – On applying F-PROMETHEE, studies found that industrial, railways, health and finance and education sectors outrank in their high merit orders. Contrary, outranking shows that agriculture, defence and aerospace sectors should be more open and accessible to adopt ICT applications in order to promote e-governance processes and their implementation to make e-services available to common citizens. For better interpretation of results, graphical analysis for interactive aid is used to present the analyses.

Research limitations/implications – Research study was found useful in the assessment of ICT penetration level in to support Indo-EU relations, where PROMETHEE method is used to outrank sectors alternatives. Criteria are also weighted using fuzzy scale, and the impact of criteria on all alternatives has also been assessed. MCDM framework addresses that subjectivity lies in sectors to implement ICTs bases services. However, few other MCDM frameworks, methods such as COPRAS, GST, GRA, SAW and SWARA, can be used for the same purpose.

Practical implications – Sectors alternative involve high degree of complexity to adopt ICT applications for smooth e-governance and seek effective decision-making for investment prioritization and future development. This study also aims to address cyber security concerns of policymakers. Outranking methods of F-PROMETHEE are able to address the criteria-to-criteria impact and support decision-making in a more precise way.

Social implications – This study is inspired from the strategic implementation of the framework of the e-Government Action Plan 2016-2020 of the EU. The findings from the paper can provide referential support to the Indian Government and policymakers to support information delivery, implement cyber security policies and various sector developments.

Originality/value – This research study can act as a strong base in the decision-making process in conflicting situations of e-governance in India. This study not only can synergize conflicting ideas of various stakeholders, academicians in the Indian IT-sector but also can act as support to administrators and the policymakers to monitor the status of the India-EU Information Society Dialogue.

Keywords India, Information security, European Union, Fuzzy PROMETHEE, e-governance, ICT applications, Strategic development, IT policy, India and European Union

Paper type Research paper

1. Introduction

After India became independent, *information* has been emerged as one of the elements for strategic development and tool for e-governance. Over the past quarter of the century, the element has driven the government business and made spatial technological advancements in the Indian economy. The development has led to a governance based on the information security where the economy underwent strategic agreements with the world to synergize development including the European Union (EU). Since the adoption of 1993 Declaration, India-EU relations have developed substantially in the past two decades. Over the time, many initiatives evolved in both the nations, which include tremendous focus on sustainable development and progress agenda at *Troika Ministerial* and captured a wide range of issues (European Union, 2006). The joint dialogue has been aiming to pursue a constructive approach not only on conventional aspects of promoting development on trade, investment and economic cooperation but also to foster research, innovation and sustainable approached of Internet based governance. Such approaches have led transformation of e-governance movement in India. As a part of EU strategy India, 13th India-EU Summit held after a gap of four years in Brussels and the Summit aimed to implement e-Government Action Plan 2016-2020. The plan is also now taking concrete actions for the development of Cross-border Digital Public Services. These services are not limited to the transformation of interoperable platforms to implement e-governance. Additionally, in the present context of challenges of implementing information and communication technologies (ICTs), information security practices, awareness and standards are playing big role to administer e-governance growth in the various economy-dependent sectors. Realizing the potential of ICTs application in

sustainable growth of sectors, many efforts have been taken for managing information security, framing comprehensive IT policy and promoting overall governance in the Indian economy. In view of this, practices, standards, guidelines and IT policy are adopted where the practices and standards rated to e-governance projects implementation are limited not only to secure critical information assets of government against loss, theft, etc. but also to ensure data confidentiality, integrity and non-repudiation across the sector. The practice governs availability of infrastructure and continuity of the IT services and ensures IT systems implementations. Many studies supported the adoption of practices, where the governance through ICT applications reported as information delivery and service delivery. These segments of delivery bring the issues of information and systems security such as architecture, standards and technology to the forefront. Therefore, focal point focus is to establish a bridge between information security, policy structure and infrastructure to adopt more and more ICTs applications to ensure ethics in overall governance to make the e-services available to the citizens.

Under the above-mentioned umbrella of the India-EU Information Society Dialogue, and challenges of India to implement ICTs based e-governance, the move supports changing behaviour of need of the economy. The e-governance focuses on delivering internet-based public services more efficiently to people. Accordingly, the country also started the implementation for the same which can enable citizens, enterprises and organizations to carry out their business with government more easily, more quickly and at a lower cost. Focusing on EU's Digital Single Market Strategy, Indian government actions are now aiming towards digital transformation in the society (Government of India [GoI], Digital India, 2015). Country seeks relevant governmental models, on the pattern of EU, where cross-border digital public services allows achieving the digital single market, and ICT systems are now at the heart of Indian agenda of supporting strategy for e-governance implementation. In the past couple of years, the economy targets sustainable development goals (SDGs) where many studies believe that effective electronic service (e-service) delivery can provide a wide variety of solution to complex problems to societal needs. Such ICT-based delivery of services including more efficiency and savings to government and businesses increased transparency and greater participation of citizens in political domain of the life (European Union, 2010). In the nutshell, it is observed that based on advancement and development, ICT influenced all areas of society, business and government. Moreover, both widespread adoption of new ICT services and also the networks recognized by EU as the powerful tools are affecting socio-economic development in India. This widespread in the information security, ICT applications to support e-governance and related matter has opened another era to the Indian administration. Challenges in the presented context require identification of sectors in a priority basis for technology service delivery with the accelerating support of ICT applications to the common citizen (Chen and Gant, 2001).

Nevertheless, due to varying characteristics of sectors and federal nature of the economy, fundamental problematic elements of *information* and *e-governance* remain as challenge to meet the unprecedented gap between the pace of technological change and the inevitable glacial pace of policy and law making. Quantifying sectors priority on the point of view of penetration of ICT application in various sectors can be a good option to deal with flexible solutions to support decision-making. However, due to barriers existing in sectors to adopt ICT and promoting e-governance to the order of sustainable development, more and adequate efforts are still required to implement EU's strategy to ensure they continue to improve the delivery of government services in India.

1.1 Objective and research agenda

As noted in the introduction, the aim is to strengthen the India-EU dialogue and to support the implementation of internet-based services in the economy. Therefore, it becomes more important to study the penetration of ICT applications in various sectors in the Indian economy. Sector development also depends on many criteria related to the ICT-based governance. Therefore, governance in various sectors is affected by effective implementation of ICT applications and their penetration levels. Many studies have been found, and it has been observed that it is very difficult to make trade-off between one side of managing threats, risks and their vulnerabilities present in sector IT-system infrastructure and another side of system utilization for the purpose of service delivery. Contextually, research gaps indentified from the various studies and literature reveals that efficacy of governance is important area to study. The study can support decision-making at an international platform to harmonize the joint dialogue and therefore must needs to be assessed.

Therefore, the scope of this research paper covers the assessment of ICTs' penetration level in various GDP-dependent sectors (gross domestic product – GDP) in the Indian economy. As ICT applications support the e-governance processes through the implementation of mission mode projects (MMPs), the study focuses on the measurement of e-governance efficacy. The research develops on sector-to-sector comparison and seeks decision-making support for effective ICT implementations. Therefore, to meet the objective of the research paper, few sectors were identified based on their GDP contribution to the economy. Those sectors include agriculture (ALS), aerospace (AS), defence (DS), education (ES), finance (FS), environment and climate change (ECCS), health, industrial (IS), international cooperation for sustainable development (it includes trade, tourism and culture and bio-diversity initiatives, awareness and implementation through ICT applications) (ICCS) and railways sector (IS). The performance of ICT applications in these sector alternatives depends on various criteria. Such criteria are selected for ranking sector to sector alternatives which are found related to IT sector development, investment to boost up governmental process, e-services initiatives, IT Policy implementation, focus on cyber threats in the sectors and dependency of e-governance progress of central sector schemes for welfare measure to common citizen and on the socio-economic condition of the sector alternatives. In a way, selected criteria affect the ICTs application and impacts efficacy of the e-governance.

To deal with the subjectivity related to many criteria chosen to support decision-making on ICTs application and to enhance their penetration in various sector, a fuzzy set theory was studied. The theory along with the PROMETHEE methodology (i.e. F-PROMETHEE) was used in this research study. Criteria ranked on fuzzy scale method developed by Chang and the integrated focused methodology is suited best approach to compare the sector alternatives (Chou and Chang, 2008). In addition to F-PROMETHEE, results from the application of the methodology using Visual PROMETHEE software were also presented to demonstrate the ranking of various sector alternatives based on the level of ICTs applications. Later results drawn from the methodology application and their research inferences highlighted using graphical analysis for interactive aid (GAIA) version of PROMETHEE software (De Smet and Guzman, 2004; Brans and Vincke, 1985, 1988).

The organization of the paper is as follows. Section 2 provides the literature review, gaps from the literature, research framework and the methodological design. Section 3 briefly describes an overview of the methodology, i.e. the F-PROMETHEE method. Section 4 highlights the overview of e-governance, basis of criteria and their weighing, sector selection and their prioritization based on the methodological steps, and the section demonstrates an application of PROMETHEE method to measure e-governance efficacy in the Indian context

of research study. Results and discussions are provided in Section 5. In the later part of the study, conclusion, limitations and future scope of work are presented in Section 6 followed by the implication aspects of the research study on theory, management and policy in Section 7.

2. Literature review

This section presents the literature review for the research study. Apart from technical codes, standards, practices and need of management, the paper presents literature studies related to select dimensions e-governance, ICT applications level in Indian sectors. The research presented in the paper seen as backbone to support digital infrastructure, information security and privacy in various sectors. In order to gain better insights into the various issues related to information security, IT policy, e-Governance and administration, literature review have been divided into various parts. The organization of this section is under the following heads. Information security in the context of e-governance:

- Threats in sectors and IT policy in the context of e-governance.
- E-governance, ICT applications and its administrative related issues.
- Review on multi-criteria decision-making (MCDM) framework to assess e-governance, the PROMETHEE and Fuzzy based PROMETHEE methodologies.

The review included in this research paper is the work produced by researchers, scholars, practitioners and systematic literature review approach is considered of presentation of the literature review. The literature review approach identifies and evaluates the existing body of knowledge (Fink, 2005). Many authors have presented a systematic literature review approach in the past and defined it as an explicit and comprehensive method of presenting and laying down the related literature. Under this backdrop of literature review, the section provides a systematic literature review firstly on issues related to information security, threats and IT policy implementation in the context of e-governance and secondly reviews on application of MCDM methods, sustainable e-governance framework to support decision-making. Research papers focused on administrative aspects of implementing e-governance also explored and presented here. Being information is an essential element to the subject of e-governance and public administration for sector development; selected papers on information security threats in various sectors are also explored and presented in the Table I.

In the context of information security, IT policy implementation e-governance, few research studies have been carried out. Those include Grimsley *et al.* (2007), Khoubati and Themistocleous (2007), Axelsson *et al.* (2010), Bertot *et al.* (2012), Hansen and Kræmmergaard (2013), Inkinen (2012), Singh and Karn (2012), Rotchanakitumnuai (2013), Sheffer Corrêa *et al.* (2014), Khan *et al.* (2014), Zahir and Muhammad (2014), Alenezi *et al.* (2015), Aldin Alaa *et al.* (2015), Kalsi and Kiran (2015), Stefanou and Skouras (2015), Dahiya and Mathew (2016) and Gupta and Suri (2017).

Literature also shows that outranking methods can integrate uncertain information using imprecise way of looking at problems (Araz and Ozkarahan, 2007; Haralambopoulos and Polatidis, 2003; Ren *et al.*, 2009). Many other studies have also been found with respect to application of the F-PROMETHEE approach (Chin-Teng, 2012; Tuzkaya, 2009). In addition to these studies, the technique provides the opportunity to select various types of preference functions. The method is unique which gives can provide a realistic definition for the decision criteria (Brans *et al.*, 1986). Therefore, characteristics of PROMETHEE approach have been found relevant to carry out this study to address varying nature of the complexities and ICT penetration level in the sector. Moreover, the method could be an

Table I.
Important papers on
information security
threats, e-
government and
administration

Sr. no.	Papers on information security, ICT applications and e-governance	References
1.	Human factors in information security	Colwill (2009)
2.	Violation of safeguards	Dhillon (2001)
3.	Computer crimes	Dhillon and Moores (2001)
4.	Insider cyber-threats	Hamin (2000)
5.	Trend of the security research	Hong <i>et al.</i> (2010)
6.	Threat prediction tool	Magklaras and Furnell (2012)
7.	Addressing bad actors and their actions	Pfleeger (2010)
8.	Common sense to insider threats	Silowash <i>et al.</i> (2012)
9.	Threat management	Steele and Wargo (2007)
10.	Analysing the past to prepare for the future	Webster and Watson (2002)
11.	An online social network for emergency management	White <i>et al.</i> (2009)
12.	Cyberterrorism	Harries and Yellowlees (2012)
13.	Economics of investment in information security	Gordon and Loeb (2002)
14.	The e-government imperative	Attal (2002)
15.	E-service delivery in public administration	Bekkers and Zouridis (1999)
16.	Public administration and public affairs	Henry (1989)
17.	e-government and e-governance	Marche and McNiven (2003)
18.	Towards an information architecture for public administration	Peristeras and Tarabanis (2000)
19.	e-government in the Asia-Pacific region	Wescott (2001)
20.	Sustainable fishing development strategies	Chiou and Cheng (2005)

efficient and effective methodology used by decision makers on conflicting environment, specifically on the subject matter of quantifying e-governance efficacy. Although it is not very popular in the literature, few studies related to the project management using the hybrid editions of F-PROMETHEE method are considered in the past. Contextually, Cheng also used F-PROMETHEE for outsourcing decisions of information systems (Cheng *et al.*, 2008).

In addition to the above, few other scholars have carried out the studies related to F-PROMETHEE methodology. Chou and Chang (2008), Dagdeviren (2008), Dejan *et al.* (2011), Diakoulaki and Karangelis (2007), Geldermann and Rentz (2001), Geldermann *et al.* (2000), Goumas and Lygerou (2000), Moreira *et al.* (2009), Ozgen *et al.* (2011), Kabir and Ahsan (2011) and Tuzkaya (2009) have also shown the application of F-PROMETHEE in the various sectors. However, Kabir and Sumi (2014), Kaya and Kahraman (2010), Oberschmidt *et al.* (2010), Ribeiro *et al.* (2013), Tavana *et al.* (2013), Vasant *et al.* (2005), Vasant and Bhattacharya (2007) and Wang *et al.* (2009) have used this technique specifically in the context of sustainable planning of various sectors. Table II provides the list of widely listed papers on PROMETHEE in IT policy, e-governance and public administration, in the domain of this paper.

2.1 Research gaps

Based on the systematic literature review, research gaps are identified. Referring to the gaps, and on these lines of administrative reforms ensuring informational delivery, the country went through many amendments and later the GoI launched the Digital India Programme as to support various e-governance initiatives (GoI, Second ARC Report, 2005). Focusing the India-EU dialogue for supporting the e-governance process, GoI has started allocating more budgets to the Digital India Programme for the year 2016-2017 to various department and sectors (As per the Union Budget of India, Estimate by Finance Ministry, Govt. of India). However, due to diversified nature of infrastructure, challenges of rural

Table II.
List of widely listed papers on PROMETHEE in information systems

Sr. no.	Papers on PROMETHEE	References
1.	Selection of hydropower stations	Mladineo <i>et al.</i> (1987)
2.	Evaluation of research projects	Tzeng <i>et al.</i> (1992)
3.	The role of weights in multi criteria decision aid, and the ranking of water projects in Jordan	Al Kloub, <i>et al.</i> (1997)
4.	Analysis of national energy scenarios in Greece	Diakoulaki and Karangelis (2007) and Georgopoulou <i>et al.</i> (1998)
5.	Prioritization of projects	Goumas and Lygerou (2000), Haralambopoulos and Polatidis (2003)
6.	Regional energy planning with a focus on renewable energies	Polatidis and Haralambopoulos (2003)
7.	Comparing cooking energy alternatives	Pohekar and Ramachandran (2004)
8.	Comparing energy technologies based on renewable, fossil or nuclear resources	Topcu and Ulengin (2004)
9.	Avoiding academic and decorative planning	Borges and Villavicencio (2004)
10.	Formulating national information technology strategies: A preference ranking model using PROMETHEE method	Albadvi (2004)
11.	Designing policy instruments	Doukas <i>et al.</i> (2006)
12.	Evaluation of residential systems	Ren <i>et al.</i> (2009)
13.	Evaluation of natural gas supply options for Southeast and Central Europe: Multi criteria assessment	–
14.	Comparing technologies	Cavallaro (2009)
15.	Evaluating public policy mechanisms for climate change mitigation in Brazilian buildings sector	Augustus de Melo <i>et al.</i> (2013)

economy in various sectors, economy development is dependent on implementation of e-Governance. This area of economy development is felt as difficult task to be implemented for growth. Many barriers across those sectors need to capture in a single and comprehensive framework to assess ICT applications or penetration level or in simple word to assess efficacy of e-governance. Thus, sector challenges inspire to conduct the study, which aims to support investments and growth of sector alternatives, which need more ICT applications for the benefit of the citizens and meet the objectives of sustainable development. Not limiting to these efforts, study can also boot IT-related infrastructure and to promote secured ICT applications. Moreover, the Indian economy seeks capital to support GDP by operating such sectors alternatives. One of the ways to justify utilization of such huge investments and promote FDI in various sectors is to implement e-governance efficiently and executing in the MMPs. Further, e-governance found as one parameter to assess for addressing the sustainable agenda and such coverage of study was indeed to meet the objectives of SDGs. The efficacy is influenced not only by many criteria but also by the type of MMPs which does. The projects implemented across the sectors (NeGP, Deity, Govt. of India, 2015-2016). Based on the literature review presented in the [Table II](#), it is observed that the research study measuring e-governance efficacy in the Indian context has not been carried out so far, especially using a MCDM approach considering comprehensive list of criteria on various dimensions of ICT applications in the sectors and the e-governance subject. Moreover, as the review focused on the subject of e-governance, MCDM framework in the context, PROMETHEE method, it has been observed that many sectors need focused and mission mode approach for effective implementation of e-governance and to achieve adequate IT infrastructure for ICTs applications.

This gap widens more specifically when the economy has to play many vital roles in executing the strategic alliances, international cooperation, maritime security and international obligations to boost up her machinery and synergy in the content of EU dialogue. As indicated above, many research gaps observed in many sectors of Indian economy implementation of IT policy and in the practices domain of information security management. Thus, assessment of ICT application penetration seems to be difficult area, and this study attempted to cover the area of research. Thus, to fill the research gaps, the research study aims to prioritize various economy-dependent sectors by identifying set of criteria using PROMETHEE methodology. The results from the study are highlighting the various strategic dimensions on development of future strategy to combat IT security threats and to accelerate the agenda based on e-governance concept (Doherty and Fulford, 2006). The complete research framework, the research design flow of the study, can understand from the Figure 1.

The next section presents the overview of methodology used for measuring the e-governance efficacy in the various sector of Indian economy.

3. Overview of research methodology

As seen in the previous section, barrier and challenges of sector alternatives are the important grey areas for e-governance implementation. The challenges include effective implementation of sustainable practices and are relates to administrative reforms, NeGP, technical, economical, infrastructure and social constraints that hinders the e-governance. These barriers are more vital to assess digital empowerment. Reasons associated with the Indian context of study become more important as ICT applications, and their penetration varies sector to sector. These sectors are affected not only by many social and economic barriers but also by the ICT applications or efficacy of e-governance. Therefore, this research study adopts Indian context and selects various sectors as alternatives for measurement of e-governance efficacy.

Therefore, to fill the research gaps for the research, this section of the research study describes about brief over view of fuzzy PROMETHEE methodology. Ranking of various sector alternatives is determined using the PROMETHEE framework of enriching the

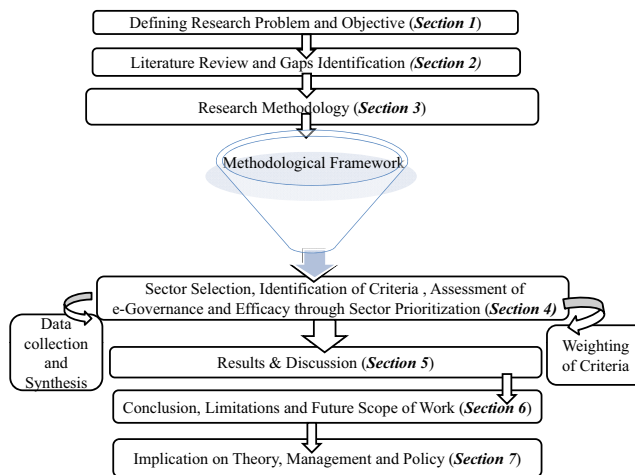


Figure 1.
Research design
framework

decision-making. For more details on the methodology, related work can be referred (Georgopoulou *et al.*, 1998; Mladineo *et al.*, 1987; Tzeng *et al.*, 1992). Research methodology framework is presented in Figure 2, and various steps involved in F-PROMETHEE are presented here:

- *Step 1:* In the first step, various sector alternatives compared based on assessment of e-governance for all the select criteria. Using preference function such as quasi level, linear and Gaussian criterion, preference expressed by a number in the interval $[0, 1]$ where (0) represents no preference or indifference and (1) represents for an exact preference. The difference in performance is classified known as generalized criterion function, which supports decisions of decision makers (Brans *et al.*, 1986).
- *Step 2:* In this step, for each pair of sector alternatives, preference index is calculated. The index denoted by $\pi(\alpha, \beta)$ is estimated and defined as preference of alternative (α) over (β) considering all identified criteria. The weights given for each criterion express as relative importance which is choice for a decision maker, and the preferably weighted index $\pi(\alpha, \beta)$ is estimated using the equation (1) (Appendix).
- *Step 3:* Here, sector alternatives ranked based on their sum indices of preference of sector alternative (α) over all the other criteria. This is compared using leaving flow ($\varphi + (\alpha)$) using equation (2) (Appendix).
- *Step 4:* In contrast to Step 3, the sum indices indicating preference of all remaining actions compared to (α) is also computed using entering flow $\varphi - (\alpha)$ as given by the equation (3) (Appendix).
- *Step 5:* In this step, net flow ($\varphi(\alpha)$) is calculated using equation (4) to provide complete ranking of all sector alternatives. This measure is known as the PROMETHEE II assessment of methodology. In the complete assessment of the methodology, the sign of $\varphi(\alpha)$ helps in identifying the ranking and prioritized decision related to sector alternatives.

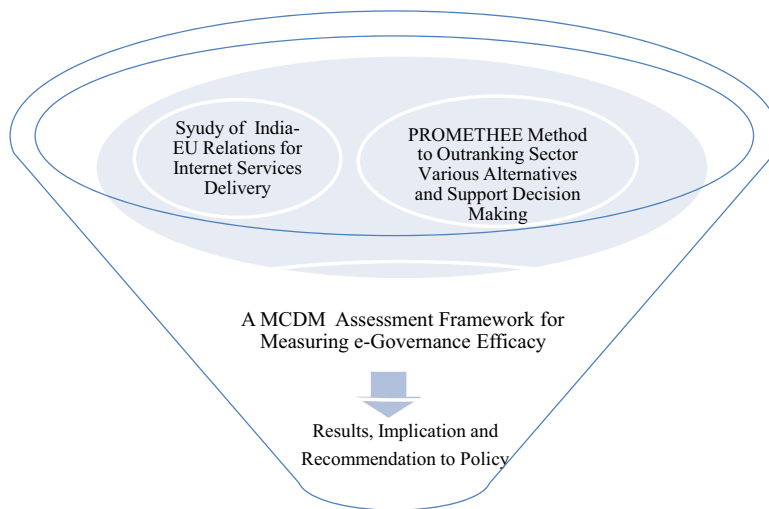


Figure 2. Framework of research methodology

In the above context, a fuzzy set is defined by a fuzzy set, which is represented using equation (5) of the Appendix. Equations (6) to (9) of the Appendix refers to the algebraic functions. To compare different fuzzy numbers, an index is calculated using the equation (10) (Yager, 1981; Bilsel *et al.*, 2006) (Appendix). For more details on fuzzy theory and its applications, various research papers by Bellman and Zadeh (1970), Dubois and Prade (1978), Goumas and Lygerou (2000), Kaufmann (1975) and Zadeh (1965, 1975) can be referred. In PROMETHEE method, MCDM problem is modelled using preference, indifference and incomparability of an alternative say (*a*) on say (*b*). The preference is represented by aPb , alb and aRb , respectively, and deviations should be incorporated and taken in to the consideration for sector evaluations accordingly. If there is not enough information for ranking the sector alternatives, strong preference and indifference vectors, weak preferences and incomparability vectors can also be handled (Topcu and Ulengin, 2004). This research paper considers the fuzzy synthetic extent analysis method developed by Chang for calculating the weights of various criteria (Chou and Chang, 2008).

3.1 Fuzzy PROMETHEE

Various equations using fuzzy numbers to calculate fuzzy linear preference function, fuzzy leaving flow ($\tilde{\varphi} + (\alpha)$), fuzzy entering flow $\tilde{\varphi} - (\alpha)$, fuzzy net flow ($\tilde{\varphi}(\alpha)$) are shown in equation (11) to equation (15) in the Appendix. To demonstrate the F-PROMETHEE approach for assessing e-governance efficacy in ten GDP-dependent sectors, MCDM approach for analyses is considered. These sectors selected based on the requirement of e-governance in the economy due to IT- infrastructure, policy implementation, and their severity for risks and threats.

Referring to the introduction section of the paper, it is noted that it is very important to assess ICT penetration level. However, sectors lack in their development their access to the administration and future planning. District authorities are responsible to take the decision to support the present challenges to implement e-governance. Due to avoid the subjectivity lies in the decision-making to support the e-governance penetration in the sectors, this paper utilizes PROMETHEE as the approach which is very simple and easily understood by the decision maker. In the PROMETHEE method, different types of preference functions devised and used in specific situations. Generally, different types of function include usual criterion, U-Shape, V-shape, level, V-shape with indifference and the Gaussian criterion. These functions can utilize to support decision-making. Among them V-shape or linear function which accounts for moderate comparison (likewise in contrary with U-shape function) establishes a linear correlation between the point of indifference (0) and the point of strict preference (1) is used in this research paper. It is also evident from the literature review that such function assesses moderate comparison of various sector alternatives, as it is difficult to outrank the sectors (the sector alternatives) based on many criteria. Moreover, the sectors differ in adoption of ICT application due to difference on their characteristics, infrastructural barriers exist there, and the issues related to cyber security in the research context. Therefore, the paper is an important research study focusing on efficacy of the e-governance in India, keeping EU dialogue in mind, for the sector development and addressing influence of many criteria on sector alternatives using the PROMETHEE methodology.

4. Quantifying e-governance efficacy

Since past few decades, there has been immense need of managing and administering the Indian economy, specifically on the aspect of handling the change required for sustainable development. Globally it has observed that both ICTs application and e-governance

perceived as an important and transformational tool to support governance in economies on various aspects of developments. In this context of governance, over the period, many resolutions have been passed by international forums including United Nations (UN), which further enforced India to adopt sustainable practices, take actions and initiatives to support its governmental processes for managing adequate amount of change for the sustainable development. Out of many international cooperation regimes, which India have with other countries to improve governmental processes, Indian-EU strategic dialogue to support internet services is found important segment to follow and implement the e-governance. To follow the same, one of the ways is to measure the implementation of ICT applications or e-governance efficacy in various sectors, as since after post liberalization period, Indian development and governmental processes have been significantly dependent on those sectors. The sector contributes significant part of GDP and overall growth of the Indian economy. These sectors not only are responsible for economic growth but also govern the sustainable development based on ICT applications, their transfusion to manage change and increase penetration levels in sectors to grow and provide e-services to the citizens. Referring to international practices and literature studies in the context, the UK, followed by Australia and the Republic of Korea, lead the world in providing government services and information through the internet, according to UN showing the progress of nations in promoting e-government (SDGs, UN, 2016). The e-Government survey provides new evidence that e-government has the potential to help support the implementation of the 2030 Agenda and its 17 SDGs. The survey also identifies that e-government is an effective tool for facilitating integrated policies and public service by promoting accountable and transparent institutions through open data and e-participation and participatory decision-making as well as by advancing online services to bridge the digital divides. Keeping the previously mentioned background in the mind, therefore, it becomes important to assess the e-governance efficacy or ICTs application penetration levels to present the implementing status of Indian-EU dialogue on the subject matter of e-governance. To address this research gap, this study covers the subject matter which shall remain incomplete in nature particularly without assessing e-governance efficacy in select GDP-dependent sectors of the Indian economy.

As observed from the above background, ICT influences all areas of society, business and government. The development and widespread adoption of new ICT services and networks have powerful effects on economic and social development. India has developed a strong capacity in ICT, capturing large and growing shares of the world market for IT and software services. With its large pool of talented IT specialists and world-class facilities for IT research and development, India is considered an important partner for Europe and vice versa. Many ICT researchers and businesses on both sides are keen to strengthen links with their counterparts. In 2001, India and the EU took further concrete steps to promote cooperation in the development of ICT and a modern information society, as expressed in the Joint EU-India Vision Statement on IT and e-governance. Under the umbrella of the India-EU Information Society Dialogue, both of EU and India have agreed to exchange views on a regular basis on internet governance.

Therefore, this section attempts to measure efficacy of e-governance in selected sectors of Indian economy, namely, agriculture, aerospace, defence, education, finance, environment and climate change, health, industrial, international cooperation and railways sectors, using F-PROMETHEE-based approach. For better representation, these are denoted as S_j ($j = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10$) and various alphabetical codes are also assigned to the sectors. To prioritize these sector alternatives, criteria selected and weighted using fuzzy synthetic extent analysis. The section describes the selection and discusses the computation of criteria weights.

4.1 Data collection and sector selection

In this sub-section, collection of data and selection of sectors for the MCDM analyses are presented. Literature observed that the country has classified its economy and developed GDP in three sectors, i.e. agriculture, industry and services. Agriculture includes crops, horticulture, milk, animal husbandry, aquaculture, fishing, sericulture, aviculture, forestry and related activities. Industry refers to the people or companies engaged in a particular kind of business activity and described as the manufacturing of a goods or service in the country. The services sector not only is the dominant sector in India's GDP but also attracted significant foreign investment flows. The sector has contributed significantly to exports as well as provided large-scale employment. Country's services sector covers a wide variety of activities such as trade, hotel and restaurants, transport, storage and communication, financing, insurance, real estate, business services, community, social and personal services and services associated with construction. In the recent years, GoI recognizes the importance of promoting growth in services sectors and provides several incentives in wide variety of sectors such as health care, tourism, education, engineering, communications, transportation, information technology, banking, finance, management, among others. ICT applications have a very important role to play in development and to support e-governance in the sectors. Such applications further promote growth in GDP and governance in the economy. With this broad classification of the service sector, the paper selects a list of ten major sectors for measuring the e-governance efficacy. Where criteria affecting ICTs applications in sectors identified from feedback received from senior level officers and experts trained under the Digital India programme. Later, criteria weighted on fuzzy scale and their impact on sector alternative are estimated. The assessment of efficacy is important where identification of grey portions in the sectors may support right directions to e-governance implementation, minimizing security breaches, utilizing infrastructure and labour force in an efficient ways and support in growth of overall GDP.

Table III shows a broad classification of the criteria where use of ratings enables decision makers to analyse each criterion with respect to other criterion for their subsequent ranking relative to each other. Based on fuzzy linguistic scale (Table IV) and fuzzy decision matrix (Table V), a Yager index is calculated using equation (10) (Appendix).

4.2 Criteria weighting

Fuzzy decision matrix "M" is constructed to measure the relative degree of importance for each criterion using fuzzy linguistic scale as shown in Table IV. The decision matrix given in the Table V, which also shows the relative importance among all 15 criteria considered for prioritizing ten sectors and have influence of growth for e-governance. For the demonstration purpose, the table presents only lower triangular values of the fuzzy decision matrix. Decision is taken on the basis weights assigned for each criterion. For this purpose, the procedure for fuzzy synthetic extent analysis given by Chou and Chang, 2008 is used. The weights obtained from fuzzy synthetic extent analysis considered in F-PROMETHEE for outranking of ten sectors and the criteria weights (w_i) are shown in Figure 3.

The importance of the criteria is affecting e-governance efficacy and assessed by their weights. PROMETHEE Rainbow diagram representing various criteria in the sectors as shown in the Figure 3, which is developed from application of Visual PROMETHEE software. It is clearly seen from the Figure 3 that efficacy of ICT applications in the sectors, i.e. finance (S5), industry (S8) and railways (S10) are influenced more by the criteria like the political interference (C11), IT professional strength (C12), employment rate (C13), economic growth of economy (C14) and impact of threats on sectors which can affect national information security(C15).

Out of total ten select sectors, they include two other sector-segments, namely, environmental degradation and climate change (S_6) and international cooperation (S_9). All these sectors are expressed as $S_j(j = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)$ and for better understating each are denoted as (S_1), (S_2), (S_3) (S_4), (S_5), (S_6), (S_7), (S_8), (S_9) and (S_{10}). The Figure 3 shows various sector positions according to their GDP contribution to the Indian economy.

4.3 Prioritization using F-PROMETHEE

After weighs of criteria estimated, various steps of F-PROMETHEE have been applied to obtain outranking of ten sector alternatives. In Step 1, these sector alternatives compared for all criteria using fuzzy scale as indicated in Table IV. Criteria Vs sector alternatives matrix “CA” is formed. After normalizing Criteria –Alternative (CA) matrix, and using equations (11) and (12) (Refer Appendix), in Step 2 fuzzy based preference index is calculated, which has been shown in the Table V. In this research paper, the linear preference function used to obtain values of preferences, strict preferences and indifference relations between each pair of sector alternatives. In Steps 3 and 4 of F-PROMETHEE method, using equations (13) and (14), positive and negative flows are also calculated and respective values of those flows as shown in the Table VII. Fuzzy preference index of each pair of the sector alternatives is calculated, and for demonstration purpose, Table VI indicated only first pair of sector alternative. In Step 5, the net fuzzy flow vector using equation (15) is calculated using sector alternative–sector

Criterion (Cj)	Description of criterion
C1	IT –Infrastructure availability (in Pre-liberalization)
C2	IT –Infrastructure availability (in Post-liberalization)
C3	Ability to IT –Policy adoption (Pre-liberalization)
C4	Ability to IT –Policy adoption (Post-liberalization)
C5	Degree of cyber threats and vulnerability impacting sector services and compliance of security standard practices
C6	Amount of investment in the sector for sustainable development
C7	IT initiatives impact on supply chain performance of e-commerce market, Sindhuja (2014)
C8	Ability of digital network in service delivery of central sector schemes (CSS)
C9	Sector ability to increase literacy rate and environmental education mandate Rezgui and Marks (2008)
C10	Support for ease of doing business
C11	Political interference and efforts to initiate concept of e-Cabinet
C12	IT-professional strength, capacity building (change management)
C13	Support employment rate
C14	Sector support to economic growth
C15	Severity of national security threats

Table III.
Criteria for e-governance efficacy assessment using PROMETHEE method

Source: Criteria identified from feedback from training programmes under Digital India programme

Linguistic scale (five-point)	Fuzzy no. (n, a, b)	n	a	b	Yager Index (Magnitude of fuzzy no.)
Very high influence (VH)	(0.75, 1.0,1.0)	0.8	1.0	1.0	0.8
High influence (H)	(0.5,.75,1.0)	0.5	0.8	1.0	0.6
Low influence (L)	(0.25,0.50,0.75)	0.3	0.5	0.8	0.3
Very low influence (VL)	(0.0,0.25,0.5)	0.0	0.3	0.5	0.1
No influence (No)	(0,0,0.25)	0.0	0.0	0.3	0.1

Table IV.
Linguistic scale of triangular fuzzy numbers (TFNs) and their modulus (YI)

Table V.
Assignment of
relative importance
to criteria vs criteria

C-C Matrix	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1		NO	VH	H	H	L	VH	VH	H	L	L	L	L	L	L
C2			NO	VH	H	H	VH	H	L	H	H	VH	VH	H	H
C3				NO	L	L	H	L	L	L	L	L	L	L	L
C4					NO	VH	H	H	L	H	H	H	H	H	H
C5						NO	VH	H	H	L	H	L	L	H	VH
C6							NO	VH	H	VL	L	L	L	L	VH
C7								NO	H	H	H	H	H	L	L
C8									NO	L	L	VH	H	L	L
C9										NO	L	L	L	L	VL
C10											NO	H	H	VL	L
C11												NO	H	L	L
C12													NO	L	VL
C13														L	VL
C14															L
C15															

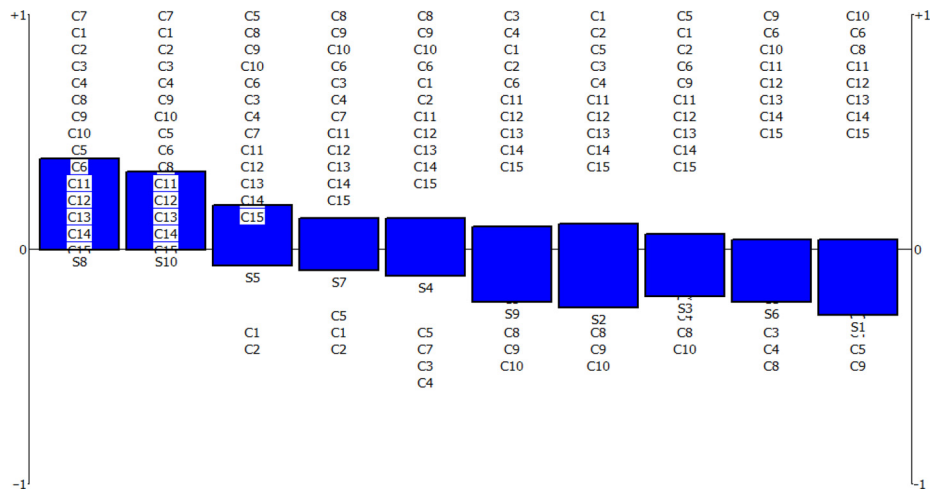


Figure 3.
Positioning of various
criteria in sector
alternative
PROMETHEE
rainbow

Table VI.
Fuzzy preference
index of first-pair of
sector alternatives

$\pi(\alpha, \beta)$ Vs Cj	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	Wi*Cj
(S1, S2)	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.05	0.00	0.07	0.02	0.00	0.05	0.06	0.00	0.029
(S1, S3)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.07	0.02	0.00	0.00	0.03	0.00	0.011
(S1, S4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
(S1, S5)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
(S1, S6)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.03	0.02	0.00	0.05	0.00	0.00	0.016
(S1, S7)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
(S1, S8)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
(S1, S9)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.07	0.02	0.00	0.00	0.03	0.00	0.011
(S1, S10)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000

alternative (AA) matrix as shown in Table VII. The summation for fuzzy net flows of all ten sectors alternative provides zero value (0) and zero value provides validation of the right results and calculations obtained from various methodological steps. However, cumulative representation of fuzzy flow measure vector and their values can be seen from the Figure 4.

4.4 Prioritization using visual PROMETHEE

The Visual PROMETHEE is a software application for outranking of various sector alternatives in a conflicting situation for decision-making. Academic version of the software application is used to rank ten sector alternatives (PROMETHEE Methods, 2013). The software enables and evaluates possible decisions according to the selected criteria. The application out ranks from best to the worst alternative for the same set of criteria which are considered in F-PROMETHEE. The software mainly highlights results in analysing the sector alternatives prioritization using GAIA representation. Therefore, using this application for out ranking of various sector alternatives justifies decisions based on the objective elements. The outputs obtained from Visual PROMETHEE are in

A-A Matrix	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Sum (S _j)	$\bar{\varphi} - (\alpha)$	Net fuzzy flow ($\bar{\varphi}(\alpha)$)
S1	0.000	0.029	0.011	0.000	0.000	0.016	0.000	0.000	0.011	0.000	0.07	0.0075	-0.013
S2	0.028	0.000	0.011	0.018	0.013	0.020	0.018	0.002	0.012	0.004	0.12	0.0139	-0.018
S3	0.022	0.023	0.000	0.009	0.007	0.021	0.015	0.004	0.012	0.006	0.12	0.0132	-0.014
S4	0.029	0.047	0.026	0.000	0.006	0.036	0.006	0.000	0.029	0.003	0.18	0.0202	0.005
S5	0.000	0.029	0.047	0.026	0.000	0.006	0.036	0.006	0.000	0.029	0.18	0.0199	0.012
S6	0.000	0.039	0.052	0.035	0.016	0.000	0.043	0.007	0.002	0.039	0.23	0.0258	0.002
S7	0.039	0.057	0.042	0.016	0.007	0.046	0.000	0.000	0.039	0.003	0.25	0.0278	0.012
S8	0.062	0.065	0.054	0.034	0.025	0.067	0.023	0.000	0.051	0.138	0.52	0.0578	0.056
S9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.0000	-0.017
S10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.0000	-0.025
Sum (S _j)	0.181	0.289	0.244	0.137	0.074	0.212	0.141	0.018	0.157	0.222	$\sum \bar{\varphi}(\alpha) =$	0	
$\bar{\varphi} + (\alpha)$	0.020	0.032	0.027	0.015	0.008	0.024	0.016	0.002	0.017	0.025			

Note: The table shows all zero values in its diagonal position and alternative to alternative values have been reported in with respect to this diagonal

Table VII. Sector alternative – sector alternative (AA) matrix, positive, negative and net flows

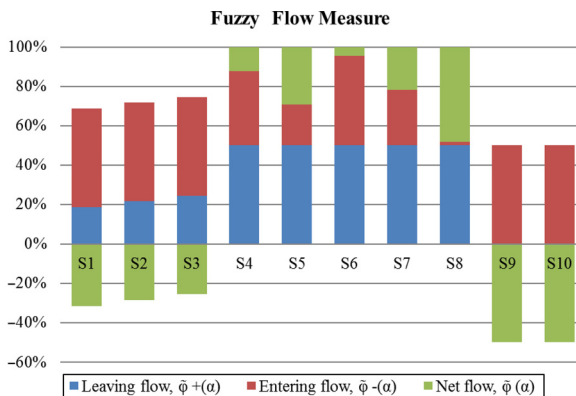


Figure 4. Fuzzy flow measure vector values of sector alternatives (%)

the forms of various figures starting from Figures 5 to 9. Figure 5 represents partial ranking of sector alternatives (which represents PROMETHEE I), Figure 6 highlights complete ranking (using PROMETHEE II), Figure 7 shows allocation of sector alternatives using PROMETHEE Diamond, Figure 8 represents PROMETHEE II network diagram, Figure 9 criteria allocations in GAIA spider web and Figure 10 highlights U-V graph of sector alternatives Vs criteria with decision axes.

5. Results and discussions

5.1 Results from F-PROMETHEE

On applying various steps of F-PROMETHEE method, the results based on positive, negative and net flows which are estimated in Section 4 have been compared in the Table VIII. Based on ranking of fuzzy leaving flow ($\tilde{\varphi} + (\alpha)$) values, industrial sector (S_8) outranks high among all ten sectors alternatives based on ICTs application penetration level. This ranking of industrial sector supports that many of central sector schemes and initiatives are implementing in the Indian industry to reach to the benefits of the common citizens. The outranking followed by health (S_7), environment segment (S_6) and found minimum e-governance in international cooperation (S_9) and railways sectors (S_{10}), therefore, need less attention to boost level of ICT application. Based on ranking of these sectors, railways and segment of international cooperation observed as less ICT penetrated

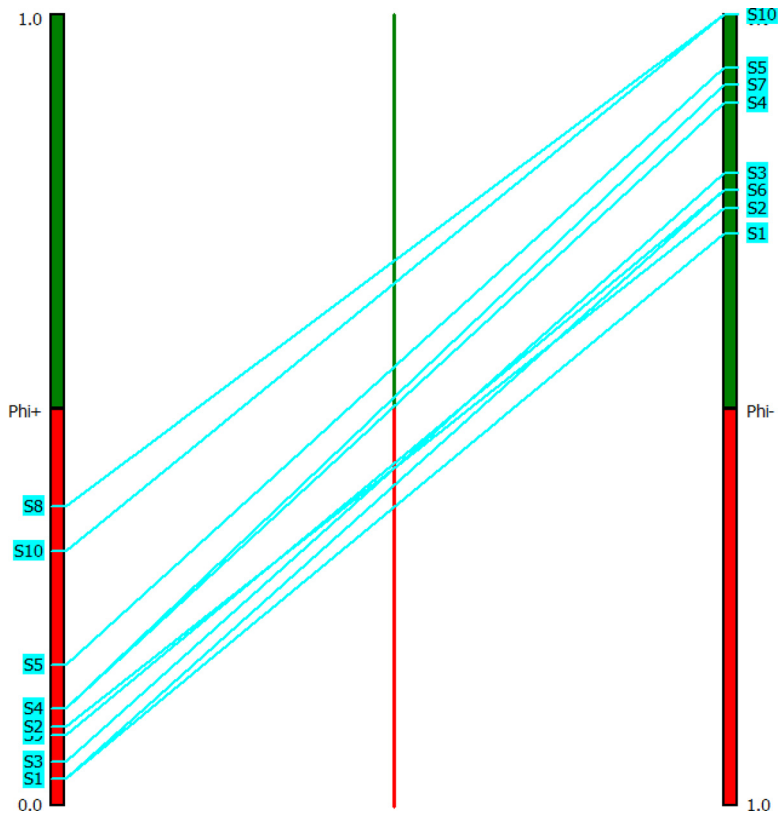


Figure 5.
Partial ranking of
sector alternatives
(PROMETHEE I)

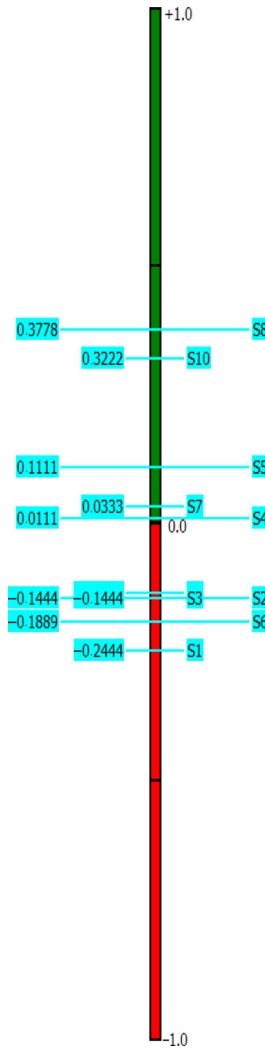


Figure 6.
Complete ranking of sector alternatives (PROMETHEE II)

sector and need more support for digitization and e-service. F-PROMETHEE I based outranking conditions are presented and shown in the [equation \(16\) \(Appendix\)](#). On the other hands, fuzzy-based entering flow ($\tilde{\varphi} - (\alpha)$) measure values, again industrial sector (S_8) outranks first then Finance sector (S_5), Health (S_7) at third followed by other sector alternatives at the lower positions. Ranking of finance sector at the second position validates the initiatives taken by the government in the sector.

However, fuzzy net flow ($\tilde{\varphi} - (\alpha)$) values shows that the sector alternatives which have positive flow values of greater than positive flow values among each other, and higher negative flow values, which leads to higher net flow of sectors as compared to positive one. Hence, this is concluded that Industry (S_2) outranks at the tenth position as compared to all other sector

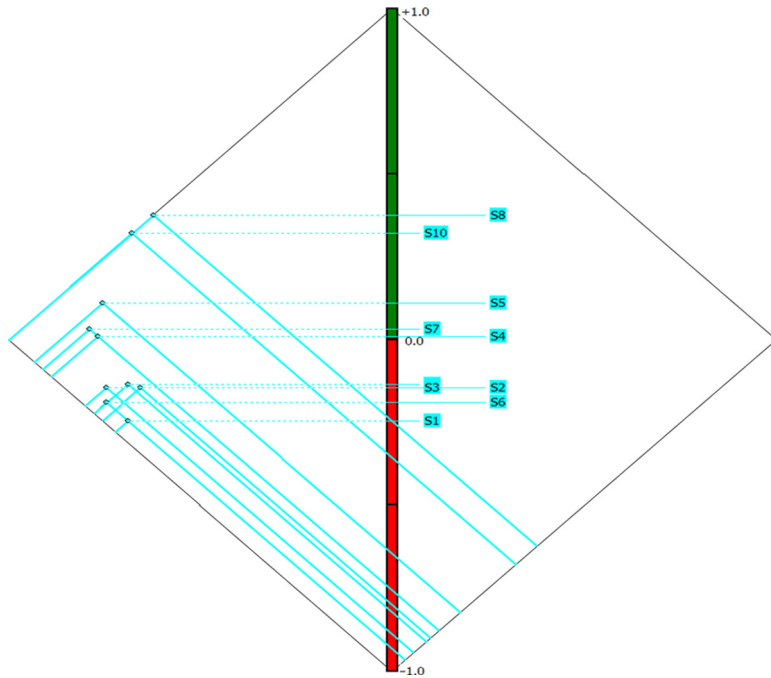


Figure 7.
PROMETHEE
Diamond

alternatives. The ranking based on positive and negative flows makes sector alternatives to attain their ranking on the aspect of various criteria affecting e-governance efficacy. Based on the characteristics of sector alternatives as discussed in the previous sections, the strengths and weakness for each sector alternatives indicated by fuzzy positive and negative flows have shown in the Figure 4. In general, it can be said that the net flow is the measure to rank of the sector alternative but sometimes the partial (PROMETHEE I) ranking is also obtained which ranks sectors differently as contrast to the complete ranking (PROMETHEE II). The condition of net flow outranking is presented in the equation (17) (Appendix).

The result as indicated above not only prioritizes various sector alternatives but also indicates direction to enlighten those sectors, which attained relatively less ranks according to their flow measures. India and the EU have effective mechanisms for dialogue at all levels. Initially, with the launching of the India-EU strategic partnership, it was necessary to further intensify the dialogue, both by actively strengthening existing mechanisms and making them more efficient and initiating dialogues in new areas of sectors considered for cooperation. It would also be necessary to put follow up mechanisms in place to effectively implement the decisions taken, with a view to ensuring a more sustained and cohesive approach to issues affecting India and the EU over an increasingly wide range of sectors. In a broader sense, based on those approaches and focusing on Indian barriers to increase ICTs to the order of pace to meet sustainable growth, the results can be used as base study to support ICT application in sector alternatives. Other areas of cooperation through joint vision can be strengthened, which are not limited to, science and information and communications technology, customs cooperation, employment and social affairs, education and training, nuclear fusion, energy research, declaration on culture, research and

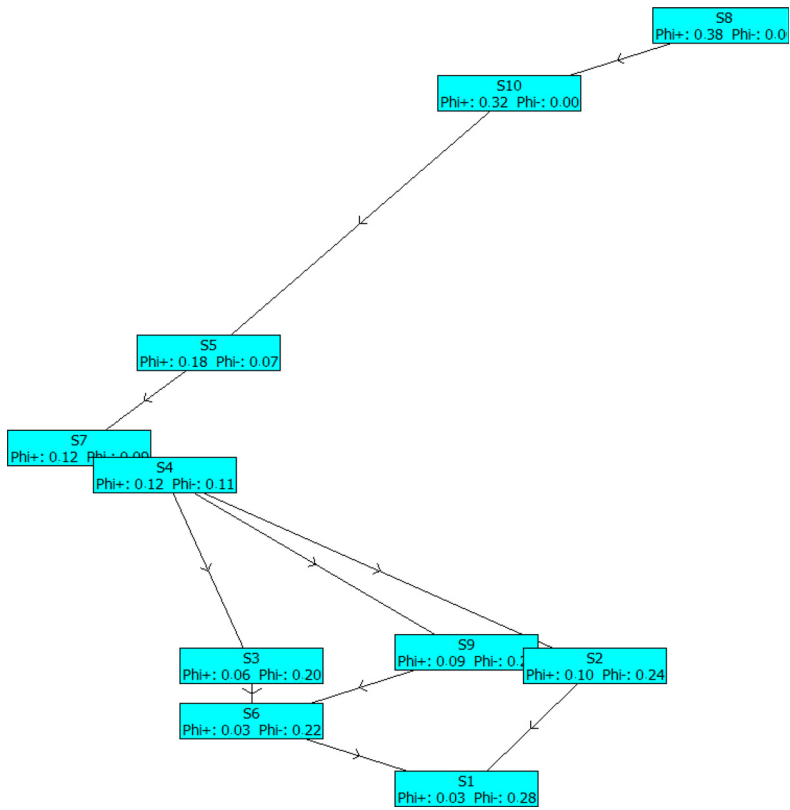
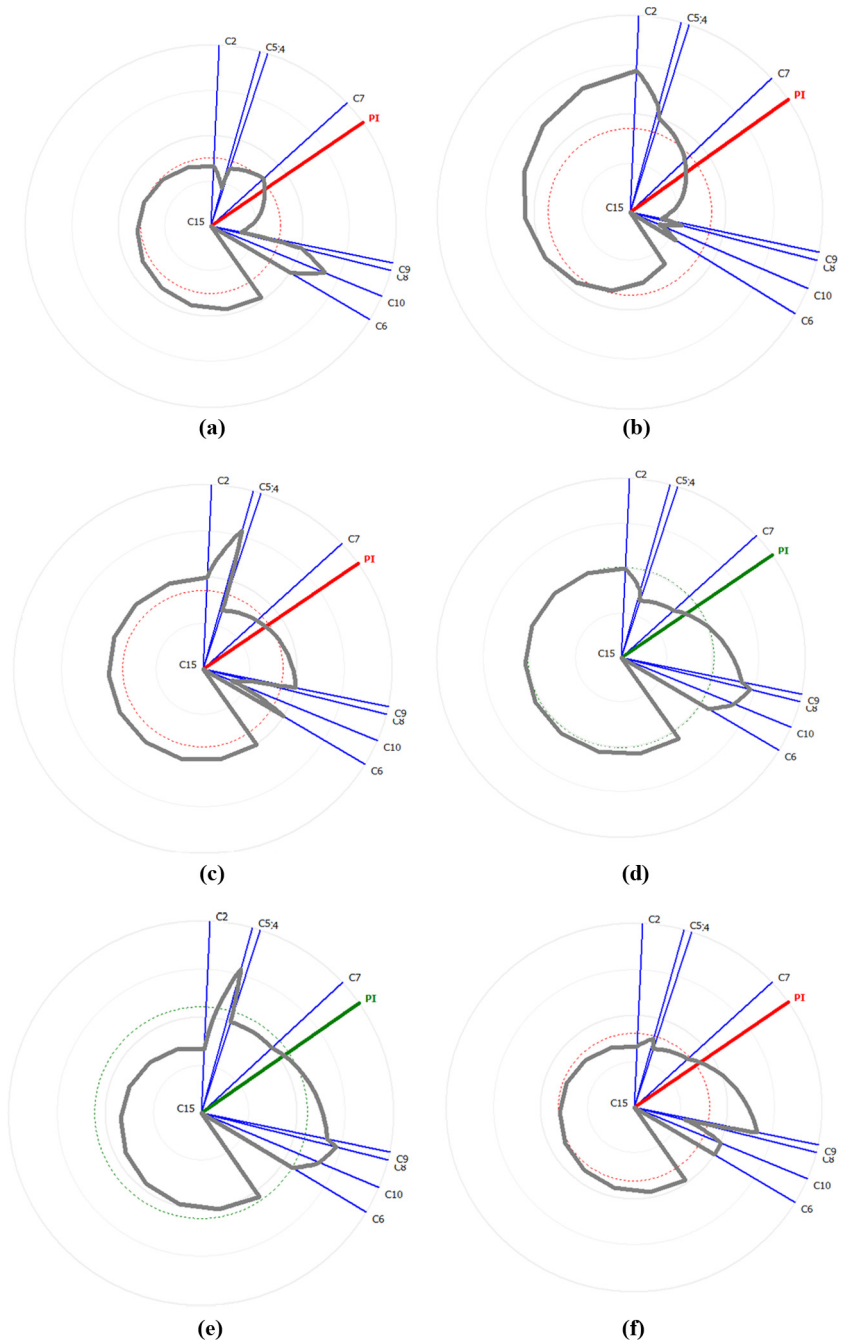


Figure 8. PROMETHEE Network

innovation cooperation, enhanced cooperation in energy, clean energy and climate partnership and overall agenda for action 2020.

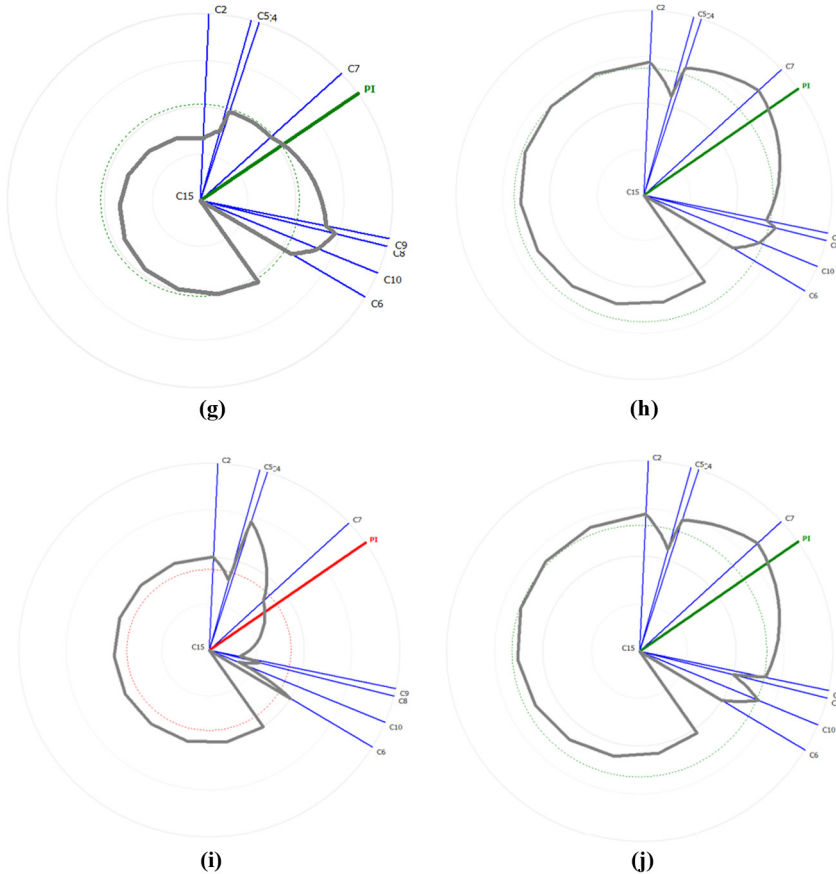
5.2 Results from visual PROMETHEE

Apart from PROMETHEE, Visual version is also used where MCDM analysis carried out in Visual PROMETHEE software and various qualitative criteria are selected using five-point Likert scale embedded in the software. Table VIII represents the result output obtained from the software. Figure 5 shows the outranking flows of sector alternatives based on partial ranking PROMETHEE I, i.e. the $\tilde{\varphi} + S_j$ as a measure of relative strength and $\tilde{\varphi} - S_j$ as measure of relative weakness compared to all sector alternatives. The results from Figure 5 highlights that the leaving flow ($\tilde{\varphi} + (\alpha)$) of industrial sector (S_8) is highest, followed by sectors such as railways (S_{10}) and finance (S_5) then other sectors outranks at the lower position of ranking. However, based on entering flow values, the results showing that railways sector (S_{10}) has adopted ICT applications significantly indicating less attention. The agriculture sector (S_1) remains the least priority to the government and need high focus to penetrate ICT applications for sector enlightenment to assists the economy. In arriving net conclusions from this, Industrial sector (S_8) outranks high among all, followed by (S_{10}), (S_5) and (S_7). However, their net flows measure values indicated in Figure 6 as the complete ranking using PROMETHEE II methodology (Table IX).



(continued)

Figure 9.
GAIA Spider web
representation of
sector alternatives



Notes: (a) Agriculture sector (S1); (b) aerospace sector (S2); (c) defence sector (S3); (d) educational sector (S4); (e) finance sector (S5); (f) environment and climate change (S6); (g) health Sector (S7); (h) industrial sector (S8); (i) international cooperation (S9); (j) railways sector (S10)

Figure 9.

Visual application outdraws the Diamond graph. The PROMETHEE Diamond is drawn from Visual PROMETHEE software as shown in the Figure 7, which jointly shows both PROMETHEE I and PROMETHEE II outranking. In the PROMETHEE Diamond, for a sector alternative say (S), the square corresponds to the $\tilde{\varphi} + (S)$ and $\tilde{\varphi} - (S)$ plane, where each criterion is represented by a point. Here, the plane is tilted about 45 degrees so that the vertical dimensions can also show and measure the net flow, i.e. $\varphi^-(S)$. This has depicted that values of $\tilde{\varphi} + (S)$ scores increase from left to the top corner and values of $\tilde{\varphi} - (S)$ scores increase from the left to the bottom corner. For each sector alternative (S_j), a cone has also drawn from the sector alternative position in the same plane. As the sector alternatives (S_8) and (S_{10}) cone overlap with all the other ones, these sector alternatives are relatively more preferred to all other sectors in PROMETHEE I of partial ranking. On the other side, the intersecting portions of cones corresponding to other sectors, namely, (S_1) to (S_7) and (S_9).

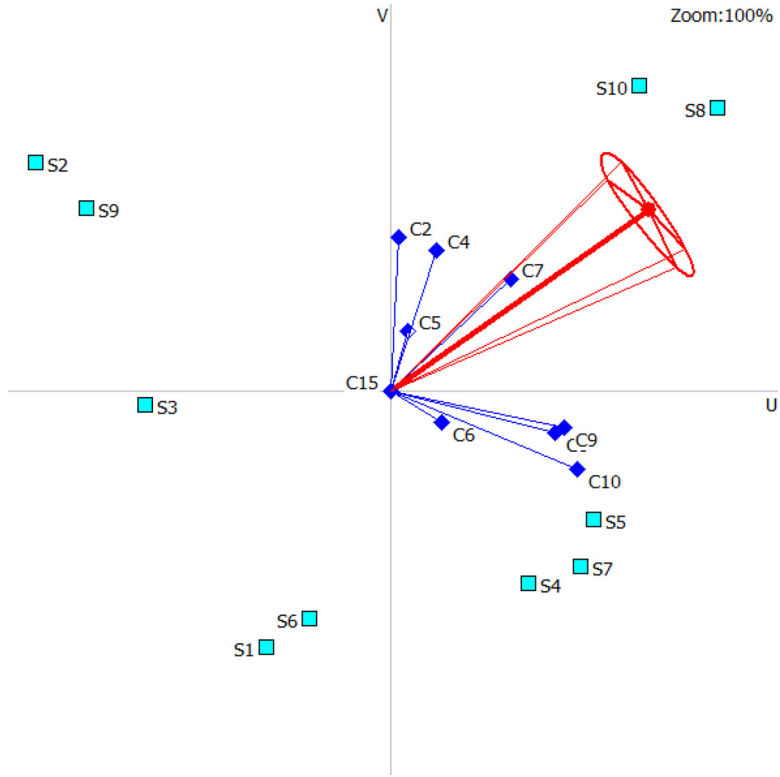


Figure 10.
U-V Graph of sector
alternatives vs
criteria with decision
axis

Sector alternative (S_j)	Leaving flow, $\bar{\varphi} + (\alpha)$	Rank ($R1$) based on $\bar{\varphi} + (\alpha)$	Entering flow, $\bar{\varphi} - (\alpha)$	Rank ($R2$) based on $\bar{\varphi} - (\alpha)$	Net flow, $\bar{\varphi} (\alpha)$	Sector rank ($R3$) based on $\bar{\varphi} (\alpha)$
S1	0.007	6	0.02	3	(0.013)	6
S2	0.014	7	0.03	1	(0.018)	10
S3	0.013	8	0.03	2	(0.014)	7
S4	0.020	4	0.02	4	0.005	4
S5	0.020	5	0.01	9	0.012	2
S6	0.026	2	0.02	5	0.002	5
S7	0.028	3	0.02	6	0.012	3
S8	0.058	1	0.00	10	0.056	1
S9	0.000	9	0.02	7	(0.017)	8
S10	0.000	10.9	0.02	8	(0.025)	9

Table VIII.
Outranking result
from F-
PROMETHEE

Figure 8 shows the PROMETHEE network diagram. The network representation is like a close-up of the Diamond view where each sector alternative represented as node and their relative positions. Here, their preferences represented by arrows and the node located in relative positions so that the proximities flow values appear in clear way. This figure clearly outlines that sectors such as industry (S_8), railways (S_{10}), finance (S_5), health (S_7) and

education (S_4) as represented by nodes are preferred more as compared to others sector alternatives.

Figure 9 represents GAIA spider web, which shows disperse of criteria in each sector alternative profiles. The utility of these webs is smarter display to understand and to support decision-making. The characteristics of web spider is instead of displaying different criteria at arbitrary angle, positions of the criteria axes in the GAIA plane are used as reference. In that way, the criteria that strongly correlated are close to each other in the GAIA web. The net flow scores represented on the web where negative values drawn at the centre of the web, whereas positive values drawn on the outer circle. A polygon has then drawn connecting all the criteria. Figure 9 represents examples of each sector alternatives (S_j).

Various parts of Figure 9, (a) to (j) represents web diagrams of agriculture, aerospace, defence, educational, finance, environment and climate change, health, industrial, international cooperation and the railway sectors. All shapes representing impact on criteria on the sectors are different from each other. The area covered by the boundary of criteria in the GAIA representation shows larger the areas larger the efficacy of e-governance in the particular sector. For example, area covered for aerospace, environment segments are comparable, and e-governance penetration is near about these sectors. However, both sector needs to be treated differently for their sustainable development. It can also be said that shown from various parts (h) and (j) of Figure 9, those sectors have attained maximum initiatives based on e-governance plan and ICT applications. Similar categorization of criteria significance as compared to rest of the sector alternatives can be referred from the Table X.

The PROMETHEE Visual application describes decision axis, which is a visual representation of weighting of the criteria in the GAIA plane. It resembles similar to weighted average of the criteria axes. As weights allocated to the criteria, the best sector alternatives are more or less influenced by the different criteria. The decision axis represented in red colour stick and shown as the projection of the all weight vectors (called decision stick) on the GAIA plane in the Figure 10. The 3D view of the decision sticks which also represents U-V graph of sector alternatives versus criteria with decision axes, shown in the same Figure 10. It is observed from this figure that the decision axis is oriented towards alternatives of industry (S_8) and railways (S_{10}) sectors. Therefore, e-governance related criteria aligned towards industry and railways sectors as the more penetrated sector alternatives.

It has been found that outranking of the various sector alternatives using Visual PROMETHEE are slightly differs from results scenario of the F-PROMETHEE. This

Sector alternative	Leaving flow, $\bar{\varphi} + (\alpha)$	Rank (R1) based on $\bar{\varphi} + (\alpha)$	Entering flow, $\bar{\varphi} - (\alpha)$	Rank (R2) based on $\bar{\varphi} - (\alpha)$	Net flow, $\bar{\varphi} (\alpha)$	Rank (R3) based on $\bar{\varphi} (\alpha)$
S1	0.3778	3	0.0000	9	0.3778	1
S2	0.3222	6	0.0000	10	0.3222	2
S3	0.1778	9	0.0667	2	0.1111	4
S4	0.1222	7	0.0889	1	0.0333	3
S5	0.1222	8	0.1111	8	0.0111	5
S6	0.0889	1	0.2222	5	-0.1333	6
S7	0.1000	10	0.2444	4	-0.1444	7
S8	0.0556	2	0.2000	7	-0.1444	8
S9	0.0333	4	0.2222	6	-0.1889	9
S10	0.0333	5	0.2778	3	-0.2444	10

Table IX.
Outranking result from visual PROMETHEE

outcome is due to little variation in linguistic scale of fuzzy and qualitative criteria chosen and later scaled in the visual PROMETHEE software application. Therefore, the linguistic scale chosen and the scale in the Visual software applications can be equalized to get same ranking of the sector alternatives. However, final decision based on both the result scenarios reflects the proximate picture of e-governance penetration in the Indian economy where much of central sector schemes and e-services initiative have to reach to the local and common people. Thereby informational service delivery can be enhanced at the grass root levels in various sectors. Due to dynamic and complex changes in the information technology, governance support for all the sectors are generally susceptible to substantial changes in the IT infrastructure, risks, breaches, policy implementation, ICT applications their adoption and based on other criteria considered in the assessment of e-governance.

6. Conclusion and future scope of work

This research paper set the priority order of ten GDP dependent sectors in Indian economy and quantified efficacy of e-governance implementation. Ten sector alternatives selected and then compared based on identified select criteria. For this purpose, fifteen criteria considered for measuring e-governance efficiency and weighted using the fuzzy synthetic method. Specifically, these criteria selected based on the various aspects of penetrating ICT applications to support e-governance in the sectors. The brief concluding remarks from the study are as follows:

- On applying PROMETHEE-I and PROMETHEE-II methods for determining the penetration level of ICT application in the sectors, results from PROMETHEE I analysis (i.e. partial ranking method) shows that sectors such as agriculture, industrial, education, environment and climate change segment are ranked relatively high as compared to other sectors in the economy.
- Based on the partial outranking, the paper recommends that a systematic future development is required for those sector alternatives, which outranked high.
- While on applying the PROMETHEE II method (i.e. PROMETHEE complete assessment), analysis recommends Industrial sector as the most penetrated by ICT applications and the scenario provide defence sector at the least order in the ranking on assessment of e-governance efficacy.
- While sectors such as education, environment and climate change need greater attention to support e-governance. Sector, which outranks least, is the Agriculture

Sector alternatives/Criteria significance	For good e-governance	E-governance concern
Sector (S_1)	C10, C8, C6	C5, C7, C2
Sector (S_2)	C2, C5, C4	C6, C8, C9, C10
Sector (S_3)	C5, C4	C6, C8, C9, C10
Sector (S_4)	C8, C9	C4, C5
Sector (S_5)	C8, C9, C10	C2, C7
Sector (S_6)	C9	C2, C5, C4, C8
Sector (S_7)	C8, C9	C4, C5
Sector (S_8)	C3, C5	C4, C6
Sector (S_9)	C4, C5	C3, C4, C5
Sector (S_{10})	C2, C9	C8, C4, C5

Table X.
Categorization of criteria significance to the e-governance in the sector

Note: Remarks: See Table II for criteria notations

sector one. The last ranking of the agriculture sector be due to many challenges related to farming practices, their computerization, ICT adoption, lower literacy rate of farmers and impacted by the criteria IT initiatives on supply chain performance in spite of huge financial support from the government.

- Based on the complete outranking, this paper recommends to have more focused approach is required for e-governance and ICT applications in those sector alternatives, which are outranked less relatively.
- Overall, the research study provided the ranking of ten GDP dependent sector-alternatives. However, more in-depth, separate study related to other sub-sectors, can be taken into the future consideration.
- MCDM approach used in this paper is very useful to support decision-making and increase the e-governance efficacy. The paper highlighted flexibility in the decision process for overall governance. Based on F-PROMETHEE it can be said using such discrete methodology for criteria weighting, this kind of MCDM framework not only can support priority based investment for the sub sectors but also may help in decision-making to enhance e-governance with minimal investment on ICT applications.
- In addition, to both complete and partial versions (i.e. PROMETHEE II and I) of methods, other advanced MCDM techniques such as COPRAS and COPRAS-G methods, VIKOR, and TOPSIS can also be used to draw strategic contours for sector development based on the e-governance strategic framework adopted from EU dialogue (Albadvi, 2004). Besides outranking, criteria selected in this study can also be determined using other methods such as SAW and SWARA. Some strategic assessment tools can also be used to map strategic intent of e-governance efficacy.
- This research study has operations cum long-term strategic intent of implementing the India-EU strategic dialogue on e-Government Action Plan 2016-2020. Thus, study may be useful to support sector developments on implementing Digital India programme towards Indian objectives of SDGs and EU directional objectives to penetrate ICT applications in India.

7. Implications on theory, management and policy

This research study shared research ideas to readers from academia, government and IT industry that have also addressed some of the concern related to various sector developments based on need of effective e-governance implementation. The section concludes the implication on theory, management and policy for respective categories of readers. The section also summarizes the key lesson learnt from the research study in the following sub-sections.

7.1 Implication on theory

Theoretically, PROMETHEE method is the best-suited method to assess the complex and large systems where subjectivity in decision-making can be addressed by weighing and comparing the criteria. The management theory built on set of criteria related to information security implementation, need of management and addressed barriers related to ICT applications in various GDP-dependent sectors in Indian economy. The PROMETHEE method also provides comparison of various decision-making criteria. The study found very helpful to assess sector-alternatives where analysis carried out

based on partial, complete and visual version of PROMETHEE applications. Thus, theory application can effectively assess priority order of penetration in ICT applications in conflicting situation of e-governance and variability in penetration levels in sectors. Moreover, both MCDM-based PROMETHEE (partial and complete methods) as the theory application to ICT applications provides enough flexibility to the decision process say to support overall governance process in this case of research paper. To the central core of the analysis covered in the research, weighting of criteria on fuzzy scale addressed the subjectivity lies in decision-making process for future development of the sectors. Briefly, this study on PROMETHEE method application paves important roles to identify the grey areas of those sectors, which found less penetrated by ICT applications. It is believed that the theory application on priority orders obtained from this PROMETHEE based MCDM theory application will support the decision-making and help in identify the prioritized sectors to enhance the e-services and delivery of central sector schemes.

7.2 Implication to management and administration

It has observed from the literature review that there are many challenges to identify need of interoperable architecture for enabling information security related networks, which primarily need digital infrastructure privacy, secured guidelines and related regulations. Overall, the output of alternatives ranking minimizes the conflicts, provides more robust decision-making for sector prioritization and their re-orientations for strategic development. Therefore, such management-oriented MCDM framework can support in identifying not only to right strategic directions for various sector development but also to national security. On these lines, this research study becomes more important which has relevant implication on the management perspective where study can fill the research gaps in the academia in the segment of Indian IT sector and also to support higher administration. Therefore, this study may be useful for managing the many sectors of the Indian economy where exchanging views between relevant authorities of India and EU, on the areas of common interest in appropriate for a joint development agenda and collaboration activities, in particular 4G, e-government, e-education and e-health. The study may be useful to Indian administration in exchanging best practices, sharing information on regulatory frameworks and promoting electronic communications. Hoping that study may synergize the minds of various actors engaged in e-governance process of Indian initiatives for making the country as the Digital economy. In addition to the above implications, aiming that Indian and the EU administration would benefit from a deepened exchange of views on developments in Europe and South Asia. Therefore, towards this end of study, India may get support from regular exchange of views on regional cooperation especially from the European Union.

Moreover, in the context of EU, the digital transformation has been as a key segment of research area for assessing e-governance efficacy. This research study may support the success of the single market strategy, help to remove existing digital barriers, beyond its boundary to India through EU dialogue and may prevent further fragmentation arising in the context of the modernization of public administration.

Apart from the scope of this study, the paper builds on MCDM theory and abstract idea of e-governance where understanding the involvement and interaction between government and its citizens through the use ICTs in various sector developments, seen as crucial when discussing across the developed world particularly in the USA. This has observed that Europe continued to lead on e-government, followed by the Americas, Oceania and Africa,

where this research study may further influence other economies and help in reshaping these geographical territories, particularly Asian economies and their extended thinking to support Indian economy and gain mutual benefits to progress on sustainable development accordingly.

7.3 Implication to policymakers

The study builds on assessment of ICT penetration level in Indian context. The study can provide decision-making support to policymaker to hold a common belief in the fundamental importance of multilateralism in accordance with the UN Charter and in the essential role of the UN for maintaining international peace and security, promoting the economic and social advancement of all peoples and meeting global threats and challenges. As seen from the study that in developing country like India, many routes of e-governance implementation have higher difficulty where few have added very little value due to ICT applications to the barriers exists in many sectors. Most of the reasons are related to improper utilization of funds on IT infrastructure and barriers of effective policy development. ICT applications need IT infrastructure-based tools to manage various challenges of sustainable goals. Thus, measurement of e-governance efficacy is being seen as important grey areas to address sector barriers and challenges by the policymakers. This research study also found very relevant to IT policy development so that priority-based investments can be made on select sectors in a prioritized manner. Hence, the research paper may be useful to policymakers and higher administration of India for designing, management and implementation of a portfolio of policy initiatives, innovative e-governance projects and partnerships related to the thematic area of governance and public service delivery and also to support India as the emerging digitalized nation.

7.4 Key lesson learnt

The paper primarily aimed to e-governance support for sector development in India. The paper not only helped in identify the various criteria related to the e-governance, its nexus with information security and management but also estimated their weights based on fuzzy scale. Using the PROMETHEE methodology, papers given the ranking of various sectors for e-governance implementation and assessed the efficacy. Last not but the least, India and the EU, as the largest democracies in the world and share common values and beliefs that make them factors of stability in the present world order.

Following the guidelines and pattern of EU strategy to support e-governance, the study analysed technical aspect of implementing ICTs applications in Indian sectors. Study also summarized on the abstract fact that India and the EU, as the largest democracies in the world, share common values and beliefs that make them natural partners as well as factors of stability in the present world order. Both also have much to contribute towards fostering a rule-based international order is it through the UN or through the World Trade Organization. As the EU evolves and enlarges, and as both faces diverse and complex global challenges, it is critically important to expand multifaceted relationship and build upon these foundations. Thus, this paper is an attempt to support Indian initiatives of digitalizing the nation and provide directions towards implementation of EU's strategy. Thus, study on Indo-EU on internet based services, ICTs applications and e-governance to implement in India, in the accordance with the UN Charter and in the essential role of the UN for maintaining international peace and security, promoting the economic and social advancement of all peoples and meeting global threats and challenges.

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$$\pi(\alpha, \beta) = \frac{\sum_{j=1}^k w_j s_j(\alpha, \beta)}{\sum_{j=1}^k w_j} \quad (1)$$

$$\varphi + (\alpha) = \frac{\sum_{\substack{b=1 \\ b \neq a}}^n \pi(\alpha, \beta)}{n-1} \quad (2)$$

$$\varphi - (\alpha) = \frac{\sum_{\substack{b=1 \\ b \neq a}}^n \pi(\alpha, \beta)}{n-1} \quad (3)$$

$$\varphi(\alpha) = |\varphi + (\alpha) - \varphi - (\alpha)| \quad (4)$$

If, $\varphi + (\alpha) \geq \varphi + (\beta)$ and $\varphi - (\alpha) \leq \varphi - (\beta)$

$$(x) = (n, a, b)LR \quad (5)$$

$$\tilde{T}_1 \oplus \tilde{T}_2 = (l_1 + l_2, n_1 + n_2, u_1 + u_2) \quad (6)$$

$$\tilde{T}_1 \otimes \tilde{T}_2 = (l_1 \times l_2, n_1 \times n_2, u_1 \times u_2) \quad (7)$$

$$r \otimes \tilde{T}_1 \cong (rl_1, rn_1, ru_1) \quad (8)$$

$$\tilde{T}_1^{-1} \cong (1/l_1, 1/n_1, 1/u_1) \quad (9)$$

Here, l and u are lower and upper limit or values of fuzzy number, respectively, and r is scalar quantity.

$$\text{Yager Index, } F(n, a, b) = \left(\frac{3n-a+b}{3} \right) \quad (10)$$

$$\text{The Preference function : } P(\alpha, \beta) = \begin{cases} 0 & \text{for } d \leq q \\ \frac{d-q}{p-q} & \text{for } q \leq d \leq p \\ 1 & \text{for } d \geq p \end{cases} \quad (11)$$

where (d) is the difference in the performance of alternative (α) and (β), (q) is the lower threshold for indifference and (p) is the upper limit for complete preference.

When using fuzzy PROMETHEE, replacing (d) of equation (11) with a fuzzy number say (m, c, d) the linear preference function is given by equations (12):

$$P(\alpha, \beta) = \begin{cases} 0 & \text{for } (m-c) \leq q \\ \frac{(n,c,d)-q}{p-q} & \text{for } q \leq n-c \text{ and } n+d \leq p \\ 1 & \text{for } n+d \geq p \end{cases} \quad (12)$$

$$\tilde{\varphi} + (\alpha) = \frac{\sum_{b=1}^n \tilde{\pi}(\alpha, \beta)}{n-1} \quad (13)$$

$$\tilde{\varphi} - (\alpha) = \frac{\sum_{b=1}^n \tilde{\pi}(\alpha, \beta)}{n-1} \quad (14)$$

$$\tilde{\varphi}(\alpha) = |\tilde{\varphi} + (\alpha) - \tilde{\varphi} - (\alpha)| \quad (15)$$

where (n) is the number of alternatives.

$$\tilde{\varphi} + (S8) > \tilde{\varphi} + (S10) > \tilde{\varphi} + (S5) > \tilde{\varphi} + (S3) \text{ and so on, for } \tilde{\varphi} + (Sj) > 0 \quad (16)$$

$$\tilde{\varphi} + (S10) > \tilde{\varphi} + (S5) > \tilde{\varphi} + (S7) > \tilde{\varphi} + (S4) \text{ and so on} \quad (17)$$

About the authors

Dr Vivek Soni, currently a Research Fellow at School of International Studies, Jawaharlal Nehru University, New Delhi (India), is a Management Consultant and Academic Expert in the areas of energy security management, inter-regional energy security cooperation between India and Asian economies, environment protection, climate change and sustainable development. He earned both PhD degree (Management Studies) and the MTech degree in the area of Energy and Environmental Management from the Indian Institute of Technology Delhi (IIT Delhi). He also specialized in regulations of the power sector from the Florence School of Regulation, Robert Schuman Centre for Advanced Studies of European University Institute, Italy. In India, he worked with different organizations, namely, Operations wing of DMRC, Delhi Electricity Distribution Company (DISCOM), Deloitte Touché Tohmatsu India Pvt Limited and Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India. His previous assignment includes regulatory affairs related to power and energy sector, energy scheduling and generation, purchase of power from long-term energy sources (both of conventional and renewable), tariff bidding, validation and monitoring of CDM projects, conduct of education awareness on energy efficiency and implementation of Standards & Labeling (S&L) Programme under the National Mission on Climate Change launched by Honourable Prime Minister of India. On academics and research side, his research interests are in the areas of Operations and Strategy Management, Decision Science, Project Management, Development of Energy Models (LEAP, MARKAL), Time Series Modeling, Life Cycle Management, Strategic Change and Flexibility issues in GDP-dependent sectors of Indian economy. His future research interests include both conventional and non-conventional types of security, specifically the optimizing the Military Operations in Defence Sector of Asiatic as well in the Eurasia Region (as per the interests of Government of India for strategic development), environmental sustainability assessment, natural resource management, circular economy, mining sector, management of biodiversity, coastline management, e-governance in grey sectors and also the social and educational development aspects of climate change in north-eastern region development. He is associated with various national and international professional bodies, and his research work has been published in national magazines and international journals such as *International Journal of Energy Sector Management*, *Sustainable Production & Consumption*, *Journal of Advances in Management Research*, *European Journal of Management*, *Journal of International Management Studies*, *Global Journal of Management and Business Research*, etc. He is being conferred upon prestigious *Bharat Vikas Award* by Institute of Self Reliance by Union Minister, Govt. of India and also Emerald Literati Network Awards for Excellence for the year 2017 by Emerald Publishing, United Kingdom. His service contribution as the reviewer of *International Journal of Energy Sector Management* and the *Journal of The Institution of Engineers (India) Series-B* and also as the life member of esteemed All India Management Association and Institution of Engineers (India), Kolkata are highly appreciable in the academics as well as in the Indian industry domain. Vivek Soni is the corresponding author and can be contacted at: soninitian@gmail.com

Rashmi Anand earned her Bachelor of Technology in Computer Science and Engineering and Masters of Business Administration in e-business (IT+ Marketing) from University of Lucknow. During her tenure of academic assignments and involvement with banking sector in the past four years, she has published many research papers in reputed national magazines and journals. Currently she is a research officer monitoring and developing capacity building for *Digital India* Programme at Indian Institute of Public Administration (IIPA), New Delhi in India. She is focal point for training district level officers of Indian Civil Services under the Digital India Programme of Government of India. As a PhD scholar at University of Lucknow since past four years, her interests are deepened in to the academics and research related to e-governance, IT-Policy, cyber security and management-related issues of the Indian IT-sector. She has been part of training of various capacities building programmes of senior level civil servants at IIPA, New Delhi and various programmes of Ministry of Electronics and Information Technology, Government of India. She is the life time member of Computer Society of India, Mumbai.

Dr Prasanta Kumar Dey is a Professor of Operations Management at Aston Business School. He won the Vice Chancellor award for research excellence in 2012. Prior to joining Aston University in 2004, he worked for five years in the University of the West Indies in Barbados as a Director of

graduate project management program and 13 years in Indian Oil Corporation Limited, India as a project executive. He specializes in supply chain management and project management. He has published more than hundred research papers in leading international refereed journals. He has accomplished several research projects in supply chain optimization and project management maturity studies in manufacturing, services and construction globally covering both small and medium-sized enterprises (SMEs) and large sectors. His projects have been funded by Ford Foundation, Research Council UK, British Council, West Midlands Manufacturing Advisory Services, EU and ERDF. His industry clients include Jaguar Land Rover, Rolls Royce, JCB, L'Oreal, NHS, Britons Carpet, Cemex, General Dynamics, Unocal and several organizations in SMEs in the UK and abroad. He has delivered long term executive development programs and facilitated numerous workshops for executives in Barbados Government, the healthcare professionals in Maltese hospital and National Health Services in the UK, the project executives in JCB, Jaguar and Land Rover, Atkins and the Country and HR managers in L'Oreal. Dr Dey has developed several decision support systems that include supplier performance evaluation, supply chain performance measurement, sustainability performance framework, risk management and currently engaged in developing decision support systems for optimizing bio-energy (including waste to energy) supply chain design and operations. His work helped numerous SMEs in the developing countries like India, Bangladesh and Thailand to deal with their sustainability issues and challenge. He helps many city councils in the UK and municipalities in India for developing strategies and policies for solid waste management. He is the editor in chief of *International Journal of Energy Sector Management*.

Dr Ambika Prasad Dash is the Senior Faculty and Professor in the area of Finance and Strategy. He earned his PhD from Indian Institute of Management, Ahmedabad, and has been pioneer mentor in the development of power sector and also in the academics since past 25 years in the country. He is author of several books and currently he is serving as Director to the Noida International University, Noida, India.

Professor Devinder Kumar Banwet is Ex. Emeritus Professor of DMS IIT Delhi in the area of Operations & Supply Chain Management and the Fellow of Institution of Engineers (India). He is a graduate mechanical engineer, a Masters in Industrial Engineering and a PhD from I.I.T. Delhi and currently, he is serving as the Vice Chancellor of University of Engineering and Management at Kolkata. His has made significant contribution in publications related to Operations Management. His areas of research interest include Operations Management, Supply Chain and Logistics Management, Project Management, IT-enabled DSS, Industrial Systems Engineering, TQM, Manufacturing Strategy, Technology Management, Materials Management, Facilities Planning, OR Modeling, Telecom Systems and Entrepreneurship Management.

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