REMOVING MANAGEMENT BARRIERS IN IMPLEMENTATION OF INTEGRATED OPERATIONS SOLUTIONS IN INDIAN UPSTREAM COMPANIES

A thesis submitted to the
University of Petroleum and Energy Studies

For the award of
Doctor of Philosophy
in
Management

BY
Rajeev Goyal

May, 2021

SUPERVISOR (s)
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Dr. Sumeet Gupta
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DECLARATION

I declare that the thesis entitled "Removing Management Barriers in Implementation of Integrated Operations Solutions in Indian Upstream Companies" has been prepared by me under the guidance of my Supervisor Dr. S. K. Pokhriyal, Professor of Oil and Gas, Energy Management, School of Business, University of Petroleum and Energy Studies, Co-Supervisor Dr. Sumeet Gupta and the external Supervisor Dr. R.K. Mallick, Global Consultant-Oil & Gas. No part of this thesis has been formed as the basis for the award of any degree or fellowship previously.

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CERTIFICATE

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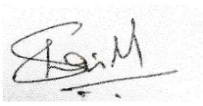

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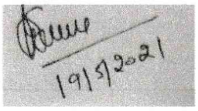

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ABSTRACT

Industry 4.0 or Digital Transformation [117] has been the industry buzz word for more than a decade but adoption of Integrated Operations is a long drawn process in Indian Upstream Oil & Gas sector [81] due to numerous management barriers [64]. Every company wants to implement it but finds it difficult to pinpoint the exact reasons for delay in implementation of such digital initiatives. The researcher decides to narrow down the barriers in his study on 'Removing Management Barriers in Implementation of Integrated Operations Solutions in Indian Upstream Companies'. The slow pace of adoption results in delayed production increase in the Indian upstream Oil & Gas sector to the tune of US $ 675 million over a decade. The researcher formulates his Research problem as to "Identify management barriers for implementation of a customized Integrated Operations solutions for capturing the potential opportunity loss for Indian upstream companies".

The theoretical underpinning selected was Value-based adoption model [95] to measure intentions of adopting Integrated Operations technology by the perceived value and risks, depending upon the management decision process undertaken by various upstream companies in India. The Theoretical Gap was in not knowing the exact management barriers that are dominant for Indian upstream companies which ultimately impact the belief and assumptions in decision makers' minds..

Aligning the Theoretical Gap with the Research Problem, the researcher states the Research Objectives as (1) To identify the management decision-making barriers for implementation of Integrated Operations solutions in Indian upstream companies (2) To identify the efficiency parameters for the implementation of Integrated Operations solutions in Indian upstream companies

(3) To suggest a customized solution and organisation readiness with emphasis on optimistic, pessimistic, and innovative approach for implementation of Integrated Operations solutions for Indian upstream companies.

The researcher uses a combination of exploratory and analytical approaches to elucidate "how?" the measured variables or barriers can enhance the adoption [102] of Integrated Operations. The researcher adopts "Modified Grounded Theory" [89] and "Confirmatory Factor Analysis" as the appropriate research methods for the above mentioned three Research Objectives.

The output of Research Objective 1, Research Objective 2 and Research Objective 3 provide a comprehensive understanding of the barriers which are slowing down the execution of Integrated Operations by Indian upstream companies. Researcher explains how the conceptual lens framework evolved during the course of research and helped the researcher map these variables at four different stages of research for RO1, RO2 and RO3. Starting from the preparation of a draft list of 18 barriers from the literature survey, the researcher conducted a pilot study by interviewing 10 Integrated Operations experts from National O&G companies and private O&G companies in India for framing the right questions for the survey questionnaire meant for primary data collection. The researcher selected these experts with more than 20 years of experience in execution of Integrated Operations concept [63]. Semi-Structured Interviews were conducted to collect data as it allows the researcher to add a new question or to rephrase the questions as or when the situations demand. The data analysis starts with the survey response data received from 141 respondents followed by final data output verification with another 10 Integrated Operations experts after two years of pilot study.

Research has three stages of data analysis. The first stage of data analysis – for

finding the relevant measured variables and sub-variables for designing the survey questionnaire for the second stage of analysis – to identify the management barriers for execution of Integrated Operations. Last stage of analysis - last round of interview transcripts for validating the output of second stage analysis. The research method followed for the first and last stages of analysis is Modified Grounded theory; and for the second stage, Confirmatory Factor Analysis.

For Research Objective 1, the researcher infers that the (1) IO Education and (2) IO Adoption are the dominant management barrier measured variables with (i) User inclination towards IO (ii) IO learning ability of user (iii) Business Performance improvements with IO technology (iv) User friendliness for using IO technology as the measured sub-variable causing slow management decisions in adoption of Integrated Operations. One of the findings is that the Market Price of IO technology - a measured sub-variable - has the least impact on such decision making. For Research Objective 2, the researcher infers that the measured variables (1) Higher Visibility features (2) Predictive analytics features [72] are significantly important efficiency parameters along with the measured sub-variables (i) IO Real time dashboards (ii) IO Key Performance Indicators (iii) Early corrective actions features (iv) Handheld based software applications, for the effective execution of Integrated Operations solutions. For Research OBjective 3, the researcher infers that IO Optimism and IO Innovation are the dominant measured variables for successful implementation [10] of the customised IO solution.

The researcher enriches the base model – Value-based (technology) adoption model [95] by adding the dominant measured variables which would help Indian upstream companies and other industry researchers to unlock the untapped potential of Integrated Operations in India upstream sector.

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First and foremost, big thanks to the almighty “Vaishno Devi Maa” for all the blessings, for providing this opportunity and the ability to conduct the research work. I am extremely grateful to my Supervisor Dr. S. K. Pokhriyal, Co-Supervisor Dr. Sumeet Gupta and External Supervisor Dr. Ravi Kumar Mallick for providing all the motivation and guidance during this research work. Without their support, it was impossible for me to carry out this quality of work along with my challenging high profile jobs requiring me to travel 60-70% of the time. I did have some anxious moments during the research period when it was taking a back seat because of being overwhelmed with too many things on my to-do list in professional and personal life. However, constant motivation and clear guidance from Dr. S.K. Pokhriyal helped me overcome all such barriers.

Acknowledging contribution from the IO / DOF community members in India without which this research would not have been possible. However, the majority of the respondents requested anonymity considering the sensitive nature of this research related to investment decisions by the Upstream companies in India.

Many thanks to my wife, two grown up children and my father who were always there to support me with complete understanding of my challenges. Without their sacrifices on the personal quality time at home / vacations, I would not have been able to complete this research in time.

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get a better perspective on the Research Methodology in my research context – Many thanks for your valuable tips.

Many thanks to Dr. Prerna Gaur – my college batchmate currently Director of East Campus of Netaji Subhashchandra College of Engineering, Dwarka, New Delhi who had initially planted the thought of pursuing this research back in 2012. And Dr. Parag Diwan – who had initially encouraged me in February 2013 to apply to UPES. I am also thankful to my cousin Dr. Rakesh Kumar Goyal who kept motivating me at a personal level from time to time during this research.

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LIST OF ABBREVIATIONS

AGFI : Adjusted Goodness-of-Fit Index

BG : British Gas

BP : British Petroleum

CA : Cronbach's alpha index

CAD / CAM : Computer aided design / Computer aided manufacturing

CFA : Confirmatory Factor Analysis

CDO : Chief Digital Officer

CDTC : Competence destroying Technical Change

CFI : Comparative Fit Index

CIO : Chief Information Officer

CMIN : Chi-square/df

COO : Chief Operating Officer

CO2 e : CO2 equivalent

CTO : Chief Technology Officer

DCS : Distributed Control System

d_G : the geodesic distance to compute this discrepancy in model fit

DGH : Directorate General of Hydrocarbons

DoF : Digital Oil Field

DT : Digital Transformation

d_ULS : the squared Euclidean distance to compute this discrepancy in model fit

D.V. : Dependent variables

E&P : Exploration and production

ERP : Enterprise Resource Planning

FoF : BP's Field of Future, an Integrated Operations initiative

GFI : Goodness-of-fit Index

GTA : Grounded theory approach

HOEC : Hindustan Oil Exploration Company

HMSAM : The hedonic-motivation system adoption model (2013)

i-Field : Chevron's Integrated Operations initiative

IIF : Integrated Information Framework

IIOT : Industrial Internet of Things

Ind 4.0 : Industry 4.0 / Industries 4.0

IO : Integrated Operations

IoT : Internet of Things

IOC : Integrated Operations Centre or International Oil companies

IP : Intellectual Property

IT : Information Technology

I.V. : Independent variables

KPI : Key Performance Indicator

KPIs : Key Performance Indicators

LOB : Line of business

M-GTA : Modified Grounded Theory Approach

MIT : Massachusetts Institute of Technology

mboed : Million barrels of oil equivalent

NELP : New Exploration Licensing Policy

NFI : Normed fit index

NPV : Net Present Value

NTNU : The Norwegian University of Science & Technology

O&G : Oil and gas

O&M : Operations and maintenance

OECD : Organisation for Economic Cooperation and Development

OLF : Oljeindutriens Landsforening (Norwegian Oil & Gas Association)

ONGC : Oil & Natural Gas Corporation

OSC : Operations Service Centre

PCFI : Parsimony Normed Fit Index

PhD : Doctor of Philosophy

PLC : Programmable Logic Controller

R&D : Research & Development

RFI : Relative fit index

RMSEA : Root Mean Square Error of Approximation

RO : Research Objective

ROIC : Return on invested capital

RP : Research Problem

RQ : Research Question

RTOC : Real Time drilling Operations Centre

SCADA: Supervisory Control & Data Acquisition

Smart Fields : Shell's Integrated Operations initiative

SPE : Society of Petroleum Engineers

SQL db : Structured Query Language database

SRMR : Standardized root mean residual

STDEV: Standard Deviation

TAM : Technology Acceptance Model

The Field of the Future : BP's Integrated Operations initiative

TLI : Tucker-Lewis Index

TPB : Theory of planned behaviour (technology specific)

TRA : Technology readiness assessment

TRAM : Technology Readiness Acceptance Model

UAE : United Arab Emirates

UPES : University of Petroleum & Energy Studies

VAM : Value-based Adoption Model

WEF : World Economic Forum

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Chapter 1
INTRODUCTION AND INTEGRATED OPERATIONS OVERVIEW

1.1 RESEARCH MOTIVATION

Scholar got the motivation to undertake this research while he was interacting with various c-level executives of upstream Oil & Gas companies globally and in India, who had been facing various barriers in order to adopt Digital Transformation initiatives with focus on improving the revenue or lowering the costs. These upstream players entered India with NELP (New Exploration Licensing Policy) implementation after the 1990s with sole focus on bringing in new technology partners to expedite new findings and increase in O&G production. Scholar has been experiencing these barriers as an Operations expert while working for the upstream companies in India for 20 years until 2009, and as a Global Digital Transformation Industry Expert since 2010. Indian companies have not been spending in spite of all the business benefits available to organizations with Integrated Operations solutions.

Since the early 1990s, all the major upstream companies have been focusing on improving their operational excellence. They did take lead on this right from the time when the first digital wave in India was prompting Upstream Oil and Gas companies adoption of digital technologies like Supervisory Control Data

Acquisition (SCADA), Programmable Logic Controller (PLC), Distributed Control System (DCS) as early as the 1980s with clear focus on better field operations control, safety improvements, reservoir potential and operational efficiency improvements. But the upstream companies in India somehow could not take the real advantage of this second digital oilfield [36] wave in the 21st century by resorting to analytics and data integration in a significant manner. For instance, a single drilling rig at an oilfield [155] can produce terabytes of information consistently, however just a little part of it is utilized for decision-making. Adopting analytics based technology solutions linked with Industrial Internet of Things (IIOT) sensors [137] / devices on top of DCS / ERP / other software applications allow Upstream companies to become less reactive and rather more proactive for increasing the overall productivity of the organisation.

In this second wave of IO / DoF [139], Indian upstream companies have not yet taken full advantage of using data integration and analytics in a meaningful way. While conducting the survey In India, Cairn Energy is the leading player in the Digital Oilfield initiative; however most of the focus is towards incremental operational performance improvements [7] with the use of digital technologies. Indian upstream companies were still struggling on the implementation side due to unidentified management barriers [64] faced by stakeholders including business partners.

1.2 OVERVIEW OF THE RESEARCH

The researcher shares the reason for the motivation of this research and gives out an outline of the digital developments occurring in the Oil and Gas industry around the world in Chapter 1 – "Introduction & Integrated Operations overview". The researcher emphasizes on the importance of Integrated Operations initiatives and how major upstream companies globally have unlocked the potential business value through Integrated Operations initiatives in developed countries, and how Indian upstream companies can embrace this digital transformation [117] with identification of the business challenges.

In Chapter 2 – "Review of existing literature", the researcher explains the extent to which Indian upstream companies have taken (in other words 'not taken') the advantage of Integrated Operations as per the available literature. The researcher provides themewise funneling of Research Gaps and high level Research Parameters (draft measured variables). The researcher finds out in the Literature Review that the Modified Grounded Theory has never been applied by researchers in Indian upstream sector.

In Chapter 3 – "Theoretical underpinning selection and theoretical gap", the researcher narrows down on the Value-based adoption (VAM) model as the appropriate theory to explain the Integrated Operations adoption barriers. Organizations/ researchers have been applying this value-based adoption theory [88] with clear beliefs and acceptance criteria; however it has never been applied by any researcher for Indian upstream sector. The researcher explains with a conceptual lens framework across all the four stages of research, how these theoretical variables are related to each other.

The researcher aligns the Theoretical Gap with the business problem, states the Research Problem, Research Questions and three Research Objectives in Chapter 4. The Title of the Research is finalized as "Proposing the Research Problem, questions & objectives".

In Chapter 5, the researcher describes the Research Process, Research Design, Research Methodology for the study. The researcher selects various Indian companies for data collection on all three Research Objectives and does it with a pilot study first with few Integrated Operations experts with use of Modified Grounded Theory research tool, followed by designing the survey questionnaire which is sent out to 400 participants. The researcher explains in subsequent chapters how the conceptual lens framework evolved during the course of research and helped the researcher map these variables at four different stages of research for RO1, RO2 and RO3. The researcher explains the measured variables and sub-variables for all three Research Objectives. Data is collected through survey questionnaires and followed by final output data verification through a few Integrated Operations experts using Modified Grounded Theory again for Research Objective 1, Research Objective 2 and Research Objective 3.

The researcher carries out the Research data analysis in Chapter 6 for Research Objective 1 - identification of the barriers for implementation of Integrated Operations solutions in Indian upstream companies. The relevant variables are identified using Modified Grounded Theory and Confirmatory Factor Analysis. The output of the first step becomes the input to the next step and continues until the last subsequent stage.

In Chapter 7 – The Research Objective 2 is answered by identifying the efficiency parameters for the implementation of Integrated Operations solutions in Indian upstream companies. The relevant variables are identified using Modified Grounded Theory and Confirmatory Factor Analysis.

In Chapter 8 – The Research Objective 3 is answered by identifying Customized Integrated Operations Solutions and the readiness. The relevant variables are identified using Modified Grounded Theory and Confirmatory Factor Analysis.

Chapter 9 - summarises the findings and deals with strategies to enhance the adoption of Integrated Operations in India by upstream companies.. This chapter answers the Research Problem.

Chapter 10 – describes the influence on Indian upstream industry with the identified dominant barriers through this research and how it enriches the Value-based Adoption model with the answers gathered through Research Objective 1, 2 & 3. The contribution to the industry is a validated model that can enhance the adoption of Integrated Operations.

Chapter 11 - The researcher furnishes the Limitations and future scope of research in this chapter.

1.3 DIGITAL TRENDS

Industry 4.0 is the buzzword of the decade which is a big leap from 3.0 that was focused on data aggregation from DCS (Distributed Control System), PLC (Programmable Logic Controller), sensors or any data historian or point software systems to help at field / site location level. All the industry sectors have been taking some Industry 4.0 initiative to improve revenue and cost aspects of business with realtime decision making possible with Integrated Operations (IO) / Digital Transformation (DT) implementation across the enterprise.

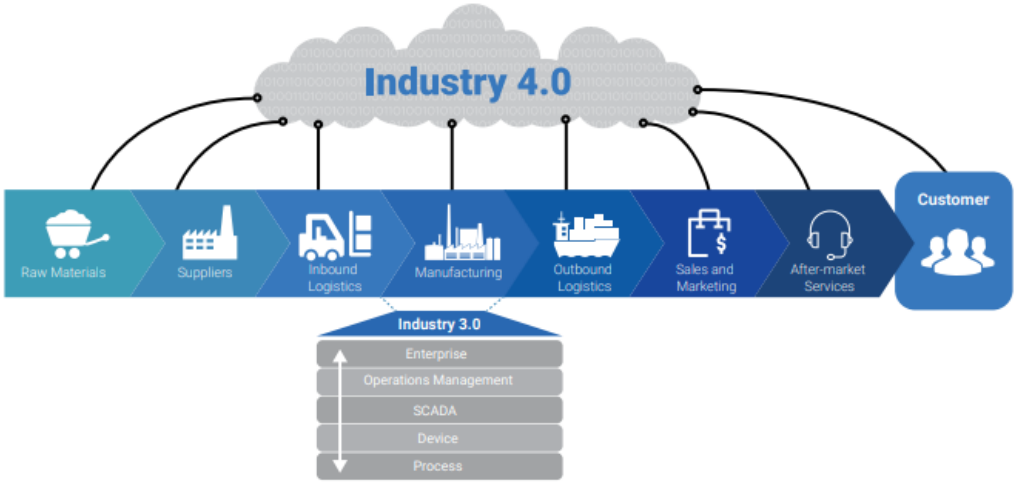
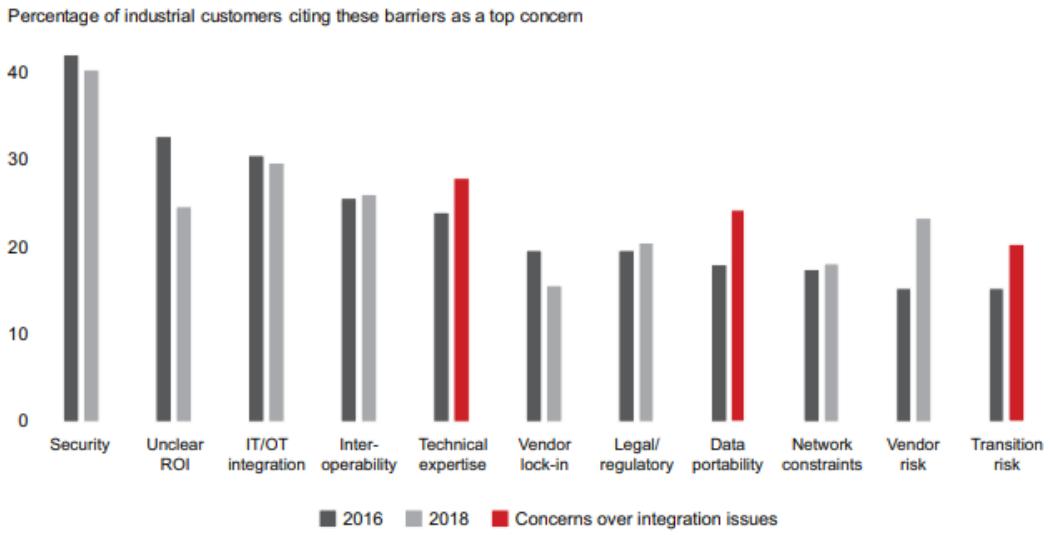


Fig 1.1 : Industries 4.0 concept, Source : Accenture [159]

As compared to other industrial sectors, the upstream Oil & Gas industry with big dollars is supposed to embrace digital transformation [117] in a revolutionary manner. All the latest IT technologies like big data [84], cloud computing, and advanced analytics which are in demand and have good potential for the Oil and Gas industry. Distributed computing can give savvy and constant information to the executives which improve business adequacy by coordinating every one of the storehouses of corporate business data. Large information and examination can help manage large chunks of information by getting intelligent insight with

meaningful information for decision makers. All the structured and unstructured data from multiple sources can be analysed with inbuilt innovative data models. Mobile devices provide that extra dose of technology enablement where information is available on the go for all the stakeholders thus making it truly a real time business environment. Customer behaviour and customer relationships are managed with social channels in a quick, direct and cheap manner. Industrial Internet of Things (IIoT) [112] is easily available with cheaper and affordable sensors [137] which are helping gather all the real time information with vast volumes of data that can be accessed.



Bain IoT customer survey, 2016 (n=533, industrial customers=182); Bain IoT customer survey, 2018 (n=627, industrial customers=329)

Notes: Industrial segments include discrete manufacturing, process industries, production sites, building, infrastructure and utilities

Fig 1.2 : Integrated Operations customers' concerns in the past two years; Source : Bain & Company [158]

1.4 GLOBAL INTEGRATED OPERATIONS SCENARIO

The Oil & Gas industry has assumed a significant part in changing the world monetarily since the time the mechanical unrest began. Be that as it may, in 21st century, with a wide range of business issues going from scaled down benefit because of falling rough costs, successive financial plan and timetable invades to difficulties in finding good talent or Information Technology (IT) challenges like cyber attacks affecting the Oil and Gas industry, Integrated Operations or Digital Transformation [159] is the only new practical solution to tackle such business challenges.

Integrated Operation (IO) is a term which originated and was first used in Norway around 2005 by Statoil, the Norwegian Upstream company. IO meant for integrating data from various sources including the sensors, Programmable Logic Controller (PLC) and Distributed Control System (DCS) and various software and data historians / systems. Later other terms like Digital Oilfield (DoF)[139] / Digital Transformation (DT) [117] / Industrial Internet of Things (IIOT) [22] were introduced with similar objectives. Therefore, these terms are used interchangeably in this research from time to time. In Upstream globally, many versions of Integrated Operations or Digital Oilfields like i-Field [72], Smart Fields [11], The Field of the Future [43] etc had been attempted by various international companies like Chevron, Shell, BP etc over the years. Following are the focus areas or synonyms typically under the Digital Transformation / Integrated Operations umbrella.

- Digital Oilfield (DoF)
- Industries 4.0
- Digital Transformation (DT)

- Integrated Operations (IO)
- Internet of things (IOT)
- Remote Operations Centre
- Smart Dashboards
- Big Data Analytics
- Cloud computing
- Integrated framework
- Artificial Intelligence
- Intelligent alert / event mgmt
- Asset Management
- Mobile devices
- Edge connectivity
- Sensors / Field data capture
- Wearable technology
- Collaboration tools
- ERP / SCADA
- Cyber security
- Open data standards / connectors
- 3D modelling
- Connected Worker

In layman's words, Integrated operations (IO) refers to new work processes facilitated by new information and communication technology solutions with efficient human involvement, focused on higher operating efficiency in oil and gas exploration and production (E&P). Proven Integrated Operations solutions like Integrated Operations Centre (IOC) have been available globally for more than a decade focusing on improving various business efficiency parameters as

shown in the IOC solution at conceptual level in Fig 1.3. IOC provides an Integrated Information Framework (IIF) connecting decision makers to existing software applications and the databases [127] through seamless work processes, by having all data flow through instrumented, interconnected and intelligent systems.

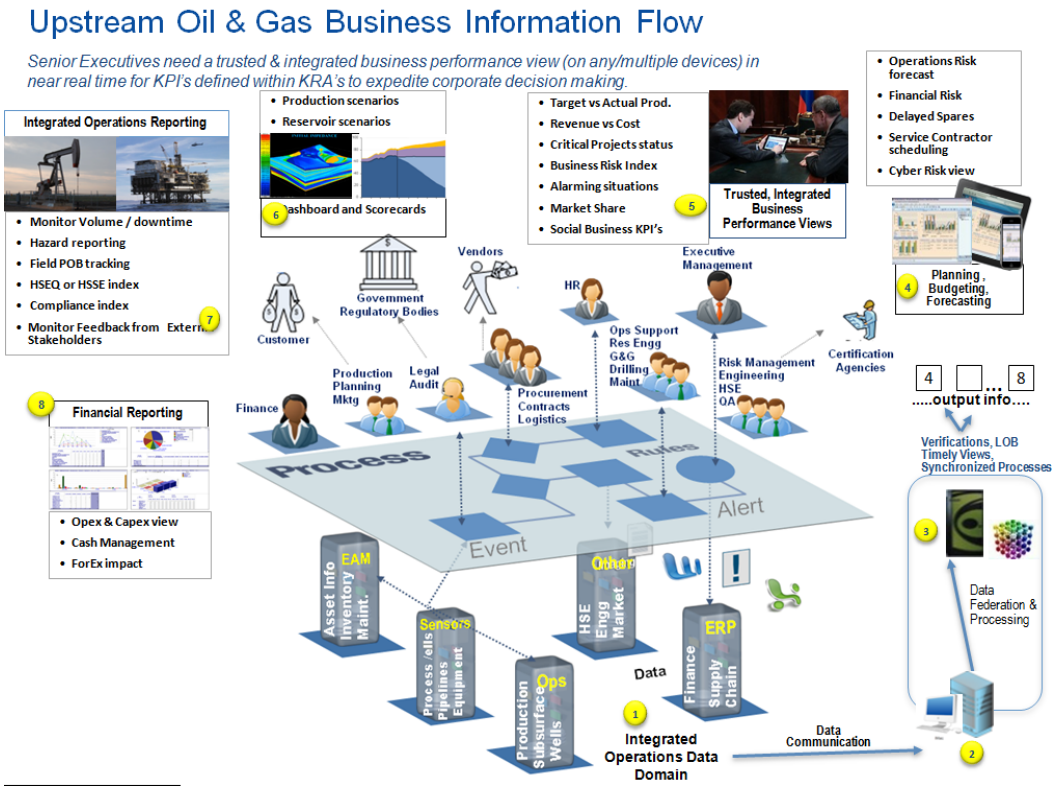


Fig 1.3 : Integrated Business Information Framework using IOC [80]

Integrated Operations (IO) gives private and public area associations an uncommon chance to drive new wellsprings of significant worth — including the possibility to computerize up to 50 percent of manual cycles.

The Integrated Operations has entered all the major Upstream companies worldwide which can be estimated from the investments made in IO / DT by

these companies. It has helped organisations connect people, processes and assets in a seamless manner, for expediting decision making dependent on continuous/close to constant perspective on business tasks. Investigating every one of these advances in a creative way would help receive multifold rewards and that too dramatically, when contrasted with their viability as independent separate sending. This would positively affect the organizations with another degree of associated and savvy Oil and Gas tasks. As well as improving the operational productivity, such a digitization program would permit organizations to serve their clients better. Innovation choices like IIoT and cell phones are arising as top advanced center zones for Oil and Gas organizations, according to a new Accenture study (see Fig 1.4), huge information [30] and examination [17].

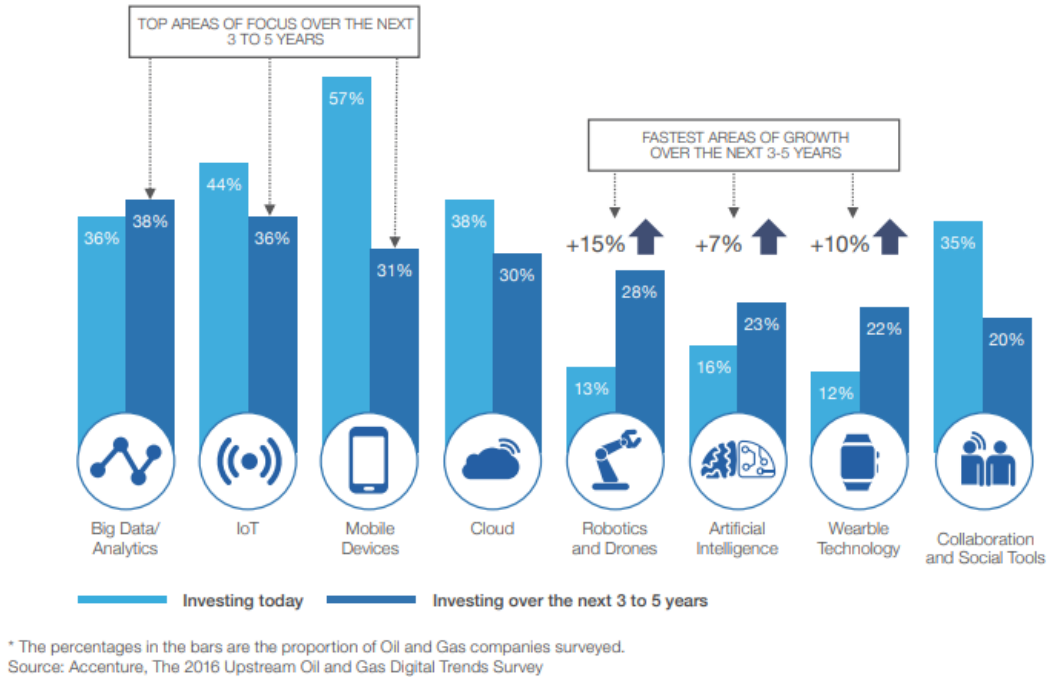


Fig 1.4 : Investments in Digital Technologies, Source : Accenture [51]

While Integrated Operations could be a wellspring of positive change, there are various provokes that should be defeated to understand its maximum capacity for both business and society. This dramatic upscaling of the worldwide data stream has made new difficulties around network safety [93] and information security across all organizations, all areas. This is making different difficulties like changing client assumptions, social change, obsolete guidelines, and ability deficiencies – to give some examples.

1.5 NEED FOR INTEGRATED OPERATIONS

Being in the industry for the last 25 years both as a business user and then as the solution provider, scholar had been observing the industry developments and barriers in this area of Integrated Operations. Already proven globally, IO is the technological leap that is allowing upstream companies to become more proactive and less reactive in managing their business. As per the literature survey, adoption of Integrated Operations is one of the major factors for running an efficient, safer and profitable business based on quicker decisions making with the help of real time information resulting from IO. Many experts predict that in excess of 20 billion associated gadgets will be there by 2020 from IIOT viewpoint [33]. Upstream organizations will exploit this innovation development to improve the stakeholder's user experience by getting all the information on ongoing operations remotely. Various stakeholders in different departments, be it Operations or Maintenance or Reservoir or Drilling or Sub surface or Supply Chain, will see the same universal truth of operations from their own domain perspective. All the stakeholders will be able to make faster decisions with Integrated Operations based solutions instead of spending extra time on

managing the data coming from siloed historians and software requiring manual intervention.

According to at first sight data accessible through writing review, obstructions to IO execution incorporate administrative systems that are attempting to adjust to another time of information sharing along esteem chains; an absence of open information combination guidelines coming from different info sources; IT requirements to share data across the association and partners; and the IT keen labor challenge [85] to supplant a maturing labor force. Also, a significant number of some senior industry pioneers have not yet realigned their attitude to accept the force of advanced potential. This is especially so when advanced is considered at odds with profoundly dug-in security worries in upstream industry, which can be set off, for instance, by conversation of automated resources. Underlying boundaries coming up from such traditionalist methodology are another sluggish speed breaker to advanced change [159], while the business is battling by not taking a more test, "fail-fast" approach because of the worry identified with potential results of such change by the executives.

1.6 MANAGEMENT BARRIERS IN INTEGRATED OPERATIONS

A Management Barrier is a factor causing delay in implementation of a management decision causing loss of time or revenue to the organisation. Oil and Gas firms face significant boundaries to harvest the maximum potential of digital initiatives. According to writing, from an overall administration point of view, there are six regular administration hindrances [64] to a successful authoritative change - 1) Cultural Barriers, 2) Improper Communication, 3) Inadequate Strategic Direction, 4) Lack of Consistency, 5) Lack of Perceived Ownership and 6) Resistance to change. From the point of view of implementation of the

Integrated Operations, following are the key inhibitors for initiating endeavors to beat the difficulties in opening the worth of digitalization for industry and society.

i) *Regulatory Guidelines* : Data security guidelines are outdated and not, at this point, fit the modern necessities. Licensed innovation arrangement systems have not yet accepted this new climate of information sharing as part of integrated value chains, where companies feel secure and confident, by sharing their data without compromising any individual company's business value.

ii) *Lack of standardization* : Even after so many decades of IT development, industrial data coming from various sensors [137] is still not standardized. It remains without complete integration across various platforms. On top of that, the ownership of data between various stakeholders, operators, suppliers and contractors is not very clear. There is no clarity on standardization of data sharing protocols for the accessible data, with too complex and too obscuring without any clear insights.

iii) *Environment :* For digitalization to pass on the entirety of its normal benefits, it ought to be facilitated in an industry from one completion to the furthest edge. For Oil and Gas, operational viability, by and large productivity, and prosperity should be expanded if distinctive existing IT systems, gear with sensors, etc are granting required data and sorting out some way to one another. As indicated by the advancing circumstance, that "top layer" of information sharing has not totally sorted it out.

iv) *Culture and mentality :* Oil and Gas company are very people driven. Thusly – and in light of the fact that a few CEOs are wary about cutting

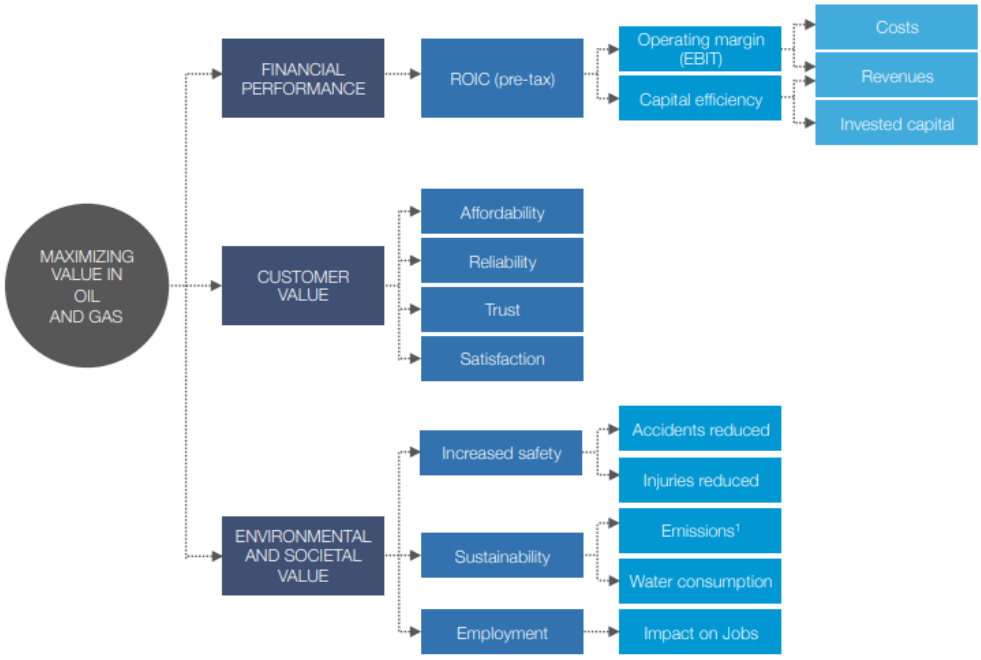
edge – pioneers are not zeroing in on opportunities to motorize. In view of other mechanical developments, many isolated little systems and IT courses of action have jumped up with their case to deal with the local issues; yet these are all in all the manual workarounds and careful advancement. Also, the business is typically inadequate to take a more prominent measure of an exploratory, "failfast" approach because of its moderate nature and stress over the potential results of progress.

v) *Ability :* Innovation and Technology often crash and burn – not through a shortfall of adventure or deficiency inside the development, yet through a lack of social change. Need vital for the future to be modernized, experts are to attract themselves with current troubles and plan for that tomorrow starting from today. Before the "gigantic group change", energetic experts ought to be successfully moved into the business. Regardless, twenty to thirty year old, projected to build up by far most of the workforce by the mid 2020s, at the present time favor working in organizations seen to be "greener" than Oil and Gas.

vi) *Cyber data protection :* The size of cyberattacks [93] by programmers, crooks and governments keeps on developing. Organizations and their resources will be at increased danger of assault as the Oil and Gas digital climate extends to incorporate associated figuring gadgets, work force, hardware framework, applications, administrations, broadcast communications frameworks, and the entirety of sent and additionally put away data.

1.7 POTENTIAL VALUE OF INTEGRATED OPERATIONS (IO)

Invention of the IO solutions was focused on developing the customized solutions for various Upstream stakeholders who can take quicker decisions with an intelligent real time (or near real time) based system with online monitoring of various work processes with potential to impact the revenue and cost performance of the organization. As per the World Economic Forum (WEF) [159], IO adoption is increasing, and this new era of automation will add significant value to upstream globally.



Note: ROIC = Return on invested capital

Fig 1.5 : Maximizing Value in Oil and Gas; Source World Economic Forum [159]

- To evaluate the value potential for digitalization through Integrated Operations in the Oil and Gas area to open advantages for the business, over

the course of the following decade (2016-2025), key discoveries [159] from World Economic Forum investigation incorporate the accompanying:

- Digital change in the Oil and Gas industry could open roughly $1.6 trillion of significant worth for the business, its clients and more extensive society.

- This all out assessed esteem from digitalization can additionally increment to $2.5 trillion if existing hierarchical/operational limitations are loose, and the effect of "cutting edge" advancements, like intellectual registering, is thought of (for which there are insufficient realities accessible to make an authoritative worth evaluation right now).

- Digital Transformation [159] can possibly make more than $1 trillion of business an incentive for upstream Oil and Gas firms.

- Digital Transformation could without much of a stretch make benefits worth about $640 billion for more extensive society (subtleties in the figure underneath)

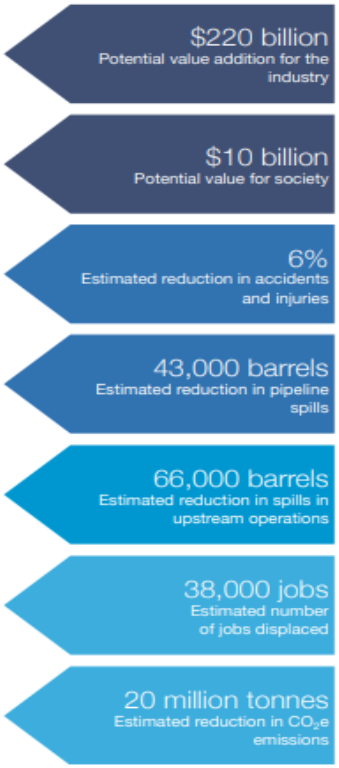


Fig 1.6 : Value at stake: New Era of Automation (All figures cumulative, 2016-2025), source : World Economic Forum [159]

1.8 INTEGRATED OPERATIONS SCENARIO IN INDIA

Organisational requirement for Digital Transformation [117] in the upstream Oil and Gas industry has consistently been there even in the first advanced wave for quite a while, when companies like ONGC and Oil India had started adopting digital technologies like Supervisory Control Data Acquisition (SCADA), Programmable Logic Controller (PLC), Distributed Control System (DCS) etc as early as in the 1980s. Their focus was on better field operations control, better understanding of reservoirs and improving safety, boosting production potential

and marginal efficiencies at oil fields. However, all these upstream companies in India could not take advantage of this second wave of digital oilfield [151] initiatives in the 21st century which was based on use of analytics [17] and data integration in a meaningful way. An easy example of a single drilling rig, which would daily be able to produce terabytes of information, however just a little part of this information is really used to make real time decisions. Adoption of analytics [153] over and above Industrial Internet of Things (IIOT) sensors [52] or connected devices in addition to DCS or any other siloed software applications allows Upstream companies to become less reactive and more proactive for optimizing the overall productivity of an organisation.

In this second wave of IO / DoF, Indian upstream companies have not yet taken full advantage of utilising data integration and analytics tools in a much more meaningful way. As per the research survey conducted, Cairn Energy has been one of the leaders in Digital Oilfield space in India but the majority of the effort had been towards steady execution upgrades just through particular utilization of computerized advancements. Indian upstream companies were still struggling on the implementation side due to unidentified management barriers faced by stakeholders including business partners.

1.9 IMPLEMENTATION OF FEW LAYERS OF INTEGRATED OPERATIONS

Integrating systems and streamlining the flow of data from field to boardroom with various stages of IO, shown in Fig 1.7, is the only solution for removing the management barriers [64] for Smarter Oil & Gas companies. High level solution approach is shown in Fig 1.8 below.

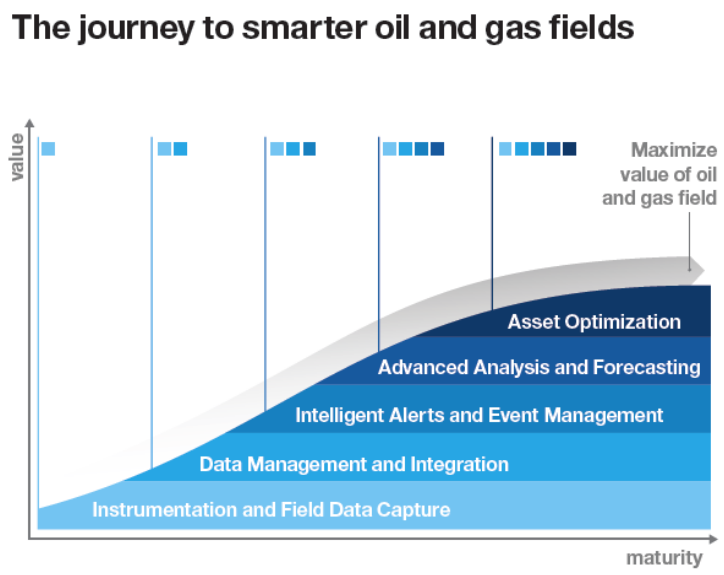


Fig 1.7 : Integrated Operations (IO); Source : IBM [80]

Based on the Integrated Operations activities in developed countries, it was observed that various oil & gas Indian companies are unable to carry out execution of Integrated Operations. With extensive literature survey on various essential steps needed to become an Integrated Upstream company, based on the Purdue model [161], it was a clear conclusion that Integrated Operations will

help Indian companies overcome management barriers with solutions like IOC etc.

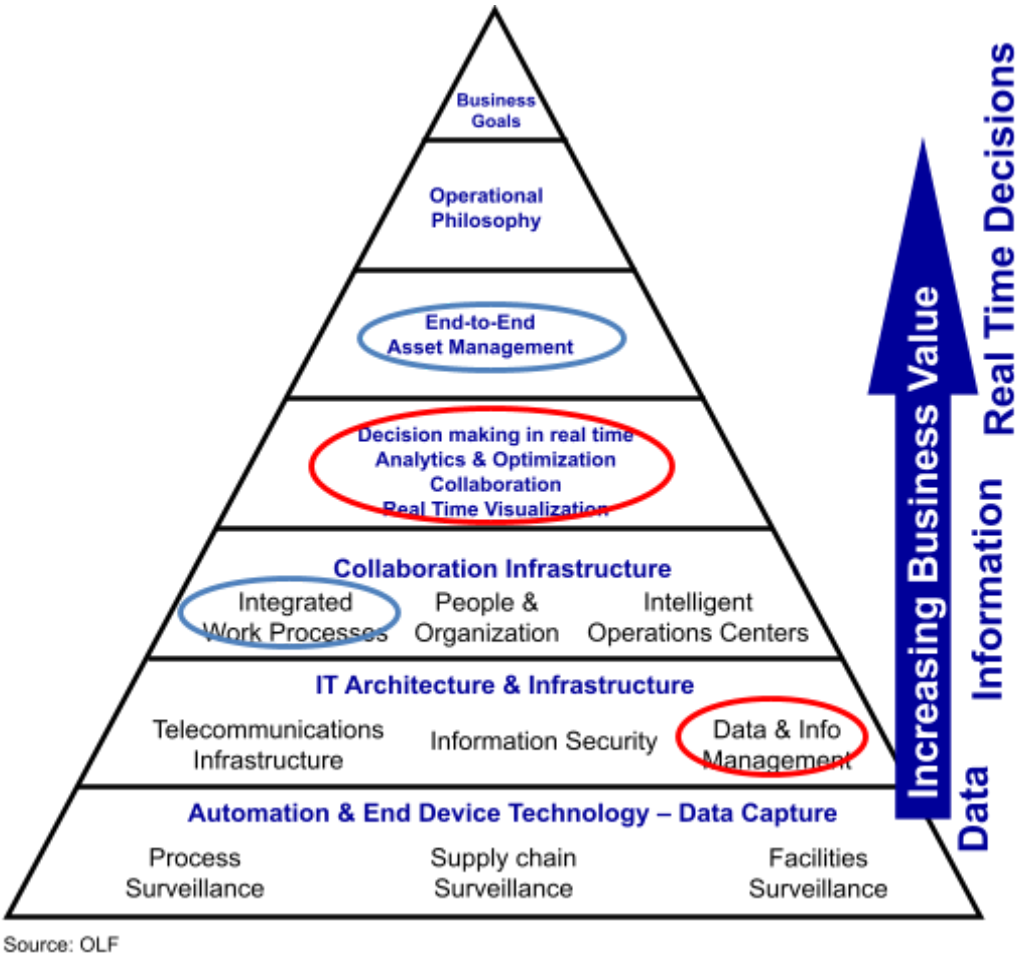


Fig 1.8 : Integrated Operations layers based on Purdue reference model; as per OLF [116]

1.10 INTEGRATED OPERATIONS STRATEGY BY MAJOR INDIAN UPSTREAM COMPANIES

Gerschenkron [59] underlined the requirement for mechanical advancements for encouraging financial improvement in nations. He expressed that non-industrial nations will be working with second rate advances and they duplicate trend setting innovations from created nations to find monetary turn of events. The requirement for financial improvement works with crosscountry innovation moves. [65] [132]

All the Indian operating companies in upstream oil & gas industry are running their business across production, drilling and exploration value chain with manual or automated business processes & systems while dealing with large amounts of complex data coming from various field instruments, plant DCS system, plant and enterprise level data servers and software applications apart from manual data in different data formats. However, integrating business processes with technology solutions has many management barriers [64] not yet identified by the stakeholders in India. execution of Integrated Operations solutions like IOC will help expedite business decisions with a clear focus on the company's objectives like production revenue, production & development cost and many other efficiency parameters.

Management barriers could be evident for Indian upstream companies with examples like – working over a sick well in the Oil & Gas field takes on an average one year due to various management barriers in decision making and deployment of services. Management barriers cause upstream companies long lead time and high inventory of spares leading to business delays hitting the revenue and the cost all the time.

With any remaining capital concentrated Indian enterprises like aeronautics, auto and downstream processing plants and so on, organizations changing their working plans of action by accepting computerized innovations, the chance for the upstream organizations in India to use the groundbreaking effect of Integrated Operations has gotten more clear. Another reason for embracing IO is how global Upstream companies have been improving their topline and bottom line business performance in spite of the worst downturn witnessed by the upstream industry, driven by a supply‐side disruption and fall in crude oil prices compared to June 2014 levels. Indian upstream companies have no choice but to follow the successful global trend.

1.11 IDENTIFICATION OF THE BUSINESS PROBLEM

Objective of this research is to analyze the management decision‐making barriers for execution of Integrated Operations solutions, in spite of available proven solutions like IOC, in Indian upstream companies based on Factor Analysis with the objective to expedite the decision making on IO investments resulting in improved organizational business outcomes.

Business Problem : Remove Management Barriers in implementation of Integrated Operations solutions in Indian upstream companies which is leading to opportunity loss.

Chapter 2

REVIEW OF EXISTING LITERATURE

2.1 LITERATURE REVIEW ON INNOVATION

“Innovation”, the popular expression stylish today, is seen as a panacea for all corporate infirmities [125]. Development works with change, extension and development. Innovation is the principal driver for Idea hatching and therefore new item improvement. Innovation works with items and additionally measures upgrades and in this way improves consumer loyalty [83]. Innovation [140] helps different organizations for broadening and business development. Development helps in investigating the neglected conceivable outcomes and gives the existence cycle benefits to the items by joining progressed expected highlights which are needed to react rapidly to the changing industry climate. Improve or Die is the "Corporate Mantra" trailed by business elements today. Innovations – in items, administrations or cycles pull in ventures and increment ROI to investors. Innovation makes profitability or effectiveness gain to the organizations independent of the ventures they work [163]. Innovation is the establishment column or the "Principle Engine" for monetary development in the always advancing worldwide market. Innovation just empowers organizations to upgrade the adequacy of the business. Development helps tackle items out of date quality issues and accordingly increment market income. Development likewise helps increment the item portfolio for the clients. To put it plainly, without development, organizations can't accomplish a serious edge in the

present exceptionally aggressive business situation – organizations that can't advance are destined to become disappointments [87]

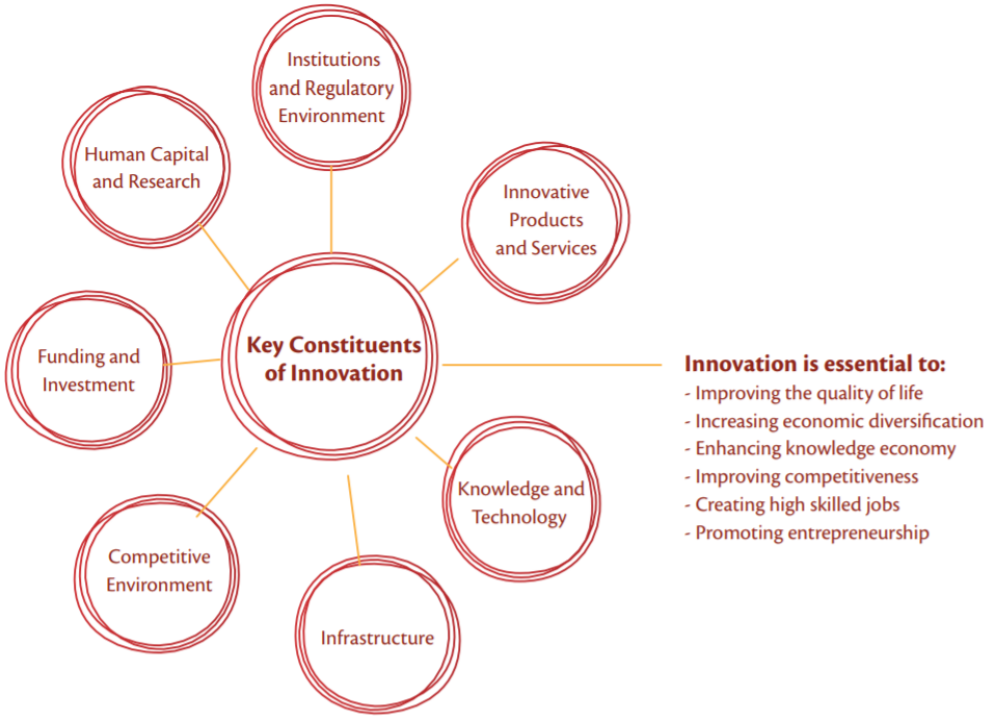


Fig 2.1 : Key constituents of Innovation [140]

Innovation / Advancement is characterized as "the presentation of something new or a groundbreaking thought, strategy or a gadget" (Webster, 2017 word reference). Wikipedia characterizes Innovation as something "Unique" or "New" to a specific market. Innovation makes the current arrangement more successful, or it can bring about something many refer to as an "advancement item" in a specific culture or market. OECD depicts development as carrying out an absolutely new item/administration or an item/administration with critical upgrades or it tends to be another technique or an administration framework which can be presented and executed in the business to improve the profitability or organization proficiency. In light of the level of Originality or Newness of

Innovation, it very well may be "New to the Firm, New to the market or New to the world" [115]. As indicated by the Business Dictionary [24], Innovation is the change of an Idea or Invention to an item or administration which makes an incentive for the client. The thought must be to such an extent that it tends to be copied in a simple way and can fulfill the requirement(s) of the market at a moderate expense. Innovation is the making of another item, interaction or extremist change that makes abundance or social government assistance [154]. Development is "crisp reasoning that makes esteem" [99]. It's tied in with presenting something new. There is no particular basis to settle on development. The Only prerequisite to order something as inventive is that it ought to perform better compared to the current one. Development is an emotional idea [105]. Pulling together or Repositioning the old in another manner is likewise development. Innovation isn't just about Innovation advances yet additionally to make items/measures less difficult [45].

Innovation and Invention are the terms which are used interchangeably in today's environment. In fact, Innovation and Invention are different [157]. Innovation is not a fancy synonym for Invention. "Invention" – the word as such has almost become extinct from business dictionaries nowadays. Innovation is the commercialization of Invention. Invention is creating something new, which has never existed before – a product, process or service. "Innovation" is all about finding a "Fit" between "Customer need" and "Invention"[57]. Innovation is about putting invention to use in a practical sense [84]. An invention which has no practical significance is of no use in commercial terms. Many "Successful Inventions" are "Innovation failures" [23]. Most of the innovations are enhancements to existing products or processes or services by implementing a single or combination of inventions. "Invention" to "Successful Innovation" requires a combination of thorough knowledge of consumer behavior, marketing

skills, management support and ample resources [66]. Herbert [74] defines innovation as an art of manipulating an invention to sell it to the real world market.

Lopez [97] breaks down innovation into four types based on "Newness" of the Technology and the "Market" where the companies operate.

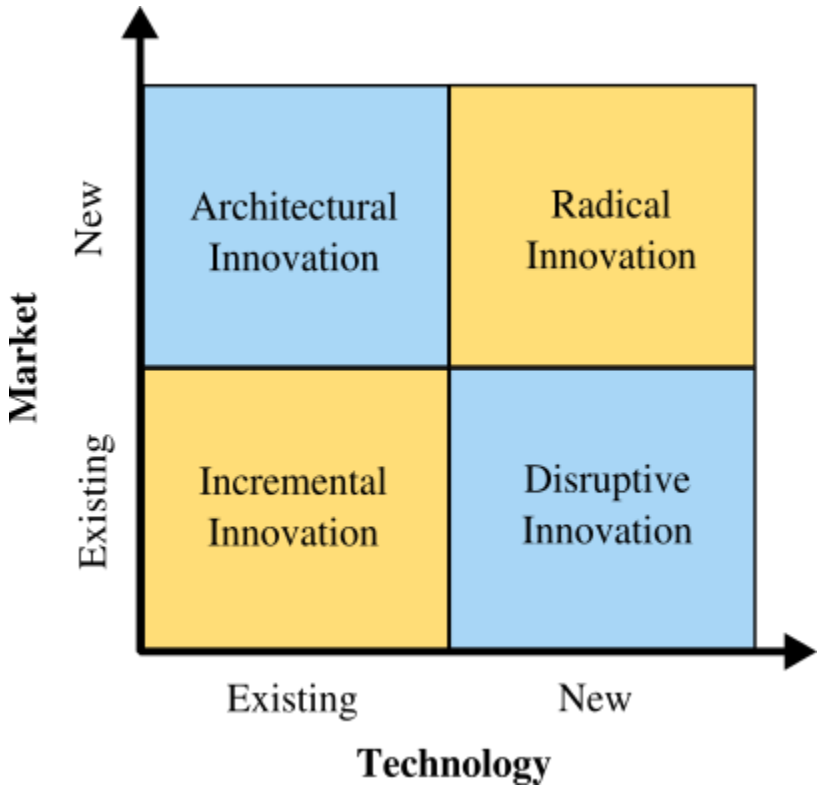


Fig 2.2 : Innovation [97]

Incremental Innovation is the process of adding extra features to your existing product (or even removing some features to enhance user convenience) and selling it to the same market. Extra features increase the frequency of usage or facilitate different applications of the prevailing product for various requirements. At times, removal of features enhances customer convenience or

lowers the value. Incremental innovation [126] focuses on increasing the value delivered by the existing product to existing customers. 70% of the innovations are incremental innovations. Architectural Innovation [97] is simply introducing the existing technology/product/Service to a new or unfamiliar market to increase customer base. Thorough market study has to be conducted before entering a new market/segment. Most often, the technology or product/service has got to be tweaked or modified to satisfy the customer requirements. Disruptive innovation [32] is about applying new technology to existing markets. The existing customers need to be educated about the newest product/technology/service. One of the advantages is that the customers are already familiar with the brand name. "Reputation" of the brand helps to a great extent in promoting disruptive innovations. Radical Innovation [130] involves introducing technologies/products or services that revolutionize the way industry operates. It makes the prevailing industry obsolete and creates new one(s). The new technology/product will have significant improvements over the prevailing ones within the market.

OECD [115] proposes four types of innovation namely (1) Product (2) Process (3) Marketing methods (4) New Organizational methods. Depending on where any organization should prioritize its resources, Innovation can be divided into (1) Internal Innovation and (2) External Innovation [14]. Involving inhouse participants during the innovation process helps companies to have more control over resources and work environments. There is a contradicting view proposed by [56] that internal participants are not able to bring in "fresh air" to the organization. External stakeholders bring their experience to the innovation table with newer perspectives on problem solving to the organization. Based on sources of innovation, categorization can be (1) Manufacturer Innovation (2) End user innovation. End users, like the organisations / firms or the consumers

improvise on the product(s) or service(s) based on their individual requirements. A standard product or service gets customized based on requirements and this is fed back to the manufacturers [55]. Listening to "customers preference / feedback" is the ideal source of fresh ideas. Another way of categorization is based on the impact of innovation to the existing market/industry. (1) Cannibalization / planned destruction (2) Market creation and (3) Competitor disruption. Cannibalization or planned phasing out of products occurs when an innovative product(s) reduces the market of the existing product(s) of the same company. Competitor disruption [48] is a concept similar to radical innovation where new markets are created due to innovation and current ways of doing things are completely replaced by better processes or service. Doblin [46] expands the concept by adding innovations in "(1) Business model (2) Networking (3) Channels (4) Brand (5) Customer experience (6) Enabling process (7) Core process". Moore [109] has added further value to the innovation literature by adding the concepts of (1) Line extension (2) Marketing Innovation (3) Value Engineering (4) Experimental Innovation (5) Value migration (6) Integration (7) Organic Innovation and (8) Acquisition. Value Engineering is a process of enhancing the product value by increasing its features or by lowering its cost. Value migration is a concept for changing the existing business model(s) of product business to satisfy the requirements of the customer(s) based on the changes in the environment.

It's often the very low success rate of innovation [138] in general that discourages firms to innovate. Success rates of innovation have been a topic of discussion since time immemorial. It's a very controversial topic. Payne [123] suggests that 90% of the innovations fail in the market. An innovation can have excellent features but it might not be appealing to customers due to sophistication in using or due to lack of aesthetic appeal or the functions may be

irrelevant to them or due to cost or fad/fashion factor. West claims that the innovation failure rates are as high as 80%. Only success stories are getting highlighted in the media. Cooper [35] argues that out of every 7 product or service ideas incubated, only 4 enter the design stage, only 2 are commercially launched and only one succeeds.

In various research papers, we come across words “Adoption” and “Diffusion” which are interchangeably used. The researcher also came across various papers during literature surveys where “Diffusion models” [135] were used in place of “Adoption” and other ways round. Actually both these concepts are theoretically different. Adoption is what an organization does and diffusion occurs across organizations [61]. Adoption refers to the stage of technology selection and utilization by an organization or an individual whereas Diffusion refers to the general spread of technology among organizations or Individuals [3]. Diffusion is considered more of a role on the supply side while Adoption is more of a demand side role or activity. “Adoption of Innovation” is the process by which a particular system adopts something “New”. Rogers [129] defines innovation “as the cycle by which development is conveyed through specific channels after some time among the individuals from a framework". Blumberg [15] states that dissemination alludes to "how an Innovation spreads inside a gathering, local area or country". It describes “how the process of adoption went – Classical S Curve or a different curve”. Adoption occurs at the individual levels. Individuals can only adopt. In short, diffusion is the cycle by which an innovation is conveyed by the innovator to the different members of the system and how the members adopt the innovation. Adoption is the process of selecting, procuring, embracing and utilising an innovation.

2.2 LITERATURE REVIEW ON ADOPTION

Gustafson [67] explains the factors affecting adoption of innovation by organizations. He attributes the factors namely (1) Innovation – Organizational Strategy fit (2) Technology Stewardship in Organization (3) Support from Innovator (4) Capability of manpower to master emerging technology (5) Continuous monitoring of innovation output. Gustafson did not take into account the external factors affecting the adoption of innovation. This model is not extensively tested in the context of organizations by other researchers.

As per Dosi Model of Innovation [47], the main source of economic growth in a country is “Innovation”. Companies learn through the “Trial & Error method” or when confronted with unexpected success. Dosi considered a technical change in a specific industry or country in terms of “Technological Paradigm” and “Technology Trajectory”. Technological Paradigm refers to a group of radical innovations which can have a significant impact on industry as a whole in catering to its requirements. Technological Paradigm defines the direction along which the further innovations or technological improvements happen or direction of further R&D. Technology is used to solve the problems faced by the Industry and the problems to be solved are selected by the “Technological Paradigm” itself. Firms in a particular industry are heterogeneous in terms of profitability, size and productivity.

Tushman and Anderson [149] proposed the concept of “Competence destroying Technical Change". Some innovations, even though very beneficial, challenge the existing technology or routines of an organization and these innovations are viewed as “Competence destroying Technical change”. In fact these “CDTC” can happen internally. Some innovation happens as unexpected outcomes of R&D

and might be very promising if commercialized. But the firm will not do so as they find it irrelevant to their current line of business.

As per Yates [162], the effects of policies and priorities of an organization on the adoption of innovation cannot be discarded. The markets are very dynamic and the environment keeps on changing. Based on market conditions, the firms will be forced to change their policies and priorities. Policy and priority changes the "Relevance" of technologies to a firm

Tolbert & Zucker [147] studied the adoption of administrative procedures from 1880 to 1935 and formulated this theory. Adoptions in the beginning happen due to the benefits of the innovative procedures & at a later stage happens due to the fact that others in the geographical area have adopted it. As the process of adoption progresses, the innovative procedure becomes a "Social fact or Norm" and others also try to adopt it for want of compliance. It ultimately becomes a "legitimacy". Early adopters [101] run ahead in the game and accept the innovative procedures for its "Performance"; and late adopters, for its "legitimacy. Early adopters evaluate a technology carefully and then only accept the same if and only if it is beneficial for them. They make a careful study about the work settings & competency of the personnel prior to adoption of the technology. But the late adopter just adopt the new technology mostly for the "sake of adopting" it – just because it has been adopted by others in the market

Roy Amara [5] points that a customer tends to overestimate the benefits of the technology in the short run & underestimate the benefits in the long run. An innovative product or an emerging technology will not be giving immediate results but in the long run it might yield results. But the customer wants immediate results. Failure of an instrument to deliver substantial benefits may slow down diffusion of innovation. To accelerate the adoption process, the

manufacturers should highlight the long term benefits and make the customer aware about the realistic short term benefits to prevent disillusionment.

Sharif & Ramanathan [135] divided the market in four categories of adopter sets for innovative products. 1. Rejecters 2. Adopters 3. Disapprovers 4. Uncommitted.

The four categories are formed by the relevant information about the product from the market or by word of mouth publicity. The process of adoption in the market is explained by the below diagram.

The market as such is uncommitted in the beginning for innovative products. As the “Uncommitted” gets relevant information regarding the innovative product, they either become “Adopters” of the product or “Disapprovers”. Disapprovers are the set of customers in the market who oppose the new technology – due to “Fear of change”. They prefer continuing their “Status Quo”.

The adopter gets converted to “Rejecters” based on their user experience or their changed environment/work settings. Based on “Bad Word of mouth publicity, at any point of time, the potential “Uncommitted customers” can become “Rejecters”.

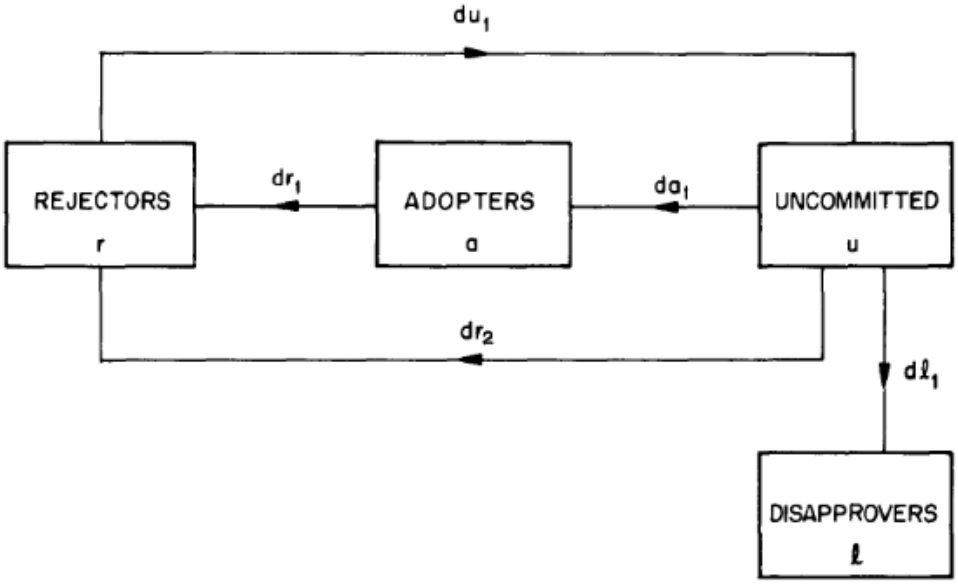


Fig 2.3 : Technology Market division by Sharif & Ramanathan [135]

Ellis's model [49] explains the diffusion process in six steps. Starting point is the customer will recognize the unfulfilled need. He starts searching for relevant information. From one source, based on the advice received regarding other helpful sources, he will "chain" to other sources. In the third step, the customer "differentiates" relevant information from irrelevant. He selects the relevant information while discards the irrelevant part. Next step is the verification of the information collected based on stories or experiences from the market or based on inputs from opinion leaders. Positive verification of information results in the adoption of the new emerging technology.

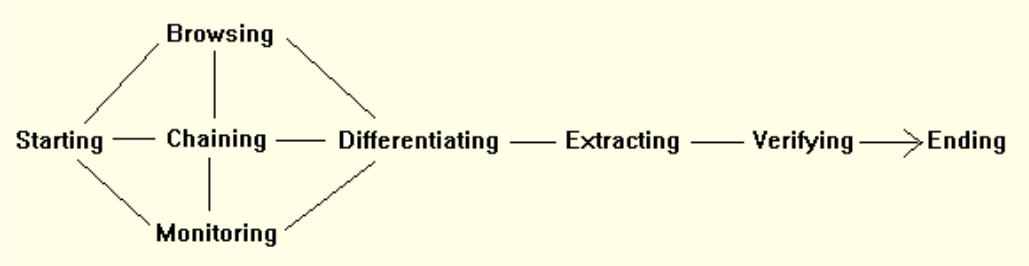


Fig 2.4 : A process model based on Ellis's characteristics [49]

Browsing & monitoring refers to the process of analyzing the external environment beyond the control of the customer which can modify or abandon the need

Hall & Hord [69] proposed a Concern Based Adoption model to implement "Changes" in organization by addressing the "Concerns" of individuals at various stages of "Implementation". People in general resist changes in absence of the necessary skill set to adopt the change. Employees in any organization must have an open mindset to accept change. The employees will have various concerns during stages of implementation.

Seven Steps involved in the Concern Based Adoption model are (1) Awareness (2) Collaboration (3) Consequence (4) Information (5) Management (6) Personal (7) Refocusing. Employees ask questions at all these seven steps. Adoption process progresses by convincing the employees about the concerns at each stage. First step, the concern of the customer as to what the change is all about should be cleared. Subsequent to that, the employee should be convinced how the change will affect the organization. The concern of the employee as to how the change will benefit the individual should be addressed properly. The benefits accrued to the employee due to this change should be convinced. One of

the main reasons the employees resist change is the absence of trust in their capacity to dominate the change. This concern can be addressed by implementing training or professional development programs. Next step is to convince the employee regarding the functionality of change in the organizational context. Theoretical concepts should work well in practical settings. The employees should be exposed to examples from other organizations or testimonials from other users about the benefits. Employees are rational and they will search for alternatives for the changes. Employees should be convinced that the "Proposed" change is best for the organization and for themselves to enhance the job performance.

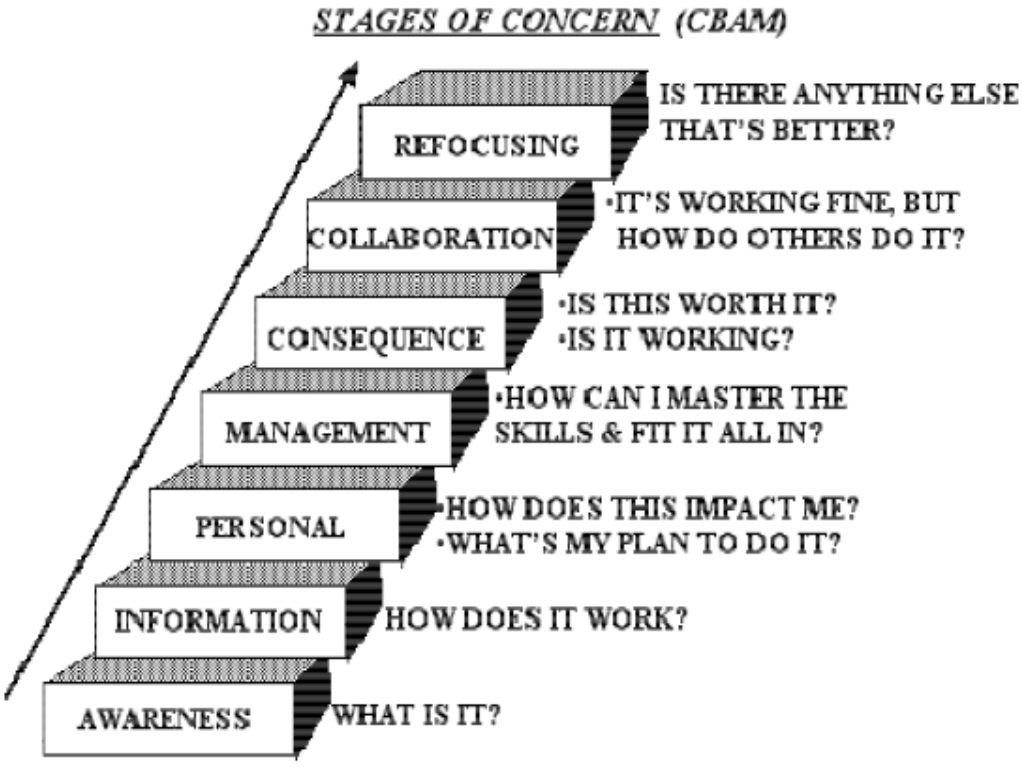


Fig 2.5 : Concern Based Adoption model [69]

Tornatzky & Fleischer [148] suggests that three factors affect diffusion of emerging technologies in an organization (1) Technology itself (2) Working environment (3) Organizational context.

Benefits of the Technology, its user-friendliness, availability & affordability affects the adoption process. After-sales support & the reputation of the firm providing the technology also have a favorable impact on the adoption. Pan & Jang [118] states that infrastructure available in the firm for the new technology implementation affects the speed of adoption. Liu suggests that the skill set to operate new technology & attitude of employees towards new technology affects the adoption process. Teo [145] stressed the importance of resolving all existing technical problems prior to implementation of technology. Thong [146] states that CEO's Innovativeness & Knowledge of Technology affects adoption.

Government regulations & Competition in the industry are other variables which affect adoption of innovation. In the context of intense competition, firms are always on the lookout for quality enhancement & Cost reduction. At times, Government regulation makes it mandatory to implement some technologies.

Size of the firm, its communication channels, the commitment of the Top management to bring about a change and lack of effective implementation strategy also impacts diffusion of innovation. Zhu [17] establishes that in large organizations, the readiness of business partners also affects the adoption of technology.

Anticipated changing trends in the market encourages some organizations to change [31]. Chan & Tam [28] argues that the pressure to comply with Industry standards & perceived barriers to progress urges organizations to search for cutting edge technologies. Perceived barriers to implementation slows down adoption.

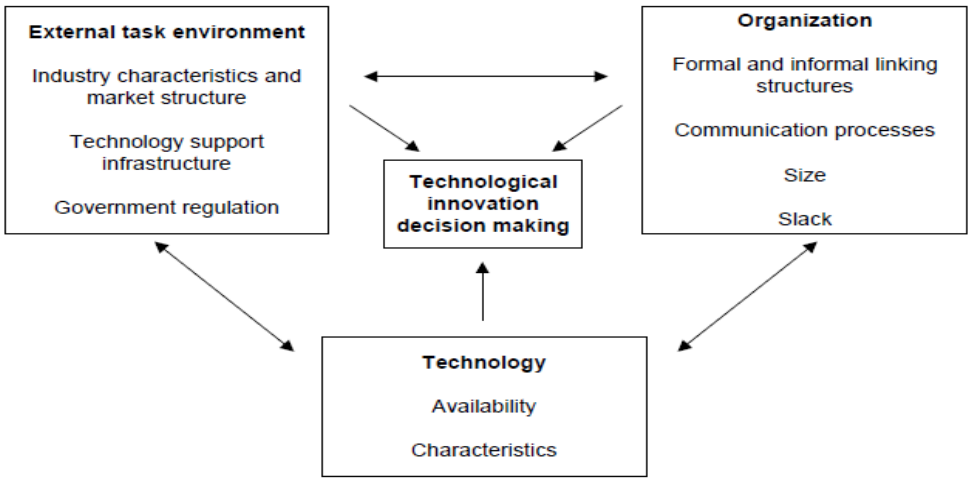


Fig 2.6 : Factors affecting diffusion of emerging technologies [148]

Cooper and Zmud [35] proposed a Six stage model for IS implementation based on earlier works done by Kwon & Zmud [91]. These stages need not follow a sequential pattern and at times many stages occur as parallel processes. Study revealed that many factors affect each stage of adoption. Sometimes the same factor affects multiple stages. So it is important to investigate in detail each stage of adoption with respect to an industry or organization and to identify the relevant factors affecting each stage.

Stages	*Activities*
Initiation	Scanning of organizational needs and IT solutions
Adoption	Negotiations to get organizational backing for IT implementation
Adaptation	Developing, installing and maintaining the IT application. Developing new organizational procedures. Training of users
Acceptance	Inducing the organizational members to use the technology
Routinisation	Use of IT application is encouraged as a normal activity
Infusion	The intended benefits from the technology is obtained through effective use of the technology

Table 2.1 : Six stage model of the technology implementation process [35]

Rosenberg [131] proposes that various adopters place various qualities on Innovation. A similar Innovation is seen diversely by various adopters regarding its utility. The example of appropriation throughout some undefined time frame follows the "S" curve. The suppositions made by Rosenberg to clarify selection are (1) the dissemination of qualities set on Innovation by various adopters follow a typical conveyance (2) the expense of development stays consistent or diminishes throughout some stretch of time (3) advancement is embraced when the adopters see worth to be more noteworthy than cost. Rosenberg additionally proposes that (1) Skill level of laborers and (2) Technical foundation/Capacity to embrace influences the reception of Innovation in organisations [138].

Dixit(s) & Pindyck [44] proposed the Real Options Framework to explain the adoption of innovative technologies. According to them, adoption decisions are influenced by three factors (1) Uncertainty [71] about the benefits (2)

Irreversibility once a decision is made (3) Option to delay. The individuals adopt only when they become convinced that the benefits are greater than the costs. This causes a delay in adoption. In the real option model – the prospect has a "call option" to adopt and they exercise this call option when they are convinced about the benefits of the technology. Luque [98] confirmed that "uncertainty" characterizes the adoption of innovative technologies like CAD/CAM & robotics in US manufacturing plants.

Lacovou [92] explains that higher the "Perceived" benefits of technology, faster the adoption. Lacovou model is based on the studies in IT innovations. Organizational readiness to adopt technology is explained along two dimensions (1) Sufficient financial resources to procure & support the technology (2) Resources [111] mainly manpower to operate the Technology & the infrastructure requirement for Technology implementation. Competitive pressure also forces the organizations to adopt an emerging technology. Sometimes due to pressure from "Partners" – the organizations will be forced to adopt an emerging technology.

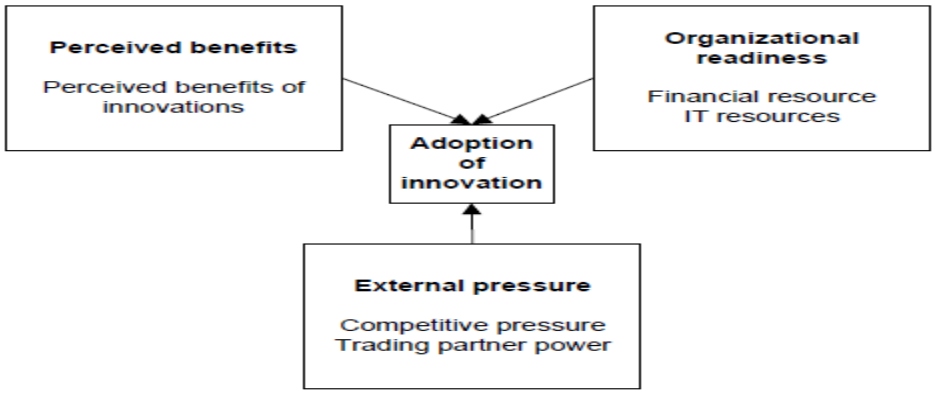


Fig 2.7 : Lacovou model of Adoption of Innovation [92]

Soares & Reis state that the number of competitor adopters & the evidence of benefits for competitors affects the diffusion of innovation.

Norris and Soloway [114] investigated about the barriers affecting the adoption of computing technologies in Education sector and concludes the barriers as (1) Lack of vision (2) Lack of initiative (3) Lack of cash (4) Old fashioned Curriculum (5) Infrastructure– Both Human & Technology (6) Time taken to change (7) Resistance from Parents (8) Proper Technology assessment.

2.3 LITERATURE REVIEW OF IO BEST PRACTICES

As per literature survey, the initial attempt of designing any Enterprise Solution system was carried out by Superior Oil for the Real Time Drilling Operations Centre (RTOC) [77]. But the real upstream leader who took this IO implementation to the next level in this space was Statoil with the first implementation of Operations Service Centre (OSC) [90] in 2000 to support five offshore rigs. Conoco Phillips had also established an onshore drilling centre [19] in 1999 though at a smaller scale. All the major global upstream O&G players had since been taking some or the other IO initiative. BP, Shell, Petrobras, Chevron, ENI, BG Group, Saudi Aramco, and ConocoPhillips, IBM are members of the Smart field Consortium at Stanford University and many other standards groups and industry forums. The aim of the Smartfields [11] Consortium is to create effective programming devices for the Innovation of oil field improvement and activities [90], including information digestion, quick recreation, model refreshing, and ideal control. However, efforts on complete IO solution implementation started in 2006 by major IOC's in developed countries. Some of the global IO success examples are highlighted below.

Chevron's IO program called "i-field" [72] running since 2002 boasts a suite of 20 advanced "tools" for Chevron operating companies worldwide. Chevron is on target to set aside a billion dollars per year when the i-field and a more extensive operational redesign are completely executed in 2016.

The Norwegian Oil Industry and North Sea operators pioneered the development [128] of IO Enterprise Solution with a high degree of collaboration between Government, Industry, and Academia. Statoil, in association with the Norwegian Oil Industry Association (OLF), the Norwegian Government, The Norwegian University of Science & Technology (NTNU), and a consortium of 20 other suppliers and institutions had established IO in the High North in 2009, to drive further progress in IO. In early 2010, Statoil began an enterprise program to deploy their IO solution across their North Sea and international assets. As per OLF, the value of IO for Statoil represented a potential of USD 50 Billion (NVP) over an eight years period for the estimates at 7% discount rate at 2007 crude oil prices.

Shell has the most successful IO program in part implementation of various IO Enterprise Solution components, with successful Smart Field [11] implementations in the US, Canada, Europe, the Middle East and Africa. Shell has developed a holistic and comprehensive approach with sustained investment in programs such as Smart Wells, New Fields "born Smart", Advanced Collaborative Environments [77], and Enhanced Oil Recovery through Integrated Reservoir Management. At one point, Shell had estimated that its IO initiative called Smart Fields program had created more than $5 Billion of business value for Shell and its partners until 2009.

BP's Field of the Future (FoF) program [43] is one of the largest IO programs in the industry. BP has implemented its FoF technology on 80% of their Top 100 wells worldwide, they have established 35 so-called Advanced Collaboration Centers around the world, and they credit FoF with an estimated contribution of more thans 50 mboed (million barrels of oil equivalent) of gross O&G annual production with real dollar benefits.

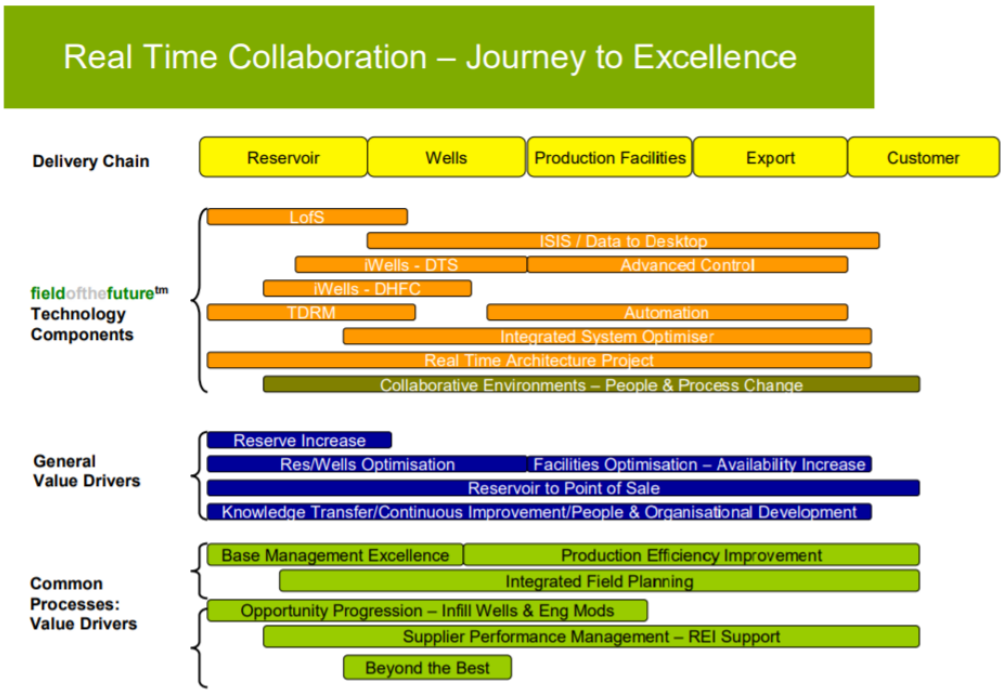


Figure 2.8. BP Field of the Future Overview [43]

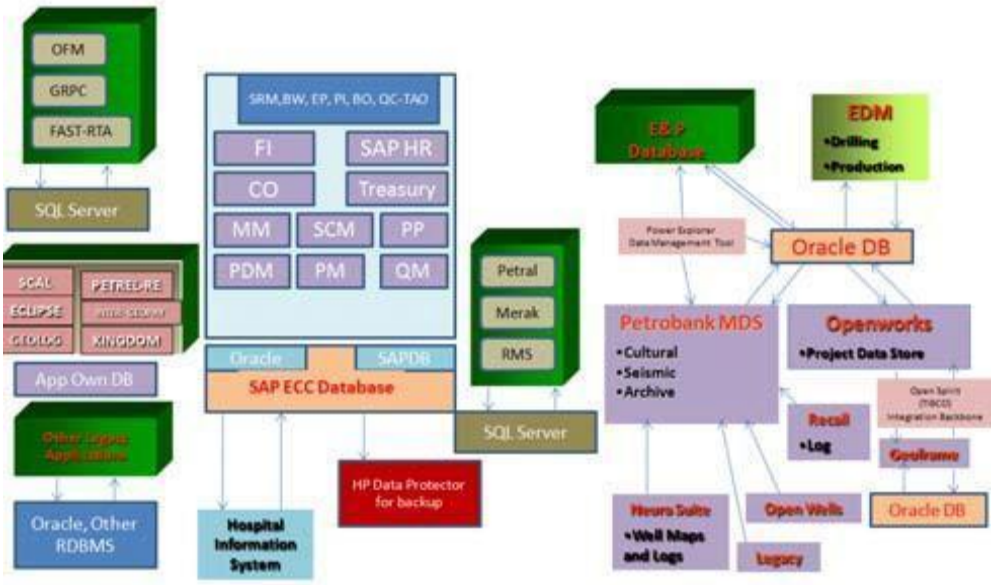


Figure 2.9. IO infrastructure of 2nd largest Indian upstream company [151]

Except Cairn India, no other Indian upstream company [107] has published papers on the implementation of IO. Cairn India also started presenting Digital Oil Field [151] in some forums in the last two years but it reflects only about implementation of the selective components of IO.

BG has been taking some IO initiatives globally; however for India offshore assets, IO work has been done in peace meals and is still limited to Maximo, ERP and niche software solutions. On the other hand, ONGC has spent heavily on SCADA and other instrumentation in the field apart from ERP [82] and point software solutions.

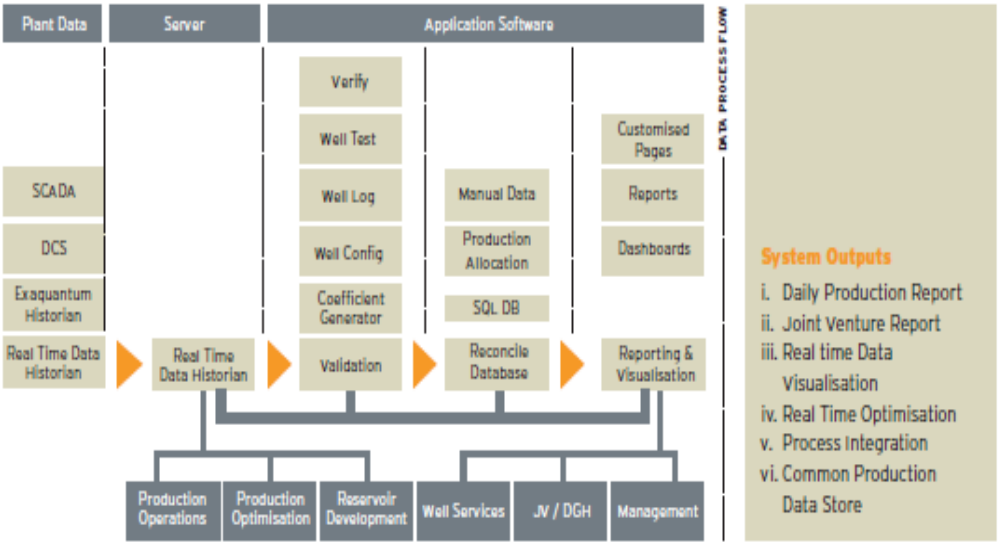


Fig 2.10 : IO infrastructure of 3rd largest Indian upstream company [151]

From a general observation of Indian upstream industry [81], it can be concluded that IO in India is still limited to few niche solution components like ERP [82], Real time well flow information, reservoir simulators [26], G&G software, RTOC, Asset Management system, DCS and other point solutions covering Finance and Logistics. In spite of all the developments in IO space and available use cases, a general conclusion is that a meaningful complete IO solution is still lacking for organisations.

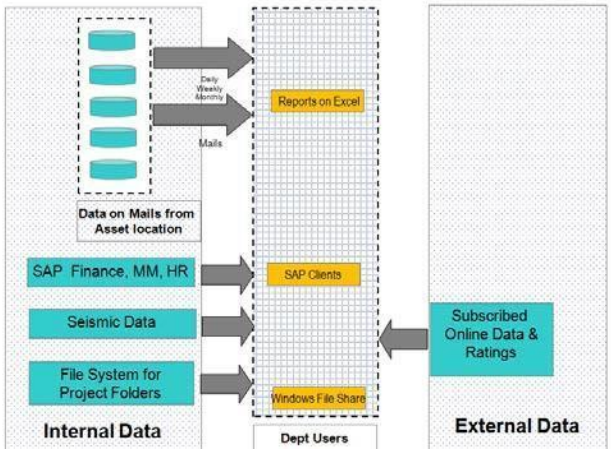


Figure 2.11 : IO infrastructure of 4th largest Indian upstream company [151]

Just a few experts tried to present the IO concept to Indian upstream companies in some oil & gas forums also but IO in India will take more time.

2.4 THEMES EMERGED OUT OF LITERATURE REVIEW

Following themes emerged from literature review leading to the need for this research :

1. Literature provides Integrated Operations implementation barriers for Norway etc but barriers have not been identified for Indian companies

2. Literature provides evidence of global companies implementing few layers of Integrated Operations but not much info for Indian scenario

3. Literature/reports acknowledge the fact that major companies have developed Integrated Operations strategy but Indian companies have not

followed the trend.

4. Literature review on application of Modified Grounded Theory in upstream companies

2.5 LITERATURE REVIEW ON BARRIERS TO INTEGRATED OPERATIONS INITIATIVES BY INDIAN UPSTREAM

An extensive literature survey has been undertaken to form the basis of an ongoing empirical research on the research subject which will help Indian companies overcome management barriers with solutions like IOC.

Lit. Ref.	Literature brief	Research Gaps
[79]	Bjørn Holst & Espen Nystad have presented to the world how life of Brage could be extended to another 10 years using the Integrated Operations concept in Norway after studying various organisational barriers.	Workflow Efficiency barriers not identified for Indian upstream companies
[42]	Derenzi D had analysed the barriers for some north sea based upstream companies	
[120]	Om Prasad Patri, Vikrambhai S. Sorathia & Viktor K. Prasanna have highlighted use of complex event processing as an emerging area that involves	

	detecting complex events, processing the events, deciding actions for each event and notifying the relevant personnel about the event, and thus simplifying process downtime barriers.	
[36]	Mark L. Crawford & Richard A. Morneau presented Workflow Efficiency barriers successfully with execution of Integrated Operations	
[86]	Johnsen S.O., Lundteigen M.A, Fartum H & Monsen J have identified barriers to remove risks in remote operations of offshore oil & gas installations	Barriers for remote operations not identified for Indian upstream companies
[150]	L J Usrem, J H Williams, N M Pellerin & D H Kaminski have analysed the remote drilling operations for Real Time Operations Centres (RTOC).	
[42]	Claus G. Bjerregaard demonstrated how Maersk Oil created a fit for purpose and cost effective Integrated Operations for brown field assets to overcome barriers between people and shared information by streaming right data to the right people at the right time	Barrier to seamless information flow to people not identified for Indian upstream companies
[139]	Andrew Steinhubl, Glenn Klimchuk, Christopher Click & Paula Morawski had presented on	

	employee productivity barrier with use of Integrated Operations concept	
[2]	L J Usrem, J H Williams, N M Pellerin & D H Kaminski have analysed the Real Time Operations Centres initiative 'people' side of decision making.	
[108]	Dr. Berit Moltu & Jakob Naerheim presented around HSE how Integrated Operations helped removing barriers by combining work process, data management across distant geographies	Information barrier affecting HSE not identified for Indian upstream companies
[27] [11]	Eduardo Camponogara, Agustinho Plucenio, Alex F. Teixeira & Sthener R.V. Campos have shared on how proven smart field technologies could be implemented to increase production with an automation system for gas-lifted oil wells.	Indian upstream companies have not been analysed for the impact of implementation with selective layers of Integrated Operations.
[100]	Ravi Madray, Carolina Coll & Gordon Veitch have successfully explored the integrated view of sub surface of reservoir using Integrated Operations concept	
[10]	Bayerl P.S., Lauche K, Badke Schaub P & Sawaryn S identified Human factors for successful	

	Implementation of Integrated Operation to create a collaborative environments	
[72] [7] [13]	Mike Hauser has spelled out on Chevron's integrated operations implementation plan focusing on predictive technologies to improve operational effectiveness	
[94]	Trond Lileng and Svein Ivar Sagatun analysed successful Integrated Operations Methodology and business benefits in Statoil	Indian upstream companies have not estimated likely opportunity loss.
[43]	Jeff Dickens, David Latin, Graeme Verra, William Blosser, Greg Edmonds, and Greg Grimshaw studied BP's integrated operations Field of the Future Programme	Indian upstream companies have neither formulated Integrated Operations implementation strategy, nor the likely efficiency parameters for evaluating impact.
[11]	Leo de Best presented Shell's Smart Fields concept defining how Shell will be implementing Integrated Operations	
[1]	Abdulaziz AbdulKarim, Tofig AL-Dhaubaib, Emad Elrafie, and Mohammad O. Alamoudi described Saudi Aramco's integrated Operations ongoing initiative Intelligent Field Program	

[141]	Agustin Diz Solari, Marta Duerias Diez, Jose Luis Pena Diez & Ashutosh Shah shared Repsol's Integrated Operations initiative in Europe.	
[68] [143]	Work done by Astrid Gynnild, Glaser & Strauss, Strauss & Corbin and Locke on The Grounded Theory was reviewed to understand its application for expert surveys.	No upstream company has ever applied Modified Grounded Theory in upstream analysis of any kind.
[136] [89]	Kenichi Shimura has compared Grounded Theory and KJ Methods for the operations environment.	
[75]	V Hepso, H Olsen, F Joannette & F Brych have given understanding on the use of different hypotheses, theories and frameworks for worldwide coordinated effort to drive business execution in upstream companies in Norway.	

Table 2.2 : Literature Survey on Integrated Operations

2.6 FUNNELING AND CONSOLIDATION OF RESEARCH GAPS

In spite of the successful history of Integrated Operations in Nordic countries, the same has not been replicated by upstream companies in India due to various unidentified management barriers. Following are major research gaps prioritised by scholar based on the literature survey :

Sl. #	Prioritised Research Gaps from Literature Survey	Indicative Research Question
1.	Indian upstream companies have not formulated an Integrated Operations implementation strategy.	What are the management barriers ?
2.	Barrier to seamless information flow to people not identified for Indian upstream companies	
3.	Information barrier affecting HSE not identified for Indian upstream companies	
4.	Barriers for remote operations with Integrated Operations not identified for Indian upstream companies	
5.	Indian upstream companies have not mapped the efficiency parameters for evaluating the likely impact of Integrated Operations.	What are efficiency parameters ?

6.	Indian upstream companies have not analysed the impact of implementation with selective layers of Integrated Operations.	
7.	Indian upstream companies have not estimated likely potential opportunity loss with Integrated Operations implementation	What is the opportunity loss ?

Table 2.3 : Indicative Research Questions from Literature Survey on Integrated Operations

2.7 RESEARCH PARAMETERS (DRAFT MEASURED VARIABLES) FROM LITERATURE SURVEY

Following high level IO barriers were shortlisted from the literature survey for further discussion in a pilot survey with a smaller group of IO experts with use of Modified Grounded Theory research tool :

1. Digital infrastructure
2. Regulation
3. Data security
4. Intellectual-property frameworks
5. Lack of standardization
6. Integrated data platforms
7. Partner Ecosystem
8. Operating Efficiency
9. Organisational productivity

10. Health and safety
11. Culture and mindset
12. Identifying opportunities to automate
13. Experimental "failfast" approach
14. IO Talent
15. Cybersecurity
16. Connected computing devices
17. Connected equipment infrastructure
18. IT implementation services

Chapter 3

THEORETICAL UNDERPINNING SELECTION AND THEORETICAL GAP

3.1 THEORETICAL UNDERPINNING

Following is the underlying theoretical model for the research, based on the literature survey before undertaking the pilot study with the IO experts. Here, IO users have their decision making perspective about new technology based on the perceived value and associated risk, and accordingly they propose such new technology initiatives to the top management. However, management decisions on adoption of the new technology is hindered by several management barriers which impacts the belief and acceptance of the new technology by the whole organisation providing the basis for ultimate decision on the adoption of technology. It is based on the Value-based Adoption Model (VAM) [88] which is explained in the next section below. VAM was selected out of several theories on account of its applicability in execution of Integrated Operations [13] with perceived value, perceived risks, belief and acceptance as the relevant factors considered in this theory.

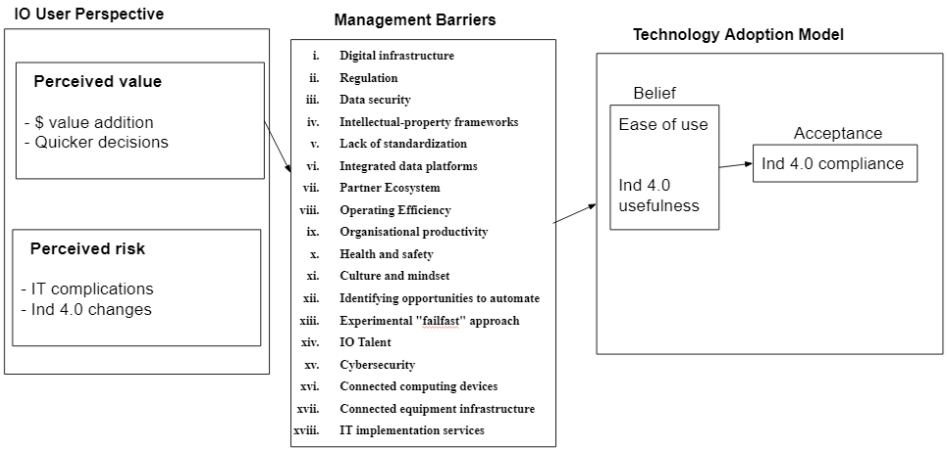


Fig 3.1 : Value-based adoption model (theoretical model from literature survey) [95]

3.2 VALUE-BASED ADOPTION MODEL (VAM)

VAM depends on the money saving advantage worldview of the behavioral decision theory, which proposes the partner's decision among different dynamic methodologies. Seen esteem is treated as a tradeoff between the "give" and "get" variables of an innovation. Kim et al. [88] made a coordinated model, the Value-based Adoption Model (VAM), to gauge aims of embracing innovation by saw esteem. In VAM, the primary influencing parts of apparent worth are seen benefits and seen penance, and the apparent worth is an examination estimation among advantages and penance. Moreover, the reception aim is straightforwardly affected by the center part "perceived value." The meaning of apparent worth in this paper mirrors this by contrasting advantages and costs, and is consequently, a marker of appropriation expectation. Consequently, this investigation proposes that subsequent to weighing the two expenses and advantages of Enterprise 4.0 for an organisation, if the executives accepts that receiving Integrated Operations will offer a greater number of advantages than costs and is beneficial to the

organization, the expectation to embrace Integrated Operations based arrangements would be available.

VAM has been widely used in the last ten years for many studies in the new internet / mobile technology space to find out how well the technology adoption happened and what were the benefits, risks and barriers in the whole adoption process. However, it was never used in upstream oil and gas studies.

3.3 OTHER THEORIES LOOKED AT

3.3.1 TECHNOLOGY ACCEPTANCE MODEL (TAM)

Technology Acceptance Model (1989) : TAM was proposed by Davis, Bagozzi & Warshaw [122] based on their studies in Information Systems [31]. TAM explains how a customer adopts or embraces a new technology or process. They are confronted with two main questions: Will the product be useful to me? Will the product be user friendly or easy to use? The two main factors affecting the adoption are (1) Perceived ease of use (2) Perceived Usefulness. These two factors create an impression - favorable or unfavorable attitude towards the adoption of a new technology.

TAM is based on the concepts put forward in the TRA & TPB model [4]. So while introducing an innovative product – the two features to be highlighted are (1) its usefulness & (2) its user friendliness. Perceived Usefulness can be described as the extent to which a customer finds a particular technology satisfies his requirement. Perceived ease of use can be characterized as the degree to which a client thinks he can use a product with minimum effort.

There are a lot of refinements for this theory.

Technology Acceptance Model 2 (2000) : Venkatesh & Davis [152] added two processes to the Original TAM model. (1) Social Influence Processes (2) Cognitive Instrumental Process. These two are considered very important for understanding the adoption of technology by the customer. He has used three variables to explain social influences – Subjective Norm, Voluntariness & Image.

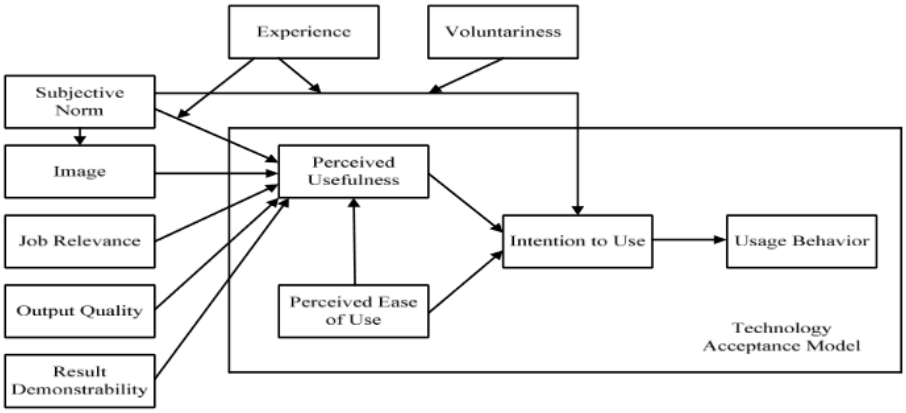


Fig 3.2 : Technology Acceptance Model (TAM2), source: Venkatesh and Davis (2000) [152]

Fred Davis developed the first incarnation over three decades ago. TAM is a data frameworks theory that models [144] how various clients grapple with tolerating and utilizing an innovation. The real framework utilized is the end-point where individuals utilize the innovation. Social aim is the factor which prompts individuals to utilize the innovation. There are numerous factors yet two of the greatest elements that arose out of before considers were the insight / perception that the innovation / technology accomplishes something helpful (perceived usefulness; U) and that it's easy to use (perceived ease of use).

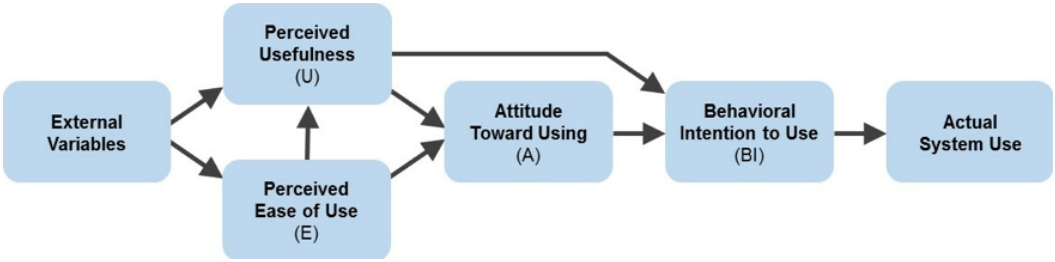


Fig 3.3 : Technology Acceptance Model [18]

However, it was not considered appropriate as compared to VAM to be taken as theoretical underpinning for this research because it focuses more on the usefulness and ease of use only which was already known in case of Integrated Operations.

3.3.2 TECHNOLOGY READINESS AND ACCEPTANCE MODEL (2012)

Porter and Donthu [124] suggest that both technology specific dimensions & personality specific dimensions affect usage of new technology. Technology specific dimensions are (1) Perceived ease of use or usability (2) Perceived usefulness as stated in TAM Model [18]. Personality specific dimensions are (1) Innovativeness and (2) Optimism. Godoe & Johansen (2012) proposes a TRAM model to explain the relationship between Personality specific & System specific dimensions. Structural equation modelling was carried out with data from 186 different Norwegian organizations. Innovative approach and Optimism significantly impact perceived usefulness and perceived ease of use. Perceived usefulness actually contributes more to the decision to adopt than perceived ease of use.

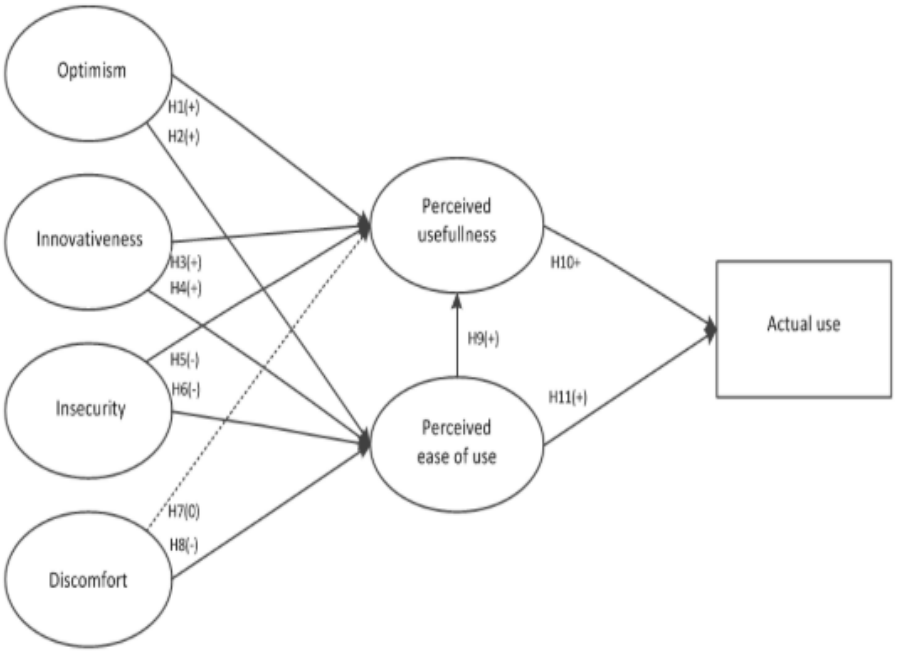


Fig 3.4 : Technology Readiness Acceptance Model (2012) [119]

3.3.3 TECHNOLOGY STEWARDSHIP THEORY (2012)

Wenger, White & Smith describes that in all markets or segments there might be some people who are well versed with the requirements of that particular market & they are also through with the technology to solve them. Market looks at them as experts and seeks advice from them regarding new products/technology. These people are called "Technology Stewards". Technology stewards are open to innovation & they recommend this technology to others in the market if it offers substantial benefits over other products. The companies with innovative products should first convince the "Technology Stewards" to speed up the adoption rate.

Technology Stewardship Theory was not selected as it focuses on adoption based on the opinion of the experts. In the case of Integrated Operations, there is a clear acceptance of IO adoption based on IO experts from other countries, and there is no doubt on the usefulness of IO technology. Focus was more on how to take that implementation decision for the organisation.

3.3.4 HEDONIC MOTIVATION SYSTEM ADOPTION MODEL (2013)

Hedonic motivation is interpreted as the tendency of human beings to embrace activities which give them pleasure while rejecting or staying away from activities which could give them pain. Customers are always in search of pleasure because they avoid pain by all means. Customers have the tendency to adopt technology or products which give them pleasurable experiences & reject products which give bitter experiences. This is the basis of HMSAM. This theory is an extension of Technology acceptance model [152].

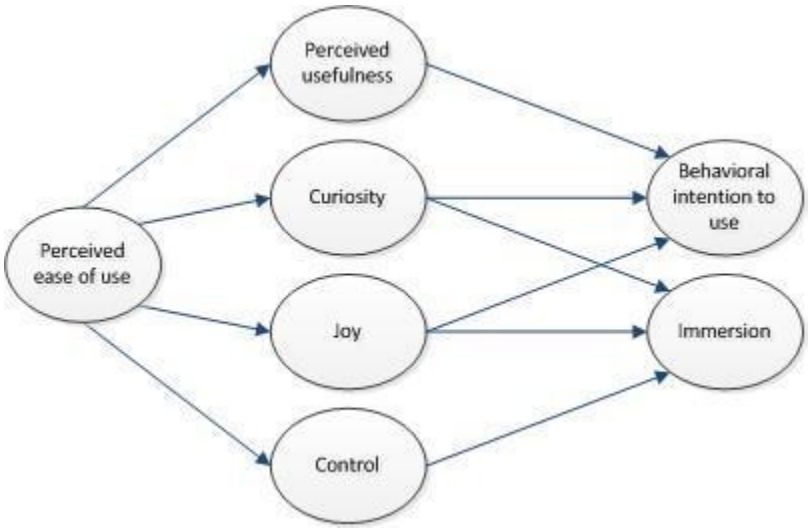


Fig 3.5 : Hedonic Motivation System Adoption model (2013) [152]

The company introducing an innovative product should incite a feeling of curiosity in the minds of customers. By providing prototypes to the customers, the company must try to convince its customers about the “User-friendliness” of the product features. Usage of the product should give a “Joyful" experience to the customer. The companies should also instill in the minds of customers – that they are competent to use the product. Control refers to the confidence on the part of the customer to use the product. Companies must also try to convince its customers about the usefulness / usability of the product in the customer's context. All these hedonistic factors lead to a favorable buying intention.

This theory being an extension of TAM [145], again it was not considered appropriate for this research because it focuses more on the usefulness and ease of use only which was already known in case of Integrated Operations.

3.3.5. MATCHING PERSON & TECHNOLOGY MODEL (1986)

Marcia J. Scherer proposed this model to understand the adoption of emerging technologies with reference to individual organizations. Company management, at times, procures innovative products/emerging technologies to enhance the work performance. But the employees due to their personal preferences & individual characteristics will show reluctance to accept the new products. Sometimes the reluctance can be due to lack of training or support from the part of the organization. So the companies, while adopting new products/methods/technology, should analyze the preferences, characteristics and competency levels of the employees. Then only then should formulate an internal adoption strategy.

However, this theory was not considered appropriate as compared to VAM because it focuses more on the barriers caused by employees / users to adopt new technology which is not the case with Integrated Operations. Usefulness and ease of use was already a well established known factor in case of Integrated Operations.

3.3.6 MORGAN AND HUNT'S COMMITMENT-TRUST THEORY (1994)

The commitment-trust theory of relationship showcasing [110] proposes that there are two key elements, trust and responsibility / commitment, which should exist for a relationship to be fruitful. Thus, clients trust these and the common dedication that assists the two players with satisfying their requirements. However, this theory was not applicable for this research as it focuses only on cooperative team behavior [155] and knowledge sharing of employees in businesses and does not really focus on the identification of management barriers in decision making for the implementation of a proven technology like Integrated Operations.

3.3.7 EXPECTATION – DISCONFIRMATION THEORY (1980)

EDT is a further explanation of Cognitive Dissonance Theory. Oliver [158] explains four main ideas in EDT. (1) Expectations (2) Performance (3) Disconfirmation (4) Satisfaction.

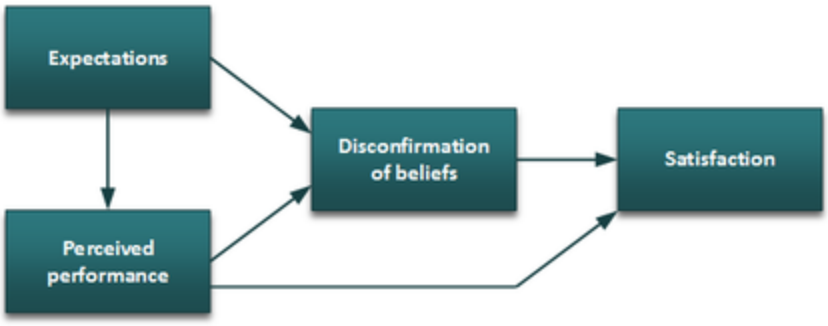


Fig 3.6 : Expectation – Disconfirmation Theory (1980) [158]

In the present serious situation where it is profoundly essential to develop to an ever increasing extent "Fulfilled clients", or put in better words "Pleased clients" who thus will become "Brand Loyal" over the long haul. EDT theory clarifies how Expectations and Perceived Performance lead to consumer loyalty.

Theory recommends that when the “perceived performance” surpasses the “expected performance” – it lessens disconfirmation, consequently disposes of it and ultimately supports affirmation. This positive affirmation prompts consumer loyalty. Seen Performance ought to be consistently equivalent to or more prominent than anticipated execution. In any case an imaginative product or services can't prevail on the lookout.

Perceived Performance straightforwardly impacts consumer loyalty.

3.4 THEORETICAL GAP

However this Value-based adoption theoretical model built from the literature survey was vague for understanding dominant barriers for the upstream companies to decide on the adoption of Integrated Operations in view of too many barriers, making it a complex decision for organisations to come up with the right implementation strategy without clearly estimating the perceived value of Integrated Operations. Moreover, no research has been carried out in India to identify the dominant barriers considering the complexity of the Integrated Operations topic which covers a vast area of upcoming technologies. The theoretical gap was in knowing which of the following barriers are really dominant for Indian upstream companies which ultimately create the belief and assumptions in decision makers' minds.

3.5 CONCEPTUAL LENS BEFORE PILOT STUDY

A conceptual framework delineates what the researcher hopes to discover through the examination. It characterizes the pertinent variables for the examination and guides on how those variables may identify with one another. Starting with the basic step of why this conceptual lens was selected, before starting the literature survey, a general perception on the key inhibitors was that following are the management barriers for initiating efforts to implement Integrated Operations was - a) Data Security [93] Regulation & Intellectual-property, b) Lack of standardization & ownership of data between suppliers, operators and contractors, c) Ecosystem for sharing of data, d) Culture and mindset , e) Talented workforce, & f) Cybersecurity etc. But such a narrow understanding was not helping in the research and it was realised that a much more detailed study is required to identify the real management barriers for execution of Integrated Operations [13]. Therefore, after the literature survey, a

much longer list of such management barriers / variables - to be precise 18 barriers - was taken and that required a conceptual framework which could categorise the relevant variables and map out those variables in understanding how they might relate to each other.

Based on the theoretical variables identified through literature survey, following conceptual framework mapping was done with 18 theoretical variables before commencing the pilot study with IO experts and collecting any data.

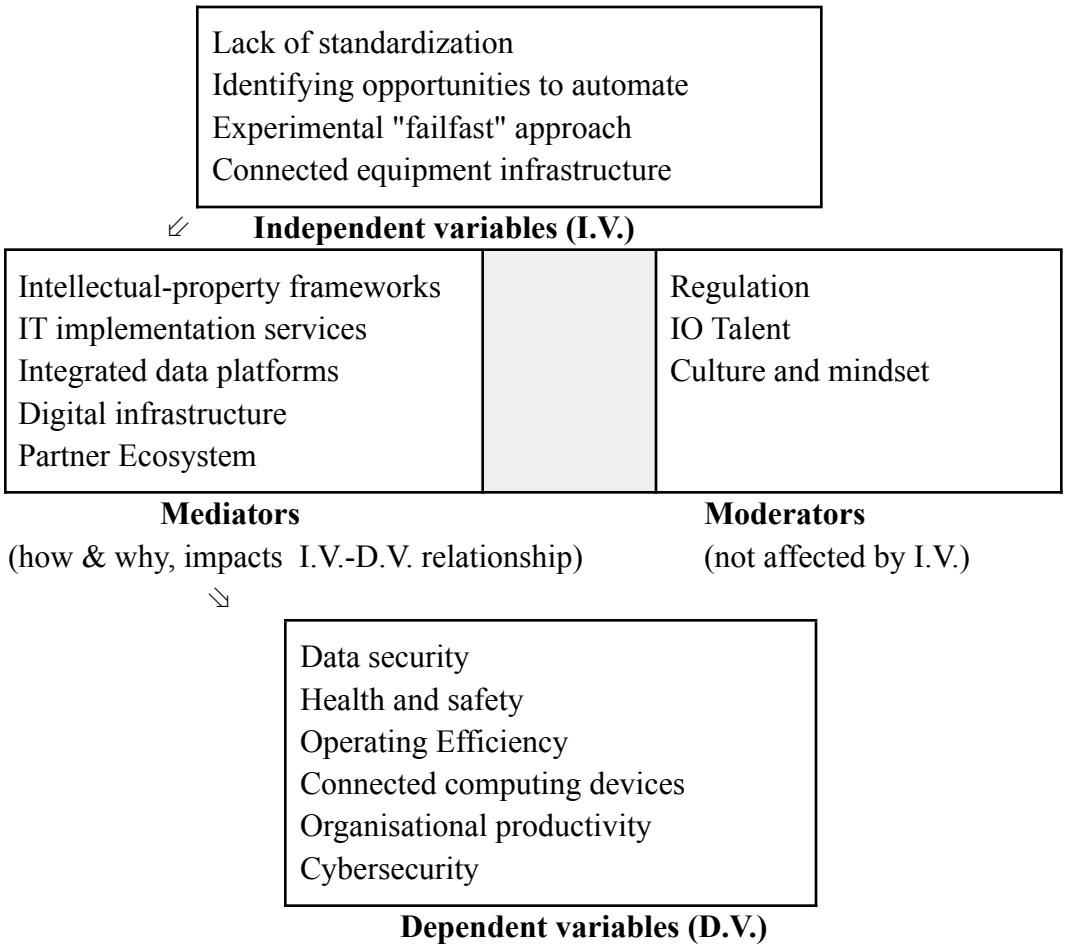


Fig 3.7 : Cause & effect relationship of theoretical variables (Conceptual framework)

This conceptual framework was making it easier to understand how these variables are related to each other, and was able to provide clarity for studying the impact of these variables on the research.

Chapter 4

PROPOSING THE RESEARCH PROBLEM, QUESTIONS & OBJECTIVES

4.1 RESEARCH PROBLEM

Identify management barriers for implementation of a customised Integrated Operations solutions for capturing the potential opportunity loss for Indian upstream companies.

4.2 RESEARCH QUESTIONS

Answer to the following Research Questions will define the overall research:

Q1. What are the barriers in management decision making for the implementation of Integrated Operations solutions?

Q2. What are the management efficiency parameters for the implementation of Integrated Operations solutions?

Q3. What level of organisation readiness will Indian upstream companies have with emphasis on optimistic, pessimistic, and innovative approach, to overcome the opportunity loss from the implementation of the customized Integrated Operations solutions?

4.3 RESEARCH OBJECTIVES

Research Objective 1 :

To identify the management decision-making barriers for adoption and implementation of Integrated Operations solutions in Indian upstream companies.

Research Objective 2 **:**

To identify the major efficiency parameters for the implementation of Integrated Operations solutions in Indian upstream companies.

Research Objective 3 **:**

To suggest a customized solution and organisation readiness with emphasis on optimistic, pessimistic, and innovative approach for implementation of Integrated Operations solutions for Indian upstream companies.

4.4 FLOW OF RESEARCH OBJECTIVES

Implication of above three Research Objectives on the study is to look at the complete decision making scenario for the upstream organisations in India with these three independent Research Objectives for completing this jigsaw puzzle - (i) What really causes the delay in decision making by the management on Integrated Operations investments? (ii) What organisation efficiency parameters are expected to change with such Integrated Operations solutions? (iii) What is that customised Integrated Operations solution and how do different organisations look at it from a strategy perspective?

Research Questions are studied further with the Conceptual Lens starting first with 18 theoretical management barriers identified from literature survey for the complete research while the focus of RQ1 is on the management decision making barriers, focus of RQ2 is on the management efficiency parameters, and focus of RQ3 is on level of organisation readiness with emphasis on optimistic, pessimistic, and innovative approach, for the implementation of the customized Integrated Operations solutions. All three Research Objectives are independent - RO1 focuses on identifying the investment decision-making management barriers applicable for Indian upstream companies for execution of Integrated Operations solutions. RO2 focused just on the specific efficiency parameters of the Indian upstream companies which can translate into clear business benefits with execution of Integrated Operations solutions. RO3 looked at the level of organisation readiness for Indian upstream companies with emphasis on optimistic, pessimistic, and innovative approach for implementation of a customized Integrated Operations solution [13].

Thus the complete research will give a clear understanding of various variables influencing the perceived value and associated risks of IO implementation, organisation's belief and the acceptance level of Integrated Operations technology with VAM as the theoretical underpinning.

Chapter 5

RESEARCH DESIGN & METHODOLOGY

5.1 RESEARCH PROCESS

In this research, the scholar has examined the management decision-making barriers for execution of Integrated Operations solutions in India with three independent Research Objectives.

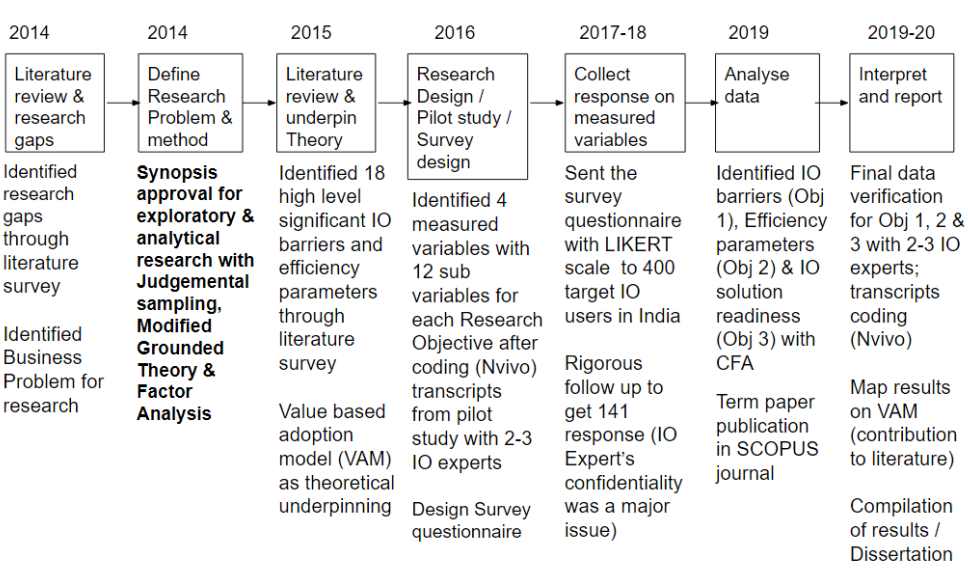


Fig 5.1 : Research Process

5.2 RESEARCH DESIGN

Mix of exploratory [50] and Analytical research approach has been taken with Primary and secondary data collected from various Upstream companies in

India, DGH, OLF, SPE, World Oil etc. to identify the barriers in management decision making for the execution of Integrated Operations solutions, the efficiency parameters and the customized Integrated Operations solutions with use of Modified Grounded Theory.

Value-based technology adoption model [95] was considered as the underlying theory after discussion with few IO experts. Two-stages of data collection and analysis are considered. In the first-stage, speak to 5-10 users with a hard core Integrated Operations background and discuss the basic research approach. Kindly note that data saturation / information immersion alludes to a point during the examination cycle where no new data can be or is found in the information investigation, and this excess signs to scientists that the information assortment may stop. Descriptive parameters assessment is carried out on the data collected from pilot study using Nvivo for three independent Research Objectives. In the second-stage, send surveys out to all the 400 target respondents, and ensure that a minimum 135 responses are collected. Confirmatory Factor analysis using SPSS Amos / Smart PLS was used to identify the barriers from the list of multiple measured variables. Then final data verification will be carried out with 5-10 IO experts with a hard core Integrated Operations background to validate the research findings, using Nvivo.

5.3 MODIFIED GROUNDED THEORY APPLICATION

V Hepso, H Olsen, F Joannette & F Brych have provided insight on the application of various theories & systems for worldwide cooperation to drive business execution in upstream companies in Norway [60]. But Modified Grounded Theory approach (M-GTA) or Grounded theory approach (GTA) [89] was generally not applied in upstream analysis.

There are two broad schools of grounded theory. In this study, Strauss and Corbins [143] version of modified grounded theory has been used. Codes naturally emerged from the interview transcripts of IO experts.

Glaser and Strauss [60] proposed grounded theory in 1967. Later, they split ways due to the difference of opinion regarding the Grounded theory approach. All other grounded theories except the Glaser Class grounded theory can be classified as “modified grounded theory”.

Glaser always supported classical grounded theory - that meant for scholars to keep the eyes and ears open and should not review any literature for coding (Bryant, A,. 2007). Glaser grounded theory is very very time consuming but still some researchers prefer this.

But Strauss was of the opinion that there is no problem deriving codes or knowledge from the existing literature.. Along with one more researcher they proposed another grounded theory in 1987 - which is called “Stauss and Corbin’s version”. The theory is “grounded” in actual data. To elaborate this comments further, the analysis and development of theories take place after the data had been collected and open coding and selective coding used. It was initiated by Glaser & Strauss [60] in 1967 to legitimize qualitative research. Grounded theory has considerable significance because it (a) provides explicit, sequential guidelines for conducting qualitative research; (b) offers specific strategies for handling the analytic phases of inquiry; (c) streamlines and integrates data collection and analysis; (d) advances conceptual analysis of qualitative data; and (e) legitimizes qualitative research as scientific inquiry.

Modified Grounded Theory Approach (M-GTA) is the modified version of GTA but is different from GTA in its strict coding procedures. It does not employ the method of coding data line by line [106]. It rather forms concepts straight from interpretations of data on an analysis worksheet. Data should not be broken down into small chunks in M-GTA.

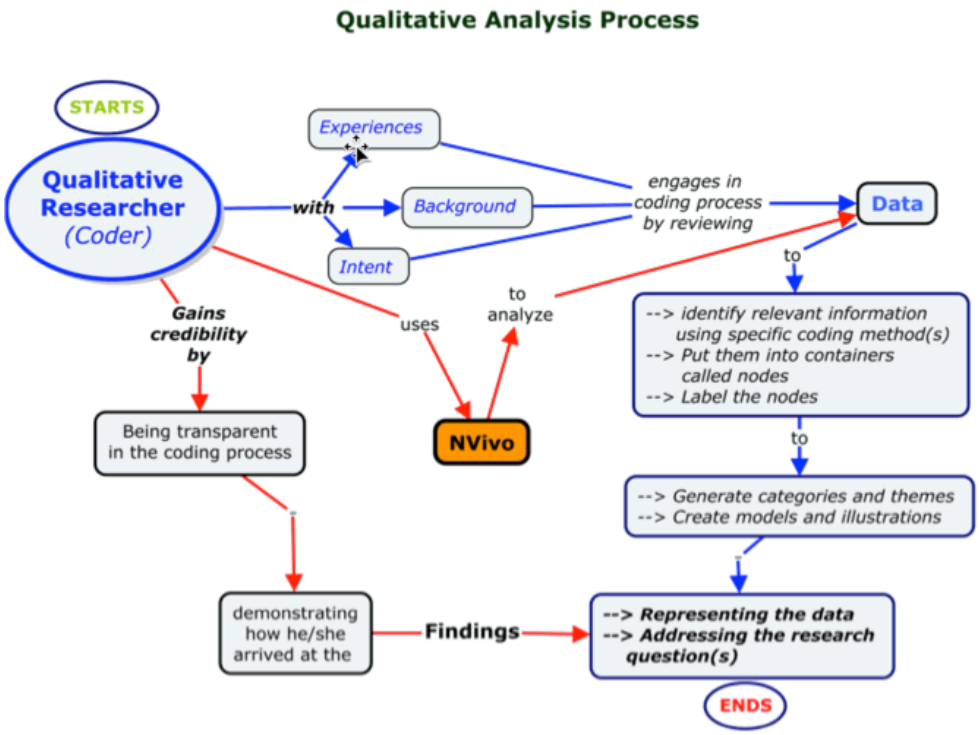


Fig 5.2 : Coding process as per Modified Grounded Theory [160]

5.4 OPEN CODING, AXIAL CODING, AND SELECTIVE CODING

Open coding, axial coding, and selective coding are those different advances which are utilized in the grounded theory technique to break down subjective information. Significant point with grounded theory is that you infer new speculations/ideas dependent on information while in different techniques, you

would begin with a current hypothesis and afterward see if your information applies to the hypothesis.

Corbin and Strauss [143] had laid out their way to deal with the open coding, axial coding and selective coding in their examination paper back in 1990s, "Grounded theory research: Procedures, groups, and evaluative measures."

To put it plainly, the initial step of grounded theory is to do open coding with your printed information and break it into discrete parts. Axial coding is drawing associations between your codes, and afterward selective coding implies that you select one focal classification that interfaces every one of the codes from your examination and toward the end catch the pitch of your exploration.

In *Open coding,* you will start collecting qualitative data, such as transcriptions from interviews, and then break your data into discrete parts and thus create "codes" and label them.

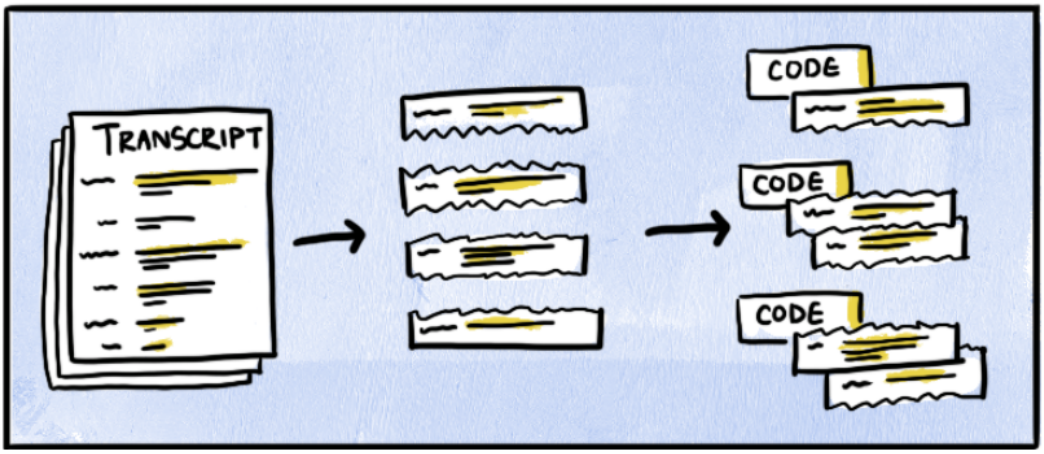


Fig 5.3 : Open Coding [160]

Open-coding is intended to open up new hypothetical prospects while drawing in with subjective information. The motivation behind separating your information and marking them with codes is to have the option to constantly come close and different comparable occasions in your information. This is finished by gathering every one of the bits of information (and even statements) marked with a specific code. This interaction empowers you to avoid any biased inclinations in your own examination.

Axial coding is the second step of coding in a grounded theory. In axial coding, you start to draw associations among codes, and arrange the codes which you had created in the open coding. With axial coding, you discover how your codes can be assembled into classifications.

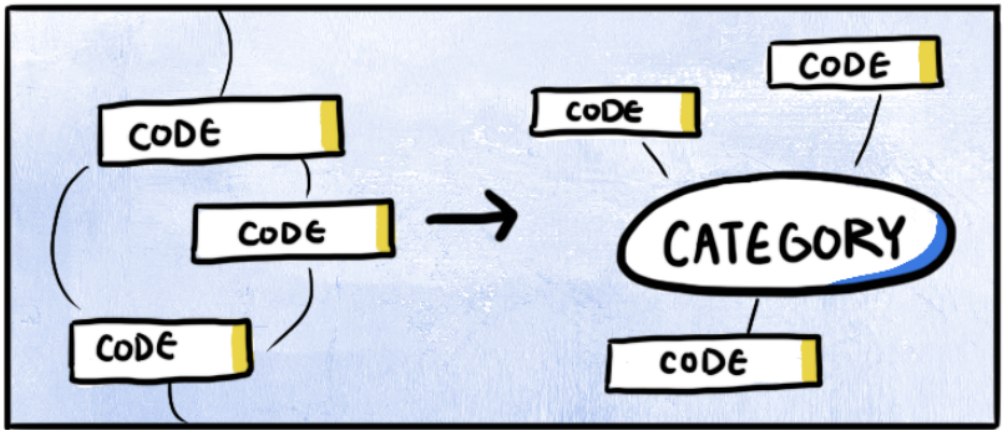


Fig 5.4 : Axial Coding [160]

Selective coding is the last step in Grounded Theory, where you connect all your categories together around that one core category, and thus define one unified theory around your research. This core category in the selective coding may

emanate from one of the axial coding stages or might be a new category altogether. The core category is ultimately representing the central thesis of your research.

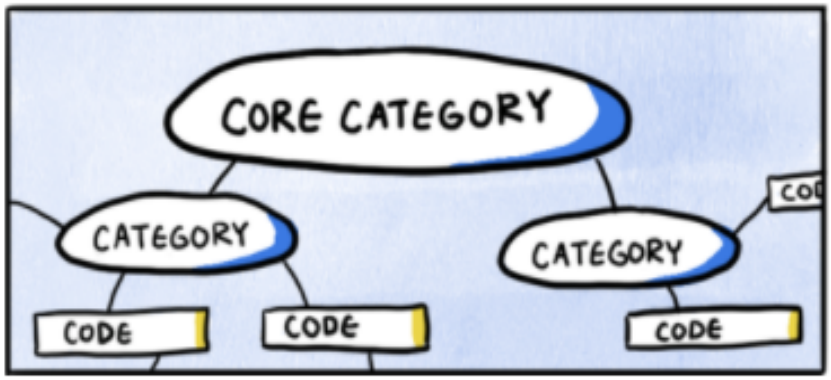


Fig 5.6 : Selective Coding [160]

Following is the step by step process for carrying out open coding, axial coding, and selective coding :

Open coding :

i) Transform your information into little, discrete segments of information

ii) Code each discrete bits of information with a descriptive label

Axial coding :

iii) Find associations and connections between code

iv) Aggregate and consolidate codes into more extensive classifications

Selective coding :

v) Bring it together with one overarching category

vi) Identify the associations between this general classification and the remainder of your codes and information

vii) Remove classes or codes that need more supporting information

Final steps :

Subsequent to having finished the open, axial and selective coding, the account of your information is assembled with a story that revolves around your overall class, and hence gives your scientific clarifications of different classifications that you found.

5.5 CONFIRMATORY FACTOR ANALYSIS

Factor analysis is the technique used for reducing a vast amount of information (large number of measured variables) into a lesser manageable number of variables. Factor analysis is done to feature the basic dimensionality of a bunch of measures.

- Data decrease tool
- Eliminates excess or duplication from a bunch of connected variables.
- Addresses corresponding factors with a more modest arrangement of "determined" factors. These inferred factors may quantify some hidden highlights of the respondents.
- Variables are framed that are moderately autonomous of each other.

Classical Test Theory Idea:

Ideal: $X_1 = F + e_1 \quad var(e_j) = var(e_k)\ ,\ j \neq k$

$X_2 = F + e_2$

...

$X_p = F + e_p$

Reality: $X_1 = \lambda_1 F + e_1 \quad var(e_j) \neq var(e_k)\ ,\ j \neq k$

$X_2 = \lambda_2 F + e_2$

...

$X_p = \lambda_p F + e_p$

(unequal "sensitivity" to change in factor)

- F is a latent (i.e. unobserved, underlying) variable called a *factor*.
- X's are the observed variables.
- e_j is a measurement error for X_j.
- λ_j is the "loading" on factor F for X_j.
- X's are *standardized* prior to beginning a factor analysis, i.e. converted to z-scores.
- F is also standardized, that is the standard deviation of F is 1 and the mean is 0.

$Corr(X_j\ ,\ X_k\ ) = \lambda_j \lambda_k$

- Note that the correlation between X_j and X_k is completely determined by the common factor F.
- Factor loadings (λ_j) are equivalent to correlation between factors and variables when only a single common factor is involved.

5.6 RESEARCH METHODOLOGY FOR RESEARCH OBJECTIVE 1

(Significant management barriers will be identified using Factor Analysis with the objective to expedite decision making resulting in improved efficiency parameters)

1st step : Identify high level significant IO management barriers through literature survey

2nd step : Pilot study with 2-3 IO experts to identify the measured variables for the survey questionnaire for Research Objective 1

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 1

4th step : Estimate the potential IO loss in India with the IO experts

5th step : Sent the questionnaire with LIKERT scale for Research Objective 1 to 400 target IO users in India and get minimum 135 responses

6th step : Identify dominant IO barriers for Research Objective 1 with Confirmatory Factor Analysis

7th step : Pilot study with 2-3 IO experts to validate the final data for Research Objective 1

8th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data for Research Objective 1 with 2-3 IO experts

final step : Finalize result for Research Objective 1 and map it to Value-based Technology Adoption Model

5.6.1 SOURCES OF DATA FOR OBJECTIVE 1

After a literature survey, draft IO management barriers were identified and discussed with few IO experts through a pilot study to identify the measured variables (using Modified Grounded Theory research application) for primary data collection through a survey questionnaire for Research Objective 1. This survey questionnaire was distributed to 400 participants from Indian upstream companies that are producing oil and gas and have scope for adopting Integrated Operations based technological solutions. Total 141 stakeholders from ONGC, Oil India, ONGC Videsh, Cairn Energy, BG, HOEC, Essar etc provided responses after rigorous follow up. Majority of these participants responded on the condition of anonymity due to the sensitive nature of management's view on such initiative and subsequent investment. After Confirmatory factor analysis, final data verification was carried out with a few IO experts using Modified Grounded Theory research application.

The secondary data was collected from BI Norwegian Business School, DGH, OLF, Norwegian University of Science and Technology, Purdue university, Society of Petroleum Engineers, World Oil, and other Research Journals.

5.6.2 SAMPLING FOR OBJECTIVE 1

Judgemental Sampling technique was used considering the limited number of people with expertise in the Integrated Operations area being researched. In this survey questionnaire with 5 point Likert scale, stakeholders were asked to assess 4 measured variables and 12 sub-variables for Research Objective 1.

Our preliminary list contained 400 target respondents but only 141 participated and the majority of the participants preferred to be anonymous considering Integrated Operations as a confidential business initiative of the organization. As an essential for pre-preparing, missing reactions were wiped out and the last example was made out of 141 respondents.

Age (years)	25-35	36-45	Above 46	Total	%
O&M	12	42	11	65	46%
IT	28	31	17	76	54%
Total	40	73	28	141	
%	29%	51%	20%		100%

Table 5.1 : Sample Distribution

Among the examples acquired, 46% were from Operations and Maintenance (O&M) department and 54% were from the Information Technology (IT) side, which compares generally to the allotment of the veritable population. The Specific O&G space nuances of our model are presented in Table 5.1.

Sample size gives the premise to the assessment of sample error and effects on the capacity of the model to be effectively assessed.

$n = N / (1 + Ne^2)$

n= corrected sample size, N = population size, and e = Margin of error (MoE), e = 0.05 in light of the research condition. In a limited population, when the original sample gathered is over 5% of the populace size, the remedied sample size is controlled by utilizing the Yamane's recipe

Precision alludes to how close gauges from various samples are to one another. At the point when the standard error is little, sample estimates are more exact; when the standard error is enormous, sample estimates are less accurate.

	Inputs
Estimated Proportion	0.15
Desired precision of estimate	0.05
Confidence level	0.95
Population size	400

Table 5.2 : Results : Sample population size required for specified input

For Population = 400,	Sample size is 139

Table 5.3 : Sample size

	AP = 0.01	AP = 0.02	AP = 0.05	AP = 0.1	AP = 0.2	AP = 0.5
Precision = 0.01	381	753	1825	3458	6147	9604
Precision = 0.02	96	189	457	865	1537	2401
Precision = 0.05	16	31	73	139	246	385
Precision = 0.1	4	8	19	35	62	97
Precision = 0.2	1	2	5	9	16	25

Table 5.4 : Sample size table for varying prevalence and precision values

5.6.3 PILOT STUDY INTERVIEW PROTOCOL FOR OBJECTIVE 1

Pilot study with few IO experts was conducted resulting in the transcripts on the following pages.

Transcript #1 for pilot study (#PS1-T1-IOE01-d2-B01-MH)

29th March, 2016

Telephonic Interview IO expert#1 (O&M head of Company#2) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from theIO expert
1.	What kind of barriers are faced by the IO users typically?	Users feel a lack of education on the right use cases for meaningful implementation of IO initiviates . And users face delay in approval from the decision makers for implementing the final approved use case.
2.	How do you decide on the right IO solution required?	We take some industry benchmarks from other peer companies who are ahead of using IO implementation. Then we follow and pick the IO focus areas suitable for our operations.
3.	What is the first step in adoption of IO by the organisation?	We focus on key performance indicators which can tell us what is happening in near real time.
4.	How comfortable are users with IO adoption initiatives ?	Users are still trying to learn new software solutions. It is extra work for them considering IO is still a novel concept.
5.	How do business users keep themselves abreast with IO developments worldwide?	Users curious to learn on this subject are sent to attend IO conferences and are encouraged to present papers in such professional conferences.

6.	How do you decide if a certain IO project will be beneficial to organisation?	We do cost benefit analysis of individual IO pilot project based on the solution pricing estimates, before making a decision to roll it out.
7.	How easy it is to maintain the IT complexity of the rolled out solution?	We prefer subcontracting it to some IT expert company for regular upkeep and maintenance of the IT infrastructure. Better to leave it to the experts and focus more on getting the business benefit expected from such a solution.
8.	Which all departments are ready for trying IO solutions ?	Production and Maintenance are always the the first users. Reservoir and Drilling are the next followed by Purchase, Logistics etc.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises

Table 5.5 : Transcript #1 for pilot study

Transcript #2 for pilot study (#PS1-T2-IOE02-d3-C01-GJ)

4th April, 2016

Telephonic Interview IO expert#2 (IT head of Company#3) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from theIO expert
1.	What kind of barriers are faced by the IO users typically?	Many users struggle to use the software solutions at times. They are unable to understand the background logic of the IT solution which creates a barrier in meaningful implementation of IO initiviates .
2.	How do you decide on the right IO solution required?	We focus on the user's operations / business needs and try to source out solutions with real time visibility and analytical capabilities from various IT players. Make sure that they have already implemented such a solution earlier for some clients to avoid delays due to such learnings.
3.	What is the first step in adoption of IO by the organisation?	List out use cases by users first. Then lay out an IT roadmap from IO perspective with clear use cases and the software solution components needed. Then break it into a phase wise roll out plan.
4.	How comfortable are users with IO adoption initiatives ?	Users are not very comfortable with IO adoption because it involves learning new ways of working with software.
5.	How do business users keep themselves abreast with IO developments worldwide?	IT department keeps sharing any development in and around Digital Oilfield with business users. Frequent internal discussions are held to avoid any communication gap on the likely

6.	How do you decide if a certain IO project will be beneficial to organisation?	Business user departments take care of this aspect. They would do the cost benefit exercise of the project. We focus on the underlying IT framework cost aspects.
7.	How easy it is to maintain the IT complexity of the rolled out solution?	Easy to maintain provided users highlight any technical glitches to the IT department. We subcontract AMC to an IT vendor and attend to issues pointed out by users..
8.	Which all departments are ready for trying IO solutions ?	IT department takes lead on this followed by O&M, Drilling etc.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.6 : Transcript #2 for pilot study

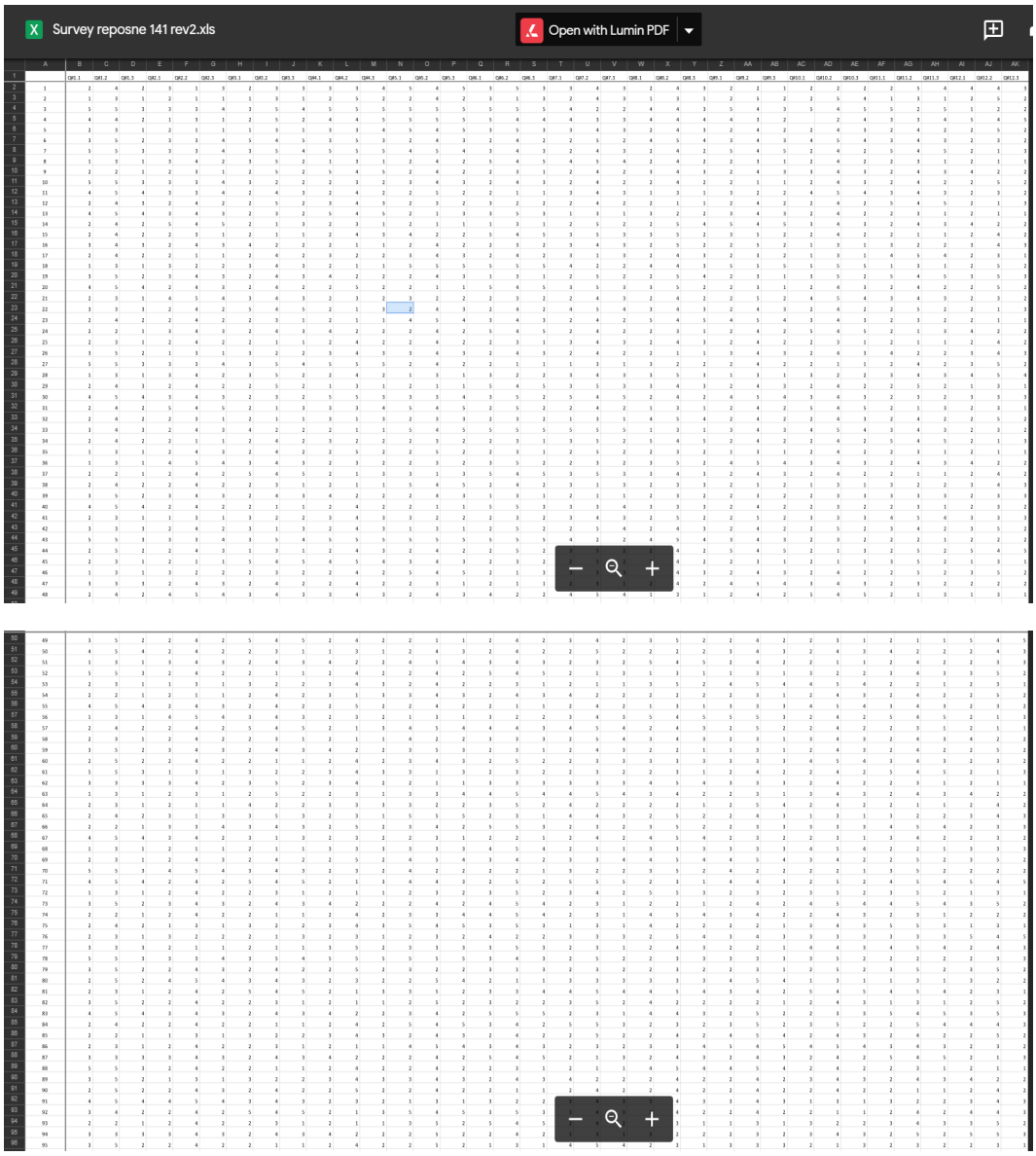
5.6.4 SURVEY QUESTIONNAIRE FOR OBJECTIVE 1

Research Objective 1	Measured variables for Objective 1	Measured sub-variables for Objective 1	Ref Q# from Survey
Identify IO Investment barriers	IO Education	User inclination towards IO	Q1.1
		User curiosity about IO	Q1.2
		IO learning ability of user	Q1.3
	IO Organisation Drive	Global Upstream Industry assessment of IO	Q2.1
		Enterprise-wide drive for IO	Q2.2
		Industries 4.0 benefits with IO technology	Q2.3
	IO Cost	Market Price of IO technology	Q3.1
		Acquisition cost of IO technology vs Savings	Q3.2
		Maintenance cost of IO technology	Q3.3
	IO Adoption	Business Performance improvements with IO technology	Q4.1
		Wider functionality coverage with IO technology	Q4.2
		User friendliness for using IO technology	Q4.3

Table 5.7 : Measured variables for Research Objective 1

5.6.5 DATA COLLECTION THROUGH SURVEY RESPONSES FOR OBJECTIVE 1

As an essential for pre-preparing, missing responses were wiped out and the final sample was made out of 141 respondents.



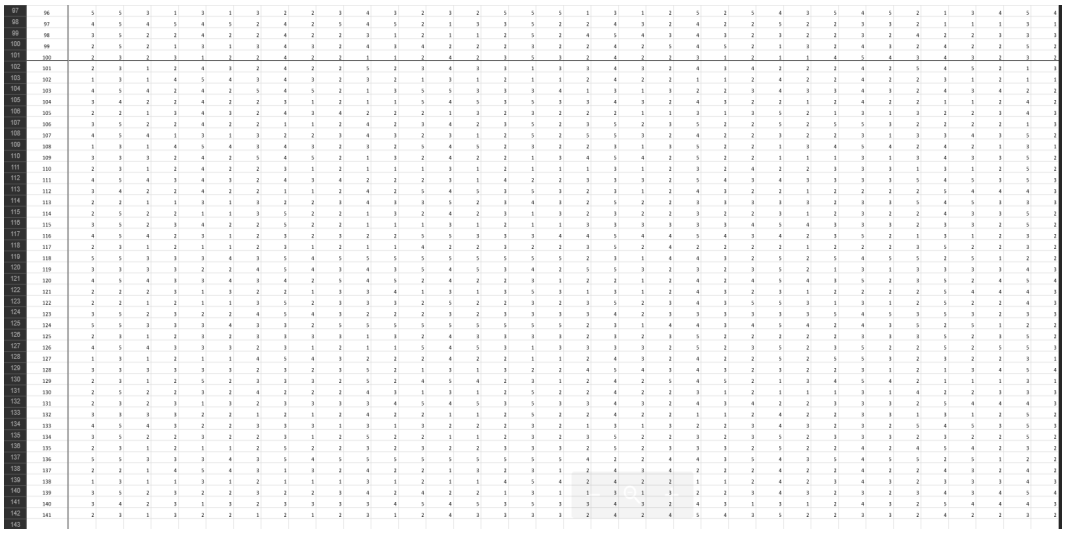


Table 5.7 : Survey response on Likert scale (for Research Objective 1)

5.6.6 FINAL DATA VALIDATION TRANSCRIPTS FOR OBJECTIVE 1

Final data verification discussion with few IO experts was carried out resulting in the transcripts on the following pages.

Transcript #1 for final data validation (#FD123-T1-IOE05-d2-E01-DL)
25th July, 2018

Telephonic Interview IO expert#5 (Digital Oilfield Production Manager of Company#5) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	It is important in second phase because unless user departments and top management see the quick wins in first phase of IO initiative, they don't believe in the new concepts.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Yes, that is true. It depends on the top management team members. How much knowledge they have about it.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Lack of education by users and lack of willingness to adopt by top management are the significant barriers which delay budget approvals.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	Market price combined with the expected returns on such investments is important. So benefits are more important than the price.

5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Both are very important. Curiosity and willingness to learn has to be there.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	Perception is that IT complications are bound to be there and immediate solution readiness must be there. And it is always there. So no issues.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Any reference case helps us feel more confident about any of the Ind 4.0 solutions.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Depends on how much info top management needs to get convinced. To answer, yes both are important factors.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	IO is built on few important pillars which includes these two for sure.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	Slowly handhelds are becoming part of every IO solution component.
11.	How important is the Manpower Effectiveness for designing the IO based solution?	Not a lot. It depends on which solution involves more manpower.
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	Point solution era is kind of over. Now, it is all about integrated solution with real time visibility, not confined to any one solution.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises

Table 5.8 : Transcript #1 for final data verification

Transcript #2 for final data validation **(#FD123-T2-IOE01-d2-B01-MH)**

5th August, 2018

Telephonic Interview IO expert#1 (O&M head of Company#2) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	It is not that important to push for a drive all across the company. It can be understood with a contrasting example like HSE initiative which is mandatory to run across whole organisation but not IO.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Yes, indeed. Main reason for that is lack of clarity on how such new technology initiatives will help us.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Cost and education, I would say. Justification of the return on investment is the major reason.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	As long as budgeting takes care of the current price, it is not important as compared to the 4.0 returns which is far more important.

5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Most essential points. This is where the whole game starts.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	It's critical for Operations and the back up support ensures that we don't run into any problem.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Important but not critical. Yes, we do take ideas from other operators but ultimately it is our operations which needs to be improved further.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Significantly important as without these two elements, we shall have a great risk exposure.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Both are highly highly important. Even decades back when DCS was introduced, it was based on these two concepts only.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	It is gaining importance as everyone can access information on-the-go.
11.	How important is the Manpower Effectiveness	It should ideally be an important criteria while designing any solution. Hopefully, it gets better in future.

	for designing the IO based solution?	
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	We try to minimise point solutions especially due to lack of integration capabilities because different vendors try to protect their own IPs.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.9 : Transcript #2 for final data verification

Transcript #3 for final data validation (#FD123-T1-IOE03-d1-D01-TN)

8th August, 2018

Telephonic Interview IO expert#3 (COO of Company#4) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	Being a smaller organisation, economies of scale are not that important for our operations. That's the reason, we are unable to go to that enterprise level on IO.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Yes we do struggle here in India.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Absence of willingness to try new concept and not knowing the full potential are the biggest barriers.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	This whole concept of IO is there only because of its savings potential. So benefits have to outweigh the price.
5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Absolutely important, both points.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	Whole organisation is sitting on some or the other IT network. So it is handled on a day to day basis and

		handled well. So not a challenge as such.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Other companies' success reference cases are very important. That sets the benchmark for us to achieve.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Both domain expertise and confidence on the IO solution are very important.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Obviously the most important part of any solution for Integrated Operations.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	With everyone having some handheld device, it is becoming crucial.
11.	How important is the Manpower Effectiveness for designing the IO based solution?	It is important to reduce our dependence on manpower. Especially offshore where there is limited space.
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	Scattered Point-software based solutions are plenty and shall remain there in time to come irrespective of integrated operations.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.10 : Transcript #3 for final data verification

5.7 RESEARCH METHODOLOGY FOR OBJECTIVE 2 (Significant efficiency parameters will be identified using Factor Analysis based on impact of implementation of Integrated Operations solution in the Indian upstream companies)

1st step : Identify high level efficiency parameters through literature survey

2nd step : Pilot study with 2-3 IO experts to identify the measured variables for the survey questionnaire for Research Objective 2

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 2

4th step : Sent the questionnaire with LIKERT scale for Research Objective 2 to 400 target IO users in India and get minimum 135 responses

5th step : Identify dominant IO Efficiency parameters for Research Objective 2 with Confirmatory Factor Analysis

6th step : Pilot study with 2-3 IO experts to validate the final data for Research Objective 2

7th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data verification for Research Objective 2 with 2-3 IO experts

final step : Finalize result for Research Objective 2 and map it to Value-based Technology Adoption Model

5.7.1 SOURCES OF DATA FOR OBJECTIVE 2

After a literature survey, IO efficiency parameters were identified after interviewing a few IO experts through a pilot study. With these measured variables (identified using Modified Grounded Theory research application after processing the pilot study transcripts), primary data collection was carried out using a survey questionnaire for Research Objective 2. This survey questionnaire was distributed to 400 participants from Indian upstream companies that are producing oil and gas and have scope for adopting Integrated Operations based technological solutions. Total 141 stakeholders from ONGC, Oil India, ONGC Videsh, Cairn Energy, BG, HOEC, Essar etc provided responses after rigorous follow up. Majority of these participants responded on the condition of anonymity due to the sensitive nature of management view on such initiative and subsequent investment. After Confirmatory factor analysis, final data verification was carried out with a few IO experts using Modified Grounded Theory research application.

The secondary data was collected from BI Norwegian Business School, DGH, OLF, Norwegian University of Science and Technology, Purdue university, Society of Petroleum Engineers, World Oil, and other Research Journals.

5.7.2 SAMPLING FOR OBJECTIVE 2

Judgemental Sampling technique was used considering the limited number of people with expertise in the Integrated Operations area being researched. In this survey questionnaire with 5 point Likert scale, stakeholders were asked to assess 4 measured variables and 12 sub-variables for research objective 2.

Our preliminary list contained 400 target respondents but only 141 participated and the majority of the participants preferred to be anonymous considering Integrated Operations as a confidential business initiative of the organization. As an essential for pre-preparing, missing reactions were wiped out and the last example was made out of 141 respondents.

Among the example acquired, 46% were from Operations and Maintenance (O&M) departemnt and 54% were from Information Technology (IT) side, which compares roughly to the appropriation of the genuine population. The Specific O&G space subtleties of our example are introduced in Table 5.1 to 5.4 above.

5.7.3 PILOT STUDY INTERVIEW PROTOCOL FOR OBJECTIVE 2

Pilot study with few IO experts was conducted resulting in the transcripts on the following pages.

Transcript #3 for pilot study (#PS1-T3-IOE03-d1-D01-TN)

22nd April, 2016

Telephonic Interview IO expert#3 (COO of Company#4) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from theIO expert
1.	What kind of barriers are faced by the IO users typically?	Lack of understanding of the real solution due to gap in their understanding of IT jargon. Second factor is willingness to try newer ways newer solutions alongwith regular day job.
2.	How do you decide on the right IO solution required?	If a solution has been tested and tried somewhere, we look at that case study and ensure that the solution is real and adds to operational benefit.
3.	What is the first step in adoption of IO by the organisation?	Educating IO users and managing the change management side of it. It is important that the users are mentally ready for this change.
4.	How comfortable are users with IO adoption initiatives ?	Generally, users do not show initiative in such projects because they will be losing control over information which is restricted to a large extent with them. Therefore, user friendliness of the solution is a critical factor.
5.	How do business users keep themselves abreast with IO	IT department helps share any new development in and around Digital Oilfield with business users. Their willingness to learn new things is the motivating factor. Frequent internal

	developments worldwide?	discussions are held to avoid any communication gap on the likely adoption of such solutions by other operators.
6.	How do you decide if a certain IO project will be beneficial to organisation?	Business user departments take care of this aspect. They would do the cost benefit exercise of the project. We focus on the underlying IT framework cost aspects and help budget holders to decide on the target project estimate in line with the market prices of such digital solutions.
7.	How easy it is to maintain the IT complexity of the rolled out solution?	With team work from all the departments, it is easy to maintain provided users highlight any technical glitches to the IT department. We subcontract upkeep of the system to an IT service provider.
8.	Which all departments are ready for trying IO solutions ?	It starts with users curious to try new software solutions. Then IT department supports on this followed by actual use cases by O&M, Drilling etc.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.11 : Transcript #3 for pilot study

Transcript #4 for pilot study (#PS1-T4-IOE04-d4-A01-AS)

20th May, 2016

Telephonic Interview IO expert#4 (Head Drilling of Company#1) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from theIO expert
1.	What kind of barriers are faced by the IO users typically?	Drilling has been using remote communication and drilling software for last 8-10 years now. Only gap is integrating real time data with other user departments like Reservoir, G&G, Production etc. That's still a barrier.
2.	How do you decide on the right IO solution required?	Any solution which answers questions on drilling risks is our go to solution. And it has been developed by our drilling contractors and some drilling specific software supplies over last one decade.
3.	What is the first step in adoption of IO by the organisation?	Saving in drilling cost and drilling risk mitigation are the initial steps in IO adoption by our organisation apart from real time visibility of the ongoing drilling operations.
4.	How comfortable are users with IO adoption initiatives ?	Very comfortable because that makes drilling less risky and cost effective.
5.	How do business users keep themselves abreast with IO developments worldwide?	Working with reputed international drilling contractors keeps our drilling and evaluation experts updated with latest software knowledge and developments.
6.	How do you decide if a certain IO project will be beneficial to organisation?	Criteria is simple. It should help reduce drilling time and minimize any drilling surprises.As long as we are safe and on time, the project is beneficial.
7.	How easy it is to maintain the IT	At times, not that easy to maintain due to multiple drilling contractors needed data to be

	complexity of the rolled out solution?	shared among various users. But we manage fairly well with IT support from our expert contractors.
8.	Which all departments are ready for trying IO solutions ?	Drilling and G&G departments are ready for sure because of the decade long history in this space.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.12 : Transcript #4 for pilot study

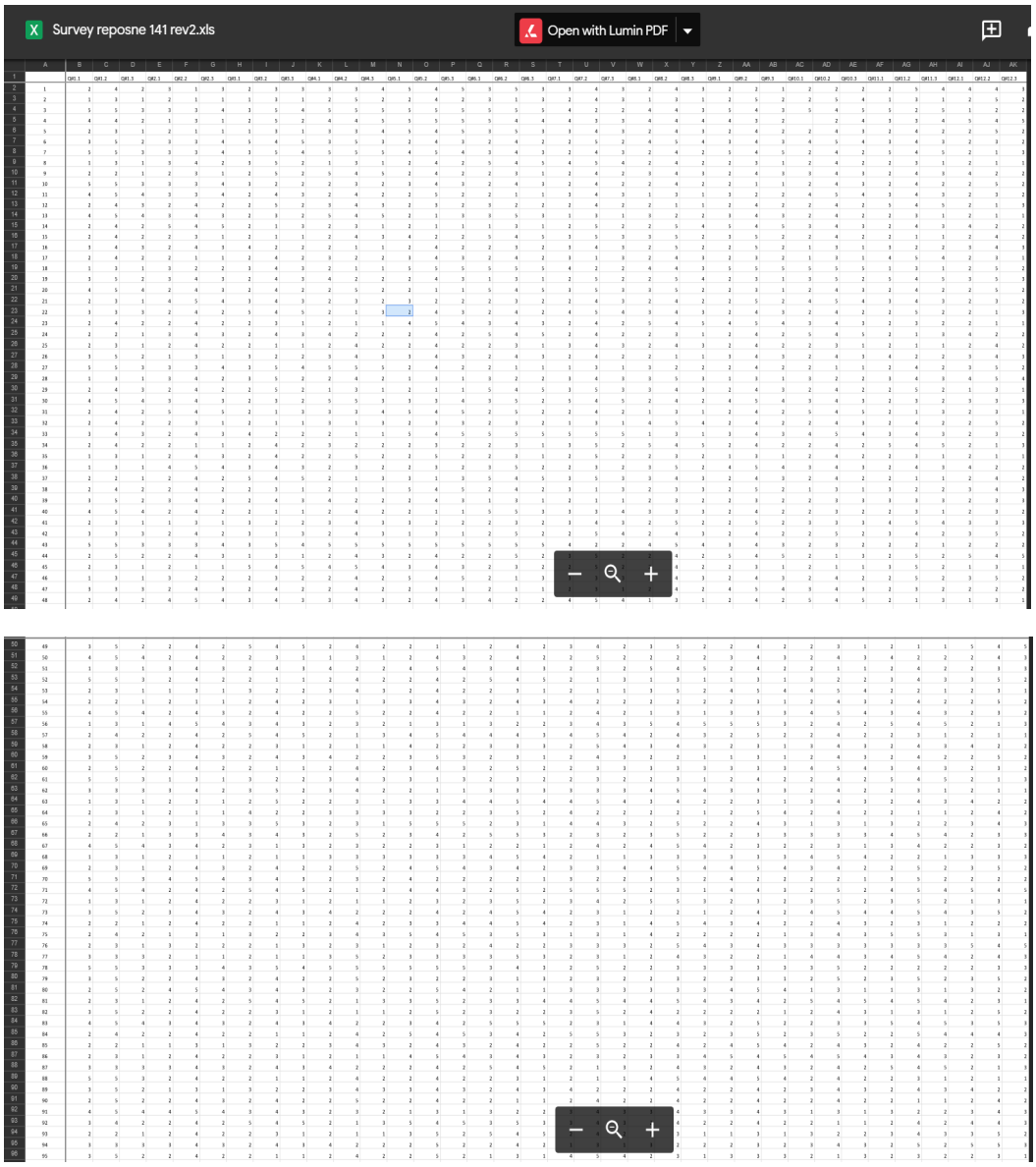
5.7.4 SURVEY QUESTIONNAIRE FOR OBJECTIVE 2

Research Objective 2	Measured variable for Objective 2	Measured sub-variables for Objective 2	Ref Q# from Survey
Identify IO Solutions efficiency parameters	Higher Visibility features	IO Real time dashboards	Q5.1
		Data integration from various applications	Q5.2
		IO Key Performance Indicators (KPIs)	Q5.3
	Predictive analytics features	Value addition to business performance improvement	Q6.1
		Alerts and Recommendations for Process & Assets	Q6.2
		Early corrective actions, to handle process upset	Q6.3
	Operating Efficiency	IO based solution for Operating Efficiency needed	Q7.1
		Scattered Point software based solution needed	Q7.2
		Traditional PLC / DCS based solution	Q7.3
	Manpower Effectiveness	IO based solution for Manpower Effectiveness needed	Q8.1
		Handheld based software applications	Q8.2
		Mobile / walkie talkies based solution	Q8.3

Table 5.13 : Measured variables for research (for Research Objective 2)

5.7.5 DATA COLLECTION THROUGH SURVEY RESPONSES FOR OBJECTIVE 2

As an essential for pre-preparing, missing responses were wiped out and the final sample was made out of 141 respondents.



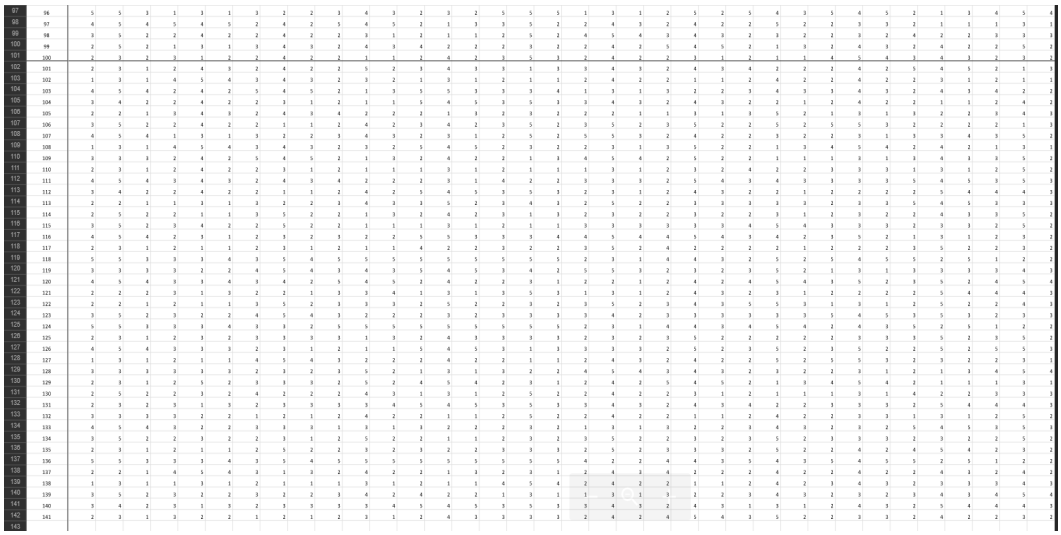


Table 5.14 : Survey response on Likert scale (for Objective 2)

5.7.6 FINAL DATA VALIDATION TRANSCRIPTS FOR OBJECTIVE 2

Final data verification discussion with few IO experts was carried out resulting in the transcripts on the following pages.

Transcript #4 for final data validation (#FD123-T4-IOE06-d2-B02-MH)

13th August, 2018

Telephonic Interview IO expert#6 (Digital Oilfield Manager of Company#2) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	It is important and we had started with online monitoring aspects in the whole organisation but it involves change management ….and people are taking time to make it an organisation wide drive. We are lacking in that.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Depends on the company. If you ask, majority of upstream oil and gas companies struggle on this in India. But in our company we do get approvals from time to time. But we have not been able to show a clear benefit thro IO due to various reasons.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption	Education and adoption for sure. Integrated Operations is like a fashion statement just like ERP in old times for most of the seniors. No one knows and

	in the implementation of IO by Oil & Gas companies?	that's why we struggle to get approvals. Devil is always in details.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	We look at the benefits while deciding on IO strategy. Unless returns look promising, no one will approve any IO project irrespective of its market prices.
5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Both are as important as support from top management on any such drive.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	Different vendors, different solutions pose different challenges. We make sure while selecting the solution that such issues do not arise.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	It's very important because we get clarity on deciding where to put money to get maximum benefits.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	It is critical starting point. Unless we have confidence on solution and unless the domain expertise is there, it would be difficult to start. As on today, this is still the focus area while planning any new IO based solution area.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Significantly important for obvious reasons.
10.	How important are handheld based software applications as	It is important given all the apps available for almost every software solution.

	a crucial part of the IO solutions?	
11.	How important is the Manpower Effectiveness for designing the IO based solution?	It is important in some cases only. Reliance on manpower is reducing gradually but it can only be minimised, can not be eliminated.
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	Stand alone point solutions are integral part of overall Integrated Operations. It will reduce gradually but that may take a decade probably because of different types of domain expertise involved.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.15 : Transcript #4 for final data verification

Transcript #5 for final data validation (#FD123-T5-IOE07-d1-B03-DL)

17th August, 2018

Telephonic Interview IO expert#7 (Director Operations of Company#2) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	In today's digital era, it is ideally as important as the need for safety and production increase in any oil and gas company. But we are more in the follower category when it comes to Integrated Operations. So IO adoption is still limited to various pockets in the organisation.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	No we don't struggle. As and when any projects are tabled with required approvals, we grant budget for that. But it is a new area so it will take some time before we come to a level where IO becomes an integral part of our operations related initiative.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Education and adoption for sure are the main barriers in execution of Integrated Operations.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	Market price is immaterial. Even if some service provider is giving us a pilot solution for free, it is tried only if it promises any benefits.

5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Yes, very important. It is the curiosity to learn more which takes us forward, in every subject.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	It used to be an issue a decade back but now it is under control.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	It is critical because all the technical know how comes from the western world.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Very important because of within any oil and gas company, there are numerous domain. And that domain knowledge is crucial for solving business problem.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Real time view of operations is very important for taking quick critical decisions involving safety and productivity of our company.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	It is becoming more and more important. Wherever personal mobiles are allowed, those personal devices help in this.
11.	How important is the Manpower Effectiveness for designing the IO based solution?	Important. The whole idea of Integrated Operations is to minimize dependence on the individual decisions.
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	We use hundreds of software coming from multiple companies. Challenge is to integrate these for common goal.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.16 : Transcript #5 for final data verification

5.8 RESEARCH METHODOLOGY FOR RESEARCH OBJECTIVE 3

*(*The customized solution with management barriers removed will be prepared. The same will be validated by expert opinion of stakeholders from upstream companies in India with application of Modified Grounded Theory)

1st step : Identify the customised IO technology solution and its readiness parameters through literature survey

2nd step : Pilot study with 2-3 IO experts to identify the measured variables for the survey questionnaire for Research Objective 3

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 3

4th step : Verify the customised IO solution with the IO experts

5th step : Sent the questionnaire with LIKERT scale for Research Objective 3 to 400 target IO users in India and get minimum 135 responses

6th step : Identify the customised IO technology solution readiness parameters for Research Objective 3 with Confirmatory Factor Analysis

7th step : Pilot study with 2-3 IO experts to validate the final data for Research Objective 3

8th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data verification for Research Objective 3 with 2-3 IO experts

final step : Finalize result for Research Objective 3 and map it to Value-based Technology Adoption Model

5.8.1 SOURCES OF DATA FOR OBJECTIVE 3

After a literature survey, customised IO solution and organisation barriers for its adoption were identified after interviewing few IO experts through a pilot study. With these measured variables (identified using Modified Grounded Theory research application after processing the pilot study transcripts), primary data collection was carried out using a survey questionnaire for Research Objective 3. This survey questionnaire was distributed to 400 participants from Indian upstream companies that are producing oil and gas and have scope for adopting Integrated Operations based technological solutions. Total 141 stakeholders from ONGC, Oil India, ONGC Videsh, Cairn Energy, BG, HOEC, Essar etc provided response after rigorous follow up. Majority of these participants responded on the condition of anonymity due to the sensitive nature of management's view on such initiative and subsequent investment. After Confirmatory factor analysis, final data verification was carried out with a few IO experts using Modified Grounded Theory research application.

The secondary data was collected from BI Norwegian Business School, DGH, OLF, Norwegian University of Science and Technology, Purdue university, Society of Petroleum Engineers, World Oil, and other Research Journals.

5.8.2 SAMPLING FOR OBJECTIVE 3

Judgemental Sampling technique was used considering the limited number of people with expertise in the Integrated Operations area being researched. In this survey questionnaire with 5 point Likert scale, stakeholders were asked to assess 4 measured variables and 12 sub-variables for research objective 3.

Our preliminary list contained 400 target respondents but only 141 participated and the majority of the participants preferred to be anonymous considering Integrated Operations as a confidential business initiative of the organization. As an essential for pre-preparing, missing reactions were wiped out and the last example was made out of 141 respondents.

Among the example acquired, 46% were from Operations and Maintenance (O&M) department and 54% were from Information Technology (IT) side, which compares roughly to the appropriation of the genuine population. The Specific O&G space subtleties of our example are introduced in Table 5.1 to 5.4 above.

5.8.3 PILOT STUDY INTERVIEW PROTOCOL FOR OBJECTIVE 3

Pilot study with few IO experts was conducted resulting in the transcripts on the following pages.

Transcript #5 for pilot study (#PS1-T5-IOE05-d2-E01-DL)

25th May, 2016

Telephonic Interview IO expert#5 (Digital Oilfield Production Manager of Company#5) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from theIO expert
1.	What kind of barriers are faced by the IO users typically?	Users feel a lack of right use cases for meaningful implementation of IO initiviates . And users face delay in approval from the decision makers for implementing the final approved use case.
2.	How do you decide on the right IO solution required?	We take some industry benchmarks from other peer companies who are ahead of using IO implementation. Then we pick the IO focus areas suitable for our operations.
3.	What is the first step in adoption of IO by the organisation?	We focus on key performance indicators like real time view of operations, efficiency parameters etc. which can tell us what is happening in near real time.
4.	How comfortable are users with IO adoption initiatives ?	Users are still learning new IO solutions. It is extra work for them considering IO is still a new concept.
5.	How do business users keep themselves abreast with IO developments worldwide?	Business users attend IO conferences and are encouraged to present papers.

		They also try small pilot projects within a limited budget to ensure that they are on the right track for larger IO initiatives.
6.	How do you decide if a certain IO project will be beneficial to organisation?	Detailed roadmap with phase wise cost benefit analysis of individual IO projects is carried out by our deptt, before rolling it out to actual level.
7.	How easy it is to maintain the IT complexity of the rolled out solution?	We prefer subcontracting it to some IT expert company for regular upkeep and maintenance of the IT infrastructure. Better to leave it to the experts and focus more on getting the business benefit expected from such a solution.
8.	Which all departments are ready for trying IO solutions ?	Production and Maintenance are always the first users. Reservoir and Drilling are the next followed by Purchase, Logistics etc.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises

Table 5.17 : Transcript #5 for pilot study

Transcript #6 for pilot study (#PS1-T6-IOE03-d2-B01-MH)

9th June, 2016

Telephonic Interview IO expert#1 (Base Manager of Company#2) for Identifying IO Investment barriers

Focus : To pick the right variables for the questionnaire after discussion with 5 to 10 IO experts

Sl. No.	Question by Scholar	Answers from the IO expert
1.	What kind of barriers are faced by the IO users typically?	There is a lack of education on the right use cases for meaningful implementation of IO initiviates .
2.	How do you decide on the right IO solution required?	We follow the industry benchmarks from other peer companies who are ahead of using IO implementation. Then we pick the IO focus areas suitable for our operations.
3.	What is the first step in adoption of IO by the organisation?	Focus is on key performance indicators which can tell us what is happening in near real time.
4.	How comfortable are users with IO adoption initiatives ?	Users are still trying to learn new software solutions.
5.	How do business users keep themselves abreast with IO developments worldwide?	Users attend IO conferences and are encouraged to present papers in such professional conferences.
6.	How do you decide if a certain IO project will be beneficial to organisation?	We do cost benefit analysis of individual IO pilot project based on the solution pricing estimates, before making a decision to roll it out.
7.	How easy it is to maintain the IT complexity of the rolled out solution?	Better to leave it to the experts and focus more on getting the business benefit expected from such a solution.

8.	Which all departments are ready for trying IO solutions ?	Production and Maintenance followed by Reservoir and Drilling.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.18 : Transcript #6 for pilot study

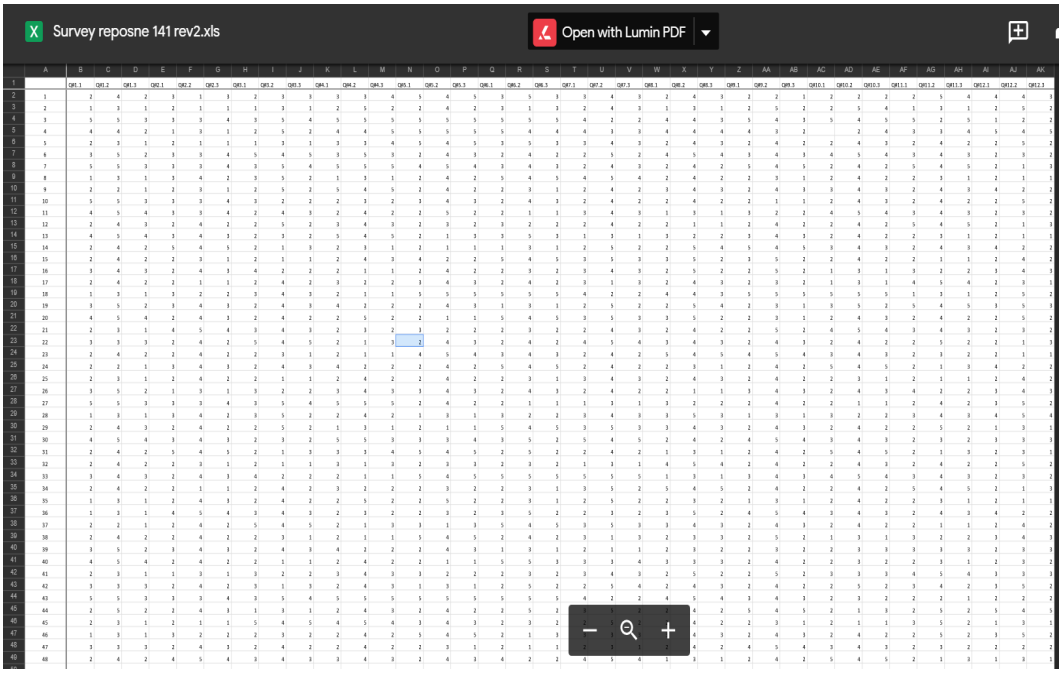
5.8.4 SURVEY QUESTIONNAIRE FOR OBJECTIVE 3

Research Objective 3	Measured variable for Objective 3	Measured sub-variables for Objective 3	Ref Q# from Survey
Measure Organisation Readiness for customised IO solution	IO Optimism	Confidence on IO technology delivery capabilities	Q9.1
		Willing to take risk for business improvements	Q9.2
		Workforce readiness to embrace Industries 4.0 changes	Q9.3
	IO Innovation	Develop own new IO use cases with analytics features	Q10.1
		Organisation willing to try pilot / proof of concepts	Q10.2
		Willing to replicate across Enterprise for larger benefits	Q10.3
	IO Wait & watch	Willing to spend on new IO solution	Q11.1
		Need Proven use cases before spending on IO	Q11.2
		Desire to achieve Industry 4.0 compliance	Q11.3
	IO Pessimism	Doubt IO technology to give business improvements	Q12.1
		IT complications created by IO technology	Q12.2
		Bad implementation due to lack of domain expertise	Q12.3

Table 5.19 : Measured variables for research (for Research Objective 3)

5.8.5 DATA COLLECTION THROUGH SURVEY RESPONSES FOR OBJECTIVE 3

As an essential for pre-preparing, missing responses were wiped out and the final sample was made out of 141 respondents.



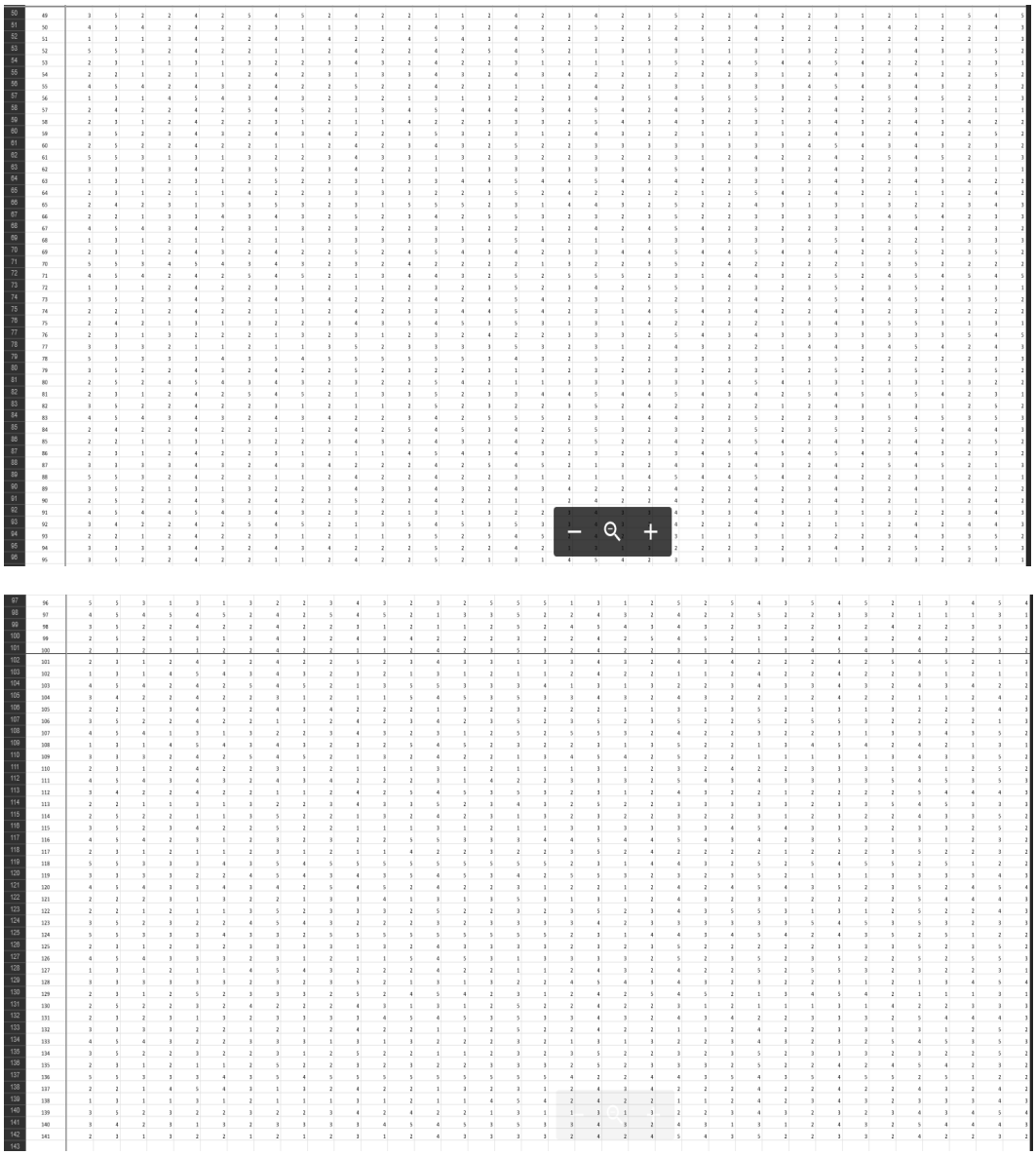


Table 5.20 : Survey response on Likert scale (for Objective 3)

5.8.6 FINAL DATA VALIDATION TRANSCRIPTS FOR OBJECTIVE 3

Final data verification discussion with few IO experts was carried out resulting in the transcripts on the following pages.

Transcript #6 for final data validation (#FD123-T6-IOE08-d5-E02-DL)

27th August, 2018

Telephonic Interview IO expert#8 (Subsurface Manager of Company#5) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	It is important as long as it is focused on common goal. So if common goal is improved production with better reservoir management, answer is yes but in reality it has never happened for any such IT based initiative.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	What is IO? If you ask G&G teams, we had been using software for more than a decade and were always getting all the budgets.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	IO Education and IO Organisation drive are the top two barriers.
4.	How important is the Market price of IO solution as	Difficult to say with confidence unless a solution is tried once. Moreover the

	compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	benefits are not just monetary, we also consider accuracy and speed of decisions which can be made with such proven digital solutions.
5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	That is the foundation. Unless we are hungry, we will not make efforts to find the food.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	Normal challenge. We deal with it every now and then. IT solution performance decides if we should renew the license every year or not.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Important off course because that becomes the starting point to try any new solution.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	G&G is all about domain expertise, more than any other department. So, yes very important.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Not that important in G&G because our analysis does not change anything immediate.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	Not important at all.
11.	How important is the Manpower Effectiveness for	It is important for G&G because our experts are costly resources.

	designing the IO based solution?	
12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	We use best in class solutions which come from different companies with provision for integrating input from one solution to others'.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.21 : Transcript #6 for final data verification

Transcript #7 for final data validation (#FD123-T7-IOE04-d4-A01-AS)

2nd Sep, 2018

Telephonic Interview IO expert#4 (Head Drilling of Company#1) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	Not really. Within a department, say drilling, it is important to have everyone aligned on such initiatives but not for the whole company. And that is the result. You can see drilling always leading in IT usage.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Yes, it has been going on department wise. Drilling, reservoir and subsurface departments had been spending on digital software but nothing really across the organisation.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Education and adoption followed by cost are the biggest barriers.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	Market price is important, especially in drilling where multiple vendors offer proven solutions. And all these solutions have to offer significant benefits like reduction on rig time etc.

5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Obviously, very important. That is how drilling has evolved over last so many years in digital leadership.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	Perception is that our ability to handle such complications is getting better with every passing year. So no worry as such.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Very important. While shortlisting any drilling vendor, it is reviewed carefully.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Both are very important. While shortlisting any drilling vendor, it is reviewed carefully.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Yes, both are very critical. Drilling is all about taking real time decisions.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	Important but not crucial in drilling. As long as the rig centralised control room has all the online info, it serves the purpose.
11.	How important is the Manpower Effectiveness for designing the IO based solution?	Not sure, it is not that critical. Certain minimum manpower is always needed in drilling.
12.	What is your opinion about the scattered	In drilling, it is left to drilling service providers. But from the company side,

	Point-software based solution for your IO strategy?	we do use some independent software which are integrated well to contractor's solution for integrated operations.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.22 : Transcript #7 for final data verification

Transcript #8 for final data validation (#FD123-T8-IOE02-d3-C01-GJ)

21st September, 2018

Telephonic Interview IO expert#2 (IT head of Company#3) for validating Research Obj 1,2 &3 findings

Focus : To confirm with 5 to 10 IO experts the dominant factors / barriers analysed after 141 survey responses and confirmatory factor analysis for all 3 objectives (without sharing the draft result as it is, to minimize the influence)

Sl. No.	Question by Scholar	Answers from the IO expert
1.	How important is the need for an Enterprise-wide drive for IO implementation ?	It is important. With Enterprise-wide drive, we are able to get all the user departments on the same page.
2.	Do top management of the Indian upstream companies struggle to decide on the IO investments in spite of clear benefits being reaped by global upstream players?	Yes, it is a difficult ask from management. Unless something is proven elsewhere, we don't get any budget.
3.	Which are the two most dominant barriers out of IO Education, IO Organisation Drive, IO Cost, IO Adoption in the implementation of IO by Oil & Gas companies?	Education and cost are the biggest barriers in my opinion.
4.	How important is the Market price of IO solution as compared to the Industries 4.0 benefits with IO technology while deciding on the IO strategy?	It's not that straight forward. User departments get budget approval only after weighing benefits from the 4.0 solutions. Once we get the project with approved budget, market price becomes an important factor for us apart from their experience.

5.	How important are the User inclination and the IO learning ability of users for the IO adoption?	Yes, it is very important. And it is important for us the IT deptt to understand this requirement of users, for a successful IT support.
6.	What is the perception about the anticipated IT complications created by IO technology in day to day operations?	That is part of the process. Once you have a technology in place, you will have some challenges. But it is not a reason to worry.
7.	How important are other Oil & Gas companies' success stories for you to spend on the new IO solution in order to achieve Industry 4.0 compliance ?	Proven reference cases increase confidence so it is important.
8.	How important is the Confidence on the IO technology delivery capabilities for a successful IO implementation? Is Bad implementation due to lack of domain expertise an important factor for being pessimistic about IO initiatives ?	Yes, delivery capabilities of the service providers are important. Lack of domain expertise is a major concern.
9.	How important are the real time IO dashboards and Key Performance Indicators (KPIs) for achieving higher Operating Efficiency through IO initiatives?	Both are very important obviously.
10.	How important are handheld based software applications as a crucial part of the IO solutions?	Handhelds are crucial part of IO solution due to quick information view point of view.
11.	How important is the Manpower Effectiveness for designing the IO based solution?	Not very important because solution should be designed assuming that manpower is not effective. So solution should take care of that.

12.	What is your opinion about the scattered Point-software based solution for your IO strategy?	Individual stand alone software will continue to be part of the integrated IO solution. Because no one company has all the solutions.

*Any mention of the company name has been omitted in the transcript, in order to stick to confidentiality promises.

Table 5.23 : Transcript #8 for final data verification

5.9 RELIABILITY AND VALIDITY IN QUALITATIVE RESEARCH

To understand reliability and validity from a broader perspective , let us look at various definitions of reliability and validity given by numerous qualitative researchers from different perspectives.

Reliability : Although the 'Reliability' term is used for testing or evaluating quantitative research, it is often used in all kinds of research. The most important test of any qualitative study is its quality as a good qualitative study helps "understand a confusing situation". The distinction in motivations behind assessing the nature of studies in quantitative and quantitative examination is one reason that the idea of reliability is immaterial in subjective exploration. As per Stenbacka [142] "the idea of reliability is in any event, misdirecting in qualitative examination. On the off chance that a subjective report is examined with reliability as a standard, the outcome is fairly that the examination is nothing but bad". Then again, Patton [121] states that validity and reliability are two elements which any subjective analyst ought to be worried about while planning an investigation, dissecting results and passing judgment on the nature of the examination. This compares to the inquiry "How could an inquirer convince their crowds that the exploration discoveries of a request merit focusing on?". To respond to the inquiry, Healy and Perry [73] attest that the nature of an examination in every worldview ought to be decided by its own worldview's terms. For instance, while the terms Reliability and Validity are fundamental measure for quality in quantitative ideal models, in subjective standards the terms Credibility, Neutrality or Confirmability, Consistency or Dependability and Applicability or Transferability are to be the fundamental rules for quality. To be more explicit with the term of unwavering quality in subjective exploration, Lincoln and Guba [96] use reliability, in subjective examination which intently

compares to the idea of dependability in quantitative exploration. They further stress "request review" as one measure which may upgrade the trustworthiness of subjective exploration. This can be utilized to inspect both the cycle and the result of the exploration for consistency [78]. Along these lines, Clont [34] and Seale [133] support the idea of trustworthiness with the idea of consistency or reliability in subjective examination. The consistency of information will be accomplished when the means of the exploration are confirmed through assessment of such things as crude information, information decrease items, and cycle notes [25]. To guarantee reliability in subjective exploration, assessment of dependability is significant [133], while setting up great quality examinations through validity and reliability in subjective exploration, expresses that the "reliability of an examination report lies at the core of issues traditionally talked about as validity and reliability". When judging (testing) subjective work, Strauss and Corbin [143] propose that the "standard ordinances of 'good science'… require redefinition to fit the real factors of subjective examination". Interestingly, [142] contends that since reliability issues concerns estimations then it has no importance in subjective examination. She adds the issue of dependability is a superfluous matter in the judgment of nature of subjective exploration. Consequently, assuming it is utilized, the "result is fairly that the examination is nothing but bad". To extend the range of conceptualization of dependability and uncovering the harmoniousness of validity and reliability in subjective examination, Lincoln and Guba [96] states that: "Since there can be no legitimacy without unwavering quality, an exhibit of the previous validity is adequate to build up the last reliability". Patton [121] with respect to the analyst's capacity and in any subjective exploration likewise expresses that unwavering quality is a result of the validity in an investigation.

Validity : The idea of "Validity" is depicted by a wide scope of terms in subjective examinations. This idea is certifiably not a solitary, fixed or all inclusive idea, yet "rather an unexpected development, unpreventably grounded in the cycles and goals of specific examination philosophies and undertakings". Albeit some subjective analysts have contended that the expression "Validity" isn't material to subjective exploration, and yet, they have understood the requirement for some sort of qualifying check or measure for their examination. For instance, Creswell and Miller [37] recommend that the Validity is influenced by the specialist's view of "Validity" in the investigation and his/her decision of worldview presumption. Subsequently, numerous scientists have built up their own ideas of "Validity" and have regularly created or embraced what they consider to be more suitable terms, for example, quality, meticulousness and reliability. The conversation of value in subjective exploration started from the worries about legitimacy and dependability in quantitative custom which "included subbing new terms for words, for instance, "Reliability and Validity" to reflect interpretivist subjective starts". The issue of authenticity in abstract investigation has not been disregarded by Stenbacka [142] as she has for the issue of trustworthiness in emotional assessment. Taking everything into account, she battles that the possibility of "Validity" should be reconsidered for emotional assessment. Stenbacka portrays the possibility of constancy as one of the quality thoughts in emotional investigation which "to be handled to ensure an assessment as a segment of genuine assessment". In searching for the meaning of painstakingness in assessment, Davies and Dodd [41] track down that the term fastidiousness in research shows up with respect to the discussion about "Reliability and Validity". Davies and Dodd fight that the utilization of the idea exhaustiveness in emotional investigation should differentiate from those in quantitative assessment by "enduring that there is a quantitative tendency in the possibility of fastidiousness, we as of now continue forward to develop our

reconception of carefulness by exploring subjectivity, reflexivity, and the social association of talking". Lincoln and Guba [96] battle that supporting the reliability of an investigation report depends upon the issues, quantitatively, discussed as "immovable quality and legitimacy". Discovering truth through extents of enduring quality and authenticity is replaced by the chance of trustworthiness, which is "strong" and setting up trust in the revelations. If the issues of unwavering quality, authenticity, trustworthiness, quality and carefulness are inferred isolating a 'extraordinary' from 'horrible' research by then testing and growing the enduring legitimacy, dependability, quality and meticulousness will be basic to the investigation in any perspective.

Testing "Reliability and Validity" : So far, the thoughts of faithful quality and authenticity as they have been renamed for their worth in emotional assessment have been presented. As of now, the request which stays to be tended to is 'How to test or increase the "validity" and likewise the "reliability" of a subjective report?

Accepting the authenticity or reliability can be intensified or attempted, more "substantial and impeccable result" may incite generalizability which is one of the thoughts proposed by Stenbacka [142] as the development for both doing and recording incredible abstract investigation. Thus, the idea of an assessment is related to generalizability of the result and as such to the testing and extending the Patton [121] states generalizability as one of the standards for quality contextual investigations relying upon the case chosen and contemplated. In this sense the Validity in quantitative exploration is quite certain to the test to which it is applied – where triangulation strategies are utilized in subjective examination. Triangulation is commonly a system (test) for improving the legitimacy and dependability of exploration or assessment of discoveries.

Mathison [103] explains this by saying: Triangulation has risen a significant methodological issue in naturalistic and subjective ways to deal with assessment [in request to] control inclination and building up substantial suggestions in light of the fact that conventional logical procedures are incongruent with this substitute epistemology. Patton [121] advocates the utilization of triangulation by expressing "triangulation reinforces an investigation by joining strategies. This can mean utilizing a few sorts of strategies or information, including utilizing both quantitative and subjective methodologies". Nonetheless, joining strategies has been tested by Barbour [8]. She contends that blending standards can be conceivable yet blending techniques inside one worldview, like subjective examination, is dangerous since every strategy inside the subjective worldview has its own presumption "regarding hypothetical structures we apply as a powerful influence for our exploration". Despite the fact that triangulation is utilized in the quantitative worldview for affirmation and speculation of an exploration, Barbour [8] doesn't ignore the thought of triangulation in the subjective worldview and she expresses the need to characterize triangulation from a subjective examination's point of view in every worldview. For instance, in utilizing triangulation of a few information sources in quantitative exploration, any special case may prompt a disconfirmation of the speculation where exemptions in subjective examination are managed to alter the hypotheses and are productive. In this view, Healy and Perry [73] elucidate on the passing judgment on legitimacy and dependability inside the authenticity worldview which depends on numerous insights about a solitary reality. They contend the association of triangulation of a few information sources and their understandings with those different insights in the authenticity worldview. Another worldview in subjective exploration is constructivism which sees information as socially developed and may change contingent upon the conditions. Crotty characterized constructivism from the social viewpoints as

"the view that all information, and thus all significant reality accordingly, is dependent upon human works on, being built all through collaboration between people and their reality, and created and sent inside a basically friendly setting". In any subjective exploration, the point is to "participate in research that tests for more profound seeing instead of looking at surface highlights" and constructivism may work with that point. The constructivist thought that the truth is changing if the eyewitness wishes it, means that numerous or conceivably assorted developments of the real world. Constructivism esteems different real factors that individuals have to them. In this manner, to obtain legitimate and dependable various and different real factors, numerous strategies for looking or assembling information are all together. On the off chance that this requires the utilization of triangulation in the constructivism worldview, the utilization of agents, technique and information triangulations to record the development of the truth is fitting. An open-finished viewpoint in constructivism follows with the thought of information triangulation by permitting members in an examination to help the analyst in the exploration question just as with the information assortment. Connecting with different strategies, like perception, meetings and accounts will prompt more legitimate, solid and assorted development of real factors. To improve the examination and comprehension of development of others, triangulation is a stage taken by specialists to include a few agents or companion scientists' translation of the information at various occasions or areas. In a connected manner, a subjective analyst can "use specialist triangulation and consider the thoughts and clarifications produced by extra scientists examining the exploration members". Triangulation may incorporate numerous strategies for information assortment and information investigation, however doesn't propose a fixed technique for all the exploration. The techniques picked in triangulation to test the "unwavering Reliability and Validity" and of an investigation rely upon the rule of the exploration.

Chapter 6

ANALYSIS OF RESEARCH OBJECTIVE 1 - THE MANAGEMENT DECISION MAKING BARRIERS FOR ADOPTION AND IMPLEMENTATION OF INTEGRATED OPERATIONS SOLUTIONS IN INDIAN UPSTREAM COMPANIES

The research design for the problems is Exploratory and Analytical. Scholar proposed to follow the following methodology *for Research Objective 1*: Significant management barriers will be identified using Factor Analysis with the objective to expedite decision making resulting in improved efficiency parameters.

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 1

6th step : Identify dominant IO barriers for Research Objective 1 with Confirmatory Factor Analysis

8th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data for Research Objective 1 with 2-3 IO experts

6.1 FINDING THE RELEVANT VARIABLES FOR OBJECTIVE 1 USING MODIFIED GROUNDED THEORY

Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for 4 measured variables and 12 sub-variables for Research Objective 1

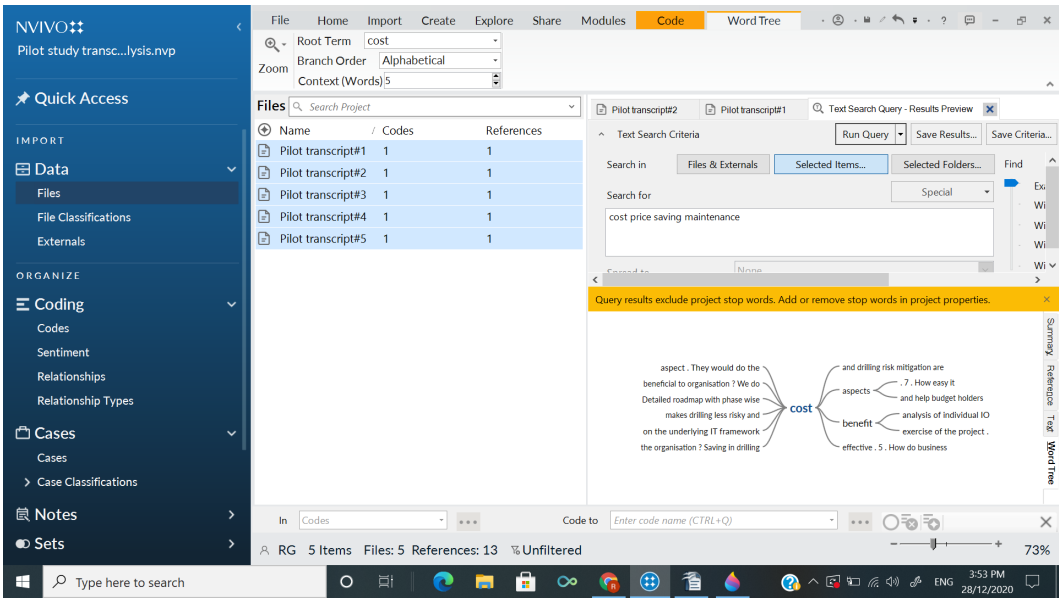


Fig 6.1 : Pilot study Coding screenshot no.1 (using Nvivo) for Research Objective 1

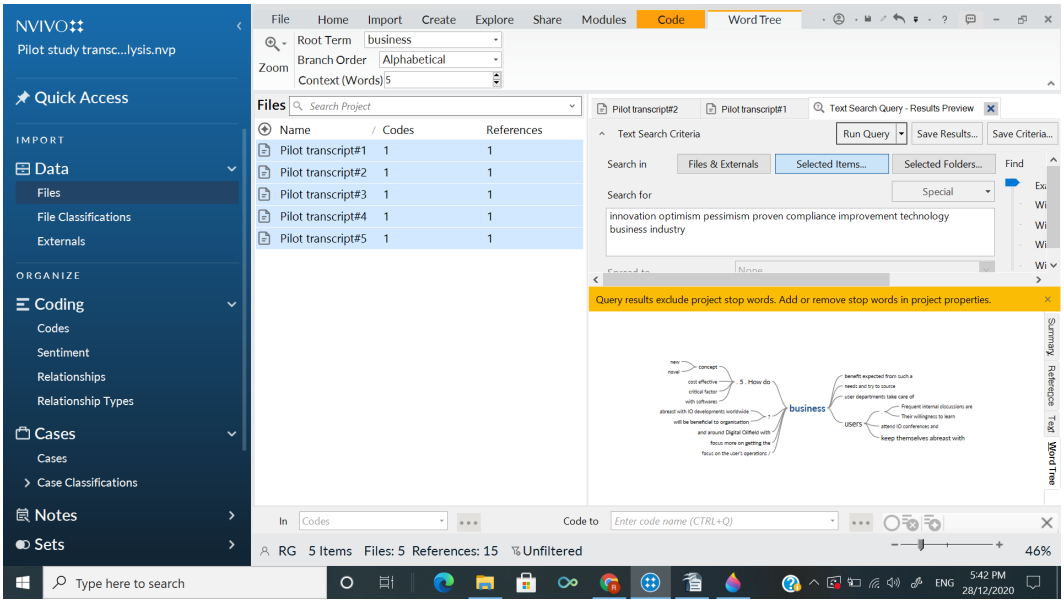


Fig 6.2 : Pilot study Coding screenshot no.2 (using Nvivo) for Research Objective 1

6.2 CONCEPTUAL LENS FOR RESEARCH OBJECTIVE 1 changed after the pilot study, as illustrated below, with inputs from the IO experts to identify the IO Investment barriers :

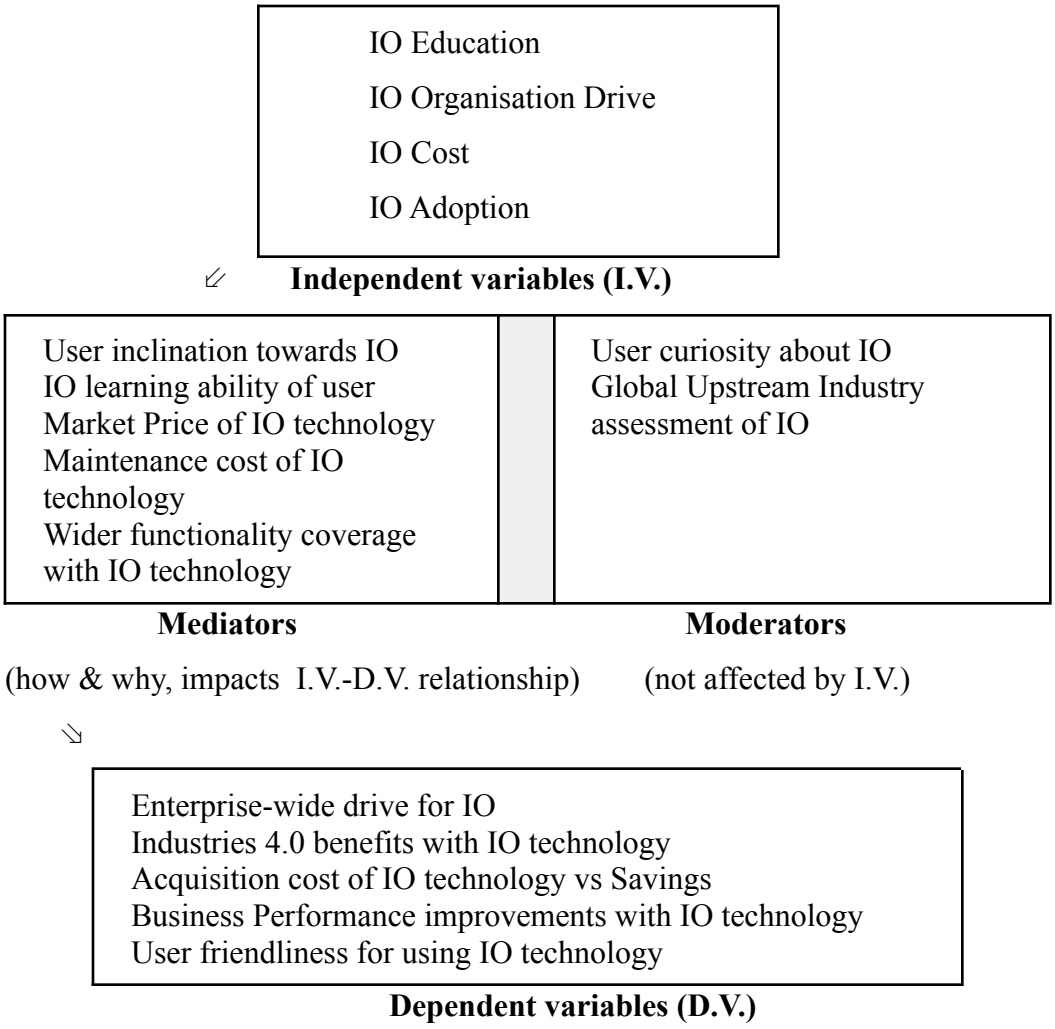
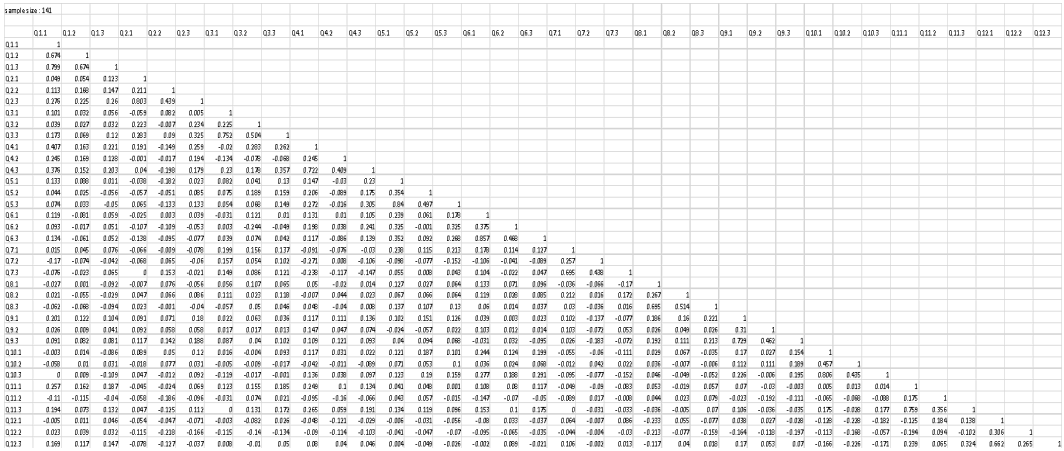


Fig 6.3 : Conceptual lens for Research Objective 1, post pilot study

6.3 CONFIRMATORY FACTOR ANALYSIS FOR OBJECTIVE 1



sample size : 141

	Q1.1	Q1.2	Q1.3	Q2.1	Q2.2	Q2.3	Q3.1	Q3.2	Q3.3	Q4.1	Q4.2	Q4.3	Q5.1	Q5.2	Q5.3	Q6.1	Q6.2	Q6.3	Q7.1	Q7.2	Q7.3	Q8.1	Q8.2	Q8.3	Q9.1	Q9.2	Q9.3	Q10.1	Q10.2	Q10.3	Q11.1	Q11.2	Q11.3	Q12.1	Q12.2	Q12.3
Q1.1	1																																			
Q1.2	0.674	1																																		
Q1.3	0.799	0.674	1																																	
Q2.1	0.049	0.054	0.123	1																																
Q2.2	0.113	0.186	0.147	0.211	1																															
Q2.3	0.176	0.225	0.16	0.803	0.429	1																														
Q3.1	0.101	0.032	0.056	-0.059	0.082	0.005	1																													
Q3.2	0.039	0.027	0.032	0.223	-0.007	0.224	0.235	1																												
Q3.3	0.173	0.069	0.12	0.163	0.09	0.205	0.752	0.504	1																											
Q4.1	0.407	0.163	0.221	0.193	-0.149	0.059	-0.01	0.203	0.262	1																										
Q4.2	0.245	0.169	0.128	-0.001	-0.017	0.194	-0.134	-0.035	-0.068	0.245	1																									
Q4.3	0.376	0.152	0.102	0.04	-0.199	0.179	0.23	0.135	0.357	0.722	0.409	1																								
Q5.1	0.133	0.088	0.011	-0.038	-0.182	0.023	0.092	0.041	0.13	0.147	-0.03	0.23	1																							
Q5.2	0.044	0.015	-0.056	-0.057	-0.051	0.085	0.075	0.188	0.159	0.206	-0.089	0.175	0.354	1																						
Q5.3	0.074	0.033	-0.05	0.065	-0.133	0.133	0.054	0.092	0.149	0.272	-0.026	0.305	0.84	0.467	1																					
Q6.1	0.119	-0.001	0.059	-0.025	0.003	0.076	-0.031	0.122	0.01	0.131	0.01	0.105	0.239	0.061	0.176	1																				
Q6.2	0.093	-0.017	0.051	-0.107	-0.109	-0.053	0.003	-0.244	-0.049	0.198	0.038	0.241	0.325	-0.001	0.325	0.375	1																			
Q6.3	0.134	-0.061	0.052	-0.128	-0.095	-0.077	0.039	0.076	0.042	0.117	-0.086	0.139	0.352	0.092	0.268	0.857	0.468	1																		
Q7.1	0.015	0.045	0.076	-0.066	-0.009	-0.079	0.199	0.156	0.177	-0.091	-0.076	-0.03	0.238	0.115	0.213	0.139	0.114	0.127	1																	
Q7.2	-0.17	-0.074	-0.042	-0.068	0.045	-0.06	0.157	0.054	0.102	-0.271	0.038	-0.106	-0.098	-0.077	-0.152	-0.106	-0.041	-0.089	0.257	1																
Q7.3	-0.076	-0.023	0.045	0	0.153	-0.021	0.149	0.066	0.121	-0.236	-0.117	-0.147	0.055	0.026	0.043	0.104	-0.022	0.047	0.695	0.436	1															
Q8.1	-0.027	0.001	-0.012	-0.007	0.076	-0.054	0.056	0.107	0.095	0.05	-0.02	0.024	0.127	0.027	0.064	0.123	0.071	0.096	-0.026	-0.066	-0.17	1														
Q8.2	0.021	-0.055	-0.029	0.047	0.069	0.064	0.111	0.023	0.138	-0.007	0.044	0.023	0.067	0.066	0.064	0.119	0.026	0.085	0.212	0.016	0.172	0.267	1													
Q8.3	-0.062	-0.068	-0.094	0.023	-0.001	-0.04	-0.057	0.05	0.046	0.043	-0.04	0.008	0.137	0.107	0.13	0.06	0.014	0.037	0.03	-0.036	0.016	0.695	0.514	1												
Q9.1	0.201	0.122	0.104	0.091	0.071	0.16	0.022	0.042	0.026	0.117	0.111	0.136	0.102	0.151	0.126	0.039	0.003	0.023	0.102	-0.137	-0.077	0.104	0.16	0.221	1											
Q9.2	0.026	0.009	0.041	0.093	0.059	0.058	0.017	0.017	0.013	0.147	0.047	0.074	-0.024	-0.057	0.022	0.103	0.012	0.014	0.103	-0.072	0.053	0.026	0.049	0.026	0.31	1										
Q9.3	0.091	0.052	0.081	0.117	0.142	0.188	0.097	0.06	0.103	0.109	0.121	0.053	0.04	0.094	0.088	-0.031	0.032	-0.095	0.026	-0.103	-0.072	0.152	0.111	0.215	0.729	0.452	1									
Q10.1	-0.003	0.014	-0.086	0.089	0.05	0.12	0.026	-0.004	0.093	0.117	0.031	0.022	0.121	0.107	0.101	0.244	0.124	0.199	-0.055	-0.06	-0.111	0.029	0.067	-0.035	0.17	0.027	0.154	1								
Q10.2	-0.058	0.01	0.031	-0.018	0.077	0.071	-0.005	-0.006	-0.017	-0.042	-0.011	-0.089	0.071	0.053	0.1	0.026	0.024	0.068	-0.012	0.042	0.022	0.076	-0.007	-0.006	0.112	0.111	0.189	0.457	1							
Q10.3	0	0.009	-0.109	0.047	-0.012	0.092	-0.119	-0.017	-0.001	0.126	0.038	0.097	0.113	0.19	0.159	0.277	0.188	0.291	-0.095	-0.077	-0.152	0.046	-0.049	-0.052	0.226	-0.006	0.195	0.606	0.435	1						
Q11.1	0.257	0.162	0.167	-0.045	-0.024	0.068	0.123	0.155	0.165	0.249	0.1	0.134	0.041	0.048	0.001	0.188	0.08	0.117	-0.048	-0.09	-0.083	0.053	-0.019	0.057	0.07	-0.03	-0.003	0.005	0.013	0.014	1					
Q11.2	-0.11	-0.115	-0.04	-0.059	-0.106	-0.094	-0.031	0.074	0.021	-0.095	-0.16	-0.066	0.043	0.057	-0.015	-0.147	-0.07	-0.05	-0.059	0.017	-0.008	0.044	0.023	0.079	-0.023	-0.192	-0.111	-0.065	-0.098	-0.088	0.175	1				
Q11.3	0.194	0.073	0.132	0.047	-0.105	0.112	0	0.133	0.172	0.195	0.059	0.191	0.134	0.119	0.096	0.153	0.1	0.175	0	-0.031	-0.033	-0.036	-0.005	0.07	0.106	-0.036	-0.035	0.135	-0.038	0.177	0.759	0.354	1			
Q12.1	-0.005	0.011	0.046	-0.054	-0.047	-0.071	-0.003	-0.083	0.026	-0.048	-0.121	-0.029	-0.086	-0.031	-0.056	-0.08	0.033	-0.037	0.064	-0.007	0.086	-0.133	0.055	-0.077	0.038	0.027	-0.038	-0.128	-0.128	-0.182	-0.125	0.184	0.138	1		
Q12.2	0.023	0.039	0.032	-0.115	-0.218	-0.166	-0.115	-0.14	-0.134	-0.09	-0.124	-0.103	-0.041	-0.047	-0.07	-0.095	-0.065	-0.035	-0.044	-0.004	-0.03	-0.213	-0.077	-0.159	-0.164	-0.118	-0.197	-0.113	-0.168	-0.057	-0.196	0.094	-0.102	0.306	1	
Q12.3	0.169	0.117	0.147	-0.076	-0.127	-0.037	0.008	-0.01	0.05	0.08	0.04	0.046	0.004	-0.049	-0.026	-0.002	0.088	-0.021	0.106	-0.002	0.013	-0.117	0.04	0.018	0.17	0.053	0.07	-0.166	-0.226	-0.171	0.229	0.065	0.324	0.662	0.265	1

Table 6.1 : 36 measured sub-variables / indicators correlations

For Objective 1, research survey focused on 12 measured sub-variables under four measured variables affecting decision making on the IO investment decision for identifying significant management barriers using Factor Analysis with the objective to expedite IO investment decision resulting in improved efficiency parameters.

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Q1.1	1	0	2.709	2	1	5	1.146	-0.539	0.534
Q1.2	2	0	3.879	4	2	5	1.048	-1.356	-0.241
Q1.3	3	0	2.142	2	1	4	1.029	-0.95	0.462
Q2.1	4	0	2.454	2	1	5	0.838	0.642	0.586
Q2.2	5	0	3.27	4	1	5	1.154	-0.283	-0.796
Q2.3	6	0	2.383	2	1	5	1.07	-0.703	0.414
Q3.1	7	0	2.617	2	1	5	0.935	1.029	1.153
Q3.2	8	0	3.248	4	1	5	1.295	-0.932	-0.433
Q3.3	9	0	2.397	2	1	5	1.154	-0.137	0.688
Q4.1	10	0	2.674	2	1	5	1.014	0.243	1.023
Q4.2	11	0	3.128	3	1	5	1.368	-1.134	-0.301
Q4.3	12	0	2.433	2	1	5	1.132	0.189	0.837

Table 6.2 : Raw data file for 12 measured sub-variables / indicators for Objective 1

sample size : 141												
	Q1.1	Q1.2	Q1.3	Q2.1	Q2.2	Q2.3	Q3.1	Q3.2	Q3.3	Q4.1	Q4.2	Q4.3
Q1.1	1											
Q1.2	0.674	1										
Q1.3	0.799	0.674	1									
Q2.1	0.049	0.054	0.123	1								
Q2.2	0.113	0.168	0.147	0.211	1							
Q2.3	0.276	0.225	0.26	0.803	0.439	1						
Q3.1	0.101	0.032	0.056	-0.059	0.082	0.005	1					
Q3.2	0.039	0.027	0.032	0.223	-0.007	0.234	0.225	1				
Q3.3	0.173	0.069	0.12	0.283	0.09	0.325	0.752	0.504	1			
Q4.1	0.407	0.163	0.221	0.191	-0.149	0.259	-0.02	0.283	0.262	1		
Q4.2	0.245	0.169	0.128	-0.001	-0.017	0.194	-0.134	-0.078	-0.068	0.245	1	
Q4.3	0.376	0.152	0.203	0.04	-0.198	0.179	0.23	0.178	0.357	0.722	0.409	1

Table 6.3 : 12 measured sub-variables / indicators correlations for Objective 1

Variables Correlation Coefficient Conclusion

User inclination towards IO factor— IO learning ability of user factor (Q1.1–Q1.3)	0.799	Strong positive relationship
Market Price of IO technology factor— Maintenance cost of IO technology factor (Q3.1–Q3.3)	0.752	Strong positive relationship
Global Upstream Industry assessment of IO factor—Industries 4.0 benefits with IO technology factor (Q2.1–Q2.3)	0.803	Strong positive relationship

Table 6.4 : Model correlation analysis for Objective 1

Confirmatory Factor Analysis

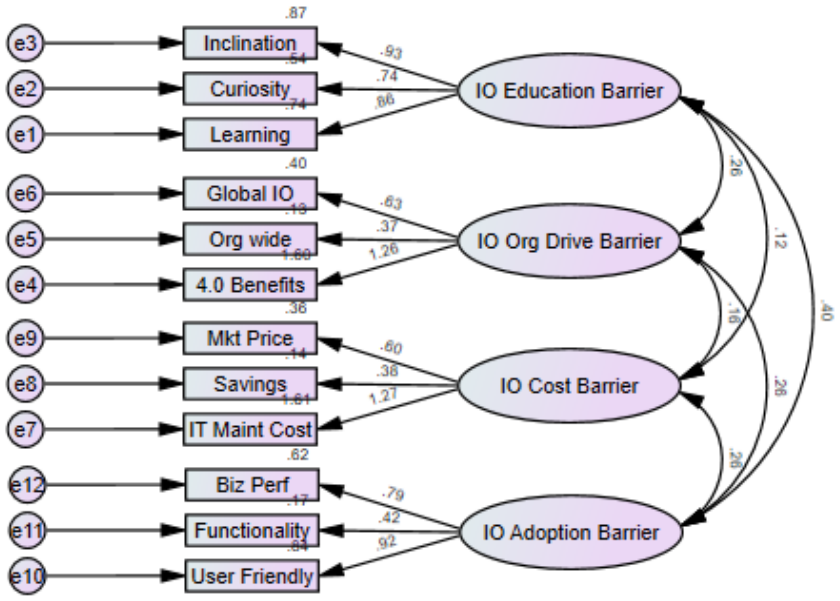


Fig 6.4. Initial CFA result for Obj 1

Confirmatory factor analysis (CFA) is a technique to demonstrate the populace covariance matrix of a bunch of factors utilizing test information from a sample

dataset. Basic fluctuation is now and again alluded to as "communality", and the particular change variance and error difference are frequently consolidated and alluded to as "uniqueness."

Initial Model Fit for Obj 1

CMIN of 3.159 is quite lower than the upper threshold of 5. P value is significant which means we have poor fit for a sample size of 141. GFI of 0.853, AGFI of 0.761, CFI of 0.882 and PCFI of 0.642 are tolerable but not great. P Close of .000 is not acceptable, it should be above 0.05 ideally. Similarly RMSEA of 0.124 is also not good, it should have been less than 0.1.

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	30	151.617	48	.000	3.159
Saturated model	78	.000	0		
Independence model	12	947.058	66	.000	14.349

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.107	.853	.761	.525
Saturated model	.000	1.000		
Independence model	.323	.505	.415	.427

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.840	.780	.885	.838	.882
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.727	.611	.642
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

Table 6.5 : Initial Model Fit Summary for Obj 1

	Q4.1	Q4.2	Q4.3	Q3.1	Q3.2	Q3.3	Q2.1	Q2.2	Q2.3	Q1.1	Q1.2	Q1.3
Q4.1	.000											
Q4.2	-.941	.000										
Q4.3	.008	.302	.000									
Q3.1	-1.658	-2.338	1.043	.000								
Q3.2	2.432	-1.403	1.048	-.038	.000							
Q3.3	.056	-2.393	.661	-.099	.220	.000						
Q2.1	.698	-.833	-1.321	-1.426	2.173	1.781	.000					
Q2.2	-2.663	-.683	-3.380	.548	-.351	.161	-.236	.000				
Q2.3	-.055	.644	-1.435	-1.404	1.825	.706	.056	-.269	.000			
Q1.1	1.289	1.058	.398	.371	-.061	.297	-1.238	.269	-.389	.000		
Q1.2	-.777	.554	-1.328	-.265	-.089	-.556	-.792	1.141	-.224	-.134	.000	
Q1.3	-.547	-.163	-1.233	-.090	-.100	-.185	-.224	.759	-.282	-.023	.431	.000

Table 6.6 : Initial Standardized Residual Covariances for Obj 1

Final Empirical Analysis and Results

Removed Q3.2 variable as values were going above 0.4. Other covariances could not be influenced, and can be attributed to the nature of technical survey with limitations mentioned later in this paper.

	Q4.1	Q4.2	Q4.3	Q3.1	Q3.3	Q2.1	Q2.2	Q2.3	Q1.1	Q1.2	Q1.3
Q4.1	.000										
Q4.2	-.957	.000									
Q4.3	.003	.751	.000								
Q3.1	-.791	-1.847	2.141	.000							
Q3.3	.063	-2.227	1.044	.000	.000						
Q2.1	.351	-.911	-1.481	-1.044	1.438	.000					
Q2.2	-2.903	-.749	-3.517	.765	-.080	-.655	.000				
Q2.3	-.342	.676	-1.359	-.569	.428	.067	-.454	.000			
Q1.1	.868	1.047	.390	.955	.727	-1.509	.058	-.500	.000		
Q1.2	-1.083	.553	-1.317	.194	-.214	-.999	.980	-.299	-.136	.000	
Q1.3	-.900	-.163	-1.221	.446	.215	-.466	.572	-.367	-.024	.466	.000

Table 6.7 : Final Standardized Residual Covariances for Obj 1

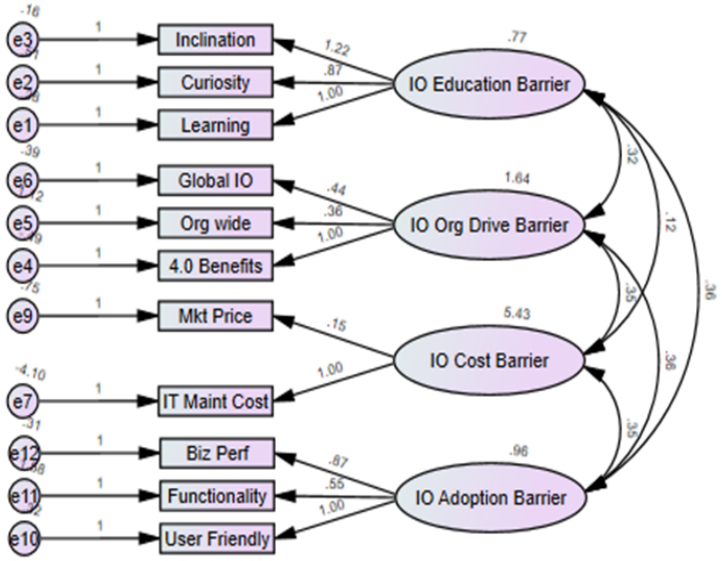


Fig 6.5 : Final CFA result for Obj 1

Final Model Fit Summary for Obj 1

For estimating the model fit, it is a typical practice to send an assortment of indices. These indices could be arranged into three classifications. The Chi-square measurement, the Goodness-of-Fit-Index (GFI) and the standardized root mean residual (SRMR) are utilized to gauge how well the estimation model replicates the noticed information that establish the main class which is irrefutably the fit files. The second is the closefisted fit records class considers the model's intricacy which incorporates the Root Mean Square Error of Approximation (RMSEA) and the Adjusted Goodness-of-Fit Index (AGFI)

At long last, the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) survey how well a predefined model fit comparative with an elective standard model that establishes the third gradual fit records class.

The suggested basic degree of worthy fit and the outcome fit files for the exploration estimation model that show a fantastic fit for every one of the three classes records are introduced in Table 6.8.

Fit Index	Recommended Critical value	Result
χ2/D.F	≤ 3	3.623
GFI	≥ 0.9	0.853
AGFI	≥ 0.8	0.745
CFI	≥ 0.9	0.880

Table 6.8 : Final Model Fit Indices after removing measured sub-variable Q3.2

6.4 RESULTS OF DATA ANALYSIS FOR OBJECTIVE 1

IO Education and IO Adoption are the significant barriers faced by Indian Upstream companies. Unless IO users and decision makers are educated more on the benefits of IO initiatives, Indian upstream companies shall struggle to go for IO investments in spite of clear benefits being reaped by global upstream players. “Price of IO technology” is the least important barrier in adoption of IO by various organizations.

Based on the variables / sub-variables identified through CFA, following conceptual framework mapping was done.

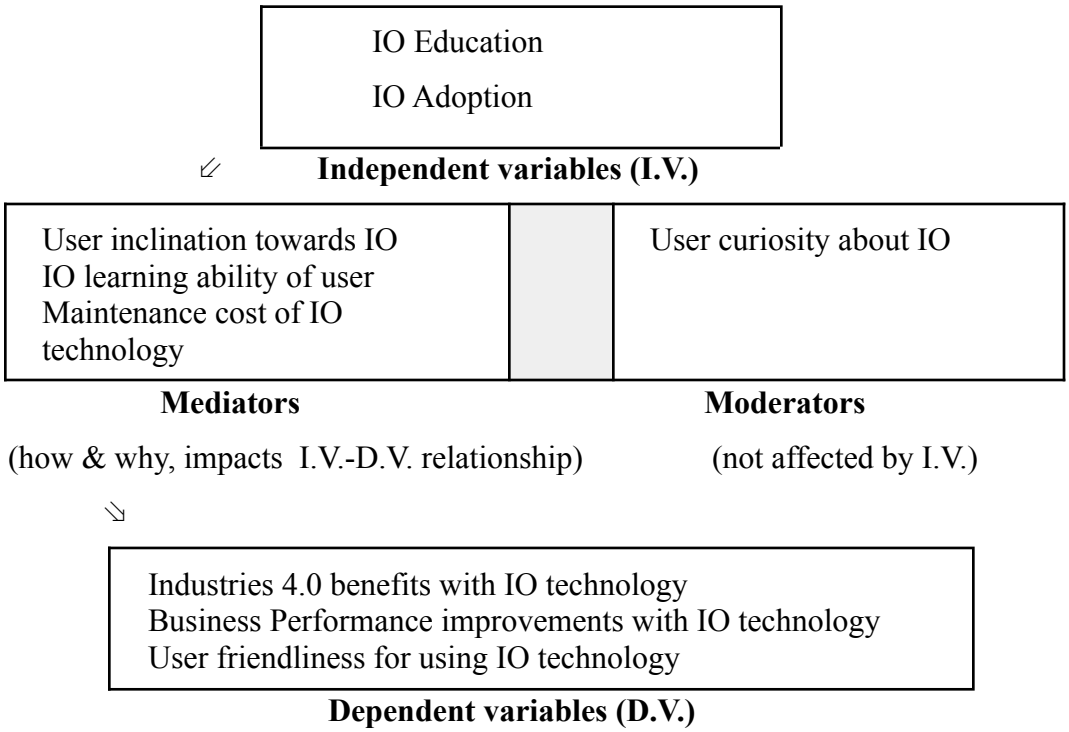


Fig 6.6 : Conceptual lens for Research Objective 1 after CFA results

6.5 FINAL DATA VALIDATION FOR OBJECTIVE 1 WITH MODIFIED GROUNDED THEORY

Final data verification with coding of the interview transcripts confirmed the findings as it is.

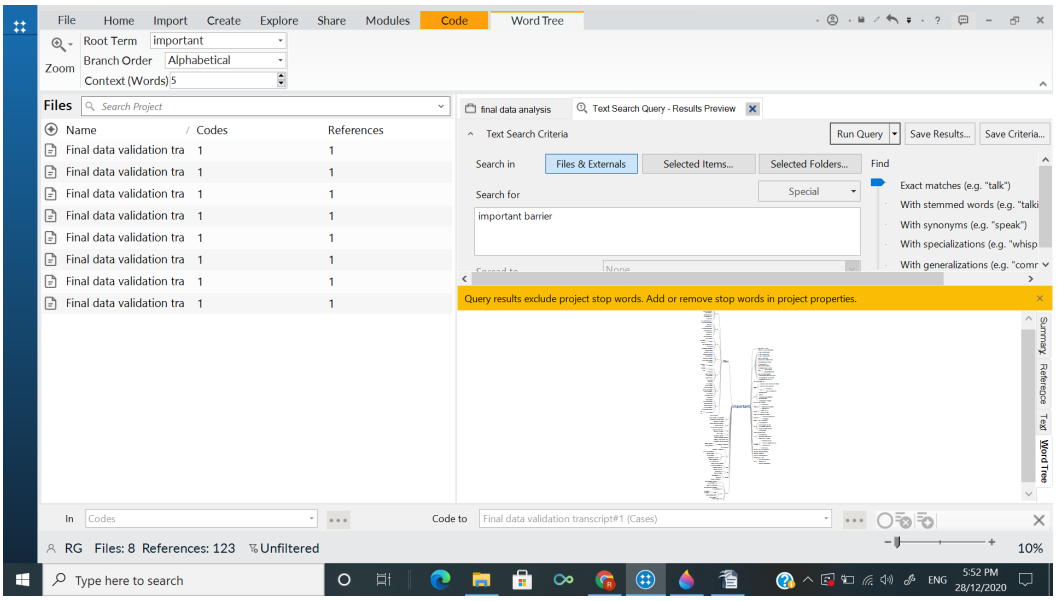


Fig 6.7 : Obj 1 screenshot no. 3 for Final data validation (using Nvivo) with use of Modified Grounded Theory

6.6 CHAPTER CONCLUSION - DOMINANT MEASURED VARIABLES FOR OBJECTIVE 1

Post final data verification, following are the significant management barriers (measured variables and sub-variables) for Objective 1 affecting the IO investment decision by upstream companies in India :

Measured variable for Objective 1	Measured sub-variables for Objective 1	Conclusions on Research Objective 1
IO Education (first significant barrier)	User inclination towards IO	More important factor
	User curiosity about IO	Important factor
	IO learning ability of user	More important factor
IO Organisation Drive	Global Upstream Industry assessment of IO	
	Enterprise-wide drive for IO	
	Industries 4.0 benefits with IO technology	Important factor
IO Cost	Market Price of IO technology	Least important (last factor)
	Acquisition cost of IO technology vs Savings	Not a relevant factor (had to be omitted in CFA)
	Maintenance cost of IO technology	Important factor
IO Adoption (second significant barrier)	Business Performance improvements with IO technology	More important factor
	Wider functionality coverage with IO technology	
	User friendliness for using IO technology	More important factor

Table 6.9 : Dominant measured variables for Objective 1

Post final data verification results, following final conceptual framework mapping was mapped.

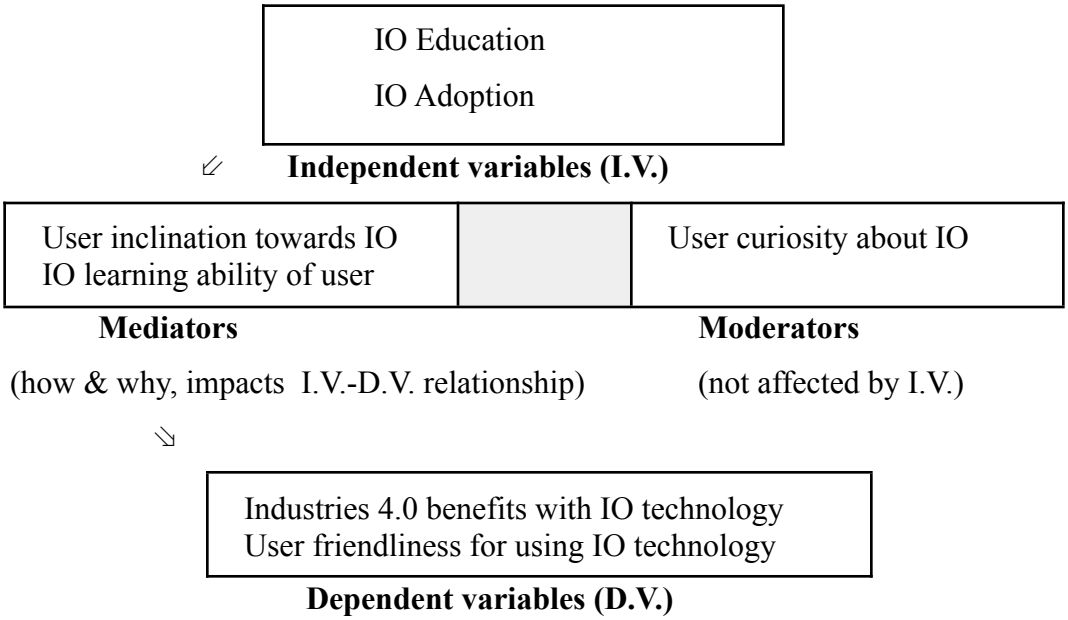


Fig 6.8 : Conceptual lens for Research Objective 1, after final data verification

Chapter 7

ANALYSIS OF RESEARCH OBJECTIVE 2 - IDENTIFY THE MAJOR EFFICIENCY PARAMETERS FOR THE IMPLEMENTATION OF INTEGRATED OPERATIONS SOLUTIONS IN INDIAN UPSTREAM COMPANIES

The research design for the problems is Exploratory and Analytical. Scholar proposed to follow the following methodology *for Research Objective 2*: Significant efficiency parameters will be identified using Factor Analysis based on impact of implementation of Integrated Operations solution in the Indian upstream companies.

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 2

5th step : Identify dominant IO Efficiency parameters for Research Objective 2 with Confirmatory Factor Analysis

7th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data verification for Research Objective 2 with 2-3 IO experts

7.1 FINDING THE RELEVANT VARIABLES FOR OBJECTIVE 2 USING MODIFIED GROUNDED THEORY

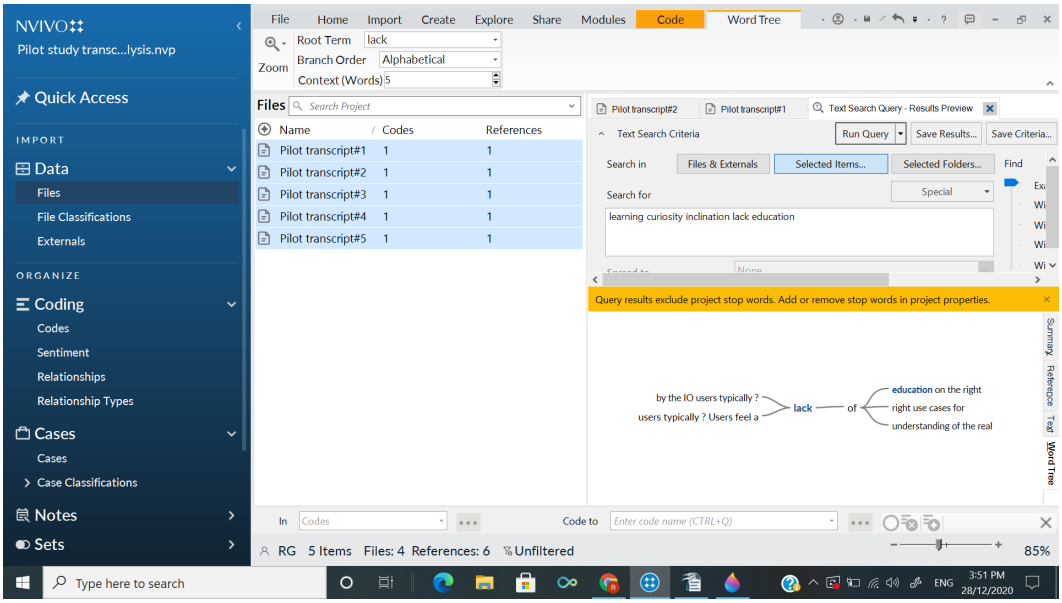


Fig 7.1 : Pilot study Coding screenshot no.4 (using Nvivo) for Research Objective 2

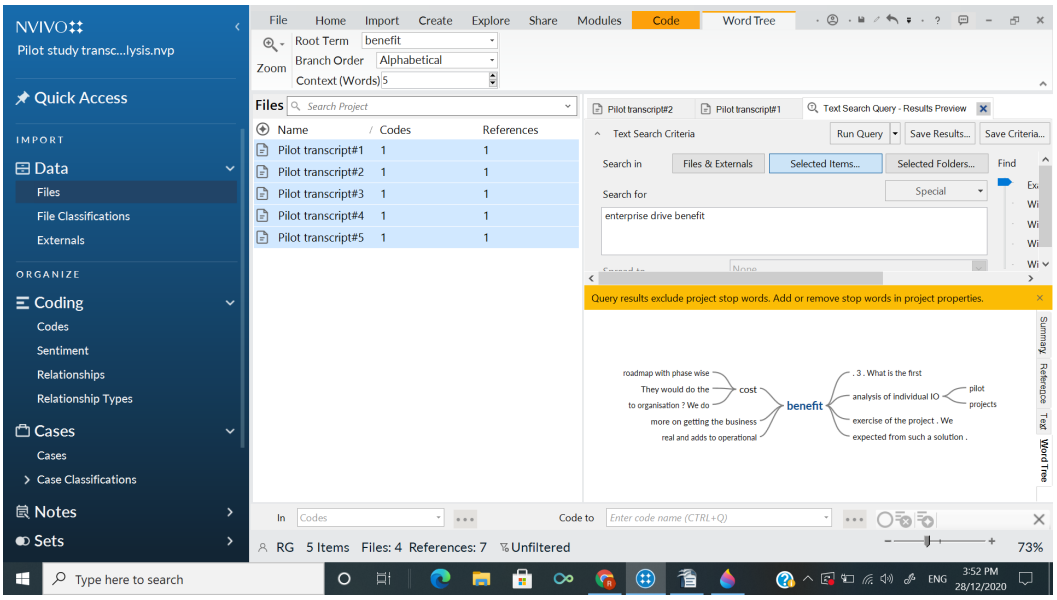
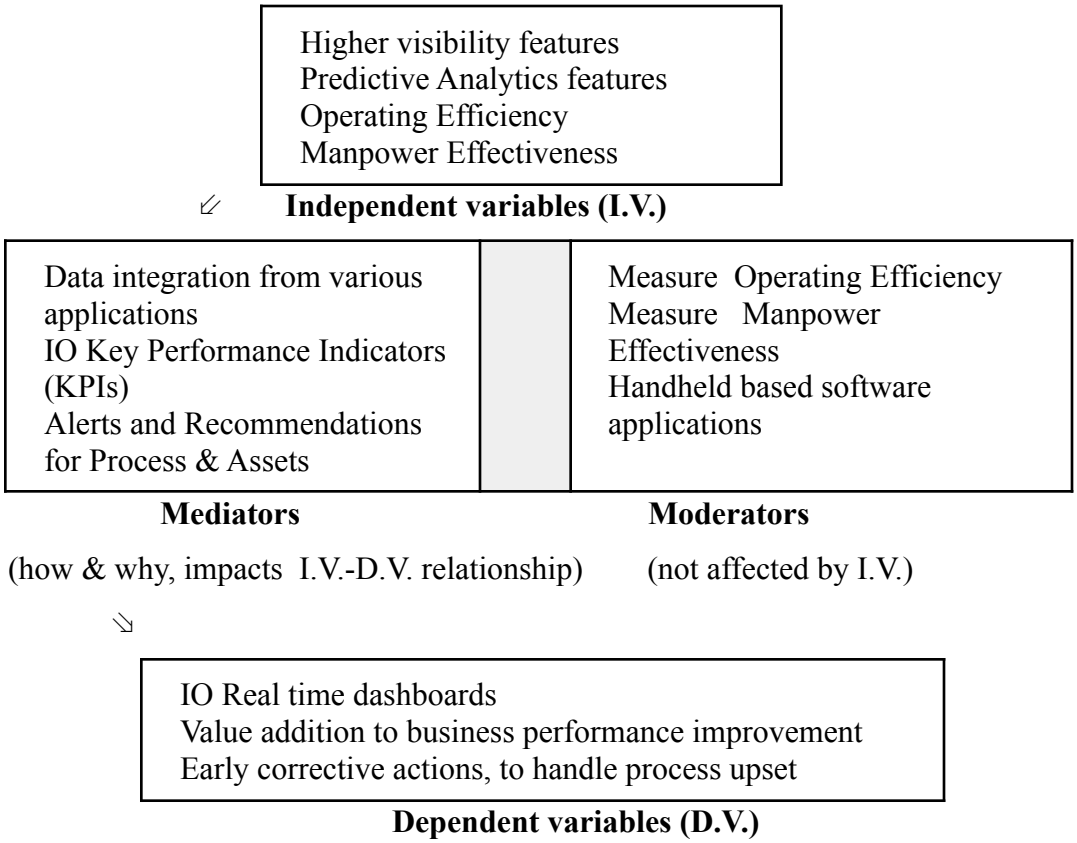


Fig 7.2 : Pilot study Coding Screenshot 5 (using Nvivo) for Research Objective 2

7.2 CONCEPTUAL LENS FOR RESEARCH OBJECTIVE 2 changed after the pilot study, as illustrated below, with inputs from the IO experts to identify IO Solutions efficiency parameters :



7.3 : Conceptual lens for Research Objective 2, post pilot study

7.3 CONFIRMATORY FACTOR ANALYSIS FOR OBJECTIVE 2

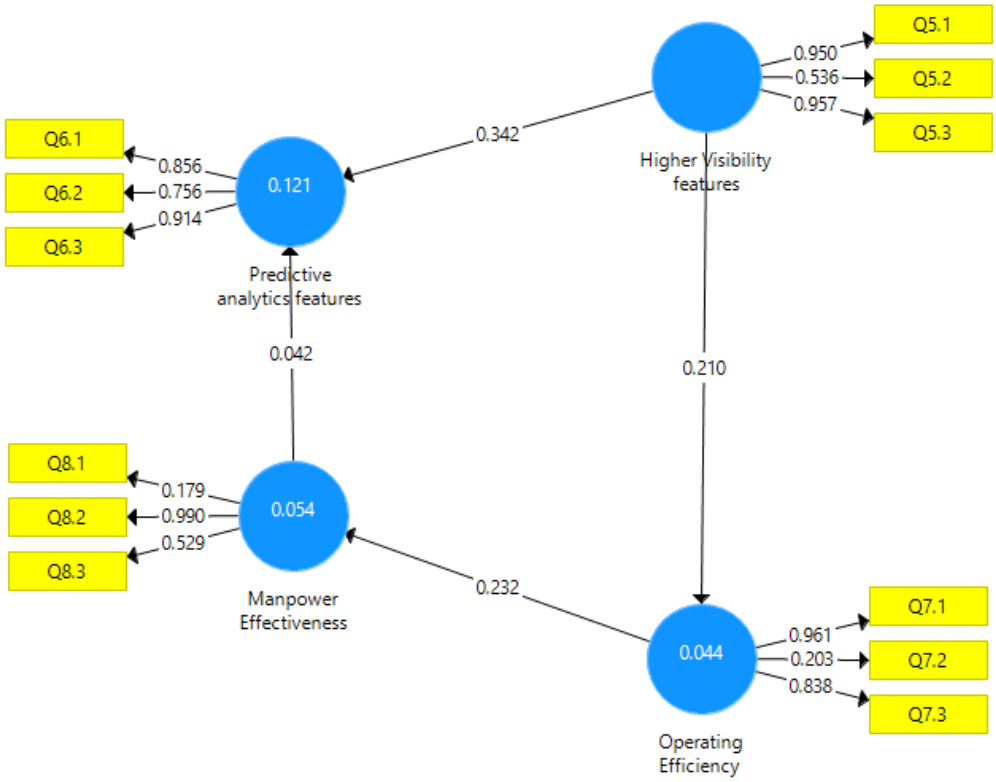


Fig 7.4 : Confirmatory Factor Analysis for Objective 2

7.4 RESULTS OF DATA ANALYSIS FOR OBJECTIVE 2

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Q5.1	13	0	2.901	2	1	5	1.257	-0.954	0.558
Q5.2	14	0	3.504	4	1	5	1.23	-0.364	-0.737
Q5.3	15	0	2.73	2	1	5	1.326	-0.871	0.527
Q6.1	16	0	2.879	3	1	5	1.095	-0.322	0.767
Q6.2	17	0	3.511	4	1	5	1.324	-0.785	-0.523
Q6.3	18	0	2.582	2	1	5	1.239	-0.461	0.614
Q7.1	19	0	2.617	2	1	5	0.965	-0.083	0.597
Q7.2	20	0	3.688	4	1	5	1.118	-0.133	-0.65
Q7.3	21	0	2.39	2	1	5	0.973	-0.246	0.407
Q8.1	22	0	2.652	2	1	5	0.982	-0.181	0.656
Q8.2	23	0	3.674	4	1	5	1.055	-0.202	-0.595
Q8.3	24	0	2.504	2	1	5	1.036	-0.243	0.455

Table 7.1 : Raw data file for 12 measured sub-variable / indicators for Objective 2

	Higher Visibility features	Manpower Effectiveness	Operating Efficiency	Predictive analytics features
Q5.1	0.523			
Q5.2	0.125			
Q5.3	0.456			
Q6.1				0.313
Q6.2				0.431
Q6.3				0.445
Q7.1			0.716	
Q7.2			-0.161	
Q7.3			0.411	
Q8.1		-0.198		
Q8.2		0.951		
Q8.3		0.178		

Table 7.2 : Outer weights for Obj 2

	Higher Visibility features	Manpower Effectiveness	Operating Efficiency	Predictive analytics features
Q5.1	0.95			
Q5.2	0.536			
Q5.3	0.957			
Q6.1				0.856
Q6.2				0.756
Q6.3				0.914
Q7.1			0.961	
Q7.2			0.203	
Q7.3			0.838	
Q8.1		0.179		
Q8.2		0.99		
Q8.3		0.529		

Table 7.3 : Out loadings for Obj 2

	Higher Visibility features	Manpower Effectiveness	Operating Efficiency	Predictive analytics features
Higher Visibility features	1	0.075	0.21	0.345
Manpower Effectiveness	0.075	1	0.232	0.068
Operating Efficiency	0.21	0.232	1	0.148
Predictive analytics features	0.345	0.068	0.148	1

Table 7.4 : Obj 2 Latent variable correlations

Discriminant validity alludes to the degree to which components are unmistakable and uncorrelated. The standard is that variables ought to relate in a strong manner to their own factor than to other different factors.

	Higher Visibility features	Manpower Effectiveness	Operating Efficiency	Predictive analytics features
Higher Visibility features	0.838			
Manpower Effectiveness	0.075	0.656		
Operating Efficiency	0.21	0.232	0.745	
Predictive analytics features	0.345	0.068	0.148	0.845

Table 7.5 : Obj2 Discriminant Validity

	Higher Visibility features	Manpower Effectiveness	Operating Efficiency	Predictive analytics features
Higher Visibility features			0.21	0.342
Manpower Effectiveness				0.042
Operating Efficiency		0.232		
Predictive analytics				

Table 7.6 : Obj 2 Path Coefficients

	Saturated Model	Estimated Model
SRMR	0.113	0.113
d_ULS	0.987	0.997
d_G	0.399	0.4
Chi-Square	282.158	282.811
NFI	0.643	0.642

Table 7.7 : Obj 2 Model Fit

The validity and reliability of results are considered as the two significant import issues in measurement theory. The unwavering quality investigation (reliability analysis) of each factor decides its capacity to yield similar outcomes in various circumstances and validity alludes to the estimation of what the factor should quantify. As a dependability gauge we utilize Cronbach's alpha (CA) that actions inside consistency. The Cronbach-α value (>0.7) of each factor implies the affirmation of dependability and reliability of inferred factors.

	Cronbach's Alpha
Higher Visibility features	0.795
Manpower Effectiveness	0.744
Operating Efficiency	0.722
Predictive analytics features	0.797

Table 7.8 : Obj 2 reliability estimates

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Higher Visibility features -> Operating Efficiency	0.21	0.153	0.207	1.016	0.31
Higher Visibility features -> Predictive analytics features	0.342	0.343	0.076	4.517	0
Manpower Effectiveness -> Predictive analytics features	0.042	0.071	0.097	0.437	0.662
Operating Efficiency -> Manpower Effectiveness	0.232	0.086	0.231	1.006	0.315

Table 7.9 : P value for Obj 2

Based on the variables / sub-variables identified through CFA, following conceptual framework mapping was mapped.

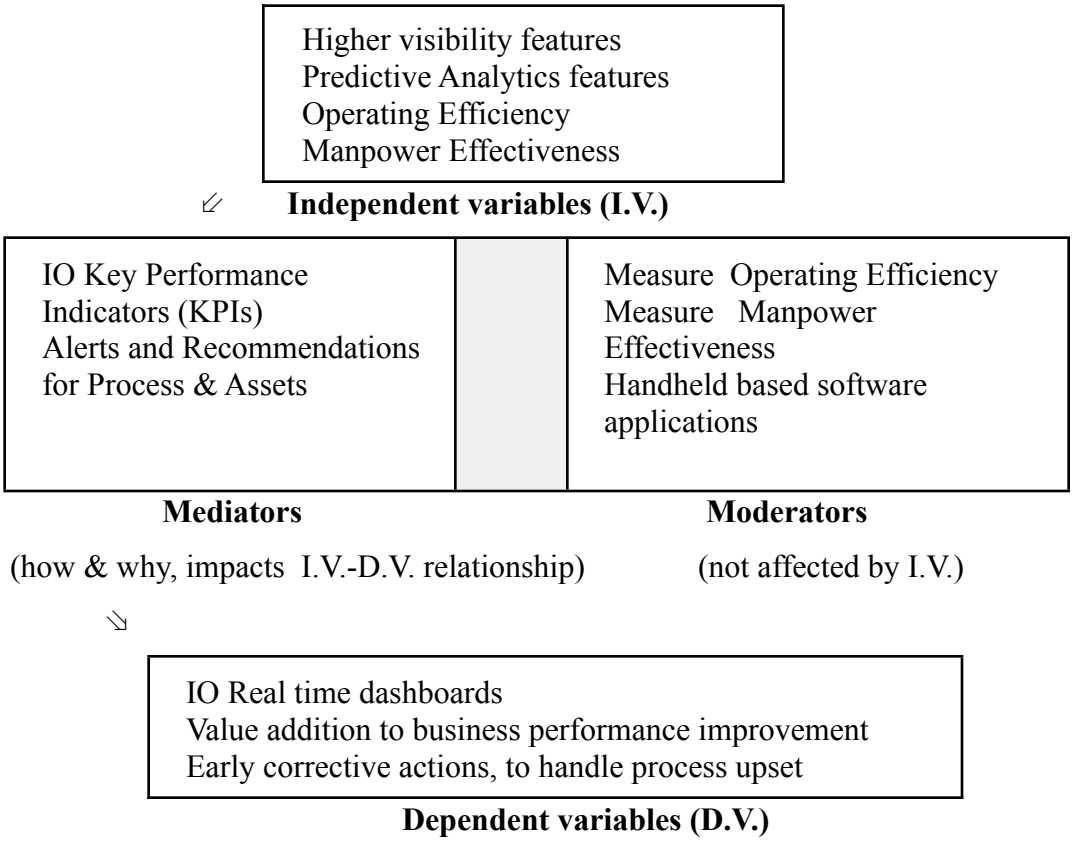


Fig 7.5 : Conceptual lens for Research Objective 2, after CFA

7.5 FINAL DATA VALIDATION FOR OBJECTIVE 2 WITH MODIFIED GROUNDED THEORY

Final data verification with coding of the interview transcripts confirmed the findings as it is.

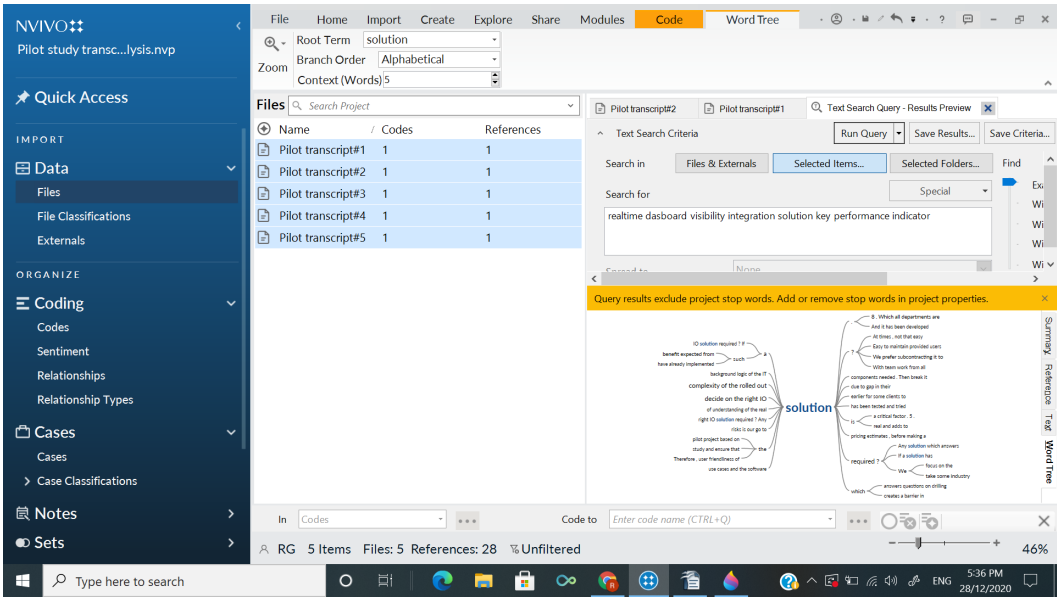


Fig 7.6 : Obj 2 screenshot 6 for Final data validation (using Nvivo) with use of Modified Grounded Theory

7.6 CHAPTER CONCLUSION - DOMINANT MEASURED VARIABLES FOR OBJECTIVE 2

Measured variable for Objective 2	Measured sub-variables for Objective 2	Conclusions on Research Objective 2
Higher Visibility features (Significantly important)	IO Real time dashboards	Very important factor
	Data integration from various applications	
	IO Key Performance Indicators (KPIs)	Very important factor
Predictive analytics features (Significantly important)	Value addition to business performance improvement	Important factor
	Alerts and Recommendations for Process & Assets	Important factor
	Early corrective actions, to handle process upset	Very important factor
Operating Efficiency	IO based solution for Operating Efficiency needed	Very important factor
	Scattered Point software based solution are important	Least important
	Traditional PLC / DCS based applications	
Manpower Effectiveness	IO based solution for Manpower Effectiveness needed	Least important
	Handheld based software applications	Very important factor
	Mobile / walkie talkies based applications	Important factor

Table 7.10 : Dominant measured variables for Objective 2

Post final data verification, following conceptual framework mapping was done with the variables / sub-variables identified.

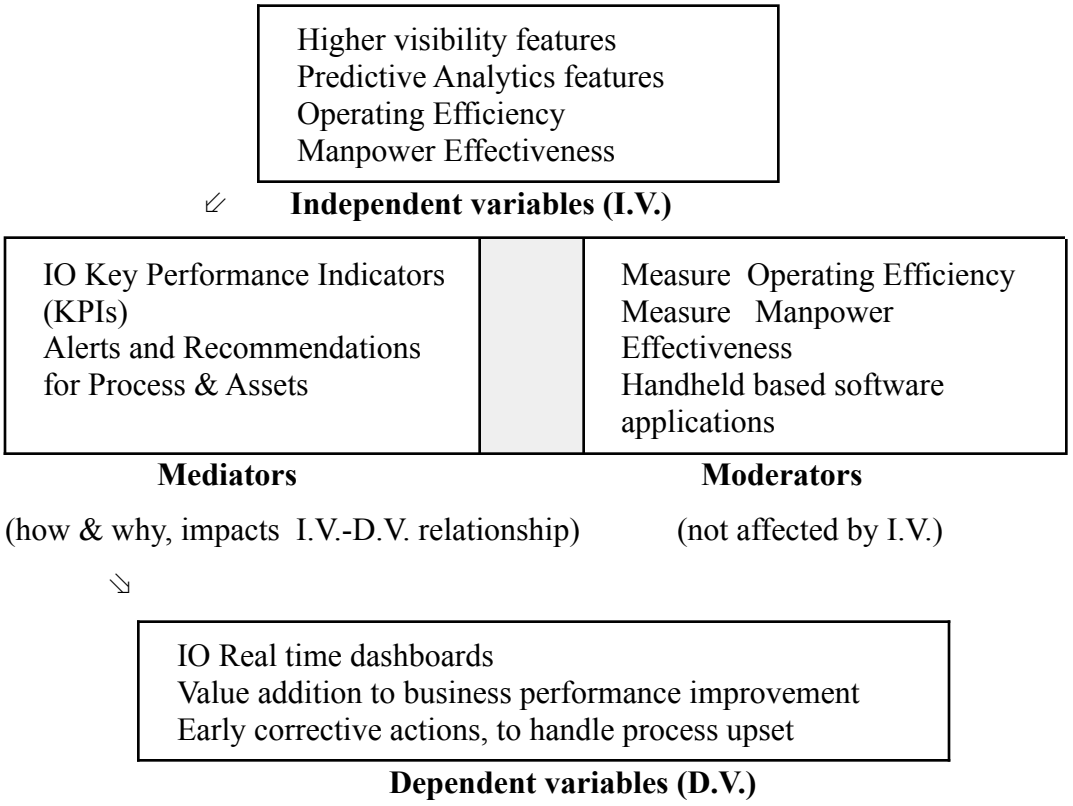


Fig 7.7 : Conceptual lens for Research Objective 2, post final data verification

Chapter 8

ANALYSIS OF RESEARCH OBJECTIVE 3 - SUGGEST A CUSTOMIZED SOLUTIONS AND ORGANISATION READINESS WITH EMPHASIS ON OPTIMISTIC, pessimistic, and INNOVATIVE APPROACH FOR IMPLEMENTATION OF INTEGRATED OPERATIONS FOR INDIAN UPSTREAM COMPANIES

The research design for the problems is Exploratory and Analytical. Scholar proposed to follow the following methodology *for Research Objective 3*: The customized solution with management barriers removed will be prepared. The same will be validated by expert opinion of stakeholders from upstream companies in India with use of Modified Grounded Theory.

3rd step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to identify the key words for finalising the survey questionnaire for the measured variables for Research Objective 3

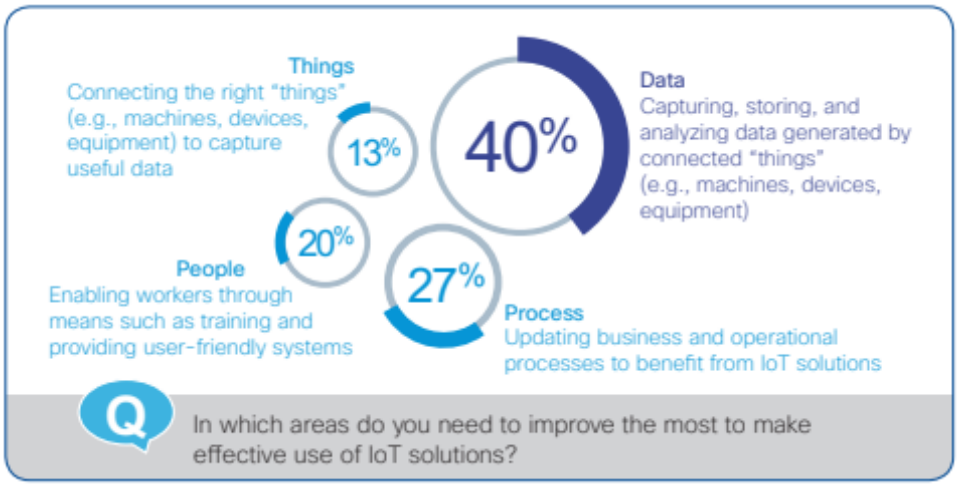
6th step : Identify the customised IO technology solution readiness parameters for Research Objective 3 with Confirmatory Factor Analysis

8th step : Coding of interview transcripts (using Nvivo) with use of Modified Grounded Theory research tool, to validate the final data verification for Research Objective 3 with 2-3 IO experts

8.1 THE CUSTOMISED IO SOLUTION

All the solution service providers, be it Information Technology companies or Consulting companies or Automation vendors or small software companies, have more or less similar solution themes. They all want to access Field data and connect it with Enterprise data, and make meaningful sense out of it so that business users can make quicker decisions. Different names are given to literally same set of solutions, like IO (Integrated Operations), IoT (Internet of Things) [16], IIOT (Industrial Internet of Things)[113], DoF (Digital Oil Field) [139] etc etc but all these names meant the same thing – digital transformation solutions around integrating data with better visual and analytics capabilities.

These solutions primarily focused on – connecting data, assets, process, people to the decision makers for quicker decision making (refer Fig 14). Different solution providers suggest these same solutions based on their own strong areas. Cisco, for example below, emphasizes on Edge connectivity because of their expertise in IIOT devices [52]. Overall idea behind this Integrated Operations solution is to spend less time on managing data / information, and rather spend more time on taking decisions with that data / information.



Source: Cisco Consulting Services, 2014 [33]

Fig 8.1. Better to process the data at the edge, closer to where it is generated.

A customized Integrated Operations solution will focus on Integrating, Automating, and Analyzing Data. And to profit by the wide scope of information produced, upstream companies should beat three key difficulties recognized by our study respondents:

- Integrating information from numerous sources
- Automating the assortment of information / data collection
- Analyzing information to successfully recognize noteworthy bits of actionable knowledge

Exclusively by tending to every one of the three would organizations be able to transform crude information into actionable knowledge / insight.

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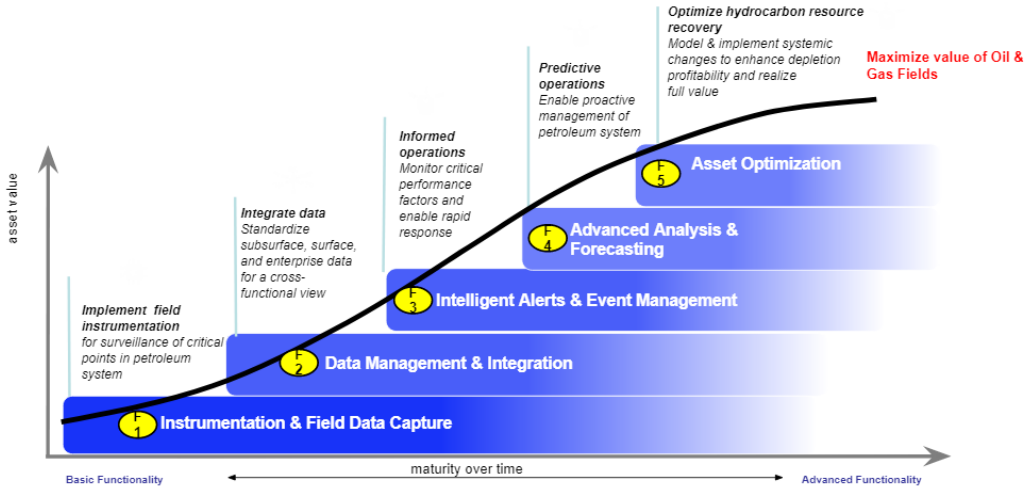

Fig 8.2 : IO Solution focus on Integrating, Automating, and Analyzing Data

In order to define the customized Integrated Operations solutions (mentioned at various figures from Fig 8.4 onwards), a typical Integrated Operations strategy roadmap [156] explains what specific initiatives every upstream organization needs to take to derive business benefits with Digital Transformation [159].

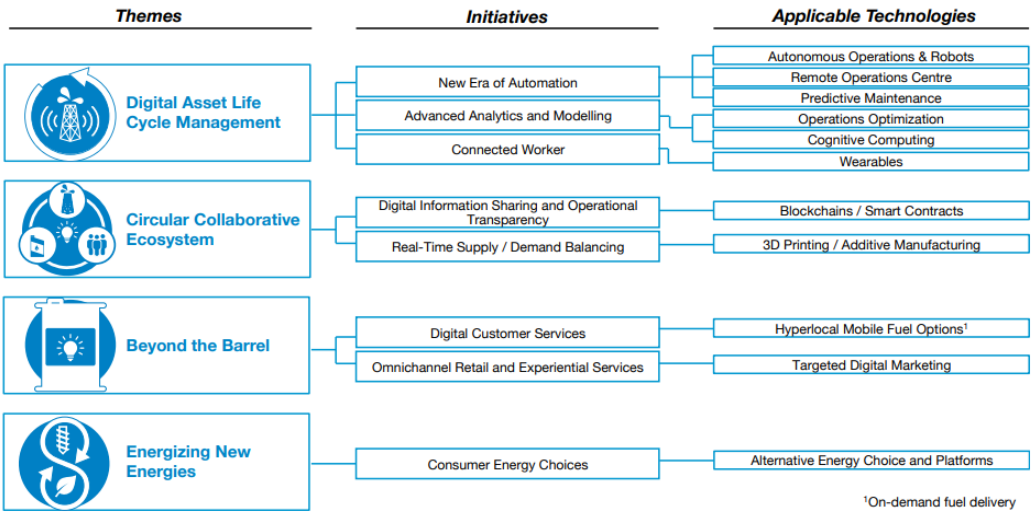

Fig 8.3: Customised IO Solution (themes & technologies)

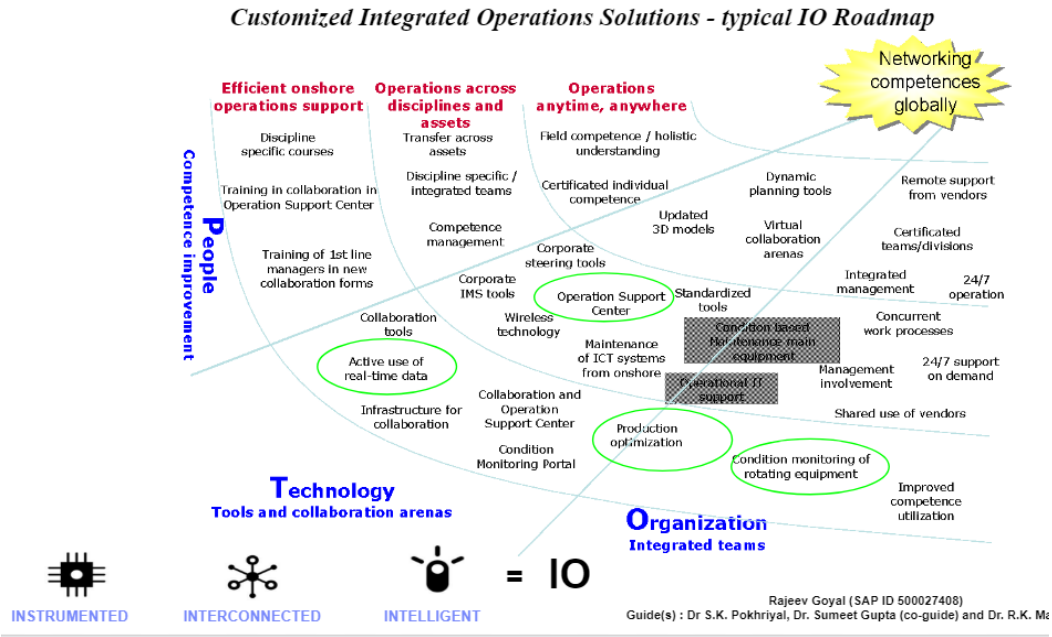

Figure 8.4: Customised IO Solution roadmap

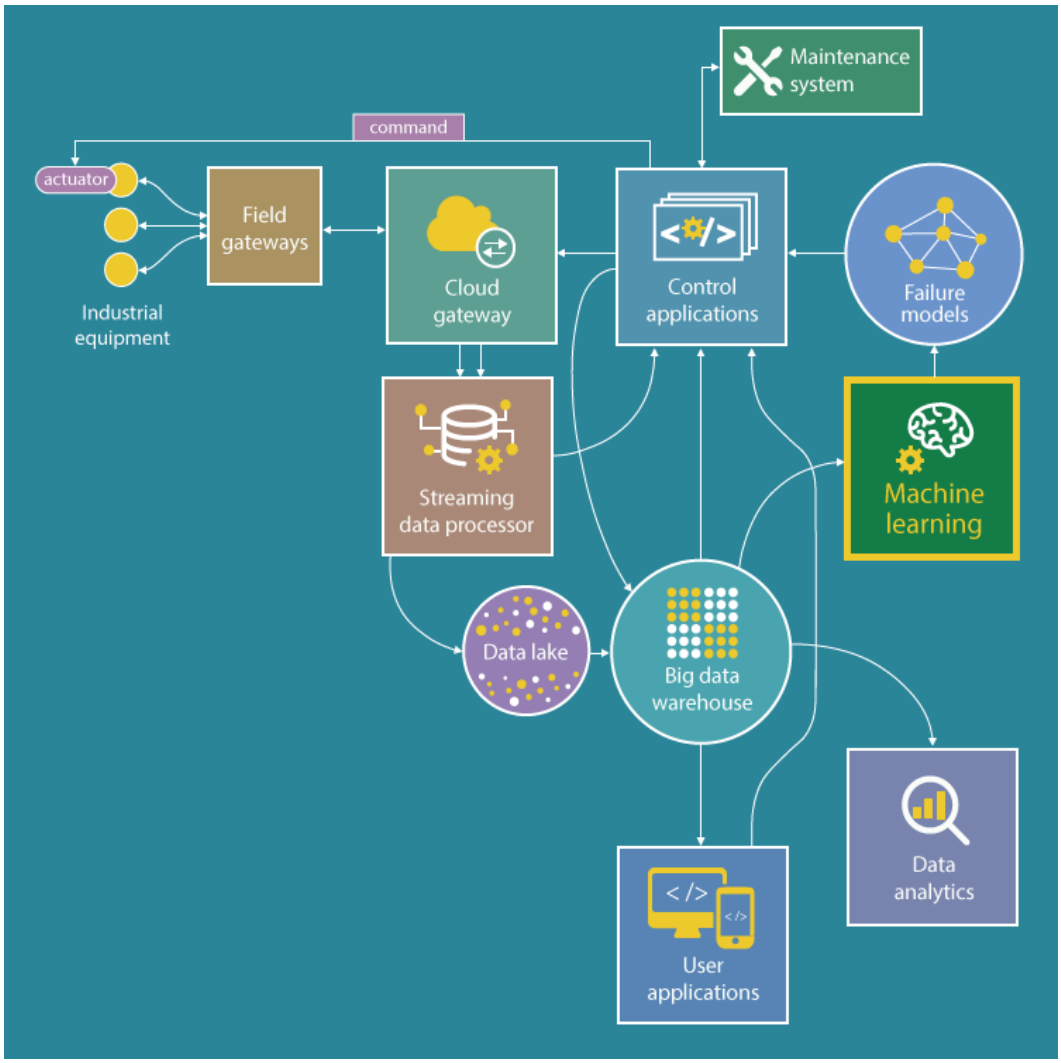

Fig 8.5: Customised IO Solution (Screenshot no.1)

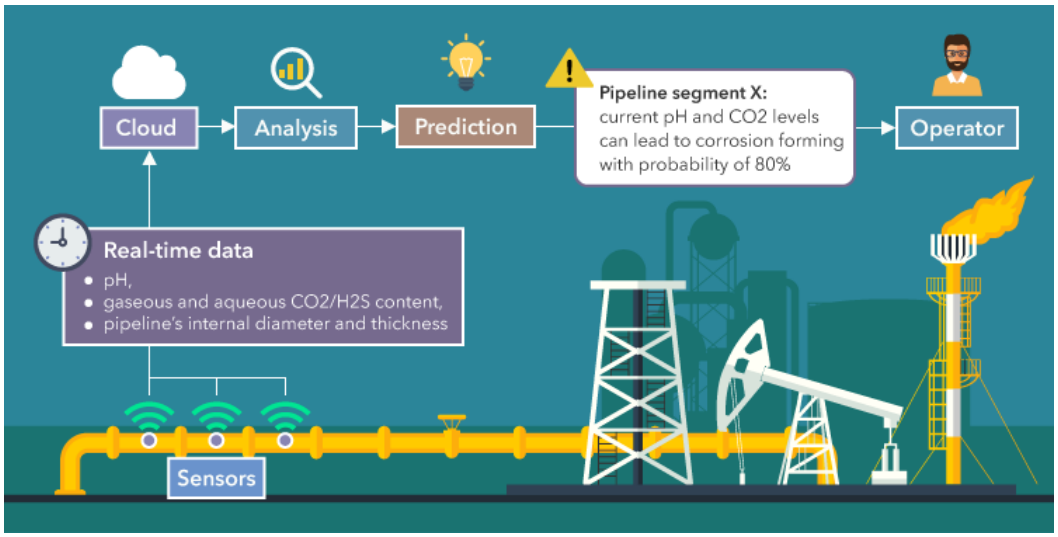

Fig 8.6 : Customised IO Solution (Screenshot no.2)

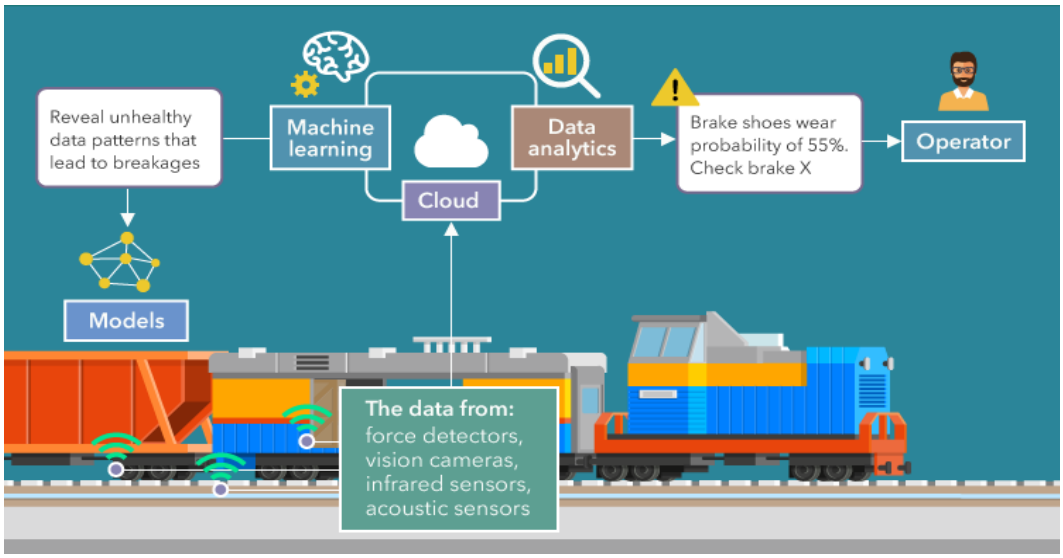

Fig 8.7: Customised IO Solution (Screenshot no.3)

8.2 FINDING THE RELEVANT VARIABLES FOR OBJECTIVE 3 USING MODIFIED GROUNDED THEORY

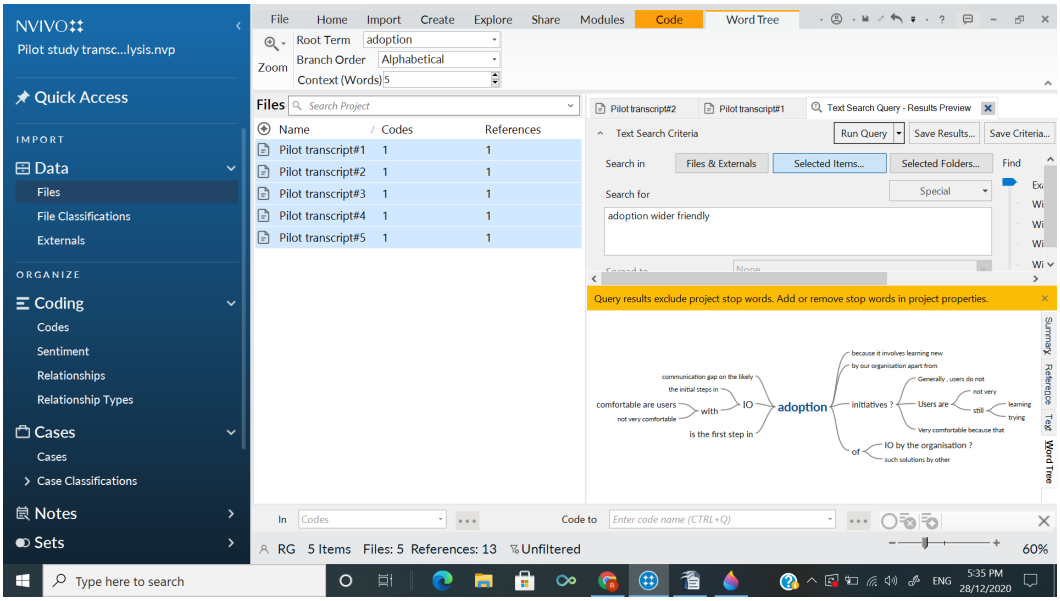

Fig 8.8 : Pilot study Coding screenshot no.7 (using Nvivo) for Research Objective 3

8.3 CONCEPTUAL LENS FOR RESEARCH OBJECTIVE 3 changed after the pilot study, as illustrated below, with inputs from the IO experts to measure organisational readiness for the customised IO solution :

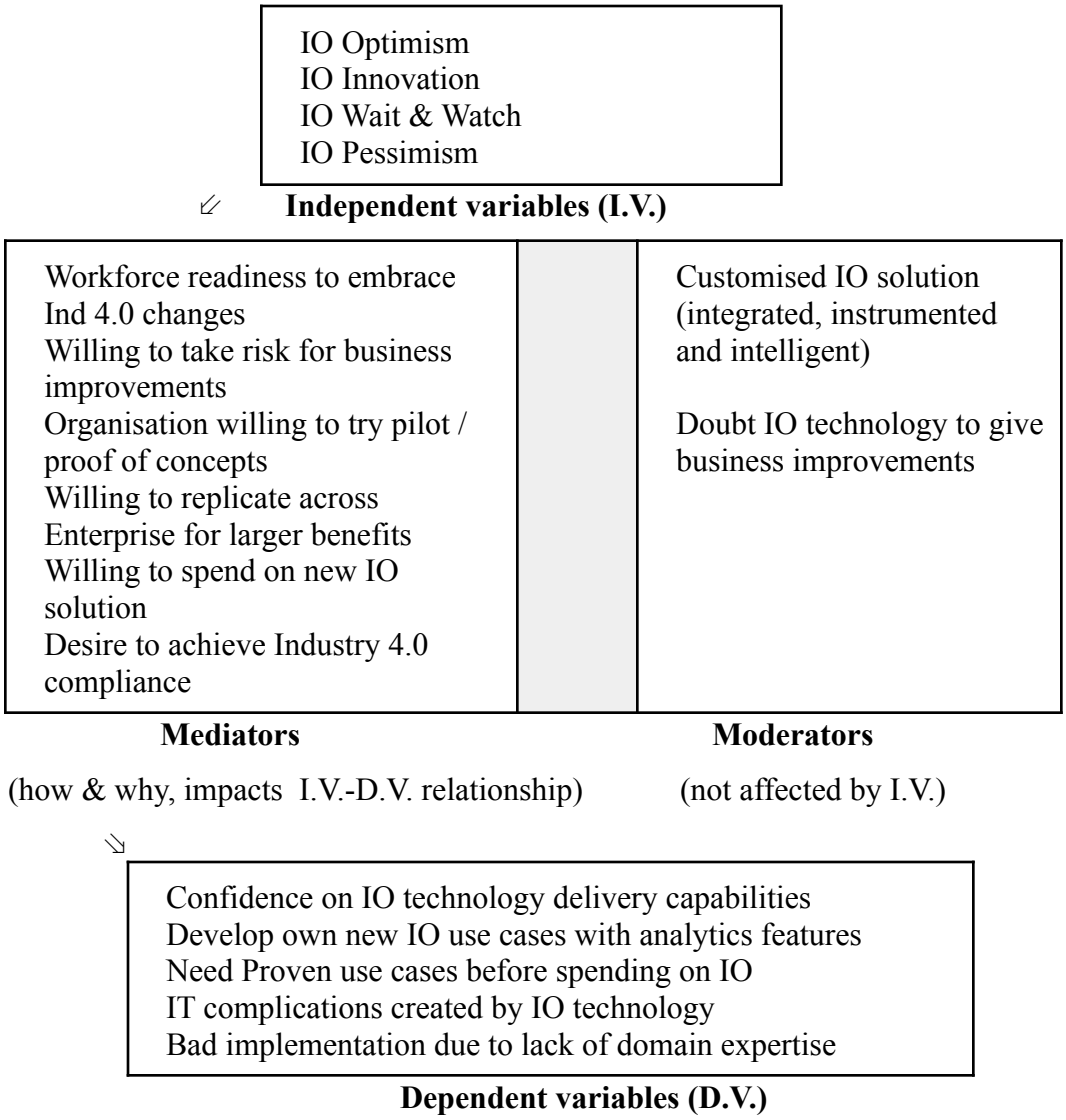

Fig 8.9 : Conceptual lens for Research Objective 3, post pilot study

8.4 CONFIRMATORY FACTOR ANALYSIS FOR OBJECTIVE 3

Twelve measured sub-variables, as per Table 5.19, focused on measuring the "IO solution technology readiness [119] perspective" in addition to other twelve measured variables for barrier identification by identifying the Integrated Operations outlook of Indian Upstream companies.

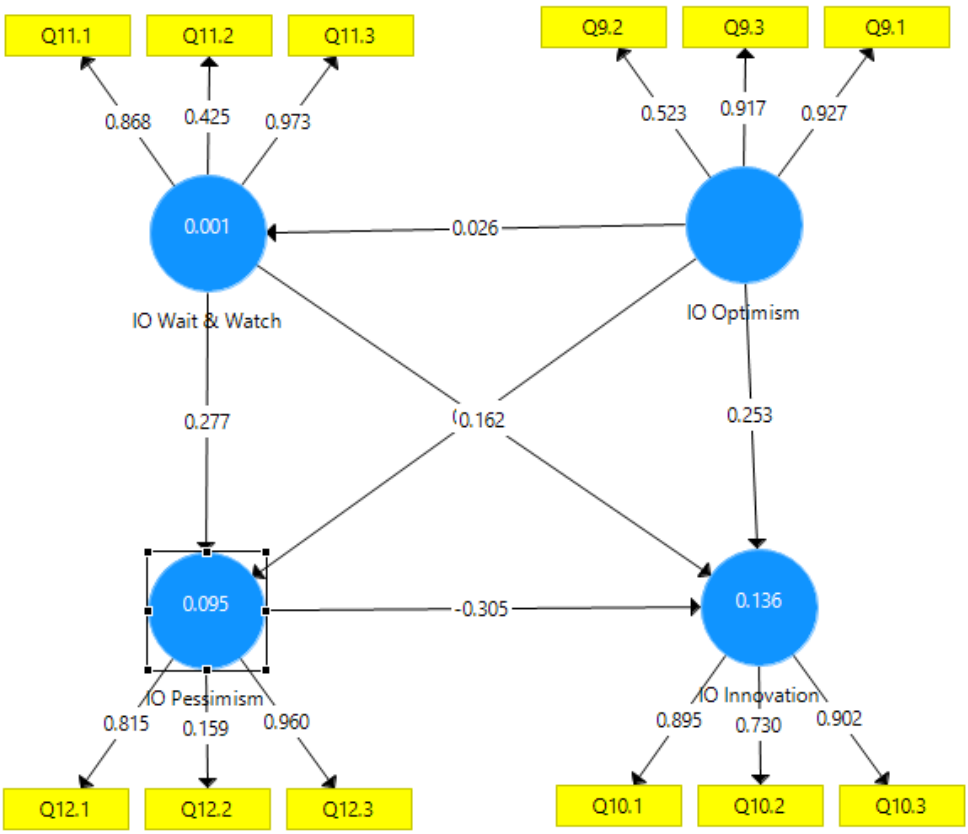

Fig 8.10 : Confirmatory Factor Analysis for Objective 3 (IO adoption outlook of the Customised solution by Indian Upstream Companies)

Perspective#1: IO Optimism (Q9.1- IO tech capability; Q9.2. Open to risk; Q9.3. Embrace Ind4.0 change)

Perspective#2: IO Innovation (Q10.1- New use case; Q10.2- Try pilot; Q10.3- Replicate across Enterprise)
Perspective#3: IO Wait & Watch (Q11.1- New solution; Q11.2- Proven cases; Q11.3- Ind4.0 compliance)
Perspective#4: IO Pessimism (Q12.1- Doubt IO; Q12.2- IT complications; Q12.3- Lack domain expertise)

8.5 RESULTS OF DATA ANALYSIS FOR OBJECTIVE 3

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Q9.1	25	0	2.645	2	1	5	0.997	0.096	0.936
Q9.2	26	0	3.674	4	1	5	1.095	-0.12	-0.665
Q9.3	27	0	2.362	2	1	5	1.005	0.069	0.618
Q10.1	28	0	2.596	2	1	5	1.038	0.144	0.875
Q10.2	29	0	3.674	4	1	5	0.993	0.483	-0.755
Q10.3	30	0	2.61	3	1	5	1.084	-0.233	0.457
Q11.1	31	0	2.716	2	1	5	1.094	-0.112	0.914
Q11.2	32	0	3.461	4	1	5	1.241	-0.661	-0.552
Q11.3	33	0	2.61	2	1	5	1.242	-0.665	0.509
Q12.1	34	0	2.567	2	1	5	0.999	-0.033	0.741
Q12.2	35	0	3.39	3	1	5	1.32	-0.936	-0.358
Q12.3	36	0	2.333	2	1	5	0.904	1.004	0.741

Table 8.1 : Raw data file for 12 measured sub-variables/ indicators for Objective 3

After we have predefined the factors, CFA was carried out to infer factors. The objective of factor analysis is the recognizable proof of relations among factors.

	IO Innovation	IO Optimism	IO Pessimism	IO Wait & Watch
Q10.1	0.895			
Q10.2	0.73			
Q10.3	0.902			
Q11.1				0.868
Q11.2				0.425
Q11.3				0.973
Q12.1			0.815	
Q12.2			0.159	
Q12.3			0.96	
Q9.2		0.523		
Q9.3		0.917		
Q9.1		0.927		

Table 8.2 : IO Outlook Outer Loadings for Objective 3

Based on the variables / sub-variables identified through CFA, following conceptual framework mapping was mapped.

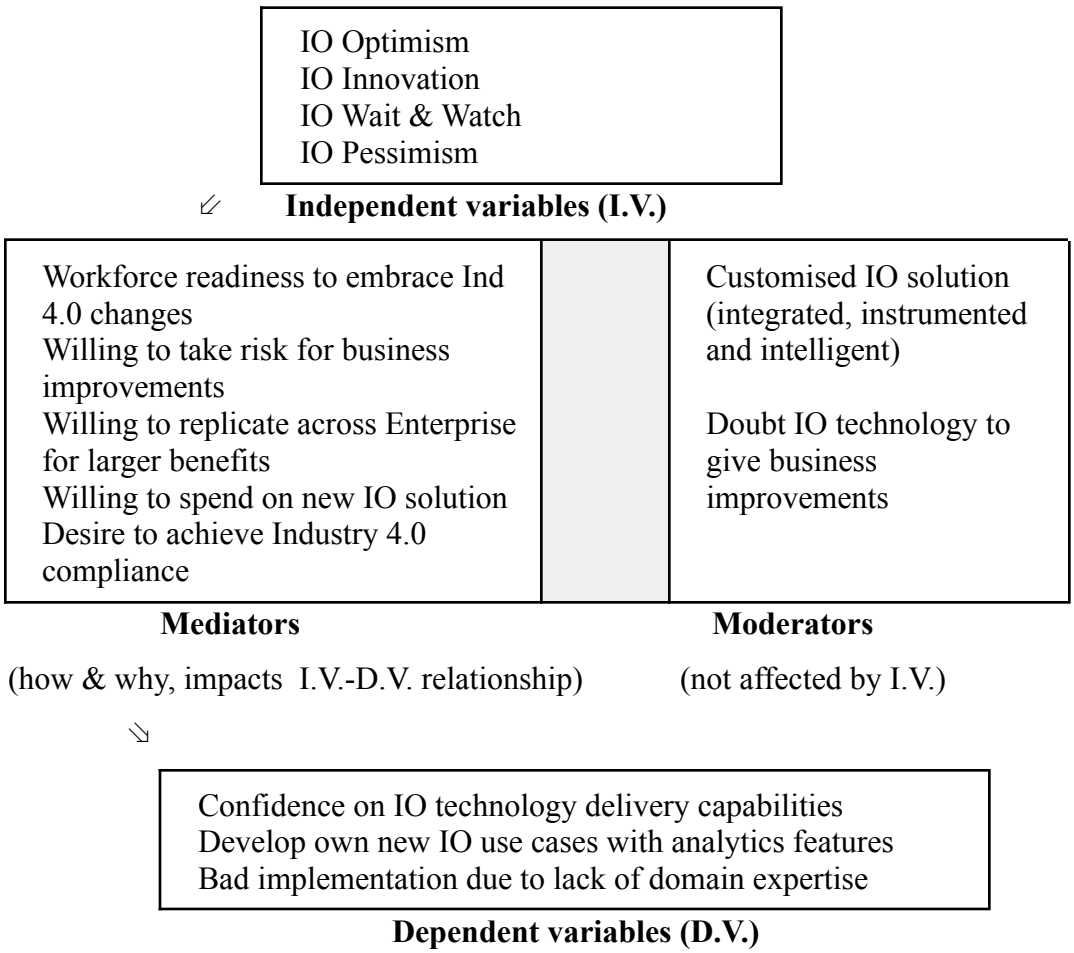

Fig 8.11 : Conceptual lens for Research Objective 3, after CFA

8.6 FINAL DATA VALIDATION FOR OBJECTIVE 3 WITH MODIFIED GROUNDED THEORY

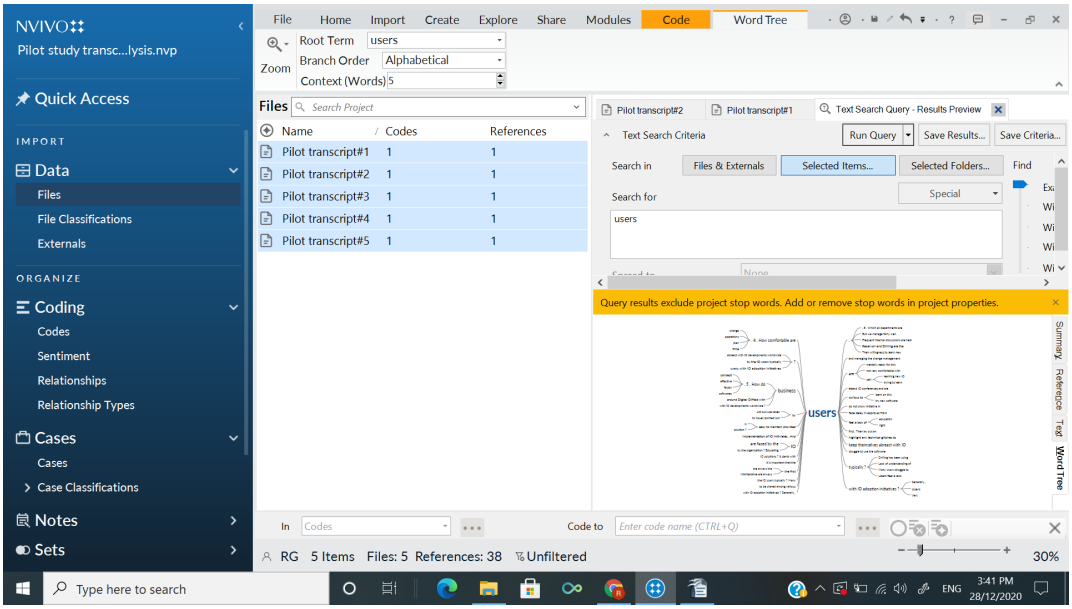

Fig 8.12 : Obj 3 screenshot 8 for Final data validation (using Nvivo) with use of Modified Grounded Theory

Considered as contributors, IO Innovation and IO Optimism are the indicators of IO technology readiness [119]. In contrast, IO Pessimism and IO Wait & watch forestall or delay, company's natural inclination to utilize IO innovation and are considered as inhibitors. Consequently, a high score estimated on these measurements will diminish the IO innovation readiness. The four measurements are genuinely free of one another; hence, any Indian upstream organization could oblige both patron and inhibitor sentiments towards innovation.

8.7 CHAPTER CONCLUSION - DOMINANT MEASURED VARIABLES FOR OBJECTIVE 3

Measured variable for Objective 3	Measured sub-variables for Objective 3	Conclusions on Research Objective 3
IO Optimism (Significantly important)	Confidence on IO technology delivery capabilities	Very important
	Willing to take risk for business improvements	
	Workforce readiness to embrace Industries 4.0 changes	Very important
IO Innovation (Significantly important)	Develop own new IO use cases with analytics features	Important
	Organisation willing to try pilot / proof of concepts	Added back only after final data verification
	Willing to replicate across Enterprise for larger benefits	Very important
IO Wait & watch	Willing to spend on new IO solution	Important
	Need Proven use cases before spending on IO	Not significantly important
	Desire to achieve Industry 4.0 compliance	Very important
IO Pessimism	Doubt IO technology to give business improvements	Important
	IT complications created by IO technology	Least important
	Bad implementation due to lack of domain expertise	Very important

Table 8.3 : Dominant measured variables for Objective 3

As evident from the IO Outlook loadings above, IO tech capability (Q9.1), Embracing Ind4.0 change (Q9.3), Willingness to try new IO use cases (Q10.1) and the Willingness to replicate IO solutions across Enterprise (Q10.3) are

biggest contributor for adoption of IO technology. While, Ind4.0 compliance (Q11.3) and Doubting IO capabilities (Q12.1) are the biggest inhibitors in adoption of IO technology by Indian upstream companies. Contrary to general belief in the industry, IT complications (Q12.2) is the smallest inhibitor in the minds of IO decision makers while looking at IO adoption.

Post final data verification, following conceptual framework mapping was done with the variables / sub-variables identified through CFA.

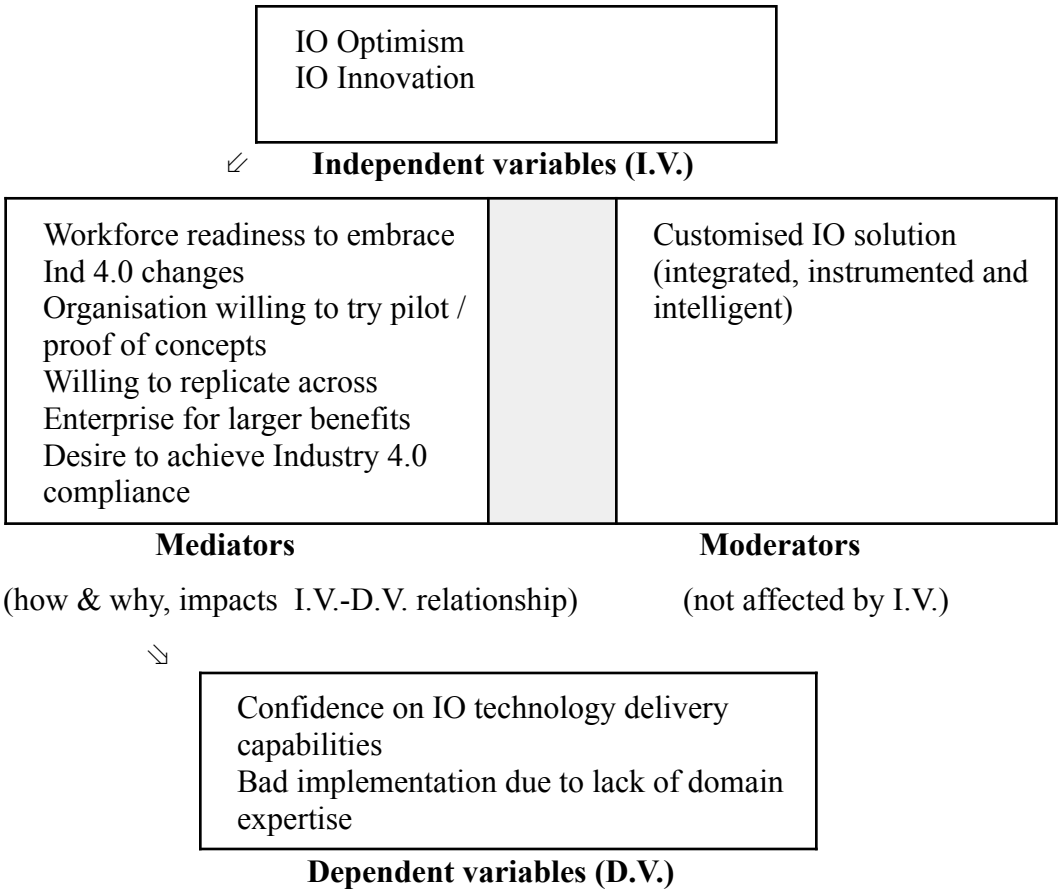

Fig 8.13 : Conceptual lens for Research Objective 3, after final data verification

Chapter 9

DISCUSSIONS & CONCLUSIONS

9.1 DISCUSSIONS

Since adoption of the Integrated Operations is fairly recent in India, upstream companies do not have any dedicated department around Digital Transformation or Integrated operations in contrast to global upstream companies who even now have Chief Digital Officer (CDO) in addition to Chief Information Officer (CIO) [163] and Chief Technology Officer (CTO). In the last decade, things have progressed a bit on this front but still the clarity and focus is missing on part of the management of the upstream companies in adoption of Integrated Operations or Digital Transformation.

Innovation Adoption Life cycle model clarifies the acknowledgment of an inventive or arising innovation throughout some undefined time frame among various arrangements of adopters with particular qualities [58]. This model partitions the entire arrangement of adopters into five classes specifically – Innovators followed by Early adopters, early lion's share, late lion's share and slow pokes. Each gathering has its own demographic and psychographic attributes. The reception cycle follows the famous bell curve. Organizations ought to be cautious about the attributes of the adopter set they are focusing on. As found in the curve, the adoption cycle begins with pioneers and the last to acknowledge the item are slouches.

Geoffrey A. Moore [109] in his well known book – "Intersection the Chasm" recommends that – in the life cycle model adoption – there can be holes between the adopter classes and he encourages to overcome this issue by figuring viable methodologies in as far as picking the most proper section, situating of the item, fitting evaluating and choosing the channel of dissemination.

Rayna and Striukova [126] set forward a procedure to overcome this issue proposed by Geoffrey A Moore [109]. The organizations ought to be incredibly cautious while choosing the client portion or adopter set. The chosen portion ought to have enough "Innovative experimenters" to work with receptions and to make a "Domino impact" to different sections so different fragments additionally will be urged to embrace the item. This "Domino Effect" prompts mass reception.

Bredillet, Yatim & Ruiz [164] studied the adoption of “Project Management” in organizations and concluded that the most important barrier to overcome to stimulate adoption was the “cultural change” required. Organizations/Individuals were very hesitant to change the “Current Way of doing thing” even when the change was for better results.

9.2 CONCLUSIONS

Business Problem “Remove Management Barriers in implementation of Integrated Operations solutions in Indian upstream companies which is leading to opportunity loss” and the identified *Research Problem* “Identify management barriers for implementation of a customised Integrated Operations solutions for capturing the potential opportunity loss for Indian upstream companies” is answered with the results of following three Research Objectives.

For Research Objective 1, the researcher infers that the (1) IO Education and (2) IO Adoption are the dominant management barrier measured variables with (i) User inclination towards IO (ii) IO learning ability of user (iii) Business Performance improvements with IO technology (iv) User friendliness for using IO technology as measured sub-variable causing slow management decisions in adoption of Integrated Operations. One of the findings is that the Market Price of IO technology sub-variable has the least impact on such decision making. For Research Objective 2, the researcher infers that (1) Higher Visibility features (2) Predictive analytics features are significantly important efficiency parameters measured variables with (i) IO Real time dashboards (ii) IO Key Performance Indicators (iii) Early corrective actions features (iv) Handheld based software applications as measured sub-variables for effective execution of Integrated Operations solutions. For Research Objective 3, the researcher infers that IO Optimism and IO Innovation are dominant factors for successful implementation [10] of the customised IO solution.

Measured variable for Objective 1	**Measured sub-variables for Objective 1**	**Conclusions on Research Objective 1**
IO Education **(first significant barrier)**	User inclination towards IO	More important factor
	User curiosity about IO	Important factor
	IO learning ability of user	More important factor
IO Organisation Drive	Global Upstream Industry assessment of IO	
	Enterprise-wide drive for IO	
	Industries 4.0 benefits with IO technology	Important factor
IO Cost	Market Price of IO technology	Least important (last factor)
	Acquisition cost of IO technology vs Savings	Not a relevant factor (had to be omitted in CFA)

	Maintenance cost of IO technology	Important factor
IO Adoption **(second significant barrier)**	Business Performance improvements with IO technology	More important factor
	Wider functionality coverage with IO technology	
	User friendliness for using IO technology	More important factor

Measured variable for Objective 2	**Measured sub-variables for Objective 2**	**Conclusions on Research Objective 2**
Higher Visibility features **(Significantly important)**	IO Real time dashboards	Very important factor
	Data integration from various applications	
	IO Key Performance Indicators (KPIs)	Very important factor
Predictive analytics features **(Significantly important)**	Value addition to business performance improvement	Important factor
	Alerts and Recommendations for Process & Assets	Important factor
	Early corrective actions, to handle process upset	Very important factor
Operating Efficiency	IO based solution for Operating Efficiency needed	Very important factor
	Scattered Point software based solution are important	Least important
	Traditional PLC / DCS based solution	
Manpower Effectiveness	IO based solution for Manpower Effectiveness needed	Least important
	Handheld based software applications	Very important factor
	Mobile / walkie talkies based solution	Important factor

Measured variable for Objective 3	Measured sub-variables for Objective 3	Conclusions on Research Objective 3
IO Optimism **(Significantly important)**	Confidence on IO technology delivery capabilities	Very important
	Willing to take risk for business improvements	
	Workforce readiness to embrace Industries 4.0 changes	Very important
IO Innovation **(Significantly important)**	Develop own new IO use cases with analytics features	Important
	Organisation willing to try pilot / proof of concepts	
	Willing to replicate across Enterprise for larger benefits	Very important
IO Wait & watch	Willing to spend on new IO solution	Important
	Need Proven use cases before spending on IO	Not significantly important
	Desire to achieve Industry 4.0 compliance	Very important
IO Pessimism	Doubt IO technology to give business improvements	Important
	IT complications created by IO technology	Least important
	Bad implementation due to lack of domain expertise	Very important

Table 9.1 : Dominant measured variables for all three Research Objectives

9.3 RECOMMENDATIONS FOR THE INDIAN UPSTREAM INDUSTRY

In spite of the business confidence in the present and future proficiency of these savvy Integrated Operations solutions, research shows that stakeholders are showing considerable reluctance on account of lack of education about IO and lack of drive towards IO adoption across the organization. Unless IO users and decision makers are educated more on the benefits of IO initiatives, Indian upstream companies shall struggle to go for IO investments in spite of clear benefits being reaped by global upstream players. Benefits of the IO technology are not well understood in India due to lack of specific use cases.

Given the returns on investments [12] of the order of 3 to 5% over a decade of the production volumes globally, Indian upstream companies have the potential of 3% increase on total domestic production of approximately US $ 675 million easily.

All major operating companies in Indian upstream energy sector need to automate business processes with an integrated IT infrastructure to lessen operational time [94]. A piecemeal way to deal with IT should be stayed away from in light of the fact that it gets cost restrictive to execute the innovation. To build the achievement rate, periodic reviews should look to distinguish and use industry best practices.

However, the key success factors which Indian upstream companies must take into account while designing and implementing IO Enterprise Solution are as follows:

1) Set up a successful, adjusted way to deal with Research and

Development, value realisation and deployment [116]. Innovation isn't the significant core interest. It must be guaranteed that any innovative work is exceptionally centered around explicit holes that could create the upper hand.

2) Grow clear linkage to business needs and useful needs as the premise of connecting with the business.

3) Zero in on deployment: Deploy IO solutions that have demonstrated success in one asset out of various asset locations – get the most worth out of what is now demonstrated prior to dispatching new drives.

4) Utilize good project management abilities: Use a staged methodology as well as fast successes to convey some early esteem and get client purchase into a more extensive program.

9.4 STRATEGIES FOR IMPLEMENTATION OF INTEGRATED OPERATIONS IN INDIA

IO programs are more fundamentally multi- disciplinary business process improvement and change management initiatives, requiring executive vision and commitment. From the information technology (IT) perspective [20], IO is always about deploying the latest technical advances which rely upon a stable IT and field automation platform, effective data management environment, and change management issues. One of the most significant barriers in organizations' approach to Intellectual Property (IP). Most of the companies generally try to guard their detailed technical strategies and proprietary domain like IP data for the competitive advantage which hinder the use of open standards. A critical link

in this IO conversation between the line of business (LOB) and IT is to establish realistic business cases for monitoring the measurable business impact of these strategic investments. Each upstream O&G company must focus on developing their own asset level, corporate level business processes and its improvement strategies, and thus deploy the IO programs which are capable of supporting the unique business issues and requirements.

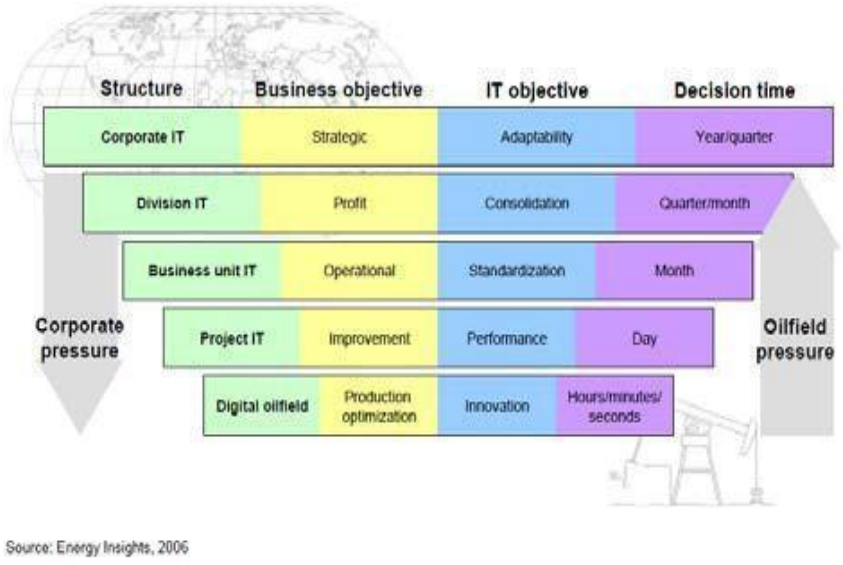

Fig 9.1 : A View of Governance in Upstream Industry

For an effective IO system, companies need to move from an applications-centric approach towards a service oriented way to deal with the administration of management information system [31], utilizing a framework approach featuring more efficient integrated data management and realtime visualization, the use of intelligent workflows, and open standard based solutions.

Indian upstream companies have to come up with a clear strategy to educate IO stakeholders within the organization so that a clear strategy roadmap [156] is in place and clear IO initiatives can be taken by management to get the Industries

4.0 benefits, already proven at global level. This would require commitment from top management in every organization. Some of the suggestions are as follows :

- Focus on making digital a priority for the senior management. Digital transformation, similar to some other change, should be supported from the top. This incorporates setting an unmistakably clear vision [156], committing funding and resources, and effectively supporting the change-management effort related with it.

- Set a very clear vision with strong commitment on funds and resources [111], and effectively champion the related change-management efforts.

- Educate / teach all the potential IO clients / users. Recognize inner IO champions.

- Must drive an organisation culture of innovation [9] and technology adoption [3]. While not all things will be created in house, organizations should open up to groundbreaking thoughts and methods of working.

- Put resources into IT insightful savvy human resources with required labor advancement programs pointed toward advancing digital transformation thinking. At last, a digitally clever labor force [85] is both a basic empowering influence of change and a critical driver for maximising value enhancement.

- Set up an orderly methodology for building up the customised / tweaked use cases and new IO capacities. It ought to incorporate every one of the choices about different alternatives between assemble or purchase capacities, alongside a program based management approach to deal with assistance to scale the innovation and the IT stages further up.

- Change the organization's data infrastructure. Information sits at the core of computerized change in the digital world, so the harmonization, reconciliation and interoperability of information stages are basic.
- Distinguish IO opportunities to develop joint effort and comprehension of sharing-economy stages. This will take into account evading the potential traps brought by changing client inclinations formed by the ascent of the sharing economy.
- Build small pilot projects with clear use cases, and measure the ROI before full scale implementation.
- Settle on a program based management approach to deal with upcoming innovative digital platforms.
- Establish a mechanism to measure the returns from IO initiatives.
- Build a 3 to 5 year IO roadmap for the organisation.

Arrow [6] examines the part of (1) Firm size and (2) Market structure on appropriation of Innovation [9]. Firms that are enormous or have a huge piece of the market pie are probably going to embrace Innovation quicker than the rest since huge firms will have better assets as far as specialized framework, reserves accessibility and Human capital. Bigger firms can undoubtedly move the expense of development to their immense market. Since the selection of Innovation lessens the benefit in the short run, organizations with a low portion of the overall industry think that it's hard to receive Innovation [54]. "Uncertainty" over the advantages [71] conveyed by Innovation is an angle which impedes the appropriation of development. Bigger firms/Firms with a huge piece of the pie will actually want to enhance this danger by continuing existing innovation in activity or exploring different avenues regarding the new

innovation with a little arrangement of clients as it were. Bigger firms receive "Scale of improving Technologies" quicker than the more modest firms since they catch "Economies of scale from Production" through an expectation to absorb information quickly and spread fixed expenses of reception across a bigger number of units.

Chapter 10

CONTRIBUTION TO INDUSTRY AND LITERATURE

10.1 CONTRIBUTION TO INDUSTRY

Importance of the scholar's research is based on the fact that Statoil is the only company in Norway which could successfully implement an Integrated Operations initiative with $50bn saving potential over the 2005-2013 period but it could not be replicated in India due to management barriers involved in taking IO investment decisions. Although other multinationals like Shell, Chevron, BP etc have their digital oilfield initiatives but not as successful as Statoil had.

This research work will contribute significantly in following ways :

- In the first place, the consequence of this research work may be the significant ramifications for both Indian Upstream companies keen on investing in Integrated Operations business and the IO user looking for business improvements with innovative thoughts around IO technology solutions.

- Second, the industry scholars can take over from this research work, and continue it further.

- Third, the aftereffect of this investigation could be a significant reference for the execution of IO technology in India and other oil & gas producing developing countries.

- Fourth, data on the factors imposing management barriers for execution of Integrated Operations is compiled for major Indian upstream companies.

10.2 CONTRIBUTION TO LITERATURE

Scholar has contributed to literature with the final conceptual lens for RO1, RO2 and RO3 (refer Chapter 6, 7 & 8 respectively).

Original VAM only focused on the benefit, sacrifice, perceived value and adoption intention.

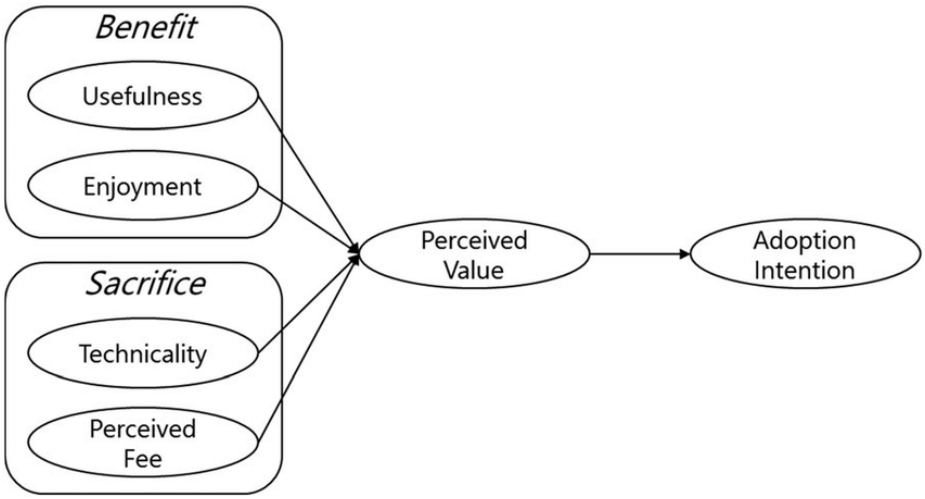

Fig 10.1 : VAM before Research (only focused on the benefit, sacrifice, perceived value and adoption intention)

As shown in Fig 10.2 below, scholar has made following pointwise contribution to VAM :

(i) The Value-based Adoption (VAM) Model [95] was never applied for Integrated Operations worldwide and for this research purpose in India.

(ii) VAM was enhanced by mentioning the management decision making barriers for technology adoption [70] like the lack of IO Education with emphasis on the benefit estimation and IO Adoption with emphasis on the User friendliness from RO1.

(iii) Similarly, VAM was enhanced with clear identification of IO Solution Efficiency Parameters (concluded from RO2) like Higher Visibility features, Improved Operating Efficiency, Predictive analytics features [72] and Data Integration capability.

(iii) VAM was further enhanced with User Perspective for Customised Solution (concluded from RO3) with clearly showing how organisations are taking different approaches on technology adoption - optimistic, pessimistic, wait & watch and innovative approach.

Organisation readiness for customised IO solution based on the cost–benefit paradigm (Value-based technology adoption model)

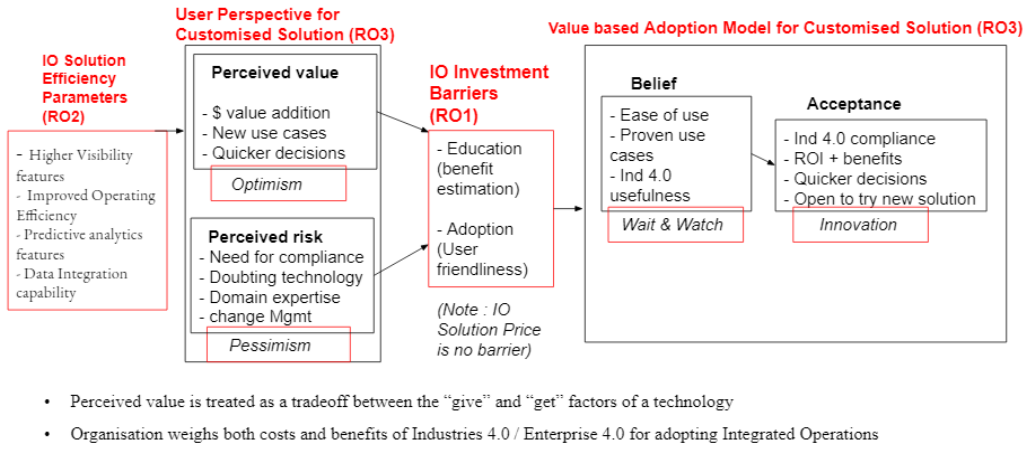

Fig 10.2 : Contribution to literature - Value-based technology Adoption Model

[70]

VAM depends on the money saving advantage worldview of the behavioral decision theory, which proposes the stakeholder's decision among different dynamic procedures. Perceived value is treated as a tradeoff between the "give" and "get" components of a technology. Kim et al. [88] made a coordinated model, the Value-based Adoption Model (VAM), to gauge aims of receiving innovation by perceived value. In VAM, the principle influencing parts of perceived value are perceived sacrifice and perceived benefits, and the perceived value is an examination estimation among advantages and penance. Moreover, the reception expectation is straightforwardly impacted by the center segment "perceived value". The meaning of perceived value in this paper mirrors this by contrasting advantages and costs, and is along these lines, a pointer of selection aim. Hence, this examination proposes that in the wake of weighing the benefits

and cost aspects of Enterprise 4.0 for an organisation, if the executives accepts that embracing Integrated Operations will offer a bigger number of advantages than costs and is advantageous to the company, the aim to receive Integrated Operations based arrangements would be available.

Chapter 11

LIMITATIONS AND FUTURE SCOPE

11.1 LIMITATIONS OF THE STUDY

Primary limitation is the comprehension of the potential dollar effect of Integrated Operations arrangements by the decision makers / partners/ stakeholders, consequently bringing down the chance of distinguishing all the management barriers. Secondary limitation is due to the Purposive Sampling method in Nonprobability sample category considering the limited number of people with expertise in Integrated Operations area being researched, the sampling with non probability does not cause estimation of sampling errors.

11.2 SCOPE FOR FUTURE STUDY

As of now, the conventional methodology of specifically receiving a bunch of Innovations and unsystematically carrying out digitalization probably won't be reasonable. All things being equal, the upstream O&G business could profit more by going after a progressive plan with an advanced spine. Digital changes can possibly make colossal incentives for both the business and society overall. Such a change will expect organizations to carry out an engaged advanced technique, supported by the CEO and leader groups, and a culture of development and innovation reception [70]. It will likewise require venture and obligation to return to and patch up cycles, framework and frameworks; and an eagerness to team up across the environment. All the empowering influences

needed for an effective change should become an integral factor for the business to tackle the actual potential coming from digitisation.

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PROFILE OF THE RESEARCHER

The researcher is a Mechanical Engineer with a Master of Management degree from Shailesh J Mehta School of Management, IIT Mumbai. The researcher has around 30 years of Upstream Oil & Gas industry experience in Production Operations, Asset Management, Sales and Digital Transformation with various leading companies like ONGC, Enron Oil & Gas, BG Exploration & Production, Baker Hughes, IBM and Honeywell across India, Singapore and Malaysia. The researcher has participated in various talks and presented on Integrated Operations in 14 different O&G forums in Australia, China, India, Indonesia, Malaysia, Singapore, Thailand, Vietnam and USA The researcher has four published papers in Peer Reviewed National and International Journals (scopus indexed) - International Journal of Contemporary Research in Engineering & Technology (ISSN no. 2250-0510) July19 issue, International Journal of Emerging Technology & Advanced Engg. (ISSN Online : 2250–2459) Volume 9, Issue 10, October 2019 and International Journal of Management (ISSN Print: 0976-6502 / ISSN Online: 0976-6510), Volume 11, Issue 9, September 2020 and Volume 11, Issue 10, October 2020. The areas of interest of the researcher are designing of Digital Transformation based relevant use cases and adoption of these solutions in a quick and smooth manner by companies.. The researcher is also Six Sigma Black Belt trained in 2019.

Rajeev's Final Thesis 18th May

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