RISK MITIGATION OF CNG REFUELING NETWORK FOR THE EASTERN CORRIDOR STATES OF INDIA

A thesis submitted to

University of Petroleum and Energy Studies

In

Energy Management

By

Atul Rawat

October 2021

SUPERVISOR(s)

Dr. Sumeet Gupta

Dr. T. Joji Rao

Department of Energy Management
School of Business
University of Petroleum and Energy Studies, Dehradun 248007
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Internal Supervisor

Dr. Sumeet Gupta
Senior Associate Professor
Department of General Management

Internal Co-Supervisor
Dr. T. Joji Rao
Professor
Department of General Management

Department of Energy Management
School of Business
University of Petroleum and Energy Studies, Dehradun 248007
Uttarakhand

October 2021

DECLARATION

I declare that the thesis titled **"Risk Mitigation of CNG Refueling Network for the Eastern Corridor States of India"** has been prepared by me under the guidance of Dr. Sumeet Gupta, Senior Associate Professor, Department of General Management and Dr. T. Joji Rao Professor, Department of General Management University of Petroleum and Energy Studies. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

Atul Rawat
SAP ID: 500049753
Department of Energy Management
University of Petroleum and Energy Studies
Knowledge Acres Kandoli
Dehradun 248001

Date 12/10/2021

CERTIFICATE

I certify that Atul Rawat has prepared his thesis entitled "Risk Mitigation of CNG Refueling Network for the Eastern Corridor States of India", for the award of PhD degree of the University of Petroleum & Energy Studies, under my guidance. He has carried out work at the Department of Energy Management, University of Petroleum & Energy Studies.

Internal Supervisor

Dr. Sumeet Gupta

Senior Associate Professor

Department of General Management,

University of Petroleum and Energy Studies

Kandoli via Premnagar, Dehradun, Uttarakhand - 248007

Date:

Dr. T. Joji Rao

Professor

Department of General Management,

University of Petroleum and Energy Studies

Kandoli via Premnagar, Dehradun, Uttarakhand - 248007

Date: 12/10/21

ABSTRACT

India is among the quickest developing economy globally and records for 18% of the world population. With anticipated economic growth, the country's energy demand, including natural gas, will probably develop. The Government expects to build the portion of natural gas in the energy blend to 15% by 2030. It has introduced a few initiatives like the presentation of Hydrocarbon Exploration Licensing Policy, natural gas pricing policy execution, creating a national natural gas grid, and growing city gas distribution (CGD) organisation. Moreover, the ascent in natural gas consumption will help the Indian Government diminish crude oil imports by 10% by 2022. The Indian Government has granted multiple licensing rounds of CGD network improvement for guaranteeing last-mile connectivity. Petroleum and Natural Gas Regulatory Board (PNGRB), the controller for downstream exercises, has granted 229 licenses through 10 CGD licensing rounds covering around 70% of India's population and 53% of the area. However, many CGD projects have failed to meet the project timelines committed to the PNGRB. CGD network expansion is a capital-intensive business and with a long payback period. It is a complex framework with many branches. Additionally, it is difficult to deal with the uniqueness, vulnerability and complexity of the project. The management of the CGD project requires a coordinated effort among the project entertainers to carry out the joint risk mitigation system.

The study estimates the national natural gas demand and CNG demand for the eastern corridor states, including West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. Further, it identifies the critical operational and financial risks causing a delay of the CGD projects and develops mitigations strategies to address them.

The research uses the mixed research methodology to achieve the objectives. The researcher has used a dynamic econometric model and Hodrick Prescott Filter to estimate national natural gas demand and CNG demand for eastern corridor states. The results of the error correction model revealed that income, price, and population are statistically insignificant in the natural gas estimation, indicating that there might be a suppressed demand within the country. The results of the Hodrick Prescott filter has also shown a rising trend for the CNG demand in the eastern corridor states of India.

The second objective results are achieved in two steps. The first step was to identify the critical operational and financial risks, followed by developing mitigation strategies to address them. The researcher has used factor analysis for determining the necessary operational and financial risks. A total of 24 risk variables comprises of 11 financial and 13 operational were identified through literature review. The identified variables were also discussed with the industry experts before finalising the questionnaire survey to gather data. The data collected were analysed using factor analysis to understand the critical financial and operational risk factors' latent structure. As a part of the result, eight financial variables were grouped into two factors, and 12 operational variables were grouped into three factors. Following this, the researcher used the grounded theory methodology to develop the mitigation strategies and SAP-LAP framework to identify the actors responsible for taking the appropriate actions.

The findings indicate that natural gas has suppressed demand for natural gas, and CGD would play a critical role in establishing it as a preferred fuel across pan-India. However, to realise this vision, the industry and Government need to work together for ensuring the completion of CGD projects, specifically in the eastern corridor region of India. The area is devoid of an operational natural gas pipeline and has many pipeline projects under construction. It is essential to have synchronisation in developing natural gas transportation pipelines, and the CGD project to ensure last-mile connectivity to the industrial, commercial and residential consumers to LPG and establish CNG as a transportation fuel. The early identification of risks and subsequent implementation of mitigation strategies will enable companies and the Government to implement joint risk management and develop the pipeline infrastructure in the region.

The findings suggest that effective implementation of joint risk management in the CGD project requires both the Government and the company to collaborate to achieve common objectives and value each other competencies. Moreover, the study's findings suggest that the mechanistic management style is suitable in a stable environment like government agencies, while an organic system is apt for changing settings. Given that the CGD projects comprise uncertainty and changes, a collaborative approach for managing projects is best.

The study's critical theoretical contribution is that JRM necessitates a blend of structured and collaborative processes, requiring a balance of mitigation approach to overcome identified risks and flexibility to deal with unforeseen events.

The study concludes by providing recommendations for the government and CGD companies to successfully implement joint risk management to avoid project delays.

ACKNOWLEDGEMENT

It gives me great pleasure to express my deep sense of gratitude to my supervisors Dr. Sumeet Gupta and Dr. T. Joji Rao, for their invaluable guidance and support during the research work. I wish to express special gratitude to Dr. Sumeet Gupta for their precious time, thoughtful insights, meticulous and critical assessment during the doctoral research process. I am also indebted to Dr. T. Joji Rao for his constant support, encouragement and guidance during the endeavour. I express a special sense of appreciation to Dr. S.K. Rai for providing invaluable suggestions to improve upon all through the course of the study.

I would also like to acknowledge my seniors and colleagues, namely Dr. Deepankar Chakarabarty, Dr. Tarun Dhingra, Dr. Anil Kumar, and Mr. Pramod Painuly, for their constant motivation and support during the study. I am also indebted to Mr. K.K. Lal, Senior Associate Librarian, UPES for his valuable guidance. I am incredibly appreciative to Dr. B.S. Negi, Former Member PNGRB, Mr. Mohit Raj, General Manager (Regulatory & Business Development), Pipeline Infrastructure Limited and Mr. Punit Gupta, Senior Officer, IOCL, for extending unparalleled support during the data collection.

I wish to express my gratitude to my father, Mr. S.S. Rawat and my mother Smt. Kavita Rawat for their blessings and motivation. I am indebted to my brother Mr. Rahul Rawat for being with me through thick and thin and having immense belief in me. My special thanks to my wife Ms. Bharti Rawat, and my children Sara and Shivaay for their constant support and care during the entire course of the research work.

NOMENCLATURE

Gt	Gigatonne
LNG	Liquefied Natural Gas
CGD	City Gas Distribution
BCM	Billion Cubic Meter
CNG	Compressed Natural Gas
PNG	Piped Natural Gas
HELP	Hydrocarbon Exploration Licensing Policy
OALP	Open Acreage Licensing Policy
Km	Kilometers
MMSCMD	Million Standard Cubic Meter per Day
PNGRB	Petroleum and Natural Gas Regulatory Board
GAIL	Gas Authority of India Limited
PIL	Pipeline Infrastructure Limited
ONGC	Oil and Natural Gas Corporation Limited
GSPL	Gujarat State Petroleum Limited
GGL	Gujarat Gas Limited
RGPL	Reliance Gas Pipeline Limited
AGCL	Assam Gas Company Limited
DFPCL	Deepak Fertilizers and Petrochemicals Corporation Limited
GIGL	GSPL India Gasnet Limited
GITL	GSPL India Transco Ltd.
IOCL	Indian Oil Corporation Limited
APGDC	Andhra Pradesh Gas Distribution Corporation
HEPL	H-Energy Private Limited
IMC	Indian Molasses Company

IGGL	Indradhanush Gas Grid Limited
GoI	Government of India
BG	British Gas
BPCL	Bharat Petroleum Corporation Limited
GAs	Geographic Area
IGL	Indraprastha Gas Limited
MGL	Mahanagar Gas Limited
AGL	Adani Gas Limited
CUGL	Central Uttar Pradesh Gas Limited
SCM	Standard Cubic Meter
MEIL	Megha Engineering and Infrastructure Limited
HPCL	Hindustan Petroleum Corporation Limited
IOAGPL	IndianOil-Adani Gas Pvt. Ltd
BGRL	Bharat Gas Resource Limited
MNGL	Mahanagar Gas Limited
TNGCL	Tripura Natural Gas Company Limited
RSGL	Rajasthan State Gas Limited
INR	Indian National Rupee
LPG	Liquefied Petroleum Gas
MTPA	Million Tonnes per Annum
L-CNG	Liquefied Compressed Natural Gas
CO2	Carbon Dioxide
EIA	Energy Information Administration
NGV	Natural Gas Vehicles
MoPNG	Ministry of Petroleum and Natural Gas
MoST	Ministry of Surface Transport

BS	Bharat Stage
NCR	National Capital Region
ARIMA	AutoRegressive Integrated Moving Average
GDP	Gross Domestic Product
SEP	Sustainable Energy Planning
SSA	Singular spectrum analysis
GIS	Geographical Information Systems
AHP	Analytic Hierarchy Process
BOT	Build Operate Transfer
RM	Risk Management
JRM	Joint Risk Management
IT	Information Technology
CCEA	Cabinet Committee on Economic Affairs
RBI	Reserve Bank of India
ECM	Error Correction Model
OLS	Ordinary Least Square
GT	Grounded Theory
SAP	Situation Actor Process
LAP	Learning Action Performance
AIC	Akaike Information Criteria
HP	Hodrick-Prescott
KMO	Kaiser-Meyer Olkin
CRM	Customer Relationship Management
OEM	Original Equipment Manufacturers
HSE	Health, Safety and Environment
RO	Retail Outlets

JV	Joint Venture
ISO	International Organization for Standardization
NGO	Non-Governmental Organization
PPAC	Petroleum Planning and Analysis Cell

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CHAPTER 1

Introduction

1. India energy scenario

India accounts for 18 per cent of the world's population; however, it consumes only 5.5 per cent of the global primary energy. Its per capita consumption is around 33 per cent of the worldwide average (Atul Rawat, 2019). The country energy use has doubled since 2000, with 80 per cent of demand still met by fossil fuels and solid biomass. India is likely to witness a significant increase in energy demand by 2040 on account of expanding economy, swelling population, rapid urbanisation and industrialisation (Agency, 2021). Under its stated policies, the country's carbon emissions are likely to double to 4.8 Gigatonnes (Gt) in 2050 from 2.3 Gt in 2018, in which coal will account for 3.3 Gt of the total carbon emission (A, 2019). India has endorsed the Paris Climate Agreement and set a target of improving emission intensity by 33-35 per cent from 2005 to 2030. The current Indian Government provides secure, cheap and clean energy to meet its emissions commitment and control energy import dependence. In such a scenario, natural gas is likely to play a significant part in the country's energy mix in future.

1.1. Natural gas in India

In the present situation, countries are confronting a challenge to improve the environmental quality amid surging energy consumption; natural gas is considered the ideal fuel for this century. With a large population and progressive macroeconomic environment, India guarantees energy security and sustainable development vital significance. Currently, natural gas accounts for 6.3 per cent of India's primary energy supply in comparison to the world average of 24.2 per cent in 2019. In 2010, natural gas's contribution to the total energy mix was roughly 10.6 per cent. However, due to a drop in domestic gas output and a rise in imported Liquefied Natural Gas (LNG) prices, its market share has declined since 2015. Driven by the surge in the natural gas sales from the City Gas Distribution (CGD) sector, natural gas consumption increased to 50 Billion Cubic Meters (BCM) in 2016 following five years of continuous decline. (Atul Rawat, 2019).

The country consumed around 59.7 BCM and produced 26.9 BCM of natural gas in 2019, as presented in Figure 1.1. The country's reliance on LNG imports is growing as the natural gas demand-supply imbalance widens. The country is the world's fourth-largest LNG importer, with 32.9 BCM imported in 2019.

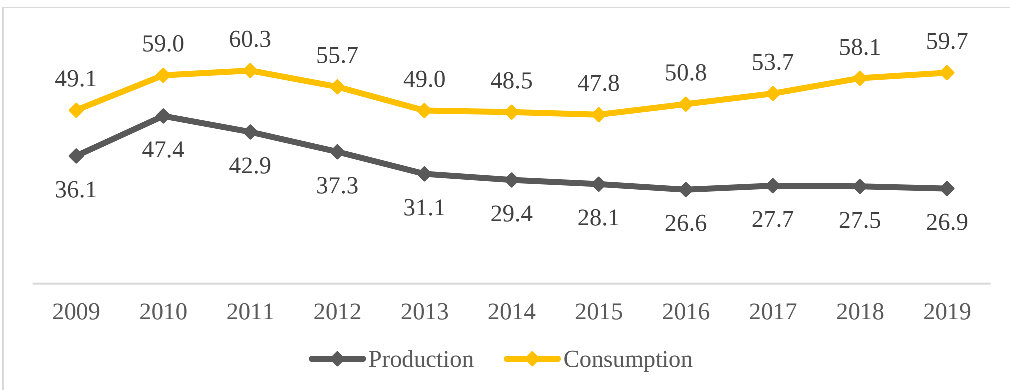


Figure 1.1: Natural gas demand-supply scenario

The country's natural gas demand has been affected by price affordability, declining domestic gas supply, inadequate infrastructure and high dependence on imported LNG. India has 44 cubic meters per capita gas consumption, considerably lower than the world average of 512 cubic meters per capita gas consumption. The primary natural gas consumer sector in India are fertiliser (28 per cent), power (23 per cent) and city gas distribution (16 per cent), together accounting for 77 per cent of natural gas consumption.

1.1.1. Future natural gas demand landscape

The country aims to reduce crude oil imports by 10 per cent by 2022 and increase the natural gas share to 15 per cent by 2030. Like compressed natural gas (CNG) and piped natural gas (PNG), natural gas is an easy alternative for petrol and diesel, establishing it as India's preferred fuel. CNG is a desirable fuel since it emits fewer pollutants, has a low cost and has a high calorific value. It reduces carbon monoxide (CO), hydrogen, and carbon dioxide (CO2) emissions by 90 per cent, 60 per cent, and 10 per cent compared to petrol and diesel. (Vaid, 2014). The Indian Government has introduced multiple policies to augment domestic production, boost its demand from different consuming sectors and achieve the commitment made under Paris Climate Summit. The initiatives introduced by the Government are:

- Hydrocarbon Exploration Licensing Policy (HELP) to improve domestic gas output in the country.
- Open Acreage Licensing Policy (OALP) bidding rounds.
- Providing marketing and pricing liberty for natural gas
- Development of National Gas Grid
- PNG and CNG would be given priority for domestic gas allocation across the country.

In India, the natural gas demand will result from the interaction of various drivers and government policy initiatives. The factors likely to play a critical role are pricing and marketing freedom, supply infrastructure development, sustainable development, emission reduction commitments made under the Paris Climate Summit, and development of end-user markets. Some of the initiatives are presented in Table 1.1.

Table 1.1: Natural gas demand drivers of India

S.No.	Drivers	Impact on gas demand
1	Gas pricing reforms	Boost natural gas exploration activities and monetization of gas reserves
2	Implementation of revenue sharing contract & OALP	Improve transparency, reduce administrative discretion and attract investment
3	Make in India to boost manufacturing contribution in GDP	The rapid rise in energy demand; more base and peak power demand
4	Improving agricultural output to meeting growing population demand for food	Boosting domestic fertilizer production
5	Growing urbanization will lead to the development of tier 2 and tier 3 city	Demand for affordable and reliable supply to support CGD expansion
6	Concept of the green corridor to become reality (pan-India CNG network)	Commercial vehicle switching over to CNG/L-CNG/LNG
7	Sustainable development to reduce carbon emissions and meet the commitment made in the Paris summit	The inherent quality of natural gas over other fossil fuels

However, it is imperative to develop a national gas distribution infrastructure to ensure a consistent natural gas supply across India. Specifically, the expansion of the CGD segment is reliant on the natural gas grid completion. CGD network expansion will increase natural gas accessibility to industrial, household, and commercial customers in the region. The CGD category, which is gradually but steadily growing at an annual rate of 8 per cent, will play a significant part in India's economic development.

1.1.2. Infrastructure imbalance restricts CGD growth in eastern India

As per the Vision 2030 report, India's natural gas market comprises six regions: northern, western, central, southern, eastern, and northeastern. The western and northern areas are responsible for the significant natural gas consumption due to a more robust pipeline network.

The pipeline infrastructure is instrumental in connecting various gas sources to the gas demand centre. These demand centres address the natural gas demand originating from the bulk users such as powers, fertiliser, CGD, etc. The emergence of the new demand centre is dependent on the availability of natural gas. The gas pipeline infrastructure has led to industrialisation and brought socio-economic changes in the related areas. India's natural gas pipeline density (0.0049 km/km2) is the lowest globally for significant countries. The natural gas pipeline grid is dense in areas with high gas accessibility and consumption, while LNG imports are possible to places where gas is not accessible.

The lack of interconnectivity of national and regional pipelines limits access to the consumer base, limiting the expansion and growth of natural gas markets in different areas. Additionally, natural gas infrastructure projects are exposed to high market risks. The other challenge impacting the development of the gas pipeline network is the under-utilisation of pipeline capacity due to the limited natural gas supply. The average pipeline capacity utilisation in India is 48 per cent, with utilisation varying between 8 per cent & 91 per cent, resulting in sub-optimisation of cost.

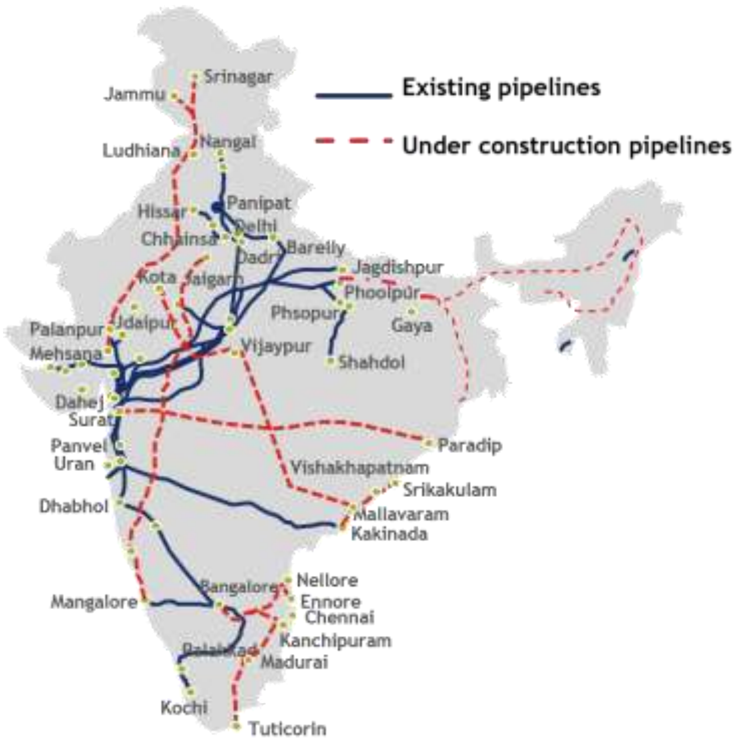


Figure 1.2: Natural gas pipeline network in India, IEX

As per the infrastructure map, natural gas pipelines density varies heavily in India, with western, northern, southern, and central regions accounting for 40 per cent, 20 per cent, 16 per cent and 13 per cent, respectively. As a result, western and northern India are home to the majority of the consumption centres.

India has around 16,994 kilometres (Km) of pipelines network for natural gas operating as of March 31, 2020. However, the eastern region of India lacks well developed natural gas pipeline network. The country is constructing around 13,775 Km of natural gas pipelines to strengthen the existing network and developing a pan-India network. Jagdishpur–Guwahati (3,546 Km) pipeline with a planned throughput of 23 Million Standard Cubic Meters per Day (MMSCMD) and Mallavaram – Vijaipur (2,042 Km) with a capacity of 72.25 Km would link the West with the East. North-East Natural Gas Pipeline Grid (1,656 Km) will provide pipeline connectivity to India's North-Eastern states, with a designed capacity of

19.2 MMSCMD. The under-construction pipeline to ensure gas supply in the eastern part are Kakinada-Vijaywada- Nellore (667 Km, 22.5 MMSCSMD), Kanai Chhata – Shriampur (317 Km, 19.2 MMSCMD), Srikakulam – Angul (690 Km, 6.65 MMSCMD) and Kakinada – Vishakhapatnam – Srikakulam (391 Km, 90 MMSCMD) pipeline (PNGRB, Natural Gas Pipelines Network in India, 2020).

In comparison to most other modes of energy transmission, gas pipeline transportation is a safe, cost-effective, and environmentally sound alternative. As a result, clients in India's eastern coastal region are likely to be denied access to natural gas until then. On the other hand, the Government and regulators are constantly pushing to create a national natural gas grid. Within a decade, the National Gas Grid will become operational and satisfy the clients' needs facing gas supply constraints in various country sections.

According to the PricewaterhouseCoopers' report on the Indian gas market, the eastern region of India is almost devoid of gas pipeline connectivity and has a low pipeline network density. More than 90 per cent of stakeholders feel that building infrastructure should come first, followed by creating demand for gas, i.e. carrier first, commodity second. The report also highlighted the importance of developing CGD networks to boost the natural gas demand and established it as the preferred transportation fuel. However, the report found that CGD networks have only limited vehicles conversion to gas from liquids because of observed gas price volatility, lack of CGD corridors, and inconvenient access at retail stations.

Table 1.2: Operational natural gas pipelines in India

Pipeline	Entity	Length (Km)	Design Capacity (MMSCMD)	States Covered
Assam Regional Network	GAIL	7.8	2.5	Assam
Cauvery Basin Network	GAIL	240.3	4.3	Puducherry, Tamil Nadu
Hazira-Vijaipur-Jagdishpur - GREP (Gas Rehabilitation and Expansion Project)-Dahej Vijaipur HVJ/VDPL	GAIL	4,222	57.3	Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat
Kakinada-Hyderabad-UranAhmedabad (East West Pipeline)	PIL	1,460	95	Andhra Pradesh, Gujarat, Maharashtra, Telangana
Dahej-Uran-Panvel-Dhabhol	GAIL	815	19.9	Gujarat, Maharastra
KG Basin Network	GAIL	877.9	16	Andhra Pradesh, Puducherry
Gujarat Regional Network	GAIL	608.8	8.3	Gujarat
Agartala Regional Network	GAIL	55.4	2	Tripura
Dadri-Panipat	GAIL	132	20	Haryana, Punjab, Uttar Pradesh
Dahej-Vijaipur (DVPL)-VijaipurDadri (GREP) Upgradation DVPL 2 & VDPL	GAIL	1,280	54	Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh
Mumbai Regional Network	GAIL	128.7	7	Maharastra
Uran-Trombay	ONGC	24	6	Maharastra
High Pressure Gujarat Gas Grid	GSPL	2,207	31	Gujarat
Hazira-Ankleshwar (HAPi)	GGL	73.2	5.06	Gujarat
Low-Pressure Gujarat Gas Grid	GSPL	57.6	12	Gujarat
Shahdol-Phulpur	RGPL	312	3.5	Madhya Pradesh, Uttar Pradesh
Assam Regional Network	AGCL	104.7	2.43	Assam
Dukli Maharajganj (EarlierAgartala)	GAIL	5.3	0.26	Agartala
Uran-Taloja	DFPCL	42	0.7	Maharastra

Source: (PNGRB, Natural Gas Pipelines Network in India, 2020)

Table 1.3: Partially commissioned natural gas pipelines

Pipeline	Entity	Length (km)	Design Capacity (MMSCMD)	States Covered
Chainsa-Jhajjar-Hissar	GAIL	455	35	Haryana, Rajasthan
Dadri-Bawana-Nangal	GAIL	886	31	Punjab, Haryana, Uttar Pradesh, Uttarakhand, Delhi
Kochi-Koottanad-BangaloreMangalore	GAIL	1,104	16	Kerela, Tamil Nadu, Karnataka, Puducherry
Mehsana – Bhatinda	GIGL	2,052	77.1	Gujarat, Rajasthan, Haryana, Punjab
Bhatinda - Jammu – Srinagar	GIGL	725	42.4	Punjab, Jammu & Kashmir
Mallavaram - Bhopal - Bhilwara – Vijaipur	GITL	2,042	76.25	Andhra Pradesh, Telangana, Madhya
Dabhol-Bangalore	GAIL	1414	16	Maharastra, Karnataka, Goa
Ennore-Tuticorin	IOCL	1421	84.7	Tamil Nadu, Karnataka, Puducherry
Jagdishpur-Haldia-Bokaro Dhamra-Paradip- BarauniGuwahati	GAIL	3546	23	Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Assam

Source: (PNGRB, Natural Gas Pipelines Network in India, 2020)

Table 1.4: Under-construction natural gas pipelines

Pipeline	Name of Entity	Length (km)	Design Capacity (MMSCMD)	States Covered
Kakinada - Vishakhapatnam - Srikakulam	APGDC	391	90	Andhra Pradesh
Jaigarh- Mangalore	HEPL	749	17	Maharastra, Goa, Karnataka
Kakinada-Vijayawada-Nellore	IMC	667	22.5	Andhra Pradesh
North-East Natural Gas Pipeline Grid (Provisional Authorization)	IGGL	1,656	9	Assam, Mizoram, Manipur, Arunachal Pradesh, Tripura, Nagaland, Meghalaya & Sikkim
Kanai Chhata – Shrirampur	Consortium of H-Energy	317	19.2	West Bengal
Srikakulam-Angul	GAIL	690	6.65	Andhra Pradesh, Odisha

Source: (PNGRB, Natural Gas Pipelines Network in India, 2020)

1.2. CGD development in India

Although India's natural gas distribution sector is still developing, the country's CGD footprints are pretty ancient. Natural gas distribution began in 1857 with the Calcutta Gas Company and the Bombay Gas Company under the Jt. stock Co-Act 1857. Coal gas was the principal source of supply. Following that, the industry remained quiet until the 1980s, when Assam Gas and Oil and Natural Gas Corporation (ONGC) joined the business. The sector received the must require thrust after the formation of Gujarat Gas Company Limited (GGCL) and the provision of the Indian Government to provide natural gas supply allocation to the company. The Indian Supreme court ordered the Gas Authority of India Limited (GAIL) to build a CGD in Delhi, Mumbai, and Baroda in the early 1990s. CNG distribution network started in the three cities in 1993, under the ruling. GAIL formed a partnership with British Gas (BG) and the Government of Maharastra in 1995 to bring CGD to Mumbai. Mahanagar Gas Limited (MGL) was the name of the registered corporation. In 1998, GAIL formed a partnership with Bharat Petroleum Corporation Limited (BPCL) in Delhi to form Indraprastha Gas Limited (IGL). Together with improved natural gas supplies, the success of these enterprises gave the Indian CGD industry a much-needed boost, attracting several new players. Figure 1.3 shows a timeline of natural gas activities in India.

India's CGD network currently covers 90 Geographic Areas (GAs) run by 36 entities, serving over 4.3 million PNG customers and 3.1 million CNG vehicles. Gujarat Gas Limited (GGL), IGL, MGL, Adani Gas Limited (AGL), and Central Uttar Pradesh Gas Limited (CUGL) collectively account for roughly 87.6 per cent of the total customer base and around 82 per cent of the CGD network.

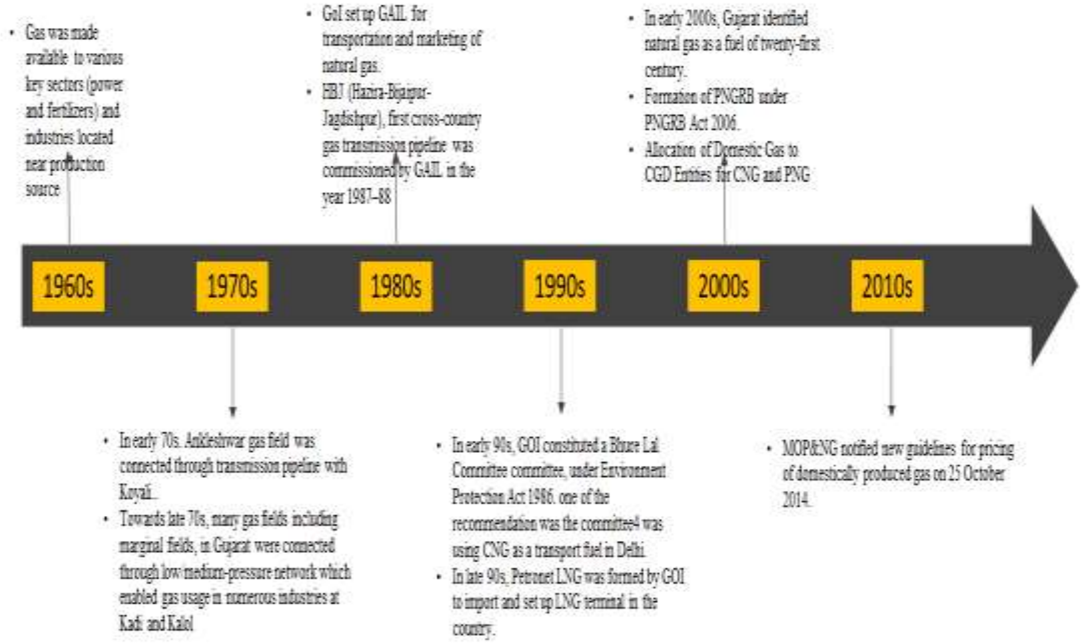


Figure 1.3: Natural gas industry growth path

In response to the CGD industry's growth, the Indian Government established the Petroleum and Natural Gas Regulatory Board (PNGRB) to regulate the CGD industry. It was formed under the PNGRB Act, 2006 and came into effect on October 1, 2007. This Act establishes a legal framework for the natural gas pipeline network expansions and city gas transmission systems; following the establishment of PNGRB, several CGD licencing rounds were conducted for CGD network expansion in India.

1.2.1. City Gas Distribution in India

The CGD network is the final link in the value chain of natural gas. It comprises a pipeline network that runs over the topography of the chosen area, serving small industrial, commercial, and residential customers. The quantity of gas supply is the primary distinction between industry distribution and industries that are within the jurisdiction of CGD. The CGD player can supply gas to the industrial customer at a rate of up to 50,000 standard cubic metres per day (SCMD), though this may be higher in some cases. In recent years, the CGD market has made sporadic progress. Despite network expansion and a faster rate of issuing new licences, the response has been lukewarm due to various modifications in the bidding requirements.

The CGD industry gas consumption has grown from less than 8.6 per cent in FY12 to about 15.1 per cent in FY19 (Division, 2020). The total length of operational natural gas pipelines is 16,994 Km, and the pipeline length under construction is 13,775 Km (PNGRB, 2020). The total sales during FY19 were 25.2 MMSMD. CNG stations expanded by 18.4 per cent year on year to 1,730 in FY19 from 531 in FY12, owing to the country's CGD expansion. Gujarat has the most CNG stations, with 548 Delhi (482) and Maharastra (400). (313 stations). Delhi leads the way in terms of CNG automobiles, with 1,065,603 vehicles, followed by Gujarat (925,286) and Maharastra (922,439) (Division, 2020). In FY19, these three companies accounted for about 77.6 per cent and 87 per cent of the total CNG stations and CNG customers, respectively. Appendix B shows the details of the CGD licences that were awarded.

1.2.2. Market Development

CGD generally grows with the assistance of four key variables: Gas supply, infrastructure, policies, and financial drivers. The business enjoys a natural benefit in building the market through supplanting existing fuels in residential, industrial, commercial, and transportation. Nonetheless, this will rely upon the overall price of gas as for contending fuels.

Reacting to this market challenge would require finding and interfacing new supplies in traditional and remote regions. Developing infrastructure would require significant capital expenditure. Timing these investments to coordinate with the market necessities impeccably would be difficult for the Indian industry. The capacity of the market to develop in such ideal stages would decide the wellbeing of the gas industry in India. The Indian gas industry needs to develop the market on similar lines as different countries to address the supply difficulties.

Integration of the gas markets has turned into a need because gas has arisen as a significant alternative energy source. Possible market integration will outfit the market to adjust risks and manage competition across regions and fuels. It would prompt adaptability in fuel consumption design, which would encourage market security and advance sustainable development.

With developing demand and expanded supply alternatives, CGD networks have started extensive interest among potential players. In any case, to tap this chance, the developers need to take a gander at the critical parts of the projects, including demand development, sufficient supply, pricing and risks factors such as regulatory impedance/assistance.

The development of the natural gas distribution segment is likewise dependent upon pricing developments by the Government of India. The current arrangement of the price of gas delivered by the PSUs at the administered price well underneath the predominant worldwide and domestic market prices for the power and fertiliser areas goes about as a disincentive for expanding domestic exploration and gas imports. The central downstream gas regulatory systems and formation of sufficient transmission infrastructure are different provokes that should be tended to for market development.

The Central and State government must reduce the taxes on commercial energy deliveries to yield ideal fuel and investment decisions. Relative prices of energy fuels might be artificial if taxes, tolls, surcharges, and subsidies are not similar across fuels. According to global practices, the fuels are compared on the calorific value, such as British Thermal Unit (BTU). All in all, they ought to be with the end goal that producer and purchaser decisions regarding fuel and machine utilisation are free of taxes, tolls, subsidies, etc.

The rapid development of the CGD network and following market development offers multiple advantages for the stakeholders concerned, particularly the customers. Earlier, the natural gas produced from the wells were flared because either its utilisation had not been acknowledged by the industry/clients or the industry was not prepared with the supply, handling, and transmission and distribution infrastructure. Market development endeavours guarantee that both angles are handled simultaneously.

The advantages of natural gas market development for stakeholders are provided in Table 1.5.

Table 1.5: Advantages for stakeholders

Stakeholder	Advantages
Industrial	Uninterrupted supply, inventory cost optimisation, improved operational efficiency, expanded mode of natural gas utilisation
Residential and Commercial	Home delivery, economical, access to clean fuel
Transportation	Emission reduction, low fuel cost, safe
Government	Fuel diversification, emission targets, import bill reduction, subsidy reduction
General pubic	Access to clean fuel, reduction in carbon emissions
Industry	Incentives for upstream companies due to assured consumption, pipeline infrastructure development, bulk sales, sales realisation

1.2.3. Trends and key developments

PNGRB, the downstream regulator, has given licences for the natural gas distribution networks development in 229 GAs across India through ten CGD bidding rounds. The GAs cover around 71 per cent of the Indian population and 53 per cent of the country area. The remaining areas will be covered for CGD network development in the subsequent bidding rounds. However, their inclusion is subjected to techno-commercial analysis, pipeline network connectivity and natural gas supply.

Infrastructure development: Post 9^{th} and 10^{th} bidding CGD round, the PNG connections and CNG stations are expected to reach 40 million and 10,000, respectively. The infrastructure expansion will attract an investment of INR 900 billion, out of which projects worth INR390 have achieved financial closure (Infrastructure, 2020).

- **Policy and regulatory development:** The Indian Government introduced a draft CGD policy in January 2020 to boost the CGD infrastructures development activities in the states. This policy proposes to use CNG/LNG as preferred fuel in public transportation and provide tax and financial incentives to spur growth. Additionally, this policy offers to set a committee to formulate conducive policies and simplify processes for clearances to develop CGD projects.
- **Upcoming bidding round:** PNGRB plans to conduct the eleventh CGD bidding round and have shared a tentative list of 44 GAs for infrastructure development. The 9^{th} and 10^{th} rounds were successful, with each GAs receiving an average of four bids, raising hope for the upcoming round (Infrastructure, 2020).
- **Improved cost economics:** PNG and CNG have price benefits over substitute fuels. PNG costs at least a rupee less than Liquefied Petroleum Gas (LPG) for domestic users for 1,000 kcal. Similarly, CNG delivered price stands at INR5.2 for 1,000 kcal compared to INR7.24 for Diesel in Delhi. Moreover, high taxes imposed on petrol and diesel make them costlier and natural gas more competitive.

- **LNG infrastructure expansion:** India now has six operational LNG terminals with a total capacity of 39.5 Million Tonnes per Annum (MMTPA). Nine LNG terminals are under construction and have a total capacity of 33.2 MMTPA. Furthermore, due to a global supply glut, LNG prices are expected to remain low for the next three to four years.
- **Technology innovation:** The improvement of technology is critical in establishing natural gas as a favoured fuel. CGD firms have been able to extend their CNG footprints and gas sales because of an integrated approach to wielding the employment of robots in the maintenance of operational pipes, acoustic leak detection technologies, L-CNG, cashless transactions, and LNG-based engines.

1.2.4. Demand drivers for the CGD in India

Since the turn of the century, the Government in India has pushed the CGD sectors. Diversification of the energy mix increased awareness of clean energy, domestic gas's priority sector position, low price compared to replacement fuels, and new commercial prospects in the natural gas distribution market are the main factors. The CGD demand drivers are highlighted in Figure 1.4.

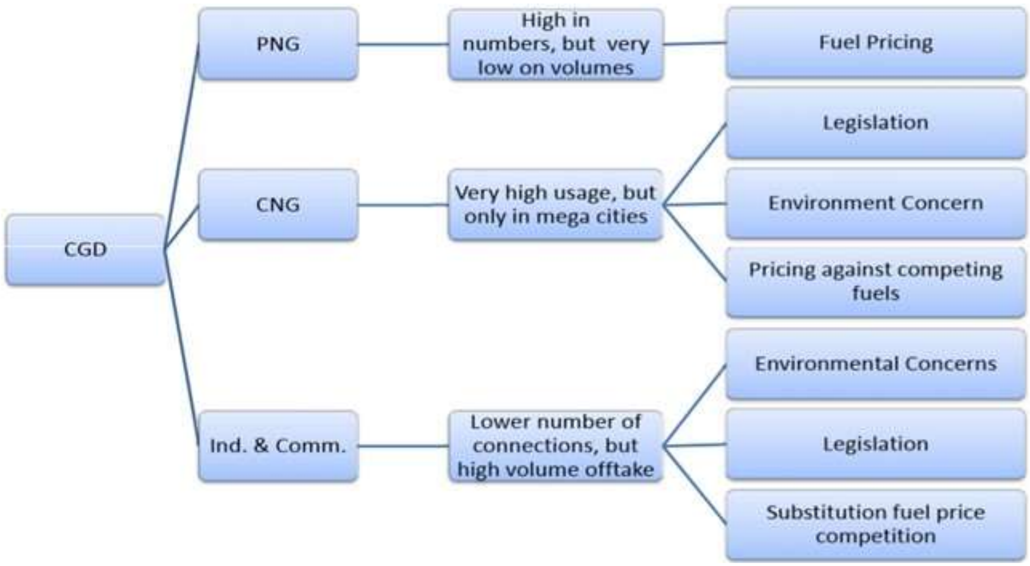


Figure 1.4: CNG Business Drivers

1.3. CNG as fuel

Natural gas is used as fuel in the domestic and commercial sectors. Natural gas is compressed to less than 1 per cent of its original volume at typical atmospheric pressure to make CNG. It's kept in gaseous form in vehicle tanks at a pressure of up to 3,600 pounds per square inch. It is economical and environmentally friendly than conventional auto fuels. It has less carbon than traditional hydrocarbon fuels, thus emitting considerably less CO2 as a vehicle fuel. It emits between 25 to 30 per cent less CO2 in traveller cars and light commercial vehicles and around 10 to 20 per cent less in trucks and transports.

Table 1.6: Physical properties comparison of available fuel

Properties	Unit	Petrol	Diesel	LPG	CNG
Relative Density	Water=1	0.74	0.84	0.55	-
Auto Ignition Temperature	°C	360	280	374	540
Flammability Range	% in Air	8-Jan	0.6-5.5	2.2-9.0	15-May
Flame Temperature	°C	2030	1780	1983	1900
Octane/Cetane No.	-	87	50	93	127

Source: (EIA, Natural gas explained, 2020)

Table 1.7: Emission comparison of fuel

Fuel/Emissions	CO2	UHC	CO	NOx	SOx	PM
Petrol	22,000	85	634	78	8.3	1.1
Diesel	21,000	21	106	108	21	12.5
CNG	16,275	5.6	22.2	25.8	0.15	0.29
LPG	18,200	18	168	37	0.38	0.29

Source: (EIA, Carbon Dioxide Emissions Coefficients, 2016)

1.3.1. CNG economics

Cost advantage over petrol and diesel has been the primary driver behind CNG vehicle growth, as shown in Figure 1.5. The pay period for CNG vehicles ranges from 1.5-5 years based on the usage of vehicles.

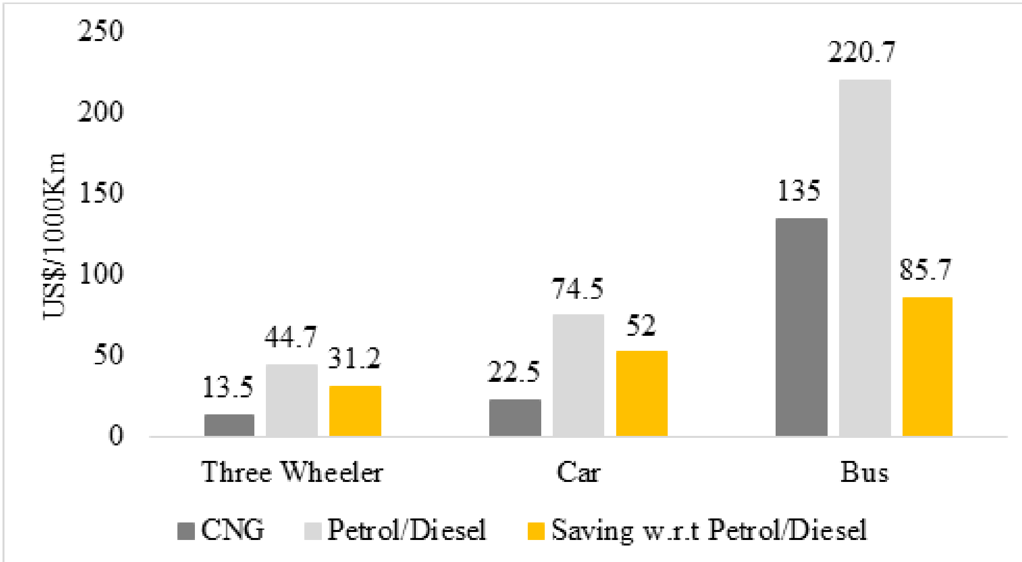


Figure 1.5: Fuel cost comparison in US$/1000, FICCI

The mileage assumption used for calculation are:

	Petrol/Diesel	**CNG**
Bus	3.5 Km/Liter	3.5Km/Kg
Car	15 Km/Liter	21 Km/Kg
Three-wheeler	25 Km/Liter	35 Km/Kg

1.3.2. World natural gas vehicles market

Globally, the acceptance of natural gas vehicles (NGV) is increasing with each passing year. According to NGV Global estimates, around 26 million NGVs are operating globally, with the Asia Pacific accounting for the two-third contribution. The top 6 countries account for 80 per cent of the total NGVs population, with China, Iran and India contributing around 50 per cent (Fevre, 2019).

Table 1.8: Natural gas vehicles by country

Country	Number of NGVs	NGV share in total Vehicle Population	NGV share in total NGV population
China	6,080,000	3.7	23.2
Iran	4,502,000	31.9	17.2
India	3,090,139	1.5	11.8
Pakistan	3,000,000	14.0	11.5
Argentina	2,185,000	9.5	8.4
Brazil	1,859,300	2.3	7.1
Italy	1,004,982	2.0	3.8
Uzbekistan	815,000	40.8	3.1
Colombia	571,668	4.7	2.2
Thailand	474,486	1.5	1.8
Total	23,582,575	NA	90.1
ROW	2,580,989	-	9.9
World Total	26,163,564	1.5	100

Source: (Global N. , 2019)

1.3.3. History of CNG

The usage of methane for vehicles dates back to the early 1930s in Italy, when CNG was first introduced. CNG was given a significant boost in the 1970s when natural gas was seen as a viable fuel to replace oil during the oil crisis. CNG vehicles became appealing because of oil price shocks in the late 1970s and early 1980s, which established CNG as an economical and reliable fuel. However, CNG's growth as a vehicle fuel has been challenging since then, up until the year 2000. In any case, after the 2000s, oil prices began to rise steadily, and CNG vehicles were allowed to establish themselves as a cost-effective and environmentally friendly fuel. NGVs have entered and exited the transportation markets of several countries since then, owing to technology advancements at various times.

1.3.4. CNG in India

India's pilot programmes began only in 1992 compare to Italy in the 1920s and New Zealand in the early 1980s. In 1992, GAIL collaborated with the Indian Institute of Petroleum (IIP), Dehradun, to launch a pilot project in three cities (Delhi, Mumbai, and Baroda) to address growing environmental and poor concerns air quality. Gujarat Gas developed a trial CNG project in Surat at the same time. The primary goals of the pilot projects were to determine the sustainability of CNG initiatives, assess the impact on air quality, and address technical and safety concerns. Table 1.9 lists the CNG stations that were built as part of pilot programmes.

Table 1.9: CNG stations in pilot projects

Station Type	Delhi	Mumbai	Baroda	Surat
Mother	1	1	1	1
On-line	3	-	-	-
Daughter	5	3	1	2
Total	9	4	2	3

Source: (Gumber, 2008).

The stations' structure and safety standards are derived from New Zealand regulations. Buses were also subjected to double fuel conversions. Around 1400 cars were converted to CNG in Delhi during the pilot phase, then 1500 and 100 vehicles were converted to CNG in Mumbai and Baroda, respectively (Gumber, 2008).

However, till 1998, the Government did not achieve the desired outcomes due to a low number of vehicle conversions and inadequate CNG infrastructure. Due to the limited transition, the Indian Government was ordered by the courts to push CNG as the preferred fuel for transportation in Delhi to alleviate air pollution issues. In 1995 and 1998, Gail launched joint ventures to construct CNG infrastructure in metro cities, forming MGL and IGL for Mumbai and Delhi. Currently, both GAs have well developed CNG infrastructure, with Mumbai having 256 CNG stations and 0.75 million vehicles and Delhi having 555 CNG stations and 1.1 million vehicles as of 31 March 2020 (IGL, 2020) (MGL, 2020).

1.3.4.1. Government policies

- **Gas use policy:** The policy ensures natural gas allocation to different dependent sectors based on domestic gas production. According to government criteria, domestic gas is first allocated to the city gas distribution sector for residential and transportation consumption. (MoPNG, 2019). Following that, gas is assigned to the fertiliser, electricity, and other sectors.
- **CNG/CGD regulations:** Indian Government established PNGRB by a notification dated March 31 2006, to oversees the petroleum midstream, downstream and natural gas distribution segment while also safeguarding the interests of consumers and businesses. It also ensures a continuous and ample supply of petroleum products and natural gas across India; It is also responsible for encouraging competition in the market and addressing concerns related to or incidental to these activities (PNGRB, 2020). PNGRB awarded 229 licences for CGD network development after ten rounds of bidding.
- **Auto fuel policy:** Vehicular emissions norms were first introduced in 1991 in India. They were further strengthened in 1996 by requiring vehicle manufacturing to upgrade technology to reduce or remove harmful emissions such as Lead and Sulphur. The Ministry of Environment and Forests published fuel requirements based on environmental standards to be met by 2000 in 1996. These guidelines were integrated into the Bureau of Indian Standards (BIS 2000) guidelines. (ICCT, 2016).

  The Ministry of Surface Transport (MoST) introduced Bharat Stage (BS) – I (BIS 2000) and BS-II vehicle emissions standards for all of India and the

National Capital Region (NCR) in April 1999, in response to Supreme Court recommendations.

In August 2002, India announced its first Auto Fuel Policy and presented the emission and fuel roadmap up to 2010. Under the Auto Fuel Policy of 2003, India introduced BS-III standards in 13 cities and BS-II standards across the country beginning in April 2005.

In April 2010, the BS-IV standard was introduced in 13 metro cities, including all metros cities (Delhi/NCR, Mumbai, Kolkata, and Chennai) and significant industrial cities (Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Agra, Lucknow and Sholapur). The remainder of India switched to the BS-III standard in September 2010. Later, the BS-IV norms were extended to additional 20 cities in October 2014 and enforced for the entire country in April 2017. Driven by deteriorating air levels in the NCR region, the Indian Government decided to leapfrog BS – V norms subjected to implementation in 2020 and preponed the introduction of BS-VI criteria in 2020 from 2024. The new norms have been introduced for the new vehicles from April 2020 and the operational vehicles from April 2021 (UITP, 2020).

The Indian Government is promoting CNG and LPG in the cities with high vehicle pollution levels by providing a fuel choice and technological combination to vehicle owners to achieve stringent emission targets. The mass emission norms for CNG and LPG vehicles are the same as applicable to gasoline vehicles.

Table 1.10: Fuel Specification under BS-VI

Fuel type	Parameter	Units	BS-VI specification
Regular Grade Gasoline	Minimum Research Octane Number (RON)	-	91
	Minimum Motor Octane Number (MON)	-	81
	Maximum Olefin Content	% volume	21
	Maximum Oxygen Content	% mass	2.7
Diesel	Maximum 95% Distillation Boiling Point	°C	370
	Density @ 15 °C	Kg/m3	820-860
	Maximum Polycyclic Aromatic Hydrocarbon (PAH) Content	% mass	11

1.3.4.2. Types of CNG stations

There are three types of stations used to dispense CNG in India.

- **Mother – Online Station:** They are used to fill large volumes of CNG into mobile CNG trailers. It helps in transporting gas to CNG stations that do not have pipeline connectivity. Typically, a CNG online station consists of a CNG compressor, CNG dispenser and storage cascade (Gumber, 2008).
- **Daughter Booster Station:** These stations are not connected to pipelines, and CNG is filled with automobiles based on the principle of pressure equilibrium. If pressure drops below 200 bar, the vehicle starts getting less gas, increasing the filling time. It may leave the customer dissatisfied. Companies install booster compressors between the mobile storage and the CNG dispenser to overcome these issues at all the daughter stations. It delivers CNG to the customer at 200 bar (Utilities, 2017).

1.3.4.3. CNG infrastructure in India

India had a total automobiles population of 216.01 million vehicles, of which 1.5 per cent were CNG based in 2018. Currently, 19 states in India have an infrastructure with 1730 retail stations. The details of CNG activities in India are provided in Table 1.11.

Table 1.11: State-wise CNG stations and NGVs

State	Company name	CNG stations	CNG vehicles
Andhra Pradesh	Bhagyanagar Gas Ltd, Godavari Gas Pvt.Ltd., Megha Engineering & Infrastructures Ltd.	44	19,794
Bihar	GAIL (India) Ltd.	2	0
Chandigarh	Indian Oil-Adani Gas Pvt. Ltd.	5	7,500
Daman and Diu	Indian Oil-Adani Gas Pvt. Ltd.	3	1,000
Delhi/NCR	Indraprastha Gas Ltd .	482	1,065,603
Gujarat & Dadra Nagar Haveli	Sabarmati Gas Ltd, Gujarat Gas Ltd, Adani Gas Ltd, Vadodara Gas Ltd, Hindustan Petroleum Corporation Ltd, Charotar Gas Sahakari Mandal Ltd, IRM Energy Ltd.	548	925,286
Haryana	Haryana City Gas Distribution Ltd, Adani Gas Limited, GAIL Gas Ltd.,	66	159,783
Karnataka	Gail Gas Ltd., Megha Engineering & Infrastructures Ltd.	13	1,093
Kerala	Indian Oil-Adani Gas Pvt. Ltd.	4	900
Madhya Pradesh	Aavantika Gas Ltd, GAIL Gas Ltd	43	35,996
Maharashtra	Mahanagar Gas Ltd, Maharashtra Natural Gas Ltd, Gujarat Gas Limited, Mahesh Gas Ltd, Unison Enviro Private Limited	313	922,439
Odisha	GAIL (India) Ltd.	6	2,640
Punjab	IRM Energy Pvt. Ltd., GSPL	6	2,202
Rajasthan	Rajasthan State Gas Limited	5	8,438
Telangana	Bhagyanagar Gas Ltd.	45	24,980
Tripura	Tripura Natural Gas Co. Ltd	9	11,688
Uttar Pradesh	GAIL Gas Ltd, Sanwariya Gas Ltd, Green Gas Ltd, Central U.P. Gas Ltd, Siti Energy Ltd, Adani Gas Ltd, Indian Oil-Adani Gas Pvt. Ltd., Torrent Gas Pvt Ltd., GAIL (India) Ltd.	128	154,091
Uttarakhand	Indian Oil-Adani Gas Pvt. Ltd.	1	100
West Bengal	Great Eastern Energy Corporation Ltd.	7	3,756
All India		1,730	3,347,289

Source: (PPAC, 2019)

Delhi, Gujarat and Maharashtra together account for 78 per cent of CNG stations and 87 per cent of natural gas vehicles population. The eastern coastal states of India account only for 102 CNG stations operating and 2 per cent of the total natural gas vehicles population despite government efforts to boost natural gas infrastructure in this region.

1.4. Challenges affecting business growth

India's natural gas distribution sector is still in its infancy, although it has witnessed robust growth in the last decade. All players in the CGD business, however, are confronted with numerous obstacles. Indian CGD industry has seen strong growth in the previous two decades. However, the sector is still developing, and companies need to overcome business risks to ensure timely project commencement.
The critical characteristics of CGD projects are:

- It is a long-term project – as the city extends, the project proceeds to grow, and business likewise develops.
- It's a high-risk enterprise with a long incubation period and low volume off-take.
- Lack of In India, trained talent to implement and manage CGD projects is scarce.
- To complete projects on schedule and budget, project sponsors must collaborate with different organisations such as municipalities, roadways and buildings departments, architects, contractors, regulatory clearance authorities, etc.
- Network design is unique in that it must consider safe and efficient operation, maintenance, market potential, and extension.

The market demand is to be evaluated for every four sections: modern, homegrown, business, and auto. Capital budgeting choice for industrial retro-fitting to switch the set-around for natural gas affects demand. In CNG demand in the transportation sector, the cost of conversion to substitute fuel is a crucial factor. Moreover, it is difficult to predict the domestic and commercial market demand because of continued city expansion.

Natural gas supply is among the restraints for the Indian CGD business, as the discretion to distribute government authorities makes natural gas supply. The price of indigenous natural gas varies from the cost of liquefied natural gas (LNG). As a result, the supply option influences economic viability.

To decide the selling price is subjected to regulatory guidelines and significantly impacts the projected cash flows. The CGD companies need to anticipate the expected gas supply to check the financial viability. The CGD projects also face multiple decision dilemmas, including design, procurement, commissioning, and construction. In the designing phase, the CGD company needs to address system redundancy, supply loading, etc. Additionally, it is critical to examine the training, monitor, audit, and inspect the process and procedures to ensure safe CGD pipeline network construction. The whole process involves contracting, performance monitoring, and management practices. Companies must manage the highest standard of health and safety during operations.

Since most of the CGD work is technical, the railways, forest department, and district administration must approve the project on time. As a result, there are significant gaps between the clients' expectations and project implementation. CGD will not be viable unless there are safeguards in place to assure project completion. The Government must consider the unique treatment of post-tax returns in the early years of CGD implementation. The project's cost and gestation duration are both relatively high. When the financial and technological concerns are considered together, it is evident that the CGD project will take time to become financially feasible (Sircar A, 2017) (Vaid, 2014).

The summary of the challenges faced by the CGD industry in India are:

- Natural gas pricing: This aids in correcting market distortions, encourages efficient utilisation, and provides an incentive to new entrants by assuring them of acceptable returns.
- Market entry barriers: This is critical for private firms in the distribution and retail industries to achieve actual market competition. Some fundamental requirements, such as the requirement of a JV with an organisation with prior expertise in the CGD business, must be reconsidered to attract new yet credible, technically and financially stable companies.
- Large capital requirements: Development of CGD network to supply 1.5 MMSCMD volume costs between INR 250 and 300 crore. Gas sales volumes build slowly, and a 50-60% comfortable level of client penetration takes around 9-10 years. A long gestation period may harm the CGD company's financial performance combined with a low volume offtake.
- Regulatory delay: Absence of single-window clearances and lack of coordination among the various governmental bodies
- Construction issues: The work of city gas companies is complicated by dense urban locations and the need to interact with several agencies and involve multiple contractors.
- Safety compliances: Natural gas is expected to be used by a large number of people. Thus 24-hour safety management is required. Also, failure in managing appropriate pressure for ensuring a safe supply of CNG and PNG could be detrimental for the end-consumers and the surroundings.
- External factors: Crude price volatility, currency exchange rate, and regulatory requirements can substantially impact the CGD entity's overall profits.

Besides that, there are specific challenges that restrict the development of CNG infrastructure in India. The country needs a well-integrated plan to achieve large-scale conversion to CNG and establish CNG as preferred fuel by developing a pan-

India CNG network. The significant challenges faced in CNG implementation are following:

- Lack of government policies: Project failure and disaster might result from a lack of interaction and collaboration with the Government when executing the CNG programme. Moreover, the absence of supporting policies for establishing CNG as preferred fuel may force consumers to opt for substitute fuel such as licensing for CNG retailing, market-based gas pricing, imposition of a carbon tax, tax exemption on import of machinery and CNG kits (Vaid, 2014) (Uddin, Iqbal, Khan, & Sakib, 2017) (Sircar A, 2017).
- Inadequate gas supply and CNG infrastructure: The availability of gas is crucial to the success of a CNG programme. There must be a sufficient and consistent supply of high-quality natural gas in regions where automobiles may easily access it. Another big concern is traffic congestion at CNG stations. With close to 200-300 vehicles arriving every hour at the stations, traffic control is significant. There are times when cars must wait over an hour for CNG to be refilled. It will be exacerbated after two-wheelers start converting to CNG. The scarcity of land is crucial spots within the planned zones has slowed the network development. Moreover, the disparity between CNG demand and CNG infrastructural development and imbalance in demand and supply are common in any region's early stage of development (Vaid, 2014) (Gumber, 2008).
- Lack of technology: The third issue is technology, namely the cost and quality of the technologies acquired and implemented. It's critical that the technology adopted is both appropriate for the environment and cost-effective. Outdated technologies, as well as innovative but untested technology, are not to be considered. The high cost and availability of technology and equipment required for CNG operations, including

conversion kits, are significant hurdles, particularly at the implementation stage. The other issue is the lack of enough competent individuals to deliver the essential services and support for the technology implemented in different project phases (Gumber, 2008) (Roychowdhury, 2010)..

- Ensuring safety: The importance of safety cannot be overstated. It is critical to address the safety of all aspects of the CNG industry, particularly CNG stations and NGVs, which have more vital involvement with the broader public. It is easier to maintain the safety standards at the retail station compared to vehicles. The lack of knowledge in vehicles owners is one of the significant issues. Another issue is the maintenance and testing of cylinders used in the CNG vehicles. These cylinders are capable of causing massive damage and injuries due to the ignorance of safety standards and the use of unauthorised CNG kits and cylinders (Gumber, 2008) (Uddin, Iqbal, Khan, & Sakib, 2017).
- Lack of awareness and training: The CGD companies find it tough to motivate people to switch over to CNG and expand their network due to a lack of information. There is a lack of awareness about the natural specifications, regulations and installations (Gumber, 2008) (Uddin, Iqbal, Khan, & Sakib, 2017).

1.5. Rationale of study

The Government has taken several steps to increase natural gas's share in the energy mix and reduce its crude oil import dependence. The Government intends to invest US$10 billion to expand gas infrastructure across India and has awarded 136 licences to grow the CGD network and develop gas corridors by promoting CNG. With the government focus on developing gas infrastructure in the Eastern India region, multiple permits were awarded to create the CGD network in the 9th and 10th CGD bidding round. As a result, there is a need for natural gas research to anticipate demand resulting from the growth of the CGD network, to identify financial and operational risks connected with the CGD network, and to provide risk-mitigation solutions to ensure that avoid project delay. This thesis is concerned with estimating natural gas demand in developed national and eastern gas corridors (West Bengal, Orissa, and Andhra Pradesh), identifying operational and financial risks associated with CGD network development, and mitigating identified risks.

1.6. Business problem

Operational and financial risks are limiting natural gas adoption in the Eastern Corridor of India.

CHAPTER 2

Literature Review

This chapter probes the current state of natural gas and CNG demand in India, drawing on previous research conducted by experts in the industry. The present literature is studied to gain a comprehensive grasp of the situation. It is critical to lay the groundwork for the existing amount of knowledge by identifying the research gaps. The research gap turns out to be the research project's beginning point.

A thoroughly performed literature review is the foundation for substantial research. The goal of the literature review is to summarise the current level of knowledge in the field. It navigates through the existing literature in the field and allows the researcher to pinpoint areas where more research can be performed. Therefore, it is imperative to conduct a focused literature review and avoid the comprehensive textbook-like approach (Rowley, 2004). The literature review is used in management research to manage the diversity of knowledge for a specific academic enquiry (David Tranfield, 2003). Not having a proper understanding of prior literature puts research at a disadvantage. As the cornerstone of research, the literature review allows the researcher to accomplish numerous critical goals, including establishing the study's context, defining the scope of the investigation, and justifying the conclusion taken.

Furthermore, a literature review summarises previous findings and examines the study methods used to attain the goals. It is beneficial if the objective is to engage in theory development (Baumeister, 1997) (Torraco, 2005). Thus, a decent literature review is a prerequisite for theoretical and methodological a refinement that leads to improved quality and usefulness of the subsequent research (Boote, 2005). There are multiple ways to conduct a literature review, including narrative or integrative reviews, systematic reviews, and meta-analyses. (Snyder, 2019).

The researcher has used a semi-systematic review approach in this study, examining how research in a specific topic has advanced over time. The literature review has supported designing research objectives, developing a research design, identifying and selecting variables, and developing a survey questionnaire. This research deals with the business problem "Operating and financial risks are limiting natural gas adoption in the Eastern Corridor of India." The researcher performed an exhaustive literature review to cull out the gap and finalise the research objectives. The procedure began with identifying patterns arising within the abstracted data of the reviewed papers, which led to the development of themes. Similar data are grouped, and a total of five sub-themes emerge, including natural gas demand-supply, green fuel adoption, CNG expansion, natural gas distribution network, and energy project risk assessment. The synthesis of literature data collected is used for two major themes: modelling for natural gas demand estimation and risk assessment of natural gas projects.

2.1. Natural gas demand estimation modelling

Energy is essential for any emerging country's long-term development, whether social, economic, or environmental. Due to sustained economic expansion, India's energy consumption has expanded rapidly during the last decade. Energy demand management is essential for effective resource allocation, making energy demand modelling and forecasting a hot topic among academics.

Demand management must consider various technical, organisational, and behavioural solutions to reduce energy consumption. Cost-effectiveness, economically viable alternatives, and ecologically responsible solutions are other factors that can influence demand. Demand management involves planning, implementing, and monitoring activities to motivate consumers, which promotes energy conservation.

On the back of technical innovations, communication improvements, and advances in manufacturing processes, demand-side management transformed in the 1990s. The focus switched from residential load control to encouraging energy efficiency for sustainable development to commercial and industrial demand management. Furthermore, it is established that energy demand gets influenced by variables including price, Gross Domestic Product (GDP), and population.

Effective energy demand management allows countries to increase operational and financial efficiency while ensuring long-term economic growth. Furthermore, energy demand management aids demand forecasting and planning, improves energy conservation, diversifies the energy mix, increases energy efficiency, develops supporting policies, and reduces carbon emissions. Furthermore, it entails creating energy models that use macroeconomic data to estimate energy demand, which aids in successful planning and policy formulation (Suganthia & Samuel, 2012).

Several novel models for energy demand forecasting have been developed over the previous decade to fulfil various aims, prove modelling philosophies, and develop new modelling approaches. Baines and Bodger, for example, constructed energy forecasting models for a country based on the current economic, social, and market variables. For energy demand analysis, (BODGER, 1984) used a market forecasting technique. These factors are frequently intertwined; for example, sophisticated modelling may necessitate a large dataset, while a shortage of data may require a simplistic model.

Many research has been undertaken to examine prevailing energy demand models for projecting energy demand in emerging countries, including India (Subhes

C.Bhattacharyyaa, 2010), (S. Jebaraja, 2006) (F. Urban, 2007). In emerging countries, four indicators often employed for demand forecasting are identified: growth rates, elasticities, specific consumption, and energy intensity. The benefits of these models are their low data requirements and simple interpretations. The model based on a single equation method frequently outperforms complex specifications and produces results with a small skill set (Subhes C.Bhattacharyyaa, 2010). Econometric methods, artificial neural network models, hybrid models, trend models, engineering economic models, system dynamics, scenario creation methods, and input-output models are standard models for anticipating energy consumption (Suganthia & Samuel, 2012).

Econometric and trend models are often identified as top-down models as they use data at the overall level. Using historical data, a trend model allows the researcher to discover a statistical relationship between energy consumption and time. In developing countries, it is the most widely used strategy for projecting energy consumption. On the other hand, econometric models link energy consumption to technology, the economy, and the environment and are well-grounded in economic theory. Furthermore, econometric models are more dependable for forecasting in the near and medium-term. Artificial neural network models are comparable to econometric models; however, they are not on economic theory. Neural networks are used in these models to determine the functional links among energy demand and its drivers.

Engineering – economy models, also recognised as end-use or bottom-up models, concentrate on a complete energy accounting employing a detailed engineering illustration of the energy system. These models use a disaggregated method to anticipate long-term energy consumption, focusing on economic, technological, and social elements and created scenarios. These models are excellent at detecting structural and technical changes (Subhes C.Bhattacharyyaa, 2010). On the other hand, end-use models are less helpful in estimating demand for emerging countries due to a lack of data. The interrelationships between various branches of a national economy or different regional economies are represented by an input-output model. It is data-intensive, making it unsuitable for underdeveloped countries.

Scenario methods and hybrid models are among the various models. The first models are the least technically advanced, and they rely on expert predictions of future performance. They are typically integrated into end-use models and require minimal data. Scenario models are still employed for long-term planning despite their lack of theoretical grounding (Shell World Energy Model, 2017). By merging the two traditions, hybrid models eliminate the methodological gaps between engineering and econometric models. These models have been routinely utilised in developing countries to anticipate energy consumption.

Among all the models for forecasting energy demand outlined above, econometric models with time-series data and pertinent demand factors are the most suitable for emerging countries. In underdeveloped countries, the lack of appropriate data limits the creation of more advanced models. Several econometric models for other energy carriers such as petroleum products, solar, wind, electricity, primary energy, or coal have been established in the past; there have been very few studies conducted on natural gas demand estimation for India. In the past, much research in emerging countries predominantly focused on residential natural gas demand. Natural gas is used in specific industries in most developing countries; hence, its energy mix is minimal. However, some exceptions exist, such as Turkey. Using the AutoRegressive Integrated Moving Average (ARIMA) model, (Erdogdu, 2010) assessed short and long-run price and income elasticities of sector-specific demand for natural gas in Turkey. Similarly, (Junchen Li, 2011) presented a natural gas outlook using a system dynamics model. Furthermore, scenario analysis is used for validating the outcomes.

2.1.1. Models of Natural Gas Demand in India

Due to constant economic expansion, India's energy demand is increasing with each passing year. Around 80 per cent and 50 per cent of India's crude oil and natural gas requirements are imported, respectively. Despite the growing natural gas usage in India's primary energy mix, the demand models used to anticipate gas demand are basic. In 1981, (Mukherjee, 1981) projected reference and optimal scenario level energy demand for India, based on 5th Working Group on Energy Policy results employed by the Government of India. Finally, the study presents an Energy-Economic Modeling framework to examine energy policy and development plans within a macroeconomic planning framework. Rao and Parikh used econometric models grounded on time series data to discuss India's demand for petroleum products capturing product-specific characteristics that influence the market (Rao RD, 1996). Reddy and Balachandra performed research in 2010 to examine the numerous elements that influence Indian energy consumption and develop the energy and environmental perspective. It was accomplished by developing an integrated mathematical model that included GDP, population growth, urbanisation, energy intensity, structural shifts, efficiency procedures, fuel swapping, commodity pricing mechanism, and environmental legislation. A Sustainable Energy Planning (SEP) scenario is created using this paradigm (Reddy BS, 2003).

(Jyoti Parikha, 2007) Created several econometric models for various petroleum products to capture factors unique to each fuel. The projections were made using two different annual GDP scenarios of 6 per cent and 8 per cent. (Jebaraj, Iniyan, & Kota, 2007) proposed forecasting models for the usage of energy resources in India based on an Artificial Neural Network. (Ujjawal Kumar, 2010) used three-time series models to forecast crude oil consumption, petroleum products, coal, power, and natural gas: Grey-Markov Model, Grey-Model with a rolling mechanism, and Singular spectrum analysis (SSA). The study demonstrates that time series models can be a feasible alternative for forecasting energy consumption.

2.2. Importance of risk identification and mitigation

Risk is described as uncertainty that arises from a variety of causes. Risk management focuses on recognising and managing significant delays and require proper actions (D., 2009). It is essential to identify and comprehend the various types of risks since this aids in formulating an appropriate risk management strategy (Crouhy, Galai, & Mark, 2006). Because of many components engaged in multiple stages, the project includes several complexities that expose the project to uncertainty and risks (Ebrahimnejad, Mousavi, & Seyrafianpour, 2010). Risk management (RM) is one of the nine primary focus areas under project management, and it is defined as "the processes concerned with conducting risk identification, analysis, responses, monitoring and controlling the process" (PMI, A Guide to the Project Management Body of Knowledge, 2004). It is an integral part of project management, according to (D. S. Kezsbom, 2001). (Turner, 1993) Proposed "risk management is a process by which the likelihood of the risk occurring or its impact on the project is reduced".

Risk identification and classification, risk analysis, and risk reduction are different stages of the RM process (Brandsater, 2002) (Duijne, Aken, & Schouten, 2008). It is regarded as a crucial tool for properly handling critical projects throughout their lifecycles (Ghosh, 2004). Risk management also provides better project and business outcomes. It also aids in better decision making during the planning and design stages by avoiding risks and maximising opportunities. Proper planning is required to reduce risk by better allocating resources to control them across processes and stakeholders (Dale F. C., 2005). The two most crucial characteristics of the RM process are risk identification and assessment. They have the most significant influence on any process (Chapman, 1998). (Redmill, 2002) Identifying the source of risk aids in the prevention of events that can go wrong and lead to hazards. The goal of risk identification is to discover risk variables and determine the significance of those risk factors. It aids in determining the aspects that may impact the project's goals and origin (Y.L.Shen, 1997). (R. C. Clark, 1990) Suggested that a recognised risk isn't risking unless it's a management issue. As a result, the risk identification process should be thorough. Any applicable data, such as historical, empirical, theoretical, expert opinion, stakeholder concerns, and so on, should be used to identify the risks (Dale F. C., 2005). (C. B. Chapman, 2003) Mentioned that risk identification is both necessary and difficult, necessitating ingenuity and a proactive approach. They support the directed-thinking process, which comprises brainstorming, individual or group interviews, and checklists. Although there is no single "best approach" for identifying risks, a good combination of procedures should be used (Hillson, Extending the risk process to manage opportunity, 2002).

Every project carries with it some level of risk. Any sort of risk has the potential to cause project delays by creating time and expense overruns, as well as under-specification (Ghosh, 2004). Natural gas distribution is a vital aspect of the energy industry, and it necessitates a significant amount of capital for infrastructure development. Several studies have been undertaken to identify technological concerns. (Ma, 2013) used Geographical Information Systems (GIS) to provide a novel quantitative risk analysis process for assessing failure rate, accident effects, and societal and individual dangers connected with urban natural gas pipeline networks. The Bow-tie model was advocated by (Hao, 2017) for analysing the hazard risks of the urban gas pipeline network. For oil and gas, (Srivastava, 2010) presented new approaches for assessing individual and cascading security risks. For controlling project risks, work packages, and activity levels, (Dey P. K., 2010) created a combined Analytic Hierarchy Process (AHP) and risk map technique. However, this method is time demanding, and the results' accuracy depends on the participants' experiences and the facilitators' effectiveness. (Han, 2011) presented qualitative and quantitative risk assessment methodologies for urban natural gas pipeline networks in China. He found the qualitative method to be more appropriate for the municipal natural gas distribution network.

(Brito, 2010) Introduced a multicriteria framework for assessing natural gas pipeline risk and divided pipeline sections into distinct risk categories. (Li, Liu, Li, & Xu, 2018) emphasised the need for operational risk management to ensure safe and smooth operations in a complex business environment. To analyse oil pipeline projects in India, (Dey P. , 2004) suggested an integrated project evaluation and selection methodology based on the analytic hierarchy approach. Investors used market, technical, and financial analyses to evaluate such enterprises. There is a scarcity of studies on natural gas pipeline distribution or the CGD business in India. The CGD sector is still in its infancy, and its application is limited to a few industries.

2.2.1. Identification and mitigation of critical operational & financial risk factors affecting CGD projects

Because this business is still in its infancy, risk management for CGD projects has not been investigated extensively. As a result, a comprehensive classification of oil and gas construction projects was undertaken based on the criteria to detect and minimise operational and financial risks. Fifty-nine significant risks associated with oil and gas building projects in Vietnam were identified by (Van Thuyet, Ogunlana, & Dey, Risk management in OGC projects in Vietnam, 2007). Ten of the identified risks were considered severe. (Mubin S. &., 2016) Found 40 risk indicators for pipeline network development projects in Pakistan. The risks were categorized into eight clusters: political, economic, organizational, technological, security, investment, natural calamity, and ecological risks. 168 oil and gas project risk indicators for engineering, procurement, and construction contracts were found and categorized into seven groups: financial, project management, proposal, human, engineering, quality and procurement, and contractual risk (Mubin S. &., 2013). (El-Shehaby, Nosair, & Sanad, 2014) Identified fifty-nine risk variables linked with the building of off-shore projects. (Dey P. T., 1994) classified 43 risks affecting the development of oil pipelines in India into four categories. (Hasan, 2016) Identified ten security threats to India's transnational oil and gas pipelines. Table 2.1 shows the risk taxonomy for construction projects in the oil and gas industry.

Table 2.1: Risk classification for construction projects in the oil and gas industry

Risk Categories	Risk Factors	Project	Country	Source
Market, Financial, Economical, Environment & Social, Technological, Political	19	Oil Pipeline	India	(Dey, 2010)
Political, Economic, Organization, Investment, Technological, Security, Natural Disaster, Ecological	40	Gas Pipeline	Pakistan	(Mubin, 2016)
Not Specified	59	Oil and gas construction	Vietnam	(Van Thuyet, et al., 2007)
Financial & Economical, Contractual & Legal, Subcontractors, Operational, Safety & Social, Design, Force Majeure, Physical, Delay	59	Rail	Thailand	(Ghosh and Jintanapakanont, 2004)
Organizational, Technical, External	26	Build–Operate–Transfer (BOT)	Iran	(Ebrahimnejad, Mousavi and Seyrafianpour, 2010)
Technical, Financial, Economic and Political, Acts-of-God, Statutory Requirement	43	Pipeline	India	(Dey, Tabucanon and Ogunlana, 1994)
Project-related, Client-related, Design team- related, Contractor-related, Materials, Labour, Plant/Equipment, External factors	30	Civil Engineering Projects	Hong Kong	(Chan and Kumaraswamy, 1997)

Construction, Financial and Economic, Performance Related, Contractual and Legal, Physical, Political and Societal	29	Hydro-Power	Taiwan	(Charoenngam, 1999)
Contractor, Owner, Shared, undecided	26	Construction	Kuwait	(Kartam and Kartam, 2001)
Project, Site, Process, Human, Authority, Technical	45	Construction	India	(Doloi *et al.*, 2012)
Physical, Technological, Construction, Laws & Regulations	10	Pipeline Security	India	(Hasan, 2016)
Site, Technical, Construction, Operating, Revenue, Financial, Force Majeure, Regulatory/Political, Project Default, Asset	50	Public Infrastructure	Australia	(Ng and Loosemore, 2007)
Safety, Environmental Conservation, Investment, Schedule, Time and Quality, Cost, Availability of Labor, Environmental and Social Measures, Collaborative Mechanism	29	Railway	China	(Guo *et al.*, 2014)
Technical, Political/Social, Market/Customer, Project Team, Resource Management, Project Management	17	Project Risk	Turkey	(Tubitak, 2007)
Owners, Designers, Contractors, Sub-contractors, Suppliers, Political, Social & Culture, Economic, Natural, Others	42	Construction	UAE	(El-sayegh, 2008)
Not Specified	40	Offshore Oil and Gas Projects	Global	(El-Shehaby, et al., 2014)
Financial, Human, Quality, Procurement & Contractual, Project Management, Proposal, Engineering	168	Oil and Gas Construction	Pakistan	(Mubin, 2013)

Client, Contractor, Consultant, Feasibility and Design, Tendering and Contract, Resources and Material Supply, Project Management, Country Economy, Political, Local People, Safety and Environment, Security, Force Majeure	51	Oil and Gas Construction	Yemen	(Mukhtar A. Kassem, 2019)
Security and societal, Pipeline location, Health & Safety and Environment, Operational Constraints, Rules and Regulations	30	Oil and Gas Pipeline Projects	Iraq	(Kraidi, et al., 2019)
Economic, Political, Local People, Environmental, Security, Force Majeure	20	Oil and Gas Construction Project	Yemen	(Khoiry, et al., 2019)
Client, Consultant, Contractor, Material, External, Communication, Interface, Contract, Labour and Equipment	43	Natural Gas Pipeline	Iran	(Fallahnejad, 2013)
Socio-Political, Socio-Economical, Organizational, Investment, Technological, Security, Natural Disasters, Ecological	38	Pipeline	Pakistan	(Mubin & Goryainov, 2007)

Source: Author

Risk mitigation strategies for construction projects in the oil and gas industry have been developed through several studies. (Van Thuyet, Ogunlana, & Dey, Risk management in oil and gas construction projects in Vietnam, 2007) Proposed various risk mitigation solutions for the construction projects, including government reform, project executive training, international collaboration, contractor assessment utilising multiple criteria decision-making processes, and increasing approval power of project managers. (Chan, 2011) Highlighted fatigue as the primary cause of construction-related accidents and proposed novel approaches to addressing the reasons. (Bigliani, Roberta, 2013) the operational hazards that affected the performance of oil and gas firms and suggested using information technology (IT) to manage them. To assist project planners, multinational firms, investors, and policymakers, (Rui, 2018) advocated a set of techniques to mitigate technical and non-technical risks (local content, community, security, and collaboration) for the development of oil and gas projects. (Sadeghi, M., & Kashani, 2016) Recommended appropriate risk management strategies to reduce engineering, procurement, and construction risks. (Dey P. K., 2012) Provided an integrated analytical framework for risk management in refining projects by merging multiple criteria decision-making methodologies and the decision tree analysis. Table 2.2 provides the taxonomy of the risk reduction technique employed in construction projects.

Table 2.2: Risk mitigation strategies implemented in the construction projects

Identified Risks	Mitigation strategies	Project	Country	Source
Political and Policy, Legal, Macroeconomic and Financial, Market, Force Majeure, Design, Project Development, Construction, Operation, maintenance, and Coordination	26	Hydro	China	(Pham and Phan, 2018)
Financial, Political, Technical, Other	20	Build-Operate-Transfer (BOT)	East Asia	(Syed Kamarul Bakri Syed Ahmad Bokharey, 2010)
Change in Law, Corruption, Approval Delay, Expropriation, Reliability and Credit Worthiness, Force Majeure, Exchange Rate, Financial Closing, Dispatch Transmission Constraints, Tariff, Interest Rate, Cost Overrun	37	Build-Operate-Transfer (BOT)	China	(Wang *et al.*, 2010)

Discount Rate, Traffic Growth, Inflation Rate, Operation and Maintenance, Project Cost	8	Infrastructure Projects	India	(Kumar, Jindal and Velaga, 2017)
Political, Legal, Economic	27	International Project	Vietnam	(Yean *et al.*, 2010)
Project Management Skills, Skilled Resources, Deliverable Delay, Technical	8	Project	US	(Royer and Ne, 2000)
Contractor, Engineering, Design, Project Delay, Drawing, Change in Scope, Payment Delay, Foreign Investment, Regulatory, Inflation, Legislative, Government, Quality, Equipment Productivity, Skilled Labor, Stakeholders, Procurement, Security, Acts of God, Force Majeure, Ground Conditions	50	Road Construction	Sri Lanka	(Taylor *et al.*, no date)
Country, Financial, Construction, Contracts, Shareholders, Market, Management, Operations and Maintenance	10	Engineering, Procurement, and Construction	Hong Kong	(Lee, Lam and Lee, 2015)
Customer, Government Rules, Competition, Environmental	22	Green Supply Chain	India	(Mangla and Kumar, 2014)
Planning, Conception, Expropriation, Construction, Environmental, Maintenance, Operation, Performance, Technological, Demand, Collection, Capacity, Competition, Financial, Inflation, Legal, Regulation, Unilateral, Public, Force Majeure	45	Water Utilities	Portugal	(Marques and Berg, 2011)
Discount Rate, Traffic Growth, Inflation Rate, Operations and Maintenance Cost, Project Cost	9	Highway	India	(Kumar, Jindal and Velaga, 2017)
Financial, Managerial, Construction, Design, Operational, Safety and Health	53	Architectural, Engineering, and Construction	Gulf Countries	(Abdul-rahman, Loo and Wang, 2012)

Partner Selection, Agreement, Employment, Control, Subcontract, Engineering, Good Relationship, Review and Renegotiation, Other	32	International Construction	Singapore	(Model, 1999)
Strategic & Business, Transport/Construction/ Completion, Operation and Maintenance, Liability and Legal, Market and Sales, Counterparty, Political, Policy and Regulatory	39	Wind Parks	Germany	(Gatzert and Kosub, 2016)

Source: Author

2.3. Theoretical Premises

As per theory-development authority (Dublin, 1978), a complete theory must include four critical aspects outlined in the upcoming sections.

What: Which constructions should be rationally included as an element of interpreting the social or individual phenomena understudy? Comprehensiveness and parsimony are two parameters for determining the amount contained in the "right" components.

How: After identifying group factors, the next task is to find a connection between them. Generally, the “arrows” are used to connect the “boxes”. By carefully identifying patterns, this stage gives order to the conception. It also frequently introduces causality.

Why: What psychological, economic, or societal aspects underpin the variable selection and postulated causal relationships? The theory's assumptions are based on this rationale—the theoretical process of putting the model together.

Logic takes the place of data as the ground for judgement during the theory-development process. If theorists aspire to influence research practice, they must persuade everyone that their ideas are sound. If the theoretical model is a helpful aide for research, by definition, every one of the connections in the model has not been tried. If all connections are empirically checked, the model is prepared for the classroom and is of little worth in the research facility. A theory-development aims to challenge and broaden existing information, not just to revamp it. Why research is directed has significant ramifications for the connection between theory development and observational study. Consolidating the Hows and the Whats produces the commonplace model, from which testable suggestions can be inferred (Whetten, 1989) (K. G. Corley, 2011).

Even though it is unreasonable to expect that theorists ought to be delicate to all conceivable limit requirements, there is the esteem in leading some straightforward mental trial of the generalizability of centre recommendations. For instance, theorists ought to be urged to ponder whether their theoretical impacts fluctuate after some time, either because other time-subordinate factors are theoretically significant or because the academic result is unsteady for reasons unknown.

Most researchers won't produce another theory without any preparation. All things being equal, they, for the most part, work on further developing what exists. Albeit, on a fundamental level, it is feasible to make a significant theoretical commitment by adding or taking away factors (Whats) from a current model; this cycle only here and there fulfils analysts. The increases or erasures ordinarily proposed are not adequate to considerably change the centre rationale of the current model. One approach to show the worth of a proposed change in a rundown of elements is to distinguish what this change means for the acknowledged connections between the factors (Hows). Similarly, to not establish a theory, expanding another variable to a current rundown ought not to be mixed up as a theoretical commitment. Connections, not records, are the space of theory (Whetten, 1989) (K. G. Corley, 2011).

Speculations frequently are tested because their suppositions have been demonstrated unreasonable (by and large by work imported from different regions). Although it is hard to assemble agreement around typical truth as around actual reality, ongoing full-scale theoretical developments, including the ecology and economic matters, exhibit this methodology's notability. Applying an old model to another setting and showing that it fills in true to form is not educational without help from anyone else. This end has theoretical legitimacy just if something about the new setting proposes the theory shouldn't work under those conditions. As such, it is desirable to explore qualitative changes in the limits of a theory (applications under qualitatively various states), as opposed to simple quantitative developments (Whetten, 1989) (K. G. Corley, 2011).

The standard component in propelling theory development in new settings is the need for a theoretical criticism circle. Theorists need to discover further information about the actual theory because of working with it under various conditions. That is, new applications ought to work on the instrument, not only reaffirm its utility (Whetten, 1989) (K. G. Corley, 2011).

In this study, the researcher has tried to address the research gap identified through the literature review, highlighting the importance of finding the management approach to mitigate the operational and financial risks causing a delay in the CGD project. The following sections highlight the importance of risk management in energy projects and discuss the various theories to deliberate on the theoretical premise.

2.3.1. Risk management in projects

Risk management in projects is presently one the most popular areas of discussion among researchers and professionals in project management. It starts with a thorough examination of all relevant data, which includes both risk and problem assessments. The information gathered, and the judgments made throughout the risk characterization and evaluation phase serves as the basis for assessing, evaluating, and selecting risk management options (Aven, 2010).

Apprehension with risk management became more evident after (Ibbs, 2000) distributed their research, which perceived this information region as one of the neediest regarding management, as analyzed in three of the four economic areas examined. In any case, (Akintoye, 1997) highlighted the viability of risk management as one of the significant worries of project experts. For (Raz, 2002) the discipline of risk management is as yet at its outset.

The following publications stand out among examinations of the nature of risks and their conceptual aspects: (Wideman, 1992), (Perminova, 2008) and (Meyer, 2002). They primarily address features of risks and their association with uncertainty, their consequences and implications on project outcomes, and ambiguities and variation, among other concerns that form the foundations of comprehending this idea. While (Bernstein, 1997) provides a comprehensive historical overview of risk and its significance to project managers, (Meyer, 2002) focus on the issues of variability and ambiguity. The work of (Ward, 2003) stands out in this line of research because of its unique thesis, which emphasizes the management of uncertainty as an alternative for risk management. It takes the broadest approach to the area.

Another feature of the risk idea is its dual nature, both from a negative (as a threat) and a positive (as an opportunity) standpoint (Hillson, Extending the risk process to manage opportunities, 2002) (Ward, 2003). Risks, in his opinion, are unpredictable events that can have a detrimental or beneficial impact on project goals. Different administrative strategies are required for every risk perspective.

Another area of project risk management research conducted by (PMI, A guide to the project management body of knowledge (PMBOK ® Guide), 2008) and different concerned bodies focus on the practical aspects of risk management. Furthermore, risk management methods and techniques become essential in terms of their applications to companies. (Hillson, Extending the risk process to manage opportunities, 2002), (Raz, 2002), (Wideman, 1992) are highlighted in this area of research. They have broadly conducted work along the two paths outlined above. The papers described below illustrate the risk vision from diverse perspectives and are based on approaches commonly used by firms interested in controlling unpredictable events in projects. These two paths demonstrate how risk management in projects has evolved. However, awareness in project risk management is drawn in part from a broader interest in project management, and it is centred in the 1990s, a period of significant growth.

(Wideman, 1992) made perhaps the most important commitments to understanding the ideas of risk by drawing out the lines of the field of uncertainty, including restricting the components of the obscure and uncertainty. Uncertainty, in this view, can be viewed as a theoretical field delimited between these two components, which become the focal point of worry for risk contemplates.

In this regard, the risks in a project have their starting point in the field of uncertainties which, thus, is available in a more or less unique structure in all projects (Perminova, 2008). The relationship risk between uncertainty embraced by the (PMI, A guide to the project management body of knowledge (PMBOK ® Guide), 2008). For instance, this relationship set up a comprehensive meaning of risk as "a questionable occasion or condition that, on the off chance that it happens, has a positive or adverse consequence on something like one the project objective."

Uncertainties pose risks and can have a severe impact on the ability to achieve end objectives. Since the set goals drive projects, it is essential to manage risks to ensure that risks are associated with projects at an acceptable management level. The following are the primary factors that make the project risky:

- Uniqueness: Every new project has its own set of unique elements that haven't been seen before.

- Complexity: Projects have various associated complexity, such as technical, commercial, interfaces or relational, etc.
- People: Availability of skilled people with relevant experience and education across the value chain.
- Stakeholders: Group of people imposing requirements, expectations, and objectives on the project, leading to conflicts.
- Change: Every project moves from the known to the unknown future with all the uncertainty associated. The delay could be relative to change in policies, regulations etc.
- Assumptions or constraints: Project scoping involves forecasting with some assumptions. Wrong predictions may lead to project failure or delay.

For (Perminova, 2008), the primary distinction between risk uncertainty is the chance to set up the likelihood of an occasion. Hence, uncertainty is described by a circumstance wherein choices are made under states of obscure probabilities. It is challenging to relate mathematical possibility esteems to them, just as there is an absence of information about the outcomes of an occasion.

One extremely intriguing element of uncertainties, inborn in also, simultaneously reciprocal to (Wideman, 1992) studies was finished by (Meyer, 2002) who proposed four sorts of uncertainty:

- Variability: irregular varieties, but unsurprising and controllable around the known destinations of cost and period;
- Foreseeable uncertainty: a couple of realized components will influence the project in an anticipated manner permitting like this that possibility plans be set up to manage the results of an inevitable event;

- Unforeseen uncertainty: at least one critical variable that impact the project that can't be anticipated, accordingly requesting arrangements when and if they happen;
- Chaos: flighty factors completely negate the destinations, arranging and way to deal with the project, requiring its rehashed and complete redefinition.

Conceptually, uncertainties can be viewed as the focal point of project management concerns. In this regard, (Ward, 2003) contend that the whole project risk management should zero in on regulating uncertainties since the risk is consistently related with dangers (or chances) of unsure occasions to the projects.

This view is shared by (Sadeh, 2000) who allude to uncertainty as something obscure and risk as something that can happen. As indicated by these creators, a large part of the risk in projects comes from uncertainty. However, different variables add to project risks, such as periods, cutoff times, costs, shortage of assets, and lack of capacities and abilities.

(Ward, 2003) showed that the customary types of managing risk will generally focus on variability occasions and little thinks about existing ambiguities in projects. For them, variability alludes to the components of a project that can expect to be unmistakable, however unsure, values, like cutoff times, expenses and quality. Vagueness is related to the absence of clearness of the information, the subtleties, and structures among different variables. There is an inclination in the conduct of those included, confined information and hazy circumstances.

Risk management is directly relevant in handling all the uncertainties associated with the abovementioned factors and is essential for project success. The implementation of risk management reduces the threats to the project, proactively captures the opportunities and turns them into positives for the project. In short, effective risk management decreases hazards, optimises chances, and guarantees that project goals are met (Hillson, Extending the risk process to manage opportunities, 2002)

Project failure is a curse terrible for any company due to huge capital investment. Around 80 per cent of oil and gas projects experience delays globally, resulting in a substantial financial effect on the companies and contractors (Hatmoko, 2019). Therefore, it is essential to explore and understand the factors leading to the project delay. However, It is not possible to altogether remove the risks in construction projects. They can be reduced significantly after identifying root causes and their management (Smith, 2014).

According to both professionals and academicians, energy construction projects are more vulnerable to risk than other industries due to inherent complexities. These problems can lead to lower performance, higher costs, scheduling delays, and, eventually, project failure (A. Nieto-Morote, 2011) (Taroun, 2014).

Natural gas pipelines network is the safest means to transport energy fuels. Thus they're the preferred mode to distribute energy globally. As natural gas usage rises, so does the need for transportation infrastructure to meet the increased demand. Pipelines provide a cost-effective and safe way to transmit natural gas across large distances. Pipelines offer a cost-effective and secure way to transfer natural gas across large distances. Though energy demand has increased in the past decade, newer predictions suggest that demand will continue to climb in the following decade.

Risk identification, assessment and management are imperative for delivering projects, preserving their economic viability, and maintaining strategic usefulness (Basak, 2019). The risk management implementation depends on the company, industrial factors, external and internal factors. Regardless of the development of risk management strategies and apparatuses, the absence of an organized and integrated methodology, just as less regard for risk management approach, has been causing a delay in the lack of successful implementation of risk management in oil and gas projects, particularly in city gas distribution projects.

2.4. Research gap

Considerable research on demand estimation for energy and risk assessment of oil and gas projects have been undertaken, according to the literature analysis. However, there isn't a single study predicting natural gas consumption at the national level, let alone India's eastern corridor states. Oil and gas projects are likewise vulnerable to many uncertainties, as evidenced by the literature analysis, and any delay results in cost escalation. CGD initiatives are similar in that they are complex and include a large number of stakeholders. Any delay in the start of CGD projects could jeopardise the country's goal of achieving a 15 per cent natural gas stake in its primary energy consumption by 2030. It is critical to estimate the natural gas demand of the CGD sector, understand the issues, identify and reduce risks causing project delay. However, this business in India is still in its early stages, and evidence from the literature suggests a scarcity of studies on project risk management. Thus, it is imperative to identify the suitable management approach to mitigate the risk causing project delay in the dynamic project environment. Figure 2.1 depicts the identified research gap.

We studied Game Theory, Fuzzy Theory, Utility Theory, and Resource-Based Theory to deliberate the theoretical premise for this study. After due deliberation, the contingency theory is found to be the most relevant for this study.

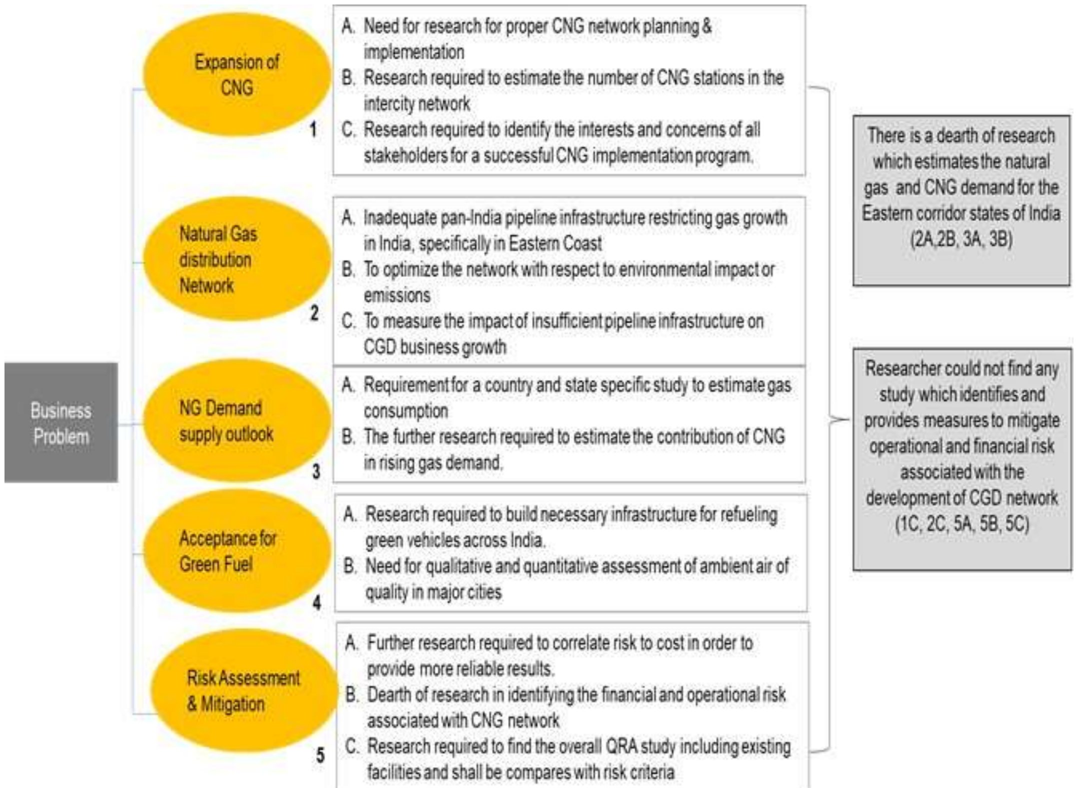


Figure 2.1: Research gaps

2.5. Review on theories used in project risk management studies

Game theory: This theory has been applied in various fields to analyze the decision-making processes. The theory focuses on problem solutions from one player's decision while emphasizes the analysis among many players. Many researchers have applied the theory to solve problems in construction engineering and management. (Kelly, 2003) mentioned that the game theory is suitable for decision making in a complex environment. (Rajbhandari, 2011) integrated game theory into classical risk management. (Aliahmadi, 2011) proposed a new method based on game theory for risk assessment of a tunnel project.

Fuzzy Theory: The theory introduced by Zadeh in 1965 has been applied to many fields for risk management. Multiple tools are used to communicate identified risks to the project stakeholders, such as risk matrix, risk list, maps and risk breakdown structure (PMI, A guide to the project management body of knowledge (PMBOK ® Guide), 2008) (T. Raz, 2001) (Macgill, 2005). To execute project risk assessment and analysis, (Carr, 2001) developed a hierarchical risk breakdown structure based on a fuzzy technique. (Zhao, 2011) suggested use of fuzzy theory for developing construction risk forecast model to analyze risk in the planning phase.

Utility Theory: The theory seeks to explain the individual’s observed behaviour and choices. (Brito A. J., 2009) Established a multicriteria methodology for risk assessment of natural gas pipelines and categorising their divisions into risk categories. He combined Utility theory and the Electre Tri technique to create the model. Based on the application of utility theory, (Kaplinski, 2013) proposed a risk analysis method. Economic data (supply, demand, seasonality), historical data, conditional probability, and utility function are used to evaluate risk.

Resource-Based Theory: This theory denies that strategic resources allow a company to gain a competitive advantage over its competitors (Barney, 1991). It originates from economic disciplines, and its application has been extended towards management, sociological, information management and knowledge management (F.J. Acedo, 2006). This theory is classified as a part of strategic management theory by (Almarri, 2014) and is often employed by project managers. (Govan, 2016) proposed a resource-based approach to develop a project causal network to evaluate the project risks.

2.6. Contingency theory in project risk management

Contingency theory was initially intended to address environmental or organisational design fit with environmental conditions. However, it was improved by including internal conditions like structural formalisation and specialisation, just as technology as contingencies (Weber, 2009). Contingency theory relies on a fit between specific components of a managerial organisation and eventualities that may improve an organization's performance (Çakır, 2012).

Different types of projects necessitate various forms of organisation. Surprisingly, project management research has only looked at a few contingency concerns that haven't been thoroughly scrutinized (Söderlund, 2004). (Dvir, 1998) Performed a thorough investigation of contingency elements and identified numerous sorts of technological uncertainties and scopes. Shenhar and Dvir then used a rationalistic approach to finding and recording crucial success criteria in their later work. (Lindkvist, 1998) Presented a contingency model to study various types of project organisations. (Shenhar, 2007) proposed a four-factor contingency framework: novelty, technology, complexity, and pace (NTCP). The framework was designed with engineering projects in mind, therefore thus gives little to projects or project management methodologies that aren't related to engineering. (Van Donk, 2008) adopted an alternate strategy to project management by tying Mintzberg's organisational contingency paradigm to it. They concentrated their research on project structure typology, paying just superficial regard to contingency elements.

Variables in contingency theory are an outcome of their internal and external environments, based on the idea that organisations are interrelated on their surroundings (Hanson, 1979) (Scott, 1981) (Wadango, 2014). The internal environment includes organisational structure, operations, and employee behaviour, whereas the external environment includes political, economic, technology, and institutional aspects (Schein, 2010) (Scott, 1981). According to (McCourt, 2001), Contingency theory is beneficial to researchers because it allows them to "demonstrate an understanding of the roots of many public management innovations in private sector practice, as well as the political context in which those innovations were applied...."

This theory centres around results instead of cycles. Contingency scholars endeavour to decide the suitable organizational construction or strategy for a specific circumstance. They don't, in any case, look at why a particular organizational structure or system becomes powerful on a particular occasion.

Contingency contemplates tending to bring about discoveries that can be summarized by the expression "it depends," which has gone under some criticism. The contingency theory has been seen as a methodology or hypothesis instead of a theory since it gives a more significant strategy to conceptualize a wonder (Schoonoven, 1981).

The contingency theory was used in research embraced by (Woods, 2009) on risk management for executive accounting in the public sector. Beforehand contingency theory has been used in the private area because of the critical risks that will be positioned on how the risk impact is estimated against the core financial statements. This theory isn't appropriate for the general area since a public place is exceptionally determined towards organizational targets instead of financial goals. Another research (Sauser, 2009) used contingency theory to re-examine the failure of project failures, as most studies pointed that project disappointments are because of the technology instead of managerial. They highlighted the loss of NASA's Mars Climate Orbiter as an example, demonstrating that the goal of "better, faster, cheaper" resulted in project failures due to managerial decision-making. Under contingency theory, the company should distinguish between specific components or an administrative organization and contingencies that will work on the organization's performance in each project. Subsequently, the possibilities could be the critical components or critical achievement factors that are profoundly critical to a project achievement that ought to be thought about during the decision-making stage by the project proprietor or manager.

In the context of project contingency theory, (Howell D. W., 2010) evaluated the literature on various project management methodologies. Uncertainty, complexity, urgency, team empowerment, and criticality were recognised as five contingency components impacting projects, and they developed a contingency framework based on project ambiguity and its consequences.

Interestingly, initial developments in the contingency theory focused on organizational structure and technological revolution as the contingency factor. (Burns, 1961) are considered pioneers of contingency theory. They studied 20 firms and offered two different management structures, mechanistic and organic. It was hypothesized that organic organizations would survive the change better than mechanistic organisations that perform better in a stable environment.

Following in their footsteps, several scholars investigated the characteristics of control and flexibility in the field of project management (Geraldi, 2008) (Koppenjan, 2011) (Lenfle, 2010) (Sine, 2006). In their respective research, the authors highlighted the importance of managing mechanistic and organic approaches to achieve the project objectives. In highly uncertain cases, a more flexible approach is required. As articulated by (Aaker, 1984), the control method tries to attenuate any undesired changes. On the other hand, flexibility refers to the ability to adjust to an unpredictable and rapidly changing environment that may impact a company's performance. According to (Koppenjan, 2011), the control method emphasises planning and control of removing ambiguity and complexity.

On the other hand, preparation and commitment are based on the joint management of uncertainty and complexity, and it necessitates collaboration among stakeholders in the projects. However, (Brown, 1997) claimed that companies frequently need to integrate two techniques because pure approaches are rarely implemented. In the ever-changing environment, it has been discovered that combining clear roles and importance with excellent communication is a successful strategy. Other researchers later concurred with the findings (Ahrens, 2004). Risk management is a fragment of the whole project management process, and both mechanistic and organic management styles influence it. In a mechanistic management style, risk management emphasizes decreasing risk in advance by identifying and allocating risks to the appropriate project participants via contracts. Forecasting is used to make the allocation. However, because of the changing environment, the forecasts are only relevant for a limited time. The organic management method is more appropriate in such a dynamic context. According to (Floricel & Miller, 2001), excellent project performance necessitates using both methodologies. (Osipova, 2013) Examine how the application of Joint Risk Management (JRM) in two projects is influenced by mechanistic (control-oriented) and organic (flexibility-oriented) management systems. JRM emphasises the necessity of collaboration among project members in controlling risk that cannot be recognized at the outset. They discovered that JRM necessitates both risk management procedures and flexibility for dealing with unplanned situations. Risk management is a formal procedure performed separately rather than jointly when a mechanistic approach is dominant. However, there is a paucity of literature on managing risk by their underlying management strategy (Osipova, 2013).

According to contingency theory, there is no proper way to do things, and the context determines the optimum approach. Because projects are by definition innovative, each one necessitates a unique, contingent strategy since many variables have altered to some level (Morgan, 1997). The study conducted on five industries found that straitjacket methods to project management do not appeal to project managers. They'd start with traditional methods, but once the projects were up and running, they'd abandon them because they were ineffective (Kureshi, 2013). He demonstrates an underlying link between contingency theory (creative approach to situations) and projects (unique and unexpected).

The researcher also observed that this theory had been broadly used for risk management in the IT and construction sector but hardly found any evidence for the application in the CGD industry. According to Project Contingency Theory, the optimum strategy to manage a project relies upon setting: various conditions require specific project organisational attributes. The project's viability is associated with how well the organisation and surroundings fit together.

2.7. Theoretical Gap

Risk management has risen to the top of both government and industry's agendas in recent years, and private sector measures to strengthen risk and internal control have been echoed by close calls for transformation in the public sector. Risk management is now seen as an essential aspect of corporate governance and a tool for achieving strategic goals by both regulators and practitioners. (Woods, 2009) developed contingency theory by founding three core contingency variables for the public sector: government policies, information and communication technology, and organization size. He recommends further investigation into the level to which the theory is broadly applicable all over the public sector is warranted based on the theoretical assertions and empirical results.

In another study, (B. J. Sauser, 2009) suggested that more research is required to associate project management arrangement frameworks to suitable management styles and practices or help in possibly foreseeing achievement or disappointment, and even give cautioning signals in an ongoing project.

(Lizarralde, 2011) stated that the existing practices to study the Temporary Multiple Organization (TMO) do not give a clear picture of its entire design, including intra- and inter-organizational relationships and informal communication among all project stakeholders. There are boundless potential setups for TMOs in development; however, the contingency theory expects that a set number of structures best react to the interior qualities of the framework and its environment (Betts, 2003) (Lawrence, 1967).

So far, many contingency factors have been acquainted with categorizing projects, including urgency, complexity, criticality, uncertainty, risk, team empowerment, and institutional project environment. In such an order, the more projects in classification have a similar degree of "risk", the more homogeneous the classification becomes. By doing this, the researcher can delimit risky project types and create and test speculations and hypotheses about these sorts of projects (Shenhar, 2007) (Howell D. W., 2010) (Barki, 2001) (Floricel, 2001) (Dille, 2011). (Howell D. W., 2010) The relationship between the company and the project affected the project management and linked it with the contingency factors. He also highlighted the need to further explore the established relationship because of its complex nature.

Contingency theory has been applied in project management, but the impact of control and flexibility-oriented techniques on the risk mitigation method in energy projects has not been explored. Additionally, there is a lack of understanding on how to handle the balance between control and flexibility. There are no simple solutions for how businesses attain the best combination. Therefore research to understand better the flaws and virtues of various approaches are critical (Osipova, 2013). Given that risk can substantially impact project goals, the impact of control-oriented and flexibility-oriented methods on the joint risk mitigation (JRM) process has not been studied. Moreover, more research to identify the features of the mechanistic and organic approach is needed for the effective implementation of JRM in the projects.

2.8. Research Problem

This study has been carried out specifically to probe how the degree of control and flexibility affects the joint risk mitigation approach in natural gas distribution projects in India. Project contingency theory has been considered a theoretical base for the research work. So, the research problem of this study is “How does the extent of control and flexibility in the projects affect the joint risk mitigation approach?”

CHAPTER 3

Research Methodology

Research methodology is a method for systematically solving a research topic. It deals with the strategies, procedures or techniques used in the data collection or analysis to reveal new facts or better comprehend a subject. This section explains why the study was conducted, the issue description, research questions, objectives, the research design used to collect data, and the results. This chapter also looks at natural gas demand forecasting at the national and state levels, the sampling method, performing a survey, and the statistical approach used to analyse the data.

3.1. Rationale behind study

Natural gas consumption in India is focused on particular regions, reflecting the state of gas infrastructure in the country. These regions include the two western states of Gujarat and Maharashtra, accounting for 40 per cent of India’s gas infrastructure. Gujarat, Maharashtra, and Uttar Pradesh collectively consume about 65 per cent of India's natural gas. However, the government has been constructing cross-country gas pipeline infrastructure to connect new regions to realise the potential for increased gas demand. Additionally, the government has awarded a license for 229 CGD GAs to ensure last-mile connectivity in 407 districts covering 27 States and Union Territories. This CGD network will cover nearly 70 per cent of the country's inhabitants and 53 per cent of its geographic area. However, there are economic growth hubs with inadequate gas infrastructure, especially in some parts of India's eastern and southern regions. The launch of a

Smart Cities initiative will accelerate the urbanization and economic growth in areas with little to no natural gas network. Therefore, it is imperative to conduct the research to estimate the potential gas demand growth from such areas and suggest the risk management (RM) approach ensure the successful implementation of CGD projects in such hubs. Given that CNG accounts for almost 75 per cent of the CGD sales, it is essential to measure its demand potential. The focus of this study is on predicting natural gas consumption at the national and sector levels and CNG demand. In addition, this research recommends a risk mitigation strategy for the operational and financial risks to the CGD projects' successful start-up.

3.2. Research problem statement

How does the level of control and flexibility in projects affect the joint risk mitigation approach?

3.3. Research questions

Few critical research questions are provided to address the gaps highlighted through an existing literature review of the natural gas industry below. They are as follows:

- What are the estimated untapped demand for natural gas and CNG for the Eastern corridor states of India?
- What are the mitigation strategies to reduce the operational and financial risks connected with developing the CGD network in India's Eastern corridor?

3.4. Research objectives

The research objectives are:

1. To estimate untapped demand for natural gas and CNG for the Eastern corridor states of India.
2. A) To Identify financial and operational risks factors associated with the CGD project

B) To develop mitigation strategies for the identified risk

C) To develop the mitigation approach for the mechanistic and organic management systems.

3.5. Research design

"A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure" (Selltiz, 1962). Research design can also be considered the conceptual framework inside which research is directed as it comprises the outline for gathering, estimation and analysis of data. The research design for this study follows a single approach, i.e. exploratory for both the objective.

3.6. Research process

Before getting into the particular research procedure and methodologies, it's essential to give a quick outline of the research process. The research process is a series of activities or processes that must be completed for research to be completed. As a result, Figure 3.1 depicts the flowchart used to meet research objectives.

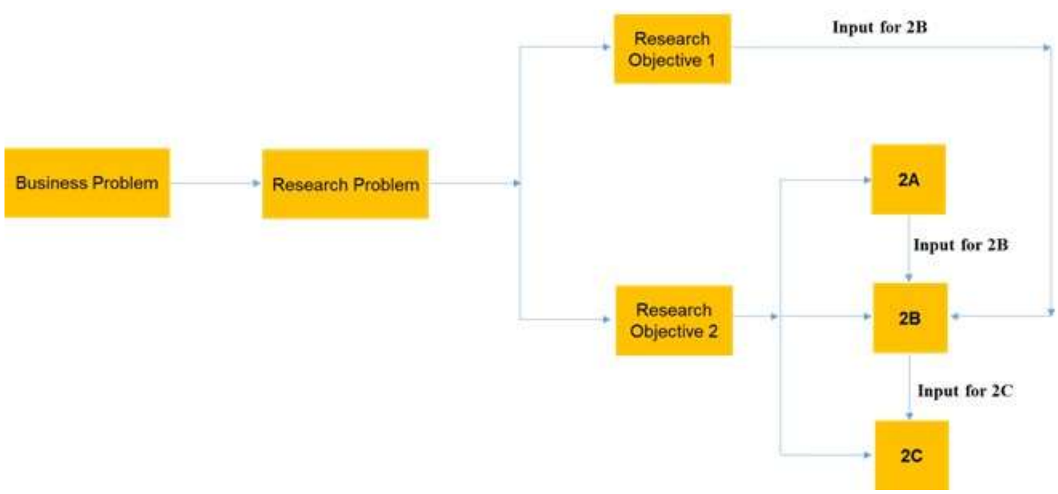


Figure 3.1: Research process

The objective wise research process is presented in Figure 3.2 & Figure 3.3 for objective 1 and 2, respectively.

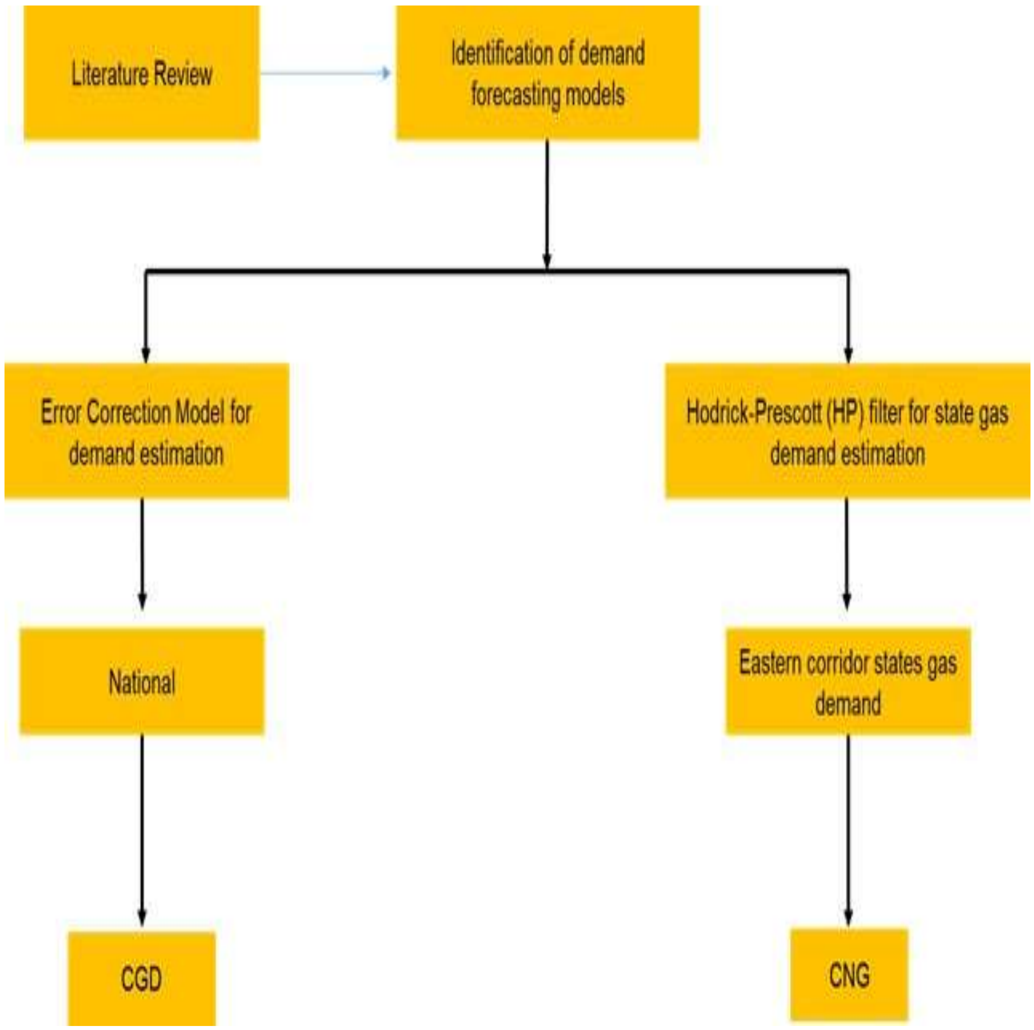


Figure 3.2: Research flow chart for RO1

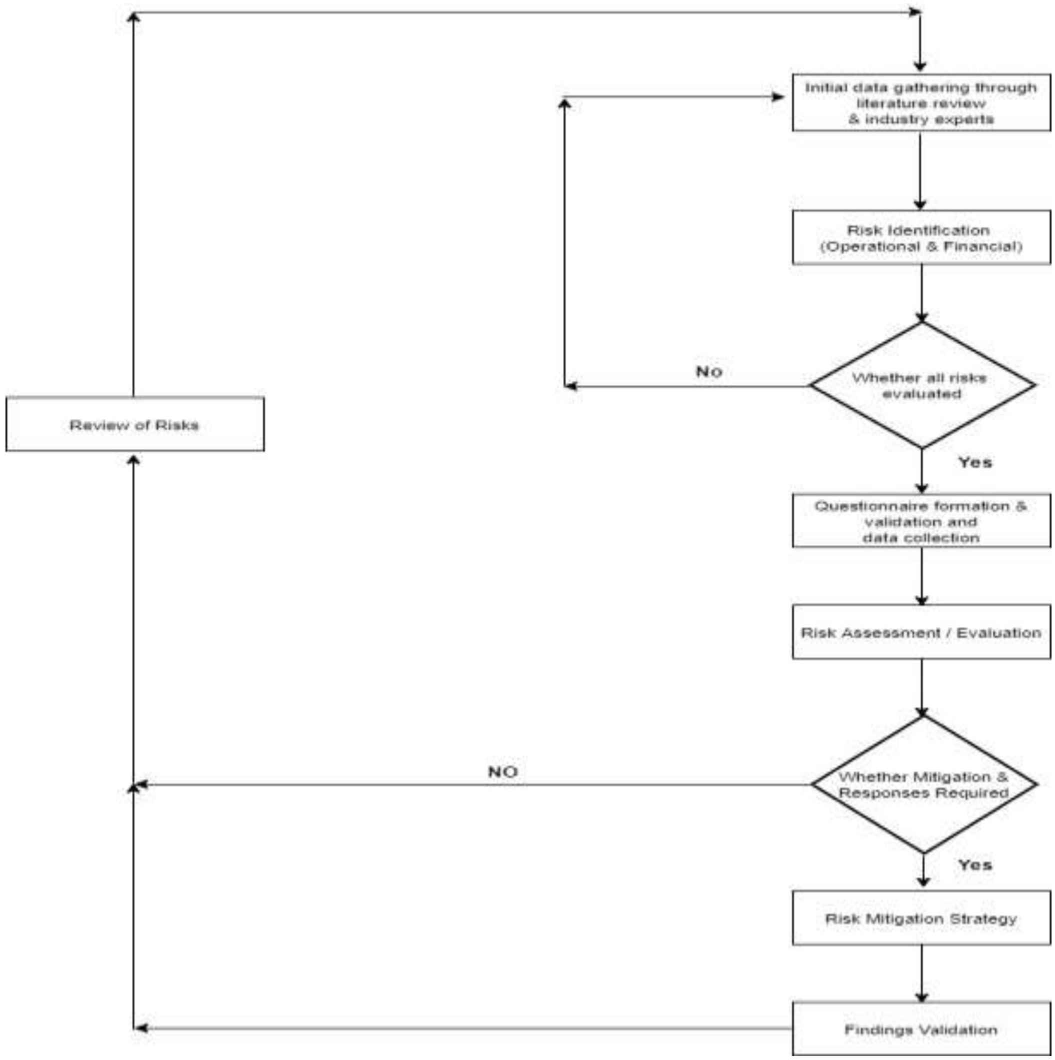


Figure 3.3: Research flow chart for RO2

3.7. Risk objective 1

To estimate untapped demand for natural gas and CNG for the Eastern corridor states of India.

The error correction model (ECM) is used for national and sector-specific demand estimation, whereas the Hodrick Prescott (HP) model is used to estimate CNG demand for eastern corridor states.

3.7.1. Data

For all of the variables, the model relies on secondary data gathered from credible sources. MGL provided the annual gas pricing statistics. Until 2014, natural gas prices in India were highly complicated. The current gas pricing policy was re-examined following the change of government in May 2014. The Cabinet Committee on Economic Affairs (CCEA) sanctioned the new domestic gas pricing policy in October 2014. The group proposed a new method for determining gas prices based on a tweak to the Rangarajan formula. The researcher utilised the annual weighted average price for this analysis because gas pricing regulation has changed several times. The data for Population, GDP and per capita income were taken from the World Bank's Development Indicators (Bank, 2021). Natural gas consumption data is sourced from Energy Statistics. In contrast, state GDP and population data are sourced from the Reserve Bank of India's annual database for computing state demand for natural gas (Office, 2021) (RBI, 2021).

3.7.2. Demand estimation model for national and sector demand

For describing the mathematical relationship between the demand variables, many functional possibilities are available for constructing the demand model – linear, non-linear, semilog, etc. The log-linear Cobb-Douglas function has been most commonly employed for demand modelling. The demand elasticities are directly estimated using the parameter estimations of the explanatory factors. These elasticities are expected to be constant. Furthermore, the non-linear nature of the variables is better represented by log-linear models (Zia Wadud, 2011).

Natural gas demand is calculated using the Cobb-Douglas formula as follows:

$$\mathbf{Gas = C\ (Price)^{\alpha}\ (GDP)^{\beta}\ [(Population)^{\gamma}]} \qquad \mathbf{(1)}$$

Considering both sides of the logarithm and the error term

$$\mathbf{In\ Gas_t = k + \alpha InPrice_t + \beta InGDP_t + \gamma[Population_t] + \varepsilon_t} \qquad \mathbf{(2)}$$

where: Gas is the natural gas demand at time t;

Price is the natural gas rate at time t;

GDP is the real GDP at time t;

[Population] is the population at time t, if the variable is included;

α, β and γ are the parameters to be assessed;

Because of the significant capital investment required and the extended project gestation period, gas demand is unlikely to respond rapidly to an increase in GDP. The model included a lagged dependent variable among the explanatory factors by building a dynamic model to solve the issue mentioned above.

$$\ln Gas_t = k + \Sigma_i \mu_i \ln Gas_{t-i} + \alpha \ln Price_t + \beta \ln GDP_t + \gamma[\ln Population_t] + \varepsilon_t \quad (3)$$

Where μ_i are the parameters to be estimated; i is the Lag length.

The empirical analysis follows certain stages of the investigation for developing an effective demand estimation model.

- **Non-stationarity:** A frequent assumption in time-series data is that the data is stationary, meaning that the mean and variance are constant throughout time. If the time-series data is nonstationary, the time-series analysis may result in erroneous and gibberish regression. To address these concerns, the researcher used the Augmented Dickey-Fuller Test and the Phillips-Perron Test to check the series' stationarity (Gujarati, 2012).
- **Multicollinearity**: It occurs when independent variables in a regression equation are correlated. The insignificant slope coefficients but high overall R-square value are due to multicollinearity among the explanatory factors. We used the Variance-inflating factor (VIF) and the Tolerance level (TOL) to solve this problem (Gujarati, 2012).

- **Heteroscedasticity:** Uneven variance is referred to as heteroscedasticity. It could happen if there are outliers in the data, if the regression model's functional form is incorrect, if data is incorrectly transformed, or if observations of different scales are mixed. Failure to account for heteroscedasticity impacts the reliability of t and F tests, resulting in incorrect conclusions regarding the statistical significance of regression coefficients. To assess for heteroscedasticity in the estimated model, the researcher employed the Breusch-Pagan-Godfrey test. (Gujarati, 2012).
- **Normal distribution of error terms:** The regression model assumes that every observation's error term is unaffected by the error term of every other observation. Satisfying this assumption helps in hypothesis testing and generate reliable confidence and prediction intervals.
- **Serial correlation denotes the relationship between a particular variable and its lagged version** over different time intervals. It makes the regression coefficient appears to be statistically significant when it is not. The Breusch-Godfrey Serial Correlation LM Test is used to overcome this problem (Bun, 2019) (Gujarati, 2012).

Error Correction Model (ECM)

The ECM method determines the process of adjusting the estimated model towards equilibrium. "It is a dynamic model that incorporates a mechanism which linked a variable to its long-term relationship from a disequilibrium equation" (Global, 2020). Phillips proposed an error correction term in economics in his examination of feedback control mechanisms for stabilisation policy. (Phillips, 1954). Sargan's work in econometric methodology was the next major milestone in ECM. He presented multiple methods of estimating equations with autocorrected errors (Sargan, 1964). After inventing ECM for the aggregate time-series relationship between consumption expenditure and income, Henry popularised it extensively. Phillips and Sargan had a significant influence on his work (D. F. Hendry, 1978)

(D.F.Hendry, 1977) (D.F. Hendry, 1984). Later, ECM was popularized by Engle and Granger. They introduced the theory of cointegration, which integrates the long-run equilibrium and the short-run dynamics (George Alogoskoufis, 1991) (Ghosh, 1993).

In this research, ECM has been used for developing the model as it works well with the demand-supply theoretical premise and shows long-term cointegration between GDP and natural gas demand. The ECM model is applied in two steps utilising the Engel-Granger process. Ordinary least squares (OLS) is utilised in the first phase with variables that are non-stationary at levels but integrated of order I (1). In the long run, the residuals of the computed regression equation are stationary, implying that the variables are cointegrated. In the second stage, the ECM explained the short-run behaviour of natural gas demand to its long-run value by using the residual from the calculated equation. The equation for the ECM is

$$\mathbf{In\ Gas_t = k + \Sigma_i\mu_i InGas_{t-i} + \alpha InPrice_t + \beta InGDP_t + \gamma[InPopulation_t] + \mathcal{E}_t} \qquad \textbf{(4)}$$

Where, $\mathcal{E}_t = \text{In Gas}_t - k + \Sigma_i\mu_i\text{InGas}_{t-i} + \alpha\text{InPrice}_t + \beta\text{InGDP}_t + \gamma[\text{InPopulation}_t]$

$$\mathbf{\Delta In\ Gas_t = k + \Sigma_i\mu_i\Delta InGas_{t-i} + \alpha\Delta InPrice_t + \beta\Delta InGDP_t + \gamma[\Delta InPopulation_t] + \psi\mathcal{E}_{t-1} + \upsilon_t} \qquad \textbf{(5)}$$

Where υ_t is the error term, and the coefficient *(ψ)* of the error correction term *($\mathcal{E}_{t-1}$)* indicates the system's speed to correct the discrepancy between long and short-run gas demand. Because the error correction term represents the residual's one-period lag value, it was used as a proxy variable for technical flexibility in the proposed model.

$$\mathbf{\mathcal{E}_{t-1} = In\ Gas_{t-1} - k + \Sigma_i\mu_i InGas_{t-i-1} + \alpha InPrice_{t-1} + \beta InGDP_{t-1} + \gamma[InPopulation_{t-1}]}$$

There are not many varieties workable for utilizing gas demand and GDP factors. In this model, the researcher used absolute gas demand to function per capita GDP, price and population. We can likewise model total gas demand about total GDP.

The other conceivable choice is to model per capita demand dependent on per capita GDP. The researcher has focused on estimating the total demand as it is the primary variable for policymakers for planning purposes.

3.7.3. CNG demand estimation for eastern corridor states

State-level CNG consumption is used as a data set for applying the HP filter method to forecast CNG demand for the eastern corridor. Hodrick and Prescott invented the HP filter in 1980, and it is a mathematical tool used in economic data analysis to remove the trend and cyclical component from a time series (Hodrick & Prescott, 1997). This approach considers that time series can be divided into a non-linear growth or trend component. The series Y_t represents the interest time series variable that is made up of a trend factor τ_t, a cyclical factor c_t and an error factor e_t, such that:

$$Yt=\tau t+ct+et \tag{1}$$

However, there is no actual observation of the trend and cycle parts. Therefore, the solution of the following standard penalty program derives the trend from a time series by using the HP filter method.

$$min_{\tau}\left(\sum_{t=1}^{T}(Y_t-\tau_t)^2+\lambda\sum_{t=2}^{T-1}[(\tau_{t+1}-\tau_t)-(\tau_t-\tau_{t-1})]^2\right) \tag{2}$$

Where λ is the positive smoothing parameter as penalization of the trend component variability, the series to be filtered will be called the input sequence τ_t and the output sequence Y_t. It is imperative to identify some related data to solve this problem; any economic time series will be mentioned as a sequence of real numbers. Each observation is an element of the sequencing process. Equation 2 has an intuitive explanation. The HP filter decomposes two components for a time series: a stationary cycle and a long-term trend, which needs the previous description of the parameter λ, which sets the trend's smoothness and determines the significant period of the cycle that will produce the filter. However, when it uses the similar λ for a series at various periodicity, the associated frequency with the cycle spectral peak will be acquired. As a result, cycles that are conflicting under time collecting will be created (Tchrakian, 2011).

3.8. For Research Objective 2 (A)

A) To identify financial and operational risks factors associated with the CGD project

The methodology uses factor analysis to analyze the data collected and identify the critical operational and financial risks causing a delay in the CGD project.

3.8.1. Sampling Design

The following points were considered to develop the sample design,

- Type of Universe: To create a sample design, the researcher needs to define the set of the universe, which could be finite or infinite. In our study, it is limited.
- Target Population: The target population surveyed for this analysis is individuals and organizations having experience or presence in the natural gas business in India, i.e. public & private sector companies, regulators, equipment manufacturers, consultants, service providers, and academia. The target population considered is 500.
- Sampling unit: The sampling unit comprises of an individual having substantial knowledge of natural gas and have around three years of experience in public or private companies, regulator, equipment manufacturers, consultants, service providers, and academia.
- Sampling technique: Stratified sampling has been used for data collection. However, their contribution to survey responses is subjected to availability.

- Sample size: Yamane (1967:886) provides a straightforward formula for calculating sample sizes. The sample size is determined utilizing the simultaneous equation:

  n = N/ (1+ N (e)2)

  Where n is the sample size, N denotes the population, and e represents the precision level.

  The sample size obtained when this formula is applied to the target as mentioned above population with a 95 per cent confidence level is

  $n = 500/(1+500*(0.05)^2) = 222$

3.8.2. Questionnaire development

Based on activities recorded with action mapping and brainstorming among the industry experts and stakeholders, the questionnaire is designed to seek response across the natural gas downstream value chain, i.e. the operator, equipment provider, supplier, customers, etc. A five-point Likert scale is used for the questionnaire ("1" as not strongly disagree to "5" as strongly agree) to collect the response for identifying critical financial and operational risks (Brown, 2010) (Vagias, 2006) (Perry, 1999). In this research, a simple categorization of risk is used, distinguishing between operational and financial risks. Operational risks are related to the operational objectives of the CGD projects and account for almost 90 per cent of the total risks (Krane, 2009). It includes supply chain issues, human resources, regulator approvals, health & safety and, consumer preference & customer base (Anirbid Sircar, 2017).

On the other hand, financial risk deals with the possibility of losing money on an investment made in the project, which includes credit and liquidity risk. Credit risk is the danger of borrowing money, whereas liquidity risks deal with funding issues, securities and assets (CARE, 2021). Respondents were required to give their opinion on the criticality of risks affecting the CGD business in India for each question. The data were analysed using factor analysis.

3.8.3. Pilot study

Before starting the formal data collection process through a questionnaire survey, a pilot study on 25 stakeholders, including CGD company officials, equipment makers, customers, and academicians. Before being sent out to a more extensive survey population, the questionnaire was vetted with stakeholders across the CGD value chain. The feedback collected aided in developing a more concise, direct, and relevant questionnaire to the goal. Following the pilot study, the final questionnaire was created, which consisted of two sections (financial risks and operational risks). The first part asked questions concerning critical financial issues affecting the CGD project, such as credit, liquidity, and taxation. The second component of the report focuses on identifying the CGD project's significant operational concerns. Customer satisfaction, health and safety, equipment manufacturers, procurement concerns, project management, and other risks are investigated.

3.8.4. Questionnaire survey administration

The questionnaire was distributed to public and private company executives, regulators, consultants, CGD service providers, and academia via an online survey platform, email, and conference participation to various midstream and downstream natural gas industry players. Data collecting was a time-limited task.

3.8.5. Research analytical tool used: factor analysis

Factor analysis was utilised in this study to break down many financial and operational risks into smaller ones. The tool used to conduct factor analysis is SPSS 26.

3.9. For Research Objective 2 (B)

To develop mitigation strategies for the identified financial and operational risks in RO2(A)

The methodology uses the Grounded Theory (GT) and SAP-LAP framework to achieve the end objectives. The result of objective 1 and objective 2(A) is used as input to achieve objective 2(B). The methodology is described in detail.

3.9.1. Research design

The research is exploratory and seeks to devise mitigation strategies for the identified risks under RO 2(A) using grounded theory research methodology.

3.9.2. Qualitative research approach

Qualitative research is an inquiry-based approach that explores a central phenomenon by asking participants general questions and collects data in the form of words and images (Creswell, 2004). The focus is on understanding the social environment through the analysis of data collected from the participants. The interpretive approach integrates human interest into a study and enables the researcher to understand and appreciate people's differences and opinions (Saunders, 2012). In this research, we focused on understanding the actual experiences of management professionals across levels involved in the RM process of CGD business.

3.9.3. The rationale behind the study

A qualitative approach is adopted in sampling, data collection and analysis to explore the experience of working professionals across the value chain in the context of RM in the CGD industry. The main advantages of this approach are:

- To examine the RM approach of CGD professionals from their perspective. It helped in the analysis as the study followed the GT approach. The researcher performed data collection and analysis simultaneously. Data collection was stopped after reaching saturation. Saturation in data indicates that further data collection would yield the same results and serve to endorse emerging themes (Fusch, 2015) (Saunders B. J., 2018). Thus, the theory is formed from the experience of the participants.

- The researcher maintained the uniqueness of the data. Each participant has a different experience in the CGD industry, depending on their exposure across business verticals.
- Given that the research problem is dealing with a niche industry, a qualitative approach allows much-required flexibility in methods and tools.
- Though the CGD industry is growing, the number of professionals working at senior and mid-management levels is limited, and extracting information was time-consuming. Data collection and analysis took place simultaneously which lasted for eight months.

3.9.4. Grounded Theory

Glazer and Strauss introduced GT in 1967, and it is characterised as "a technique of arriving at a theory suitable to its stated uses." (Charmaz, 2000) (B. G. Glaser, 1968). Straussian, Glaserian, and Constructive approaches to GT adoption are available. It is recommended that researchers select their GT methodology according to their cognitive style. (H. Heath, 2004). Also, it is crucial not to combine different GT approaches (J.C. Van Niekerk, 2009). The researcher has used a constructive technique suggested by Charmaz in this research. Charmaz underlined the importance of flexibility, stating that researchers must “learn to tolerate ambiguity” and be open to developing new categories and methodologies (Charmaz, Grounded theory as an emergent method, 2008).

The criteria on which the GT should be assessed are (B. G. Glaser, 1968):

- Fit: Conceptual codes and categories emerge from the data, Instead of using predetermined codes or categories from existing theory.
- Work: GT's ability to explain and analyse behaviour in a substantive domain, as well as anticipate future behaviour.
- Relevance: The focus of the theory is on a central process that arises in a substantive field. Its theoretical foundation in facts demonstrates the significance and importance of this main problem or process, assuring its continued applicability.
- Modifiability: The theory evolves when new evidence emerges, resulting in new categories, features, or dimensions. GT's living quality ensures its continued relevance and significance in the social reality from whence it arose.

An outline of the structure used in the research is provided in Figure 3.4.

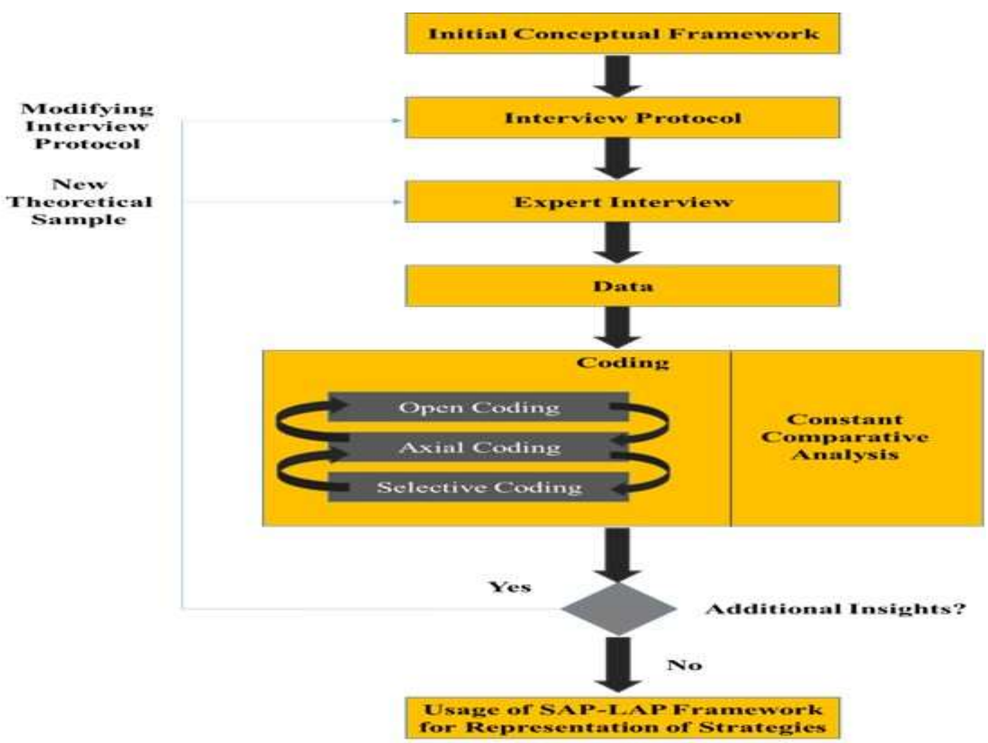


Figure 3.4: Research flow overview

Initial Conceptual Framework: To reduce the risk of preconceived theory in mind, the researcher started with an extensive literature analysis to understand the impact of risks on oil and gas projects. It allowed the researcher to create an early conceptual framework for developing interview protocols.

Interview Protocols: The development of interview protocols builds the fundamentals for the quality interview. In this research, the protocol was developed based on the findings of an initial conceptual framework. The goal of this strategy was to provide a procedure for developing mitigation solutions for the risk identified as a result of objective 2. (A).

Data Collection: A semi-structured interview is used to gather data comprised of open-ended questions seeking answers and recommendations for developing risk mitigation strategies. The CGD is in a nascent stage and has a small population of mid and senior-level management professionals. The researcher interviewed 10 CGD professionals before reaching saturation.

Data Analysis: Using the inputs received, data was collected, coded, and analysed simultaneously to find risk mitigation methods for the identified operating and financial risks. To analyse the given data, GT uses classification and conceptualization of data through systematic coding of units. "Coding gets the analyst off the empirical level by fracturing the data, then conceptually grouping it into codes that then become the theory that explains what is happening in the data. A code gives the researcher a condensed, abstract view with the scope of the data that includes otherwise seemingly disparate phenomena" (B. G. Glaser J. H., 2004). The goal of data conceptualization through coding is to establish a theory dependent on empirical evidence and then to develop a particular research theme based on data. As a result of this, "…an analyst reduces data from many cases into concepts and sets of relational statements that can be used to explain, in a general sense, what is going on. Rarely are these concepts or statements the exact word of one respondent or case (…). Usually, they represent the voices of many" (A. Strauss, 1998).

The researcher has utilized the accompanying itemized coding approach dependent on Strauss' GT rendition, which comprises three essential components: open coding, axial coding, and selective coding (A. Strauss, 1998).

- **Open Coding:** The procedure of separating data into distinct units of significance is known as open coding (Goulding, 1999). It occurs during the start of a research project. It happens during the beginning of a research project. Open coding's significant objectives are to conceptualize and mark data. The way toward arranging various wonders starts with open coding. Separate organised thoughts are assembled around a specific topic to manage more unique categories. The coding is 'unfocused' and 'open' during breaking down the data and looking for codes. The data breaks down during this process, and the GT researcher might see many codes with conceivable importance and pertinence (Goulding, 1999). The grounded scholar participates in open coding by separating, examining, looking at, naming, and sorting data. In open coding, occurrences or events are marked and gathered to create categories and properties through continuous examination (Babchuk, 1997).
- **Axial Coding:** The second degree of coding is axial coding. Unlike open coding, Axial coding reveals developing themes, refines, aligns, and arranges the ideas further. After finishing open coding and changing to axial coding, the acquired data can be set, cleaned, and ordered to make specific subject groupings in anticipation of selective coding. "Axial coding identifies relationships between open codes to develop core codes. Major (core) codes emerge as aggregates of the most closely interrelated (or overlapping) open codes for which supporting evidence is strong" (Strauss, 1998). Researchers must continuously analyse, cross-reference, and refine

topic categorization to attain the organising goal (Williams & Moser, 2019). Axial coding facilitates and advances effective content classification through three refining activities, which are:

- ✓ A detailed understanding of the data refinement and category formation analytic techniques is required.
- ✓ The constant comparison method is a method of data organisation and refinement. To make an educated research design, the researcher should know the function of the coding and related scientific exercises in axial coding, just like the other coding types. "Carrying process into the analysis is a significant piece of any grounded theory study" (Strauss, 1998).
- ✓ The third technique is "line-by-line" coding. Each written line of an interview or report is analyzed in line-by-line coding to safeguard the researcher's emphasis on the content. This methodology permits the researcher to connect profoundly with the text and recognize and classify subtleties just as explicit topical associations with different themes. “Researchers do not want to impose a pre-existing framework onto the data, but rather to let new themes emerge from it. According to (Charmaz K. , 2014), “through keeping ‘close to the data’ continuously sifting through themes, idea fragments and seemingly unrelated utterances, data categories can become thematically stabilized, defined and differentiated”. A "line by line" data analysis allows the researcher to remain diligent and, maybe, pedantically focused on detecting textual flaws. Nuances feed the construction of meaning.

In short, the relationships across themes are explicitly articulated, investigated, and categorised in axial coding. “If the development of theory rests heavily though not entirely on explanation and if explanation rests on how variables and their interrelatedness are empirically or logically established, then axial coding is the phase in which research begins to fulfil its theoretical promise" (Bengston, 2006).

- **Selective Coding:** Selective coding is the last phase of data analysis. The process by which categories are attached to the centre classification and at last become the reason for the GT is known as selective coding (Babchuk, The rediscovery of grounded theory: Strategies for qualitative research in adult education, 1997). Selective coding demonstrates the relationships between the identified vital categories. It establishes the theory by specifying the relationships between the primary classes generated from open and selective coding. The primary categories were integrated and developed to construct a more extensive theoretical structure. The research refined the codes and regrouped the relevant codes throughout this coding stage, determining which initial categories contribute to the fundamental idea. It involves deciding the research's main classification, which will build the theory. This central class exemplifies the research's chief subject and can be connected to the following significant categories. As a result of selective coding, the coding was limited to the core categories that led to the theory (A. Strauss, 1998) (Urquhart, 2012).

The focal point of the coding strategy moved from open coding to axial coding, in conclusion to selective coding, all through the research. The coding strategy, notwithstanding, is not a linear one. Maybe, it is an iterative technique dependent on consistent data correlation and analysis, which utilizes the three coding modes iteratively and much of the time simultaneously.

Following this, the SAP – LAP methodology is employed to develop mitigation strategies to address the financial and operational risks. SAP – LAP process is a holistic and flexible management approach that helps in building decision making structures. Many researchers use it in various situations in different conditions across industries such as automotive, information technology, supply chain, etc. (Majumdar & Gupta, 2001) (Mahajan, et al., 2013) (Arshinder & Deshmukh, 2007) (Palanisamy, 2012) (Thakkar, 2008). (Mangla, et al., 2014) utilized SAP-LAP structure to examine the danger mitigation methodologies in network design of green logistics. The SAP–LAP model covers the premise of flexible framework management: situation, actor, and process, as displayed in Figure 3.5.

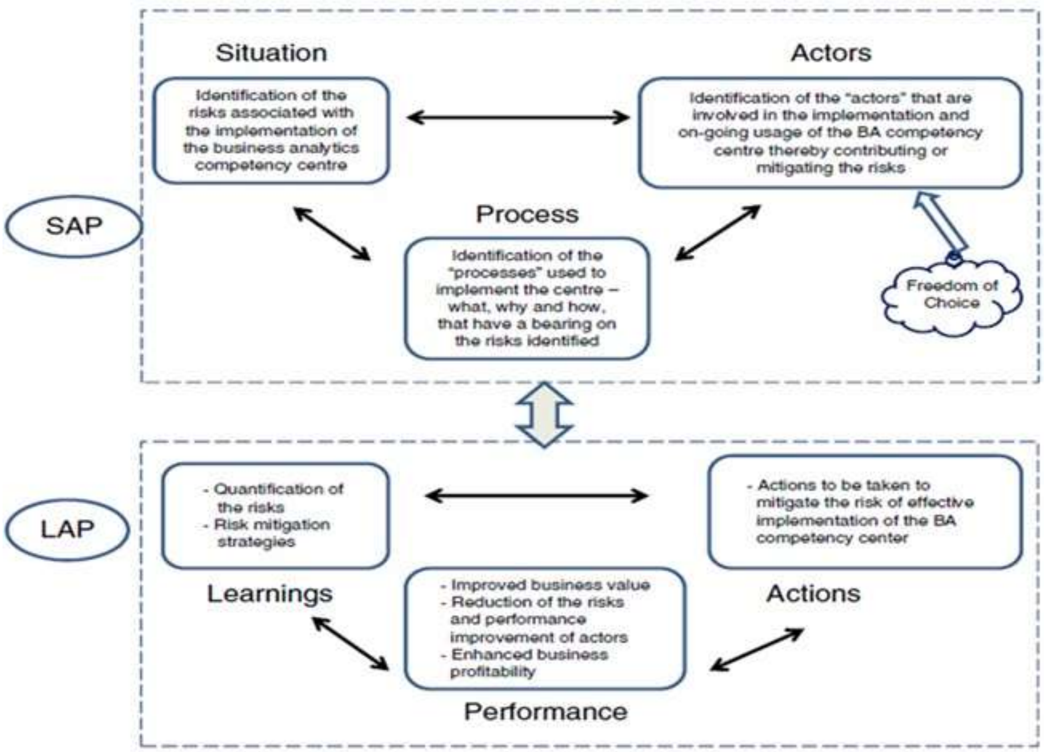


Figure 3.5: SAP-LAP framework; (Gangotra, 2016)

'Situation' addresses the condition to be managed, 'Actor' addresses the individual or part supporters connecting with the situation, and 'Process' connotes the makeover process to reproduce the situation. The following sensible advance to SAP analysis is LAP synthesis. LAP includes three parts learning, action, and performance. After learning about the actors' situations and processes, the management must take proper action on the situations, actors, and processes. Action viability prompts further developed process and actor performance and improved situational boundaries. Profitability, competitive strength, market dominance, quality, efficiency, and other company performance metrics could be used (Sushil, 2000a) (Sushil, 2001).

3.10. For Research Objective 2 (C)

To develop the risk mitigation approach for the mechanistic and organic management systems

The methodology uses the Grounded Theory (GT) to achieve the end objectives. The result of objective 2(B) is used as input to achieve objective 2(C). The methodology is described in detail.

3.10.1. Research design

The research suggests the risk mitigation approach and management style for implementing risk identified under RO 2(A) and subsequent mitigation strategies development under RO 2(B). The study is following GT to build a context-specific theory.

3.10.2. Qualitative research approach

Qualitative research is the systematic analysis of social processes in natural settings. These phenomena cover but are not limited to how people perceive aspects of their lives, how individuals and communities act, how businesses function, and how interactions shape partnerships. The researcher is the primary data gatherer in qualitative research. The researcher explores why things occur, what occurs, and what those things infer to individuals being analyzed (Bogdan, 2006) (Corbin, 2008). This research aims to learn about the actual experiences of mid and senior administration experts participating in the CGD business's RM process.

3.10.3. The rationale behind the study

A qualitative approach is adopted in sampling, data collection and analysis to identify the risk mitigation approach for risk identified in RO 2(A) and investigate how the implementation of collaborative RM based on contingency theory in the CGD projects is affected by mechanistic and organic management systems.

Burns and Stalker were crucial figures in the development of contingency theory (T. Burns, 1961). They looked at the conditions that allowed control-oriented and flexibility-oriented organisations to thrive. Following their footsteps, further investigations, notably at the company level, have supported their theory. The functions of control and flexibility in project management have also been investigated in a more recent study (Geraldi, 2008) (S. Lenfle, 2010) (W.D. Sine, 2006). However, there is still a lack of knowledge about the management style (mechanistic or organic) and the risk mitigation approach to implement risk mitigation strategies effectively. There are no ready-made solutions for how businesses can create the best possible mix. As a result, it's worth looking into how the level of standardization and flexibility in CGD projects affect Joint Risk Management (JRM). This study aims to provide a solution to this question by analysing the mitigation strategies introduced in RO 2B and recommending the best management style for the CGD company and the government to ensure the successful implementation of JRM.

3.10.4. Grounded Theory

Many of the procedures in GT are similar to those in other research methodologies. The stages in the GT are:

1. Asking research questions for the first time
2. Selection of data
3. Information gathering
4. Data analysis and interpretation

5. The research’s conclusion

The research method for every study should be directed by the research question and distinguished from other forms of an investigation by collecting and analyzing (Egan, 2002). Furthermore, it should be significant to the study and suit the investigator's requirements and abilities (Maxwell, 2005). According to (Maxwell, 2005), the research questions are “the heart, or hub, of the model; they connect all the other components of the design, and they should inform, and be sensitive to, these components.” The key advantages of GT incorporate its instinctive appeal, capacity to promote invention, conceptualization ability, and coordinated way to deal with data analysis and how researchers could use it to collect significant data (El Hussein, 2014). Figure 3.6 shows an overview of the study's framework.

Initial Conceptual Framework: The research was primarily based on a thorough examination of the literature on RM in oil and gas projects; the researcher developed an initial protocol for the questionnaire survey.

Interview Protocols: The development of survey protocols builds the fundamentals for the quality questionnaire. In this research, the protocol was developed based on the findings of an initial conceptual framework. The objective of this plan was to create a protocol for extracting the best possible data to construct a collaborative risk mitigation strategy for managing financial and operational risks associated with the CGD network.

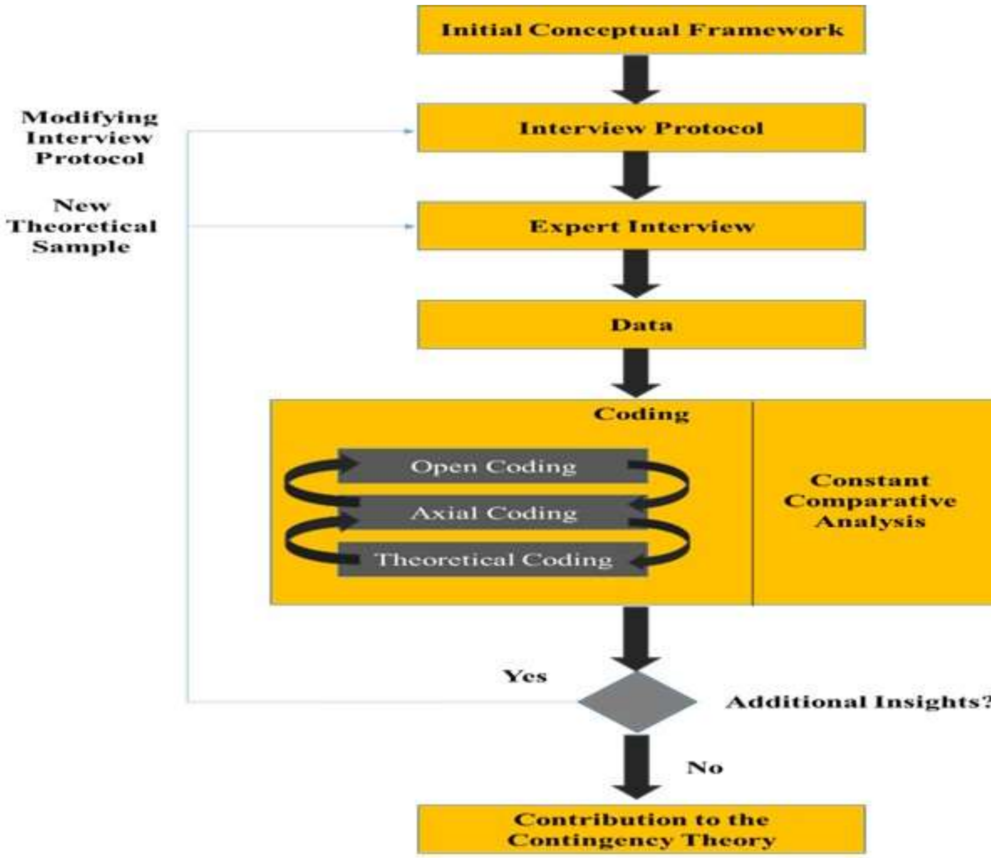


Figure 3.6: Research flow overview

Data Collection: A semi-structured interview is used to gather data comprised of open-ended questions seeking answers to identify mitigation approaches, management styles, nature of strategy and strategy implementation authority for the suggested mitigation strategies under RO 2(B). The CGD is in a nascent stage and has a small population of mid and senior-level management professionals. The researcher interviewed 10 CGD professionals before reaching saturation.

Data Analysis: Data were simultaneously collected, coded and analysed using inputs received to identify the best approach and management style for effective joint implementation of mitigation strategies.

Several theoretical codes arise in any GT-based research, but one is eventually chosen as the study's theoretical code after extensive coding and memoing. The relational model that ties all substantive codes or categories to the primary category is the theoretical code in GT research. “Substantive codes conceptualize the empirical substance of the area of research. Theoretical codes conceptualize how the substantive codes may relate to each other as hypotheses to be integrated into the theory” according to GT methodology (Glaser, 1978). Theoretical codes "weave the broken storey back together again" into "an organised entire theory" while substantive codes "break down" (fragment the facts) (Glaser, 1978) (Glaser B. , 1998). The other way of putting it is “Theoretical codes implicitly conceptualise how the codes of the substantive work will relate to each other as interrelated multivariate hypotheses in accounting for resolving the main concern” (Glaser B. , 1998). Theoretical codes should not be pre-planned; instead, they must "earn their way into the theory as much as substantive codes." (Glaser B. , 1998).

The theoretical coding result aligns with the five selection factors of the contingency theory. Further, it highlighted the importance of managing the balance between mechanistic and organic approaches for the successful implementation of JRM.

3.11. Concluding remark

Research objectives and research questions formulation based on the problem statement have been presented in this chapter. This research study logically discusses by explaining the philosophical assumptions, scientific paradigms, scientific approach, research method and research study. Further data collection methods have been discussed in this chapter. Data was collected through questionnaires and semi-structured interviews. Methods used to ensure the quality of research is described in detail using sample adequacy test, test reliability and provide stability.

CHAPTER 4

Data Analysis And Findings

The analysis of data obtained to achieve study aims and outcomes is discussed in this chapter. This chapter aims to answer the two questions posed by the research objectives: estimating natural gas demand and CNG in the Eastern corridor region and reducing the operational and financial risks involved with the expansion of the CGD network in India's Eastern corridor states. The research objectives are achieved after analysing data utilising ECM, factor analysis, and the Grounded Theory technique. The result and the findings for both goals are explored in depth.

Research Question 1: What are the estimated untapped demand for natural gas and CNG in India's Eastern corridor states?

Research Objective 1: To estimate untapped demand for natural gas and CNG for the Eastern corridor states of India.

4.1. Demand estimation for India

Two models are used for estimating India's natural gas demand: one with total GDP as the explanatory variable (Model A) and another with population and GDP per capita as the explanatory variables (Model B). Natural gas prices and lagged consumption are standard variables in both models. The researcher employed model fit diagnostics including adjusted R2, Serial Correlation LM test, Akaike Information Criteria (AIC), VIF, TOL, Residuals Normality Test, and Heteroscedasticity test to find the optimal model.

The assumption behind time-series regression analysis is that the series under study must be stationary. The unit root test is used to determine whether the variables under consideration are stationary. Table 4.1 displays the outcomes of the unit root test.

Table 4.1: Result of unit root test

Variables	Augmented Dickey-Fuller Test		Phillips-Perron Test	
	At Level	First Difference	At Level	First Difference
LTGASON	-2.4741 (0.1284)	-4.7472 (0.0004) *	-2.4741 (0.1284)	-4.7354 (0.0004) *
LPRICE	-2.2212 (0.2018)	-5.9822 (0.0000) *	-2.2401 (0.1955)	-5.9635 (0.0000) *
LGDP	-0.1485 (0.9374)	-6.1236 (0.0000) *	-0.1884 (0.9324)	-6.1436 (0.0000) *
LGDPP	0.1091 (0.9630)	-6.0803 (0.0000) *	0.0215 (0.9555)	-6.1035 (0.0000) *
LPOPULATION	1.2402 (0.9999)	-3.7104 (0.0341)**	6.1738 (1.000)	-2.9040 (0.1712)
LPGASCON	-1.6897 (0.4292)	-5.7387 (0.0000) *	-1.7201 (0.4145)	-5.1491 (0.0001) *
LCGDGASCON	-1.1980 (0.6459)	-7.6878 (0.0000) *	-1.4857 (0.5147)	-12.5847 (0.0000) *
LFGASCON	-2.2876 (0.1802)	-6.1931 (0.0000)*	-2.3158 (0.1715)	-6.2270 (0.0000) *

Source: Author's Analysis; p-value is given in parenthesis, * significant at 1%; ** significant at 5%

The stationarity results are shown in the table above, indicating that the non-stationarity of the variables has been rejected. According to the unit root test, the factors become stationary after the first difference.

Table 4.2: Result of co-integration test

Parameters Estimates	National Demand		CGD Demand	
	Model A	Model B	Model A	Model B
LTGASCON (-1)	0.9475 (0.0000)*	0.9514 (0.0000) *		
LPRICE	0.0143 (0.5893)	0.0336 (0.2740)	2.8001 (0.1168)	1.7139 (0.3210)
LGDP	0.0309 (0.0061)*		-0.5071 (0.2526)	
LGDPP		-0.0484 (0.3819)		2.8158 (0.1369)
LPOPULATION		0.1338 (0.0054)**		-2.7345 (0.0799)
LCGDGASCON (-1)			0.3409 (0.2034)	-0.0301 (0.9252)
H_O: δ=0	-5.0763 (0.0001)*	-5.3146 (0.0001)*	-5.1944 (0.0015)*	-4.4394 (0.0041)*

Source: Author's Analysis; p-value is given in parenthesis, * significant at 1%; ** significant at 5%

The estimation approach for the ECM was carried out using the Engle-Granger method. It's a two-part procedure. The variables are non-stationary at levels but integrated of order I in the first step; hence ordinary least square (OLS) is used (1). The long-run cointegration of the variables is implied by the stationarity of the residuals of the calculated regression equation. In the second stage, the error correction model (Engle-Granger, 1987, pp. 251-276) is used to convert the short-run behaviour of the dependent factors to their long-run value using the residual from the estimated equation. Table 4.2 shows the result of the estimated regression equation and residual stationarity. The results show that the estimated equation's error term is stationary, indicating that the variables are cointegrated or have a long-term or equilibrium relationship.

To estimate India's natural gas demand, we built two competing models. As a result, natural gas demand for the CGD sector is estimated. Price, GDP, and the lag value of an explained variable are among the explanatory variables in Model A. Model B contains price, GDP per capita, population, and the defined variable's lag value. The researcher emphasises the importance of adjusted R2 and AIC criteria in selecting a suitable model. Furthermore, the chosen model must meet multicollinearity, serial correlation, heteroscedasticity, and residual normality.

Table 4.3: Result of ECM for national natural gas demand estimation

Parameter Estimates	National Gas Demand			
	Model A		Model B	
	DV= D(LTGASCON)	VIF	DV= D(LTGASCON)	VIF
D(LTGASCON (-1))	1.0958 (0.0000)	3.7852	1.1071 (0.0779)	31.5964
D(LPRICE)	-0.0266 (0.6143)	1.135	-0.0148 (0.7787)	1.1339
D(LGDP)	-0.0782 (0.6979)	1.8525		
D(LGDPP)			-0.08581 (0.6846)	1.5982
D(LPOPULATION)			-0.2541 (0.9427)	17.0866
U(-1)	-0.9215 (0.0014)	3.1393	-0.9591 (0.1326)	16.2784
Ad. R^2	0.1323		0.1286	
AIC	-1.5293		-1.5049	
Serial Correlation LM Test (H_0: ρ=0)	1.1002 (0.5769)		0.2002 (0.9047)	
Heteroskedasticity Test (H_0:α=0)	6.5608 (0.1610)		7.1048 (0.2130)	
Jarque-Bera Test	4.7847 (0.0914)		8.5619 (0.0138)	

Source: Author’s Analysis; p-value is given in parenthesis, * significant at 1%; ** significant at 5%

Model A meets all of the model fit requirements for projecting total gas demand in the country. Multicollinearity, heteroscedasticity, and serial correlation are not present in Model A. The p-value of the Jarque-Bera test in Table 4.3 shows that the residual in Model A is normally distributed. The dependent variable's first lag is the only statistically significant variable, indicating a long-term impact on national gas consumption. The coefficient of error correction term is -0.92, implying that around 92 per cent of the gap between long-term and short-term national gas demand is corrected yearly. The Cusum test in Figure 4.1 shows that both Model A and Model B meet the criterion for stability (a).

Table 4.4: Result of ECM for estimation CGD demand

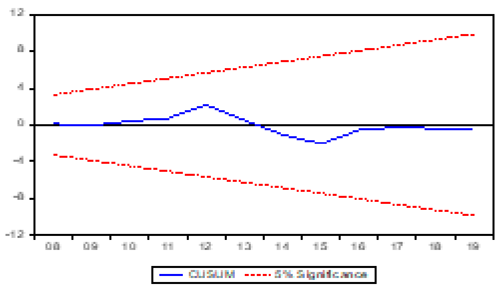
Parameter Estimates	CGD Demand			
	Model A		Model B	
	DV= D(LCGDGASCON)	VIF	DV= D(LCGDGASCON)	VIF
D(LCGDGASCON (-1))	0.2637 (0.5531)	4.394	-0.1450 (0.6167)	2.576
D(LPRICE)	2.5085 (0.2430)	1.681	1.2981 (0.4169)	1.32
D(LGDP)	-2.0541 (0.5514)	1.73		
D(LGDPP)			-7.1648 (0.1667)	4.094
D(LPOPULATION)			71.1713 (0.0915)	3.769
U(-1)	-1.1926 (0.0407)	3.86	-0.6866 (0.1425)	2.983
Ad. R^2	0.3729		0.546	
AIC	3.543		3.258	
Serial Correlation LM Test (H_0: $\rho=0$)	1.5324 (0.4648)		1.7245 (0.4222)	
Heteroskedasticity Test (H_O:$\alpha=0$)	2.9399 (0.5679)		4.2265 (0.5173)	
Jarque-Bera Test	0.7056 (0.7027)		0.5713 (0.7514)	

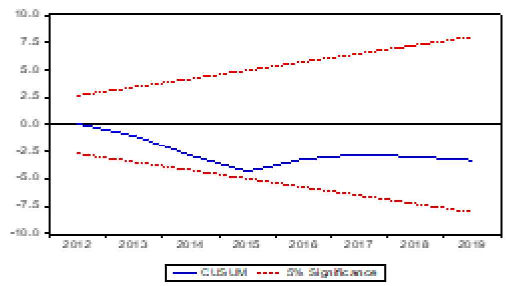
Source: Author's Analysis; p-value is given in parenthesis, * significant at 1%; ** significant at 5%

The results of both models reveal that multicollinearity, serial correlation, and heteroscedasticity are absent in CGD, as shown in Table 4.4. Furthermore, a p-value of the Jarque-Bera test reveals that residuals in both models are normally distributed. However, The researcher selected Model A because the Cusum test in Figure 4.1 (B) indicates that Model B is unstable.

A) National Demand

Model 1 Model 2

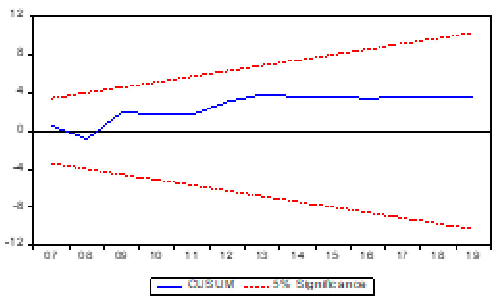




B) CGD Demand

Model 1

Model 2



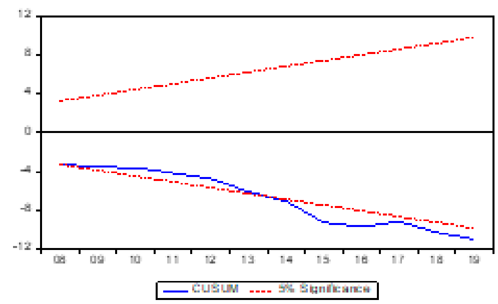
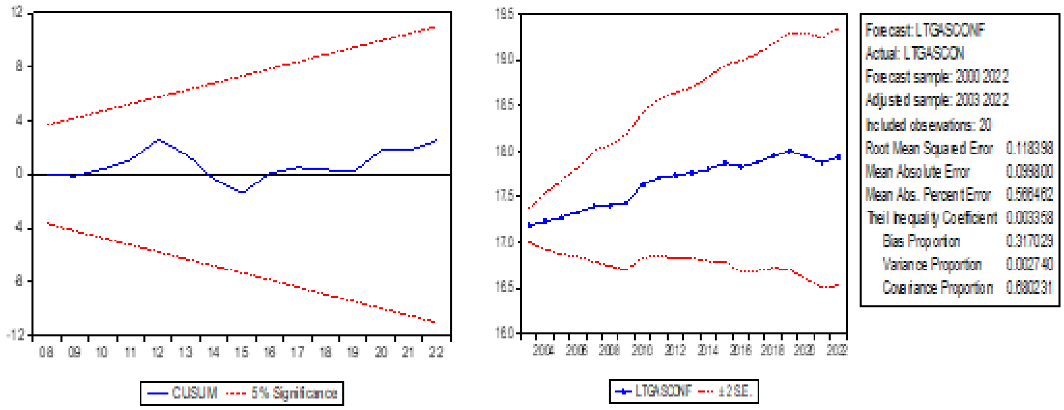


Figure 4.1: Model stability for national natural gas demand estimation

4.1.1. Natural gas demand forecast and model stability

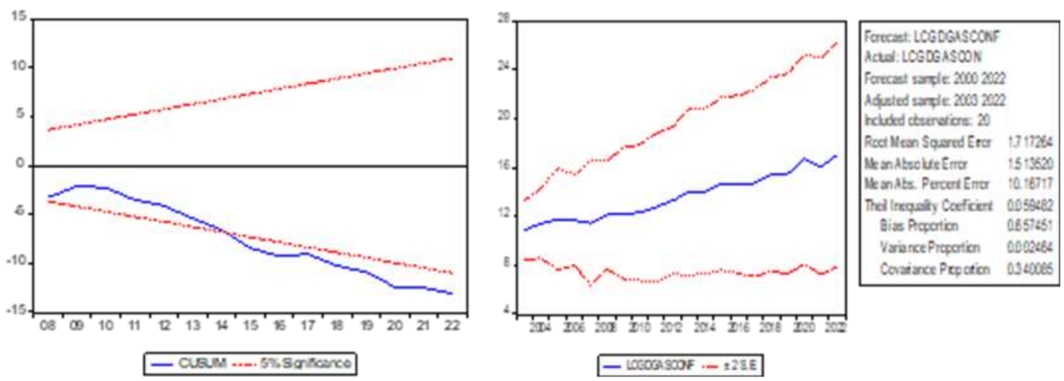
The primary objective is to forecast natural gas demand at India's national and CGD levels until 2022. The dynamic econometric model shows an association between the GDP and natural gas demand. We have used the projected GDP from the world bank and natural gas price data from Petroleum Planning and Analysis Cell (PPAC) for forecasting. Model A is considered for national natural gas demand estimation as it meets all of the requirements for forecasting. The results reveal that Model A remains stable and robust during the forecasting period, as shown in Figure 4.2(A). The forecast demand shows subdued growth due to price inelasticity of demand. It could be because of price-sensitive consumers and dependence on high priced LNG imports.

A) National Demand



Model Stability Forecast (2022)

B) CGD Demand



Model Stability Forecast (2022)

Figure 4.2: Model stability for natural gas demand forecasting

Model A is considered for estimating natural gas demand for the CGD industry. The results reveal that Model A is unstable during the forecasting period, as shown in Figure 4.2(B). However, the forecast demand shows robust growth due to the price elasticity of demand. It could be because of the CGD network expansion, leading to the growing demand for CNG in the transportation sector.

4.1.2. CNG demand forecast and model stability

Andhra Pradesh and West Bengal are the only two states in the eastern corridor of India which have seen reasonable CNG sales. Orissa introduced CNG in FY18, and there is no CNG station found operating in the data period.

Three companies are operating in Andhra Pradesh. The first company to start CGD operations is Bhagyanagar Gas Limited (BGL). The company was established in 2003 and operates in three cities (Hyderabad, Vijaywada, and Kakinada). The company has 126 CNG stations, 2.5 lakh PNG and 256 commercial and industrial consumers on 31st March 2021. Great Eastern Energy Corporation Limited is the only company selling CNG in West Bengal.

Table 4.5: HP filter result for CNG demand estimation in the eastern corridor

Year	Andhra Pradesh	West Bengal*
2007	1.5	-
2008	5.8	-
2009	6.1	-
2010	7.8	-
2011	11.9	-
2012	15.8	-
2013	24.7	0.6
2014	24.6	1.2
2015	25.8	1.2
2016	27.5	1.4

2017	28.5	1.6
2018	31.7	2.0
2019	30.9	2.5

Source: MoPNG *CNG operation started in 2013

The HP filter based forecasting

The HP filter is used with λ=100 to estimate the CNG demand trend for both the states, as shown in Figure 4.3. The HP filter is applied to the time series shown in Table 4.5.

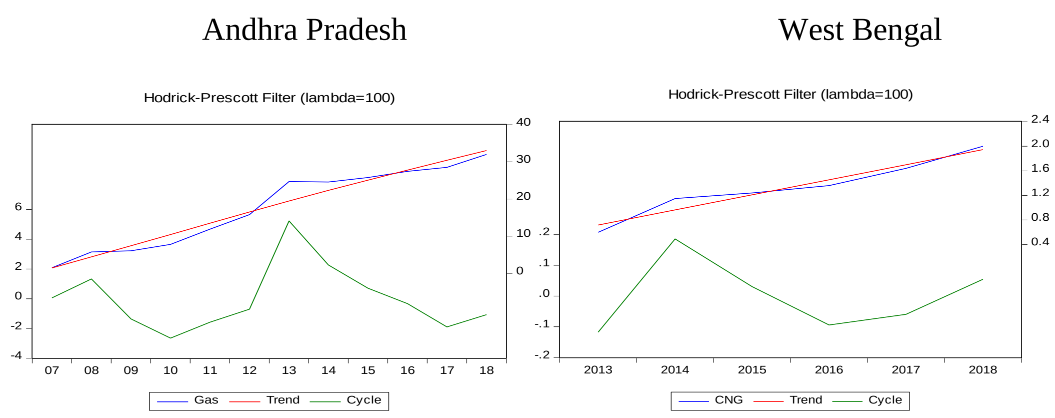


Figure 4.3: HP filter model stability

It is evident from the graph that CNG demand has followed a linear trend in both states, indicating that CNG demand is expected to surge with the expansion of the retail network. Moreover, the result indicates that there is untapped demand for CNG in the eastern corridor states of India, which will realize with the development of supporting infrastructure in future.

4.1.3. Findings

Since these variables are in logarithms, the estimated parameters show the long- and short-run elasticities of national natural gas demand to the variables investigated. Normal good demand has a negative association with price, according to economic theory. Demand (Model A) in the projected model for national natural gas shows price inelasticity of demand during the long term. In the short run, however, the price elasticity of demand is elastic. However, the projected value of the coefficient is statistically insignificant in both cases. It could be due to low natural gas prices, making customers less sensitive to price changes. The term "price inelasticity of demand" refers to a situation in which changes in product demand are always less than changes in the commodity's price.

Given the Indian government's desire to raise the share of clean energy in the country's primary energy, natural gas is expected to become a crucial fuel in the mix. Because of the long-run price inelasticity, natural gas will develop itself as a preferable fuel in the Indian energy market with the least price fluctuation. In the long run, pipeline network expansion will drive natural gas demand in India from the residential, commercial, industrial, and transportation sectors. The residential demand will come from households that use natural gas for cooking purposes. Commercial customers use natural gas for cooking and cooling purposes. Both customers have limited fuel-switching skills and rarely react to short- and long-term changes in gas prices. Natural gas is a high-quality fuel used across steel, refinery, petrochemical, heat production etc. In India, natural gas prices are formula-driven and regulated by the government. Low prices motivate companies to replace coal with natural gas while maintaining operational costs in the short run. Low pricing will cause market distortions and prevent the natural gas market from reaching equilibrium in the long run. As a result, a rise in gas prices is a viable alternative for achieving long-run equilibrium in the natural gas market, as demand is price inelastic.

In the transportation sector, a surge in natural gas prices will reduce demand in the short term nevertheless will not affect the long-term demand. The CGD expansion is expected to increase demand for CNG due to a surge in demand for natural gas vehicles in the country. Natural gas vehicles have a cheaper fuel cost than gasoline and diesel automobiles (H.X. Wang, 2015) (H. Hao, 2016). The growing acceptance of dual-fuel cars makes natural gas demand price elasticity flexible in the short and long term. In brief, long-run price inelasticity benefits the natural gas industry because the change in the quantity needed is always less than the price change, resulting in a rise in business revenue for stakeholders. Knowing the price elasticity of demand helps understand the effects of taxation and opening the local natural gas market to international trade (Burke, 2016). Implementing the carbon tax on substitute fuels would encourage people to switch over to natural gas in the short run. To keep pace with the rising demand, India needs to ensure natural gas security by boosting domestic production, importing LNG and building transnational pipelines. However, the presence of multiple natural gas pricing mechanisms has been restricting the gas market development in India. For long-term natural gas market development, the government should build a natural gas trading hub to stimulate gas-to-gas competition and ensure market-based gas pricing.

On the other hand, income elasticity of demand is a change in demand in reaction to a change in income. In the long term, the income elasticity of gas demand is positively inelastic and statistically significant. The only statistically significant value in the short and long term is last year's gas usage. Because of its high elasticity, it is more effective in the short term. It indicates that consumers' expenses will increase with the rise in natural gas demand. Thus, the government should promote domestic appliance and equipment manufacturing industries to lower switching costs and increase natural gas demand. Similarly, developing a skilled workforce will ensure quality services to enhance customer experience, adhere to HSE guidelines, and deliver value for money. Providing a tax exemption on CNG vehicles, a subsidy on natural gas-based appliances, or a reduction in pipeline tariffs would help lower end-user costs and meet long-term natural gas demand.

The researcher could not find any model specifications that suit the data for the CGD sector and the eastern corridor states. It is not unusual, given that the industry is still in its infancy in the country. Even though several licencing rounds for CGD network development have been undertaken, natural gas demand creation will take time due to the long gestation period and low population coverage. Interestingly, the CNG demand in Andhra Pradesh and West Bengal shows an increasing long-term trend per HP filter. The demand could be realized in future with the expected expansion of the CGD network along the easter-coast of India as PNGRB has awarded licenses for network development of 44 GAs through various bidding rounds (PNGRBd, 2020).

Research Question 2: What are the mitigation strategies to reduce the operational and financial risks connected with developing the CGD network in India's Eastern corridor?

Research Objective 2: The researcher has followed a three-pronged approach to achieve the objective. In the next 7-8 years, the Indian government has mandated CNG businesses to build 10,000 CNG stations and 50 million PNG connections (Bureau, 2021). The delay in CGD projects may affect the government vision of increasing natural gas share to 15 per cent by 2030. As a result, identifying and mitigating the critical risks affecting the CGD project in the country is crucial. Part A of the second objective focuses on identifying significant financial and operational risks that could cause CGD projects to be delayed. Part B focuses on developing the mitigation strategies for the risk identified in Part A. In contrast, Part C uses Part B results as input to find an appropriate mitigation approach and suggest the right management style for implementing risk mitigation strategy while contributing to the underpinning contingency theory.

RO 2(A): To identify financial and operational risks factors associated with the CGD project.

4.2. Preliminary analysis

The factor analysis is performed sepratetly on risk factors to identify the operational and financial risks related to the CGD network. This study utilized the Kaiser-Meyer Olkin (KMO) and Bartlett's test of sphericity to analyze the suitability of factor analysis. The KMO and Bartlett's test results met the criteria (KMO>0.5, Significance level >0.05) and suggested that the sample adequacy and factor analysis were valid (Field, 2018), as displayed in Table 4.6

Table 4.6: KMO and Barlett's test

		Operational	Financial
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.647	0.715
Bartlett's Test of Sphericity	Approx. Chi-Square	389.673	324.228
	Df	78	55
	Sig.	0	0

4.2.1. Factor extraction

Factor loading is defined as the correlations between variables and the factor (Paul, 1996). Critical factors and variables are those that have a high factor loading. (Guadagnoli, 1988) discovered that factors with four or more loadings greater than 0.6 are reliable irrespective of sample volume. Factors with ten or more loadings higher than 0.40 are reliable if the sample size is more than 150. Factors with a couple of low loadings should not be deciphered except if the sample size is at least 300. The researcher meets the requirements in both situations in the current investigation since the data had four or more loadings bigger than 0.6. Both the associated eigenvalues and the variance % were utilized to decide the number of factors. The factors with eigenvalues greater than one were retrieved in both cases representing around 60 per cent of the total variance (Center, 2020).

Table 4.7: Total variance explained for operational factors

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.658	20.445	20.445	2.658	20.445	20.445
2	1.576	12.122	32.567	1.576	12.122	32.567
3	1.319	10.148	42.715	1.319	10.148	42.715
4	1.163	8.946	51.661			
5	1.131	8.698	60.359			
6	.985	7.579	67.938			
7	.841	6.470	74.408			
8	.686	5.279	79.687			
9	.617	4.744	84.431			
10	.591	4.548	88.980			
11	.544	4.185	93.165			
12	.460	3.537	96.702			
13	.429	3.298	100.000			

Table 4.8: Total variance explained for financial factors

Component	Initial Eigenvalues	Extraction Sums of Squared Loadings

	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.659	24.172	24.172	2.659	24.172	24.172
2	1.523	13.841	38.013	1.523	13.841	38.013
3	1.140	10.360	48.373			
4	1.044	9.487	57.860			
5	.906	8.236	66.096			
6	.771	7.007	73.103			
7	.757	6.878	79.981			
8	.660	5.996	85.977			
9	.622	5.655	91.631			
10	.482	4.381	96.012			
11	.439	3.988	100.000			

4.2.2. Factor rotation

After factor rotation, the bulk of variables are loaded onto a single factor, and the number of variables that require explanation is reduced (Paul, 1996). There are two types of factor rotation techniques: orthogonal (Varimax, Quartimax, and Equamax) and oblique (Direct Oblimin and Promax). Varimax is the recommended approach in Orthogonal Rotation because it simplifies factor interpretation. The elements in this strategy are uncorrelated. Oblique Rotation methods are more complicated because they allow for correlation between the variables. Direct Oblimin is the most popular option in this case (Field, 2018). Because the results of oblique rotation revealed a negligible connection between the retrieved elements, in both situations (financial and operational), orthogonal rotation (varimax) was chosen.

Table 4.9: Rotated component matrix for operational factors

	Component		
	1	2	3
Skilled Workforce	.733		
Managing customers	.609		
Managers	.575		
Franchise	.489		
Lack of Facilities	.452		
Vehicle Filling			
Project Execution		.734	
Equipment & Appliances		.657	
Construction obstrtcution		.651	.408
OEM		.483	
Underground leaks			.760
Quality			.724
Environment			.497

Table 4.10: Rotatetd component matrix for financial factors

	Component	
	1	2
Interest Rate	.687	

Land Acquisition	.677	
Currency Exchange	.631	
Pay Back	.546	
Funding	.519	
Tax Burden		
Custom duties		.782
Liquidity		.740
Procurement cost		.615
Insufficient cash flow		.406
Take or Pay		

As stated in Table 4.11, eight variables out of eleven financial variables were considered in two factors, and twelve out of thirteen operational variables were studied in three factors. Tax rates, take-or-pay contracts, and insufficient cash flow are three elements that were not included in the financial risk factors. On the other hand, only one variable, vehicle filling time, was not included in any operational risk factor.

4.2.3. Reliability test

A measure's reliability refers to its capacity to deliver consistent results under varying settings. It is necessary to assess data reliability to comprehend the link between distinct data elements (Ghosh & Jintanapakanont, 2004). Cronbach alpha (α) is the most often used scale reliability metric. Factor reliability was assessed in this study by computing Cronbach alpha for all components in both situations.

The Cronbach Alpha values, which range from 0.538 to 0.649, are listed in Table 4.7. The current literature suggests that varied acceptable Cronbach Alpha values are acceptable depending on the nature of the researcher's study. (Kline, The handbook of psychological testing, 1999) referenced that the accepted value of 0.8 is adequate for cognitive tests, for example, intelligence tests, but a cut-off point of 0.7 is more appropriate for ability tests. In the early rounds of research, (Nunnally, 1978) suggested that values as low as 0.5 were sufficient.

Table 4.11: Crtical financial and operational risks affecting teh CGD business

<table>
<tr><th>Factor</th><th>Factor Interpretation</th><th>Variable</th><th>Factor</th><th>Cronbach</th></tr>
<tr><td rowspan="5">F1</td><td rowspan="5">Credit Risk</td><td>Interest Rate</td><td>0.687</td><td rowspan="5">0.64</td></tr>
<tr><td>Land Acquisition</td><td>0.677</td></tr>
<tr><td>Currency Exchange</td><td>0.631</td></tr>
<tr><td>Pay Back Period</td><td>0.546</td></tr>
<tr><td>Raising Project Funding</td><td>0.519</td></tr>
<tr><td rowspan="3">F2</td><td rowspan="3">Working Capital Risk</td><td>Custom Duties</td><td>0.782</td><td rowspan="3">0.649</td></tr>
<tr><td>Managing Liquidity</td><td>0.74</td></tr>
<tr><td>Procurement Cost</td><td>0.615</td></tr>
<tr><td rowspan="5">O1</td><td rowspan="5">Customer Relationship Management</td><td>Lack of Skilled Workforce</td><td>0.733</td><td rowspan="5">0.55</td></tr>
<tr><td>Managing Customers</td><td>0.609</td></tr>
<tr><td>Difficulty in localizing Managers</td><td>0.575</td></tr>
<tr><td>Franchise Training</td><td>0.489</td></tr>
<tr><td>Lack of Facilities</td><td>0.452</td></tr>
<tr><td rowspan="4">O2</td><td rowspan="4">Project Management</td><td>Project Execution</td><td>0.734</td><td rowspan="4">0.578</td></tr>
<tr><td>Low penetration of gas-based equipment & appliances</td><td>0.657</td></tr>
<tr><td>Construction Obstruction</td><td>0.651</td></tr>
<tr><td>Limited Original Equipment Manufacturers (OEMs) for CNG Kit</td><td>0.483</td></tr>
<tr><td rowspan="3">O3</td><td rowspan="3">Health, Safety and Environment</td><td>Locating underground leaks and pipe</td><td>0.76</td><td rowspan="3">0.538</td></tr>
<tr><td>Difficulty in quality control</td><td>0.724</td></tr>
<tr><td>Absence of Stricter Environment Regulations</td><td>0.497</td></tr>
</table>

Furthermore, a high Cronbach alpha score implies a high degree of correlation among the variables due to the questionnaire's inclusion of repetitive questions.

(Field, 2018) I discovered that increasing the items on the non-reliable scale can result in a high Cronbach alpha rating. Low Cronbach alpha is acceptable for factor analysis because this study has limited variables and low interrelatedness among the survey questions (Tavakol & Dennick, 2011).

4.2.4. Content validity and construct validation

The degree to which an assessment tool is relevant to the intended construct is determined by content validity, which is a prerequisite to criteria validity (Rusticus, 2014). Domain definition, representation, and relevance are the three critical elements of content validity (Sireci, 1998). It can be assessed subjectively by the researcher (Yusof SM, 2000). The survey questionnaire in this study is dependent on an exhaustive literature review and the assessments of subject matter experts.

Construct validity, on the other hand, refers to how well questionnaires assess the hypothesis. Pearson Product Moment Correlations were performed using SPSS to test the questionnaire's validity. The coefficients of correlation between questions and result variables range from 0.31 to 0.56 (all $p<0.05$), indicating that the questionnaire is valid (Baer, 2008).

4.2.5. Interpretation of risk factor

Factor 1 – Credit risk: The factor had a Cronbach Alpha of 0.640. The substantial loading of this component was indicated by five variables: interest rate, land acquisition, currency exchange, payback term, and project funding. The interest rate has the most significant loading factor (0.69), followed by land acquisition (0.68). The rating backs up the conclusion since stakeholders see high land acquisition costs and a long payback period as essential concerns. Once the licence for the GA is granted, the landowner demands a substantial premium on land prices. It raises the capital cost again. Furthermore, enterprises operating in smaller GAs with fewer people, fewer CNG vehicles, and fewer industrial operations are more likely to have low gas volume use and, as a result, a more extended payback period.

Factor 2 – Working capital risk: The factor had a Cronbach Alpha of 0.649. Customs duties, liquidity management, and procurement cost are three variables that significantly contributed to this factor's significant loading. Custom duties have the largest loading factor (0.78) of all the factors, followed by managing liquidity (0.74) and procurement cost (0.61).

Factor 3 – Customer relationship management (CRM): The factor has a Cronbach Alpha of 0.550. The extensive loading of this component was reflected by five variables: a lack of qualified staff, customer management, difficulties in locating managers, franchise training, and a lack of facilities. The most significant loading factor (0.73) is for lack of skilled labour, followed by customer management (0.61). Notably, both variables were among the top five operational hazards, with a shortage of skilled labour taking the top spot.

Factor 4 – Project management: The factor had a Cronbach Alpha of 0.578. Project execution, poor penetration of gas-based equipment and appliances, construction blockage, and limited Original Equipment Manufacturers (OEMs) for CNG Kits are four variables that contributed significantly to this factor's extensive loading. Project execution has the highest loading factor of all the variables (0.73).

Factor 5 – Health, Safety and Environment (HSE): The factor had a Cronbach Alpha of 0.538. Three variables reflected the significant loading of this element: detecting subsurface leaks and pipes, problems in quality control, and the lack of more onerous environmental regulations. Among all the variables, finding underground leaks and pipes has the highest loading factor (0.76), followed by difficulty in quality control (0.724). Notably, the lowest loading factor was found for the absence of greater environmental control (0.49).

RO 2(B): To develop mitigation strategies for the risks identified in RO 2(A).

Both academics and practitioners emphasise the importance of the construction sector. The oil and gas business is notable among these enterprises for various reasons, including the complexity of the construction process, strict time schedules, fines for project delays, complex supply chains, and so on.

4.3. Grounded theory-based analytical process

To develop the mitigation strategies for the identified risks in RO 2(A), the researcher has performed the following steps:

A) Conducted semi-structured interviews with the industry experts
B) Analyzed the transcript using Grounded Theory classification and codes
C) Implemented SAP-LAP framework to identify the actors and decide actions to reduce the risks associated with different business processes.

The mid and senior management professionals population is limited as Indian CGD industry is still in a growing phase. The researcher developed a list of 43 industry professionals to seek their inputs on developing mitigation strategies. However, the researcher achieved data saturation after conducting ten semi-structured interviews comprised of open-ended questions. The term “data saturation” in Grounded Theory is used to describe “theoretical saturation” (Tay, 2014). According to (Morse, 2004) “the phase of qualitative data analysis in which the researcher has continued sampling and analyzing data until no new data appear and all concepts of the theory are well developed....and their linkages to other concepts are clearly described" (p. 1123). Thus data collection could cease This concept was put forth by Glaser and Strauss (1999) "as a specific element of the constant comparison [analysis method]”. As a result, it was anticipated that data gathering would not need to continue because no new parallels or differences could be found.

Following this, the collected data was analyzed using Grounded Theory methodology. The analysis can iterate between the primary data and the emerging theoretical framework due to several stages of coding (open, axial, and selective). One of the most crucial aspects of coding is that the codes must suit the data, not the other way around. According to (Kendall, 1999),” "codes and categories are not selected before data analysis, and they are often labelled from words found in the data themselves". These codes are known as in vivo codes (Strauss A. C., 1998). The analytical process of Grounded Theory is shown in Figure 4.4. For illustration purposes, the analytical process above portrays a linear progression from 'left' to 'right' via the coding process.

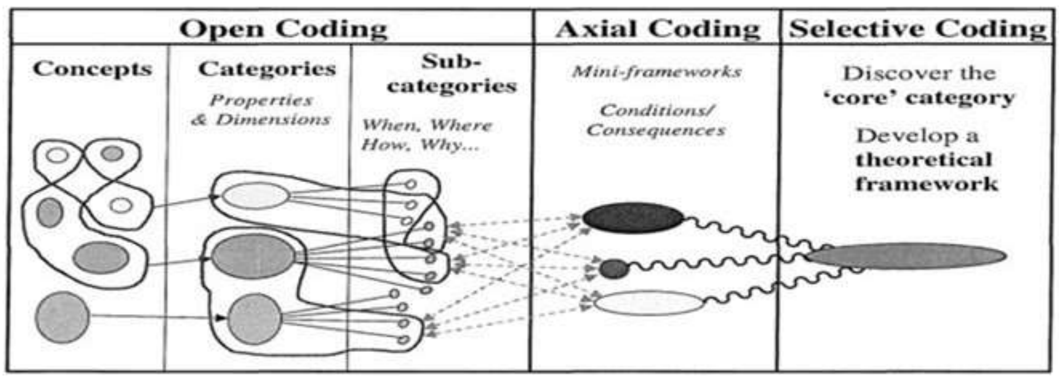


Figure 4.4: Grounded theory analytical process

Several proprietary software tools are available to aid the researcher in the coding process, such as Ethnograph and Atlas.ti, NUD*IST, and NVivo. While each package's 'user interface' differs, they all support data coding, memo storing, filters, keyword searches, standard document management, and assistance in an 'audit trail' by connecting codes and concepts to the underlying data. On the other hand, the packages will not construct codes, create categories, determine dimensions, or conceptualise or establish theories. The researcher has used NVivo 12 to analyze the interview transcripts and generate codes and memos to develop risk mitigation strategies.

4.3.1. Risk mitigation strategies

The researcher has discovered mitigation strategies for operational and financial risks affecting CGD projects in India through study.

1. **CRM:** In a world of increasing competition, achieving customer expectations is not just crucial but essential to any industry's success. The CGD industry, which is a customer-oriented industry, is no exception. CRM aids in prospect profiling, identifying requirements, and creating customer connections by offering them the most appropriate products and improved service (Dyche, 2002).

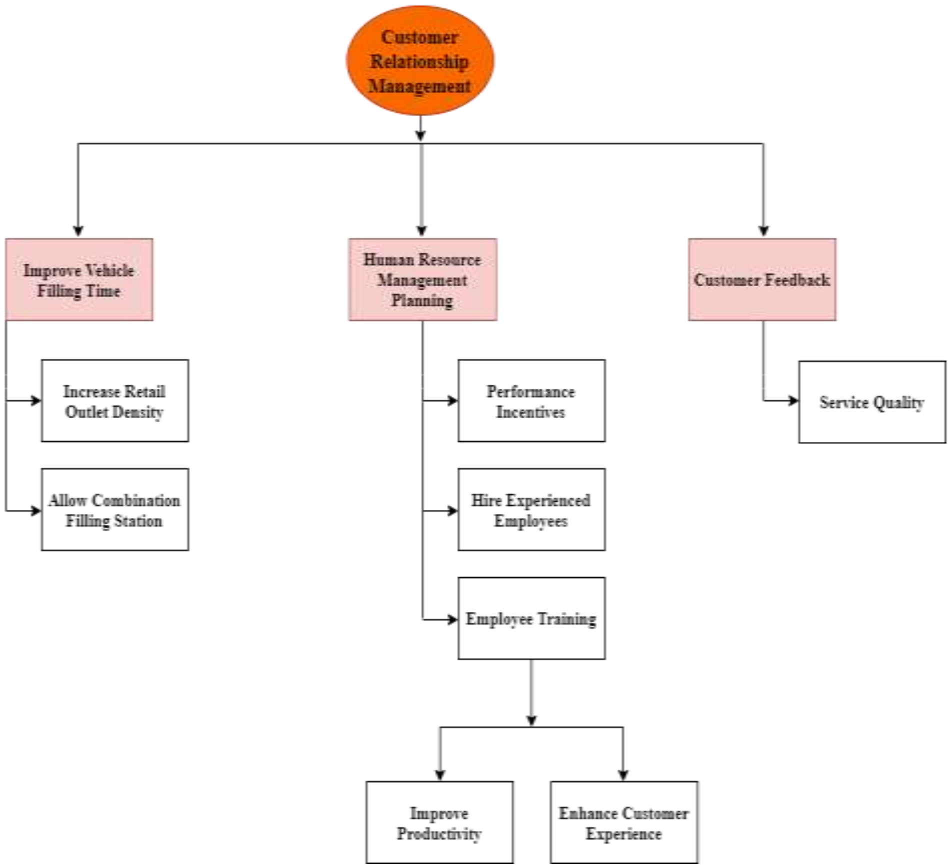


Figure 4.5: Strategies for CRM improvement

The company need to increase the retail outlet (RO) density and seek permission from the government to open combination filling stations in their respective GAs to reduce CNG filling time for the consumers. There is also a close relationship between CRM and human resource management in every organization. Ensuring the implementation of quality and transparent human resource management practices can enormously improve CRM. The emphasis should be on employee training to build their technical and commercial skills to improve productivity and reduce vehicle filling time. Moreover, the companies should focus on hiring employees with CRM experience and procure the services of local talent to build connections with the consumers.

2. **Currency exchange rate:** The CGD companies have been sourcing natural gas through multiple channels. With the expansion of the CGD network, the CGD companies would have to ensure regular supply through numerous ways, including import options.

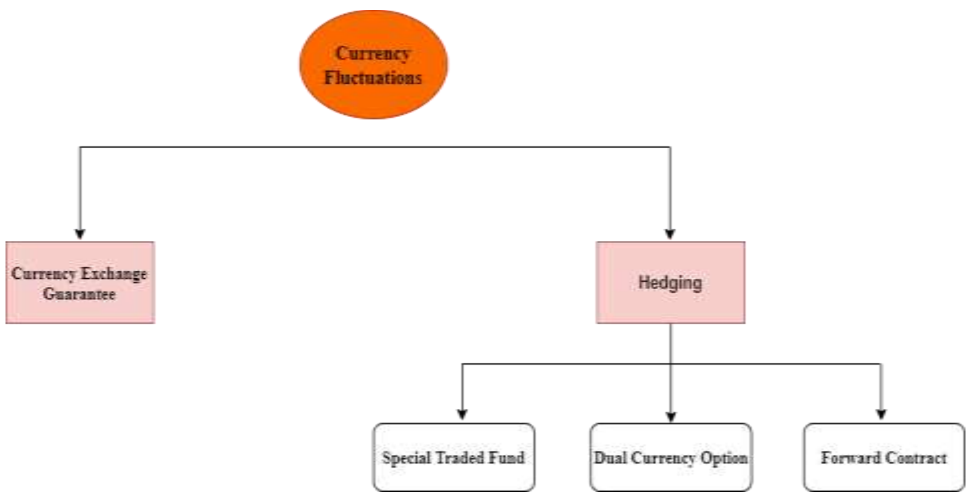


Figure 4.6: Strategies for managing currency volatility

The companies need to use hedging tools such as forward contracts, dual currency options or special traded funds and seek the local government currency exchange guarantee to minimize the impact of currency exchange volatility.

3. **Health, Safety and Environment (HSE):** Natural gas is a product that CGD company sell to its customers. Natural gas is non-toxic but can cause death through explosion if not handled with care. The accidents could occur because of operational negligence, leakage, or third party excavation.

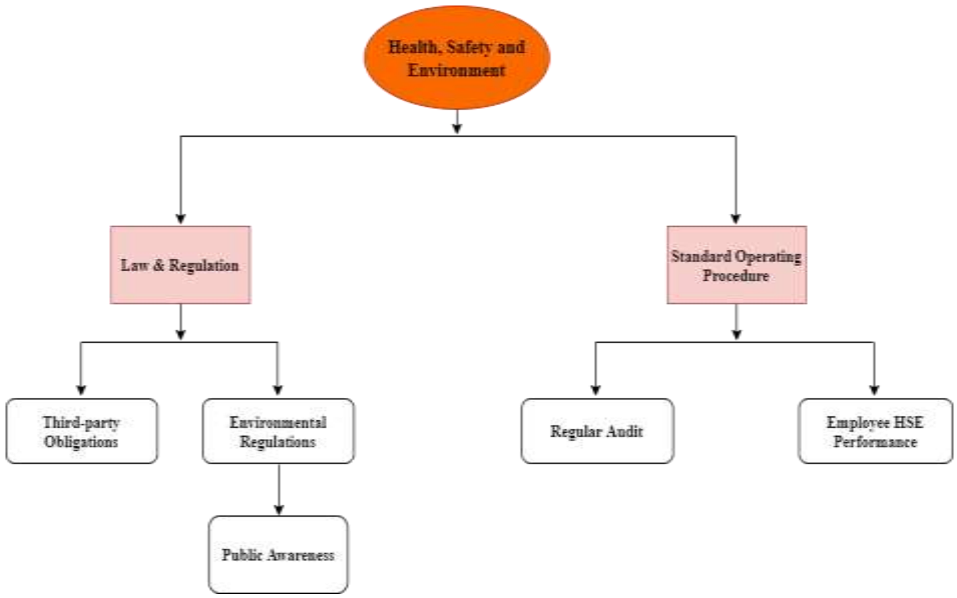


Figure 4.7: Strategies for HSE compliance

The company needs to prepare and implement a standard operating procedure for its employees to report all the operations, deal with third-party challenges, and handle emergencies. Provision of regular audits to check the preparedness and making HSE performance a part of performance review can significantly reduce the risk. To minimize the risk from third-party operations, the companies could join hands with the local government agencies to develop a system for prior intimation and run public awareness campaigns to sensitize the ordinary people to mitigate HSE risks.

4. **Interest rate:** CGD industry is a capital intensive industry, and any substantial change in interest rate could adversely impact the debt-paying capabilities of the company.

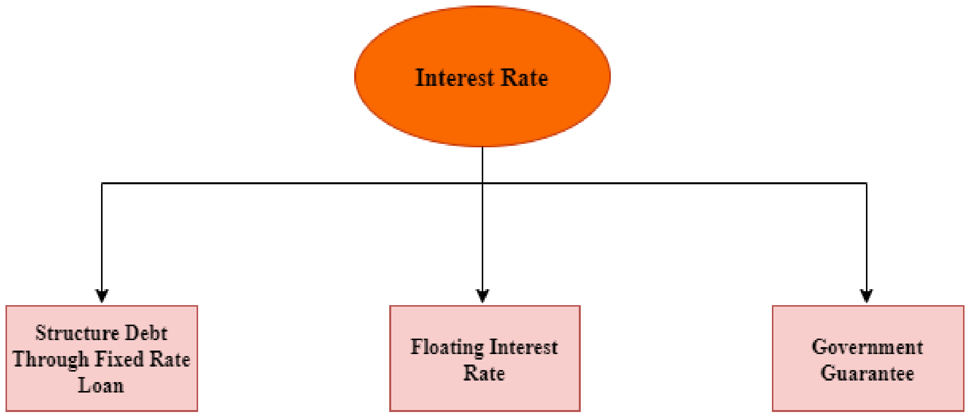


Figure 4.8: Strategies for managing interest rate

The company can go for raising finance with floating interest rates and securing the structured debt. The government can also help the companies in improving the CGD project viability by ensuring interest rate guarantees.

5. **Land acquisition:** CGD is a complex network requiring pipelines to be laid in densely populated, restricted areas, forests, river beds etc.

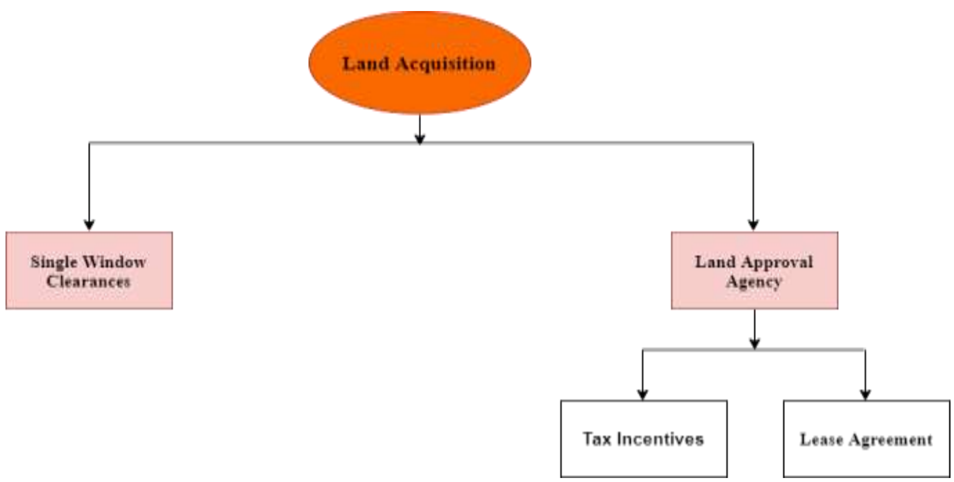


Figure 4.9: Strategies for land acquisition

The expansion of the CGD network means more delivery points to be developed. CNG sales contribute almost three-fourth of the total generated revenue for the CGD company. The company needs land access to establish CNG retail stations on the highways and prime areas in the middle of the cities. The establishment of a land approval agency for land leasing and tax incentives on land purchase could significantly reduce the financial burden on the companies.

6. **Payback period:** CGD network development involves enormous upfront capital investment and has a long gestation period as it takes 7-8 to achieve commercial viability.

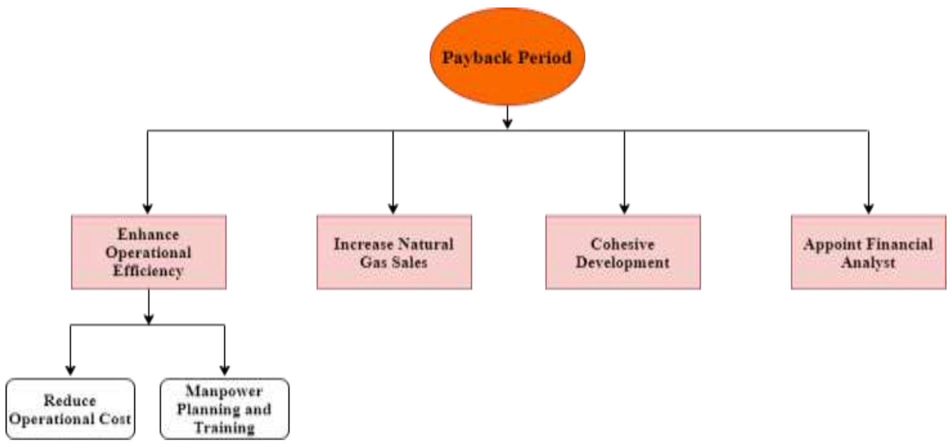


Figure 4.10: Strategies for reducing the payback period

Focus on boosting sales through aggressive marketing, ensuring cohesive network development, appointing financial analysts for business forecasting, appointing financial analysts for business forecasting and enhancing operational efficiency could help the CGD company in reducing the payback period.

7. **Delay in raising capital:** Given that the Indian CGD industry is in its infancy and has many new entrants, it is difficult to raise finance at affordable for them. The delay in raising finance may lead to an increase in the total project and payback period. It is essential for the CGD companies to expeditiously approve the tasks and keep growing short-term borrowing to meet the business requirements in case of a delay in raising project funds.

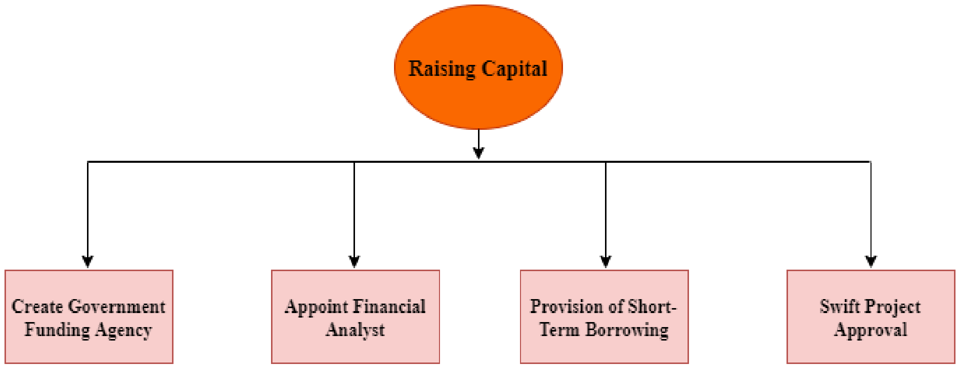


Figure 4.11: Strategies for raising capital

The appointment of a financial analyst will enable the company to understand the business dynamics and look for multiple channels to raise funds. There is also a need to set up a central funding agency for the CGD projects at affordable rates to avoid project delay and expedite the network construction process for meeting the set national CGD targets.

8. **Tax benefits:** The CGD industry is dependent on imported equipment for network construction. Abolishment or exemption on import would provide easy access to the quality equipment for performing the operations and reduce the operational cost.

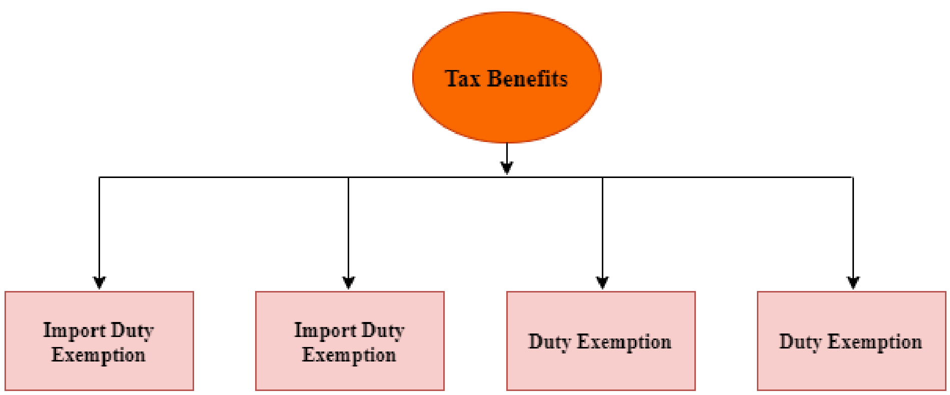


Figure 4.12: Strategies for managing taxation

Also, the exemption on excise duty would encourage companies for local manufacturing at low production costs. The government could make natural gas competitive by reducing the sales tax and bring it under goods and service tax.

9. **Working capital**: Efficient working capital management is a critical measure of an organization's sound health, as it necessitates the elimination of superfluous capital blocking to reduce financing costs (Mandal, 2010).

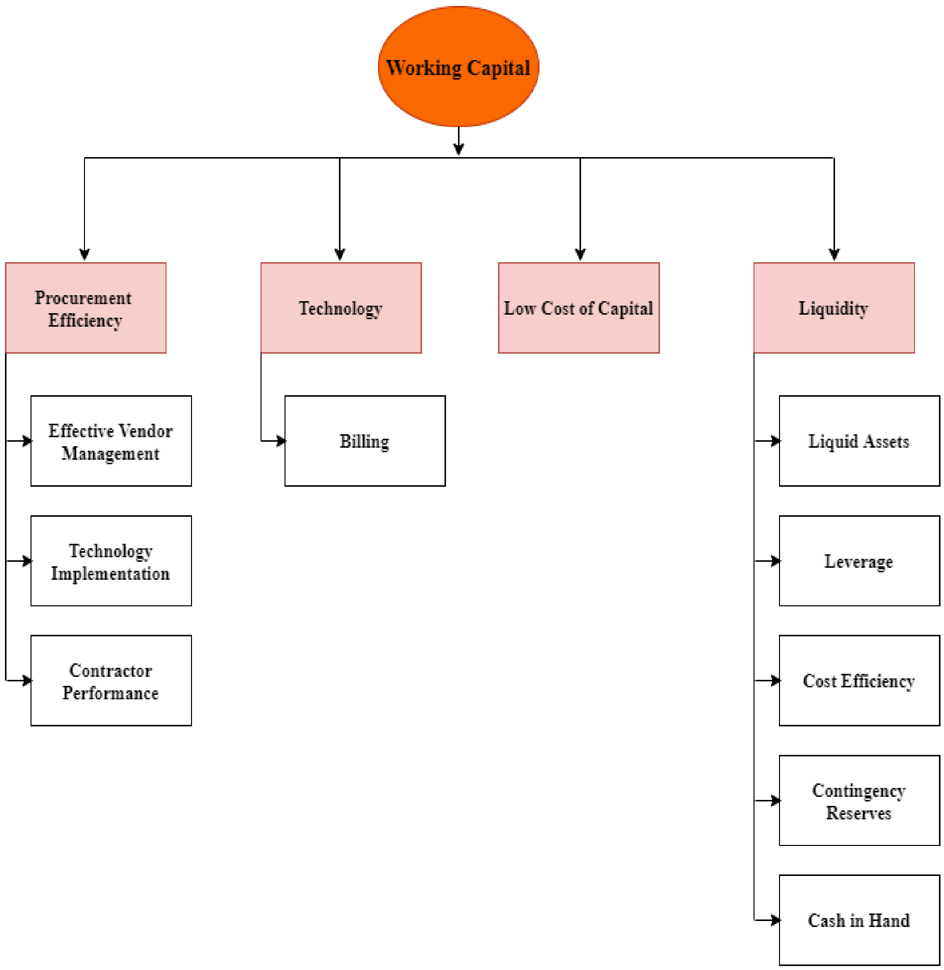


Figure 4.13: Strategies for improving working capital

The company needs to have an efficient procurement management system utilizing the best technology at its disposal to reduce costs. The technology could be leveraged for improving the billing process to improve the cash flows. The CGD project economics also need to factor in the volatility of the essential commodity prices such as steel, given the long construction and project execution period. The CGD companies with good liquidity can mitigate any issues that might adversely impact cash flows in the short term. The CGD company sell natural gas as a product which is a liquid asset. The CGD companies continued focus should be on maintaining an optimum level of working capital without involving liquidity risk. It would be beneficial for the CGD companies' long-term capital investment and daily operations. Moreover, it will enable companies to pay off their short-term liabilities.

10. **Project execution:** The CGD companies' revenue generation is directly linked with the project execution. The project's timely completion would enable companies to sell natural gas to CNG and PNG customers and reduce the payback period. However, the CGD projects are exposed to multiple risks, as shown in RO 2A. The CGD companies should ensure operational efficiency throughout the construction process. The factors include utilizing the latest available technology, setting project timelines, deciding key performance indicators for the departments and individuals involved, implementing the audit process for quality, partnering with the local suppliers, and maintaining communications with all the stakeholders throughout the project. Contractors are critical to speak in the wheel during the whole process of CGD network construction.

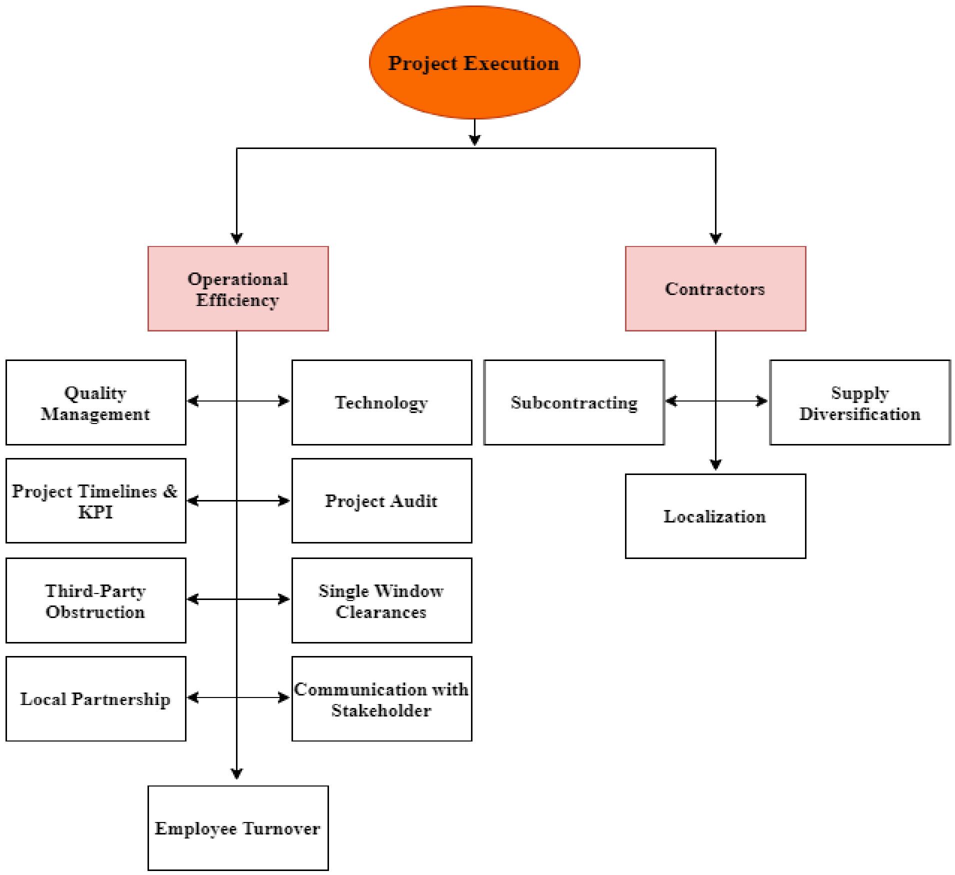


Figure 4.14: Strategies for project management

Thus, the company should ensure close coordination with the contractors to keep track of the level of subcontracting, localization of services and maintain optimum supply diversification in the projects.

The consolidated overview of developed mitigation strategies for managing operational and financial risks is provided in Figure 4.15.

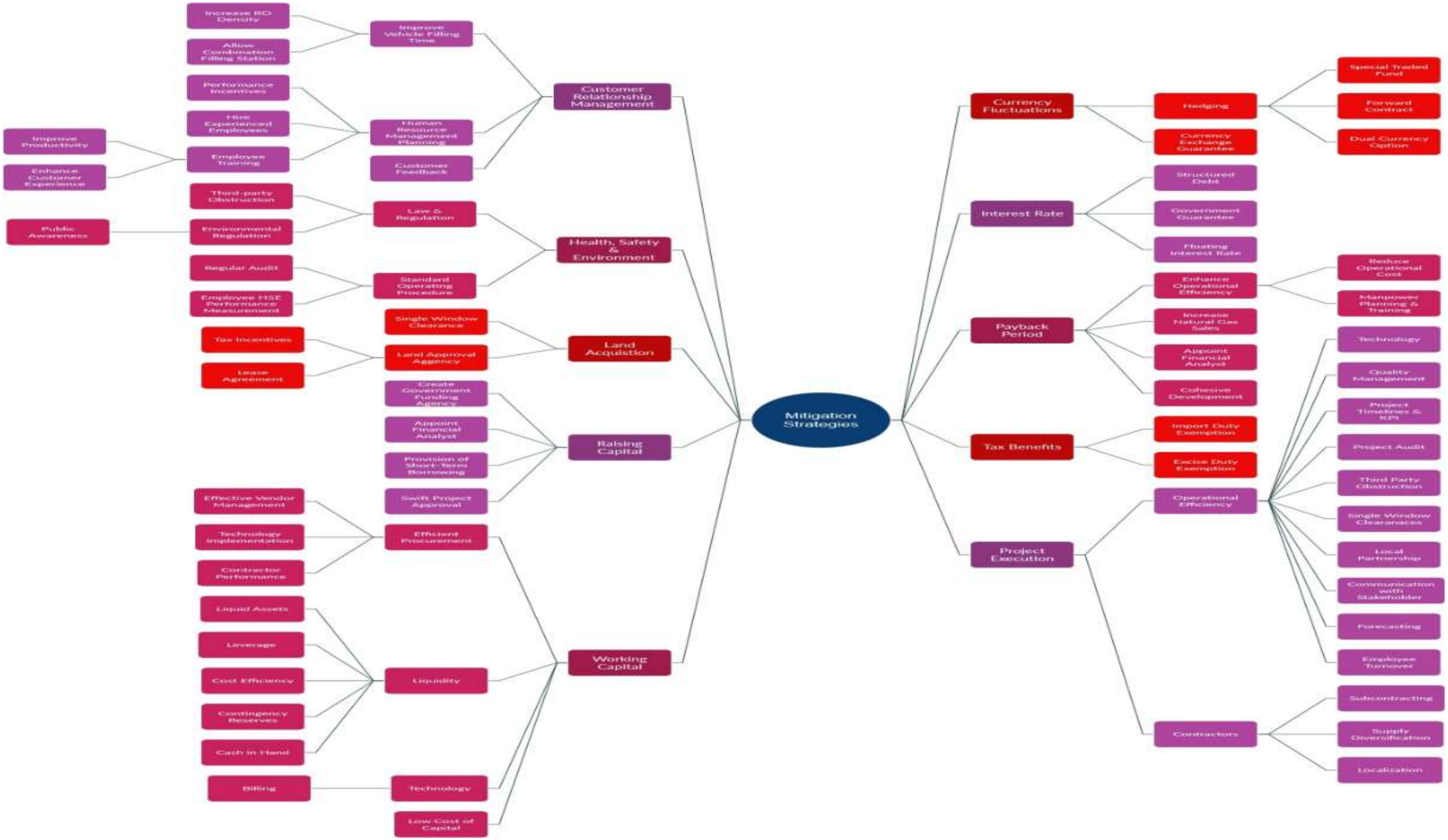


Figure 4.15: Mitigation strategies to overcome the identified risks

4.3.2. SAP – LAP Framework Analysis

Post coding, The SAP–LAP method is used to identify and offer effective mitigating measures for the operational and financial risks that affect CGD projects. Figure 4.16 and Figure 4.17 depict the detailed procedure, while Table 4.9 lists the 39 mitigation methods that were developed.

Situation: The construction of the CGD network is a complicated endeavour since it is subject to numerous dangers. Any negative impact of these elements could cause the project's start to be delayed. In the CGD industry, RM studies are scarce. Some several issues and uncertainties could cause the project to be delayed. Financial difficulties, government policies, municipal administration, business management, customer expectations, a shortage of skilled labour, and so on could all be factors. As a result, developing awareness of risk issues and effective mitigation measures for CGD projects is critical to reduce, prevent, and manage risks.

Actors: The prominent actors involved and contributing to establishing risk mitigation methods for CGD projects are divided into two categories, according to industry experts: government (regulator, policy, local administration, state agencies) and company (senior management, project manager, human resources, contractor, quality, etc.). It should be highlighted that establishing risk mitigation methods involves a collaborative and integrated approach from all CGD project participants. Project managers should disclose risk issues and mitigation strategies with top management to manage risks in CGD projects. Furthermore, senior management and the project team should be competent to control the changes in the business environment and predict how they will affect the project schedule. As a result, decisions about contractors, suppliers, and human resources should be made.

Similarly, CGD projects are critical to the government's goal of increasing natural gas's proportion in the country's energy mix. To avoid project delays, the government should maintain transparency and efficiency in decision-making and create an atmosphere that encourages open communication with the company and stakeholders. Companies and governments both have the option of deciding whether or not to involve stakeholders in decision-making.

Process: It is critical to design a detailed strategy to avoid operational and financial risks connected with CGD projects. The plans are divided into two categories to simplify things: operational and financial. The operational approach comprises procedures to address risks that affect the CGD projects' everyday duties, such as contractor issues, customer expectations, human resources, and project management.

On the other hand, the financial approach deals with financial matters such as raising funds, currency exchange rates, interest rates, taxation, etc. Both techniques use a proactive approach to developing solutions that will eliminate the identified risks and variables.

Learning: Due to the engagement of various stakeholders and significant capital requirements, CGD projects are vulnerable to unforeseen occurrences. Management and government agencies' knowledge of uncertain and unexpected events and their likelihood of occurring is equally critical. Furthermore, numerous methods must be developed for management and government to prevent delays and achieve the established goals. As a result, CGD risk mitigation strategies should incorporate organisational, social, financial, and technical aspects and a roadmap for execution.

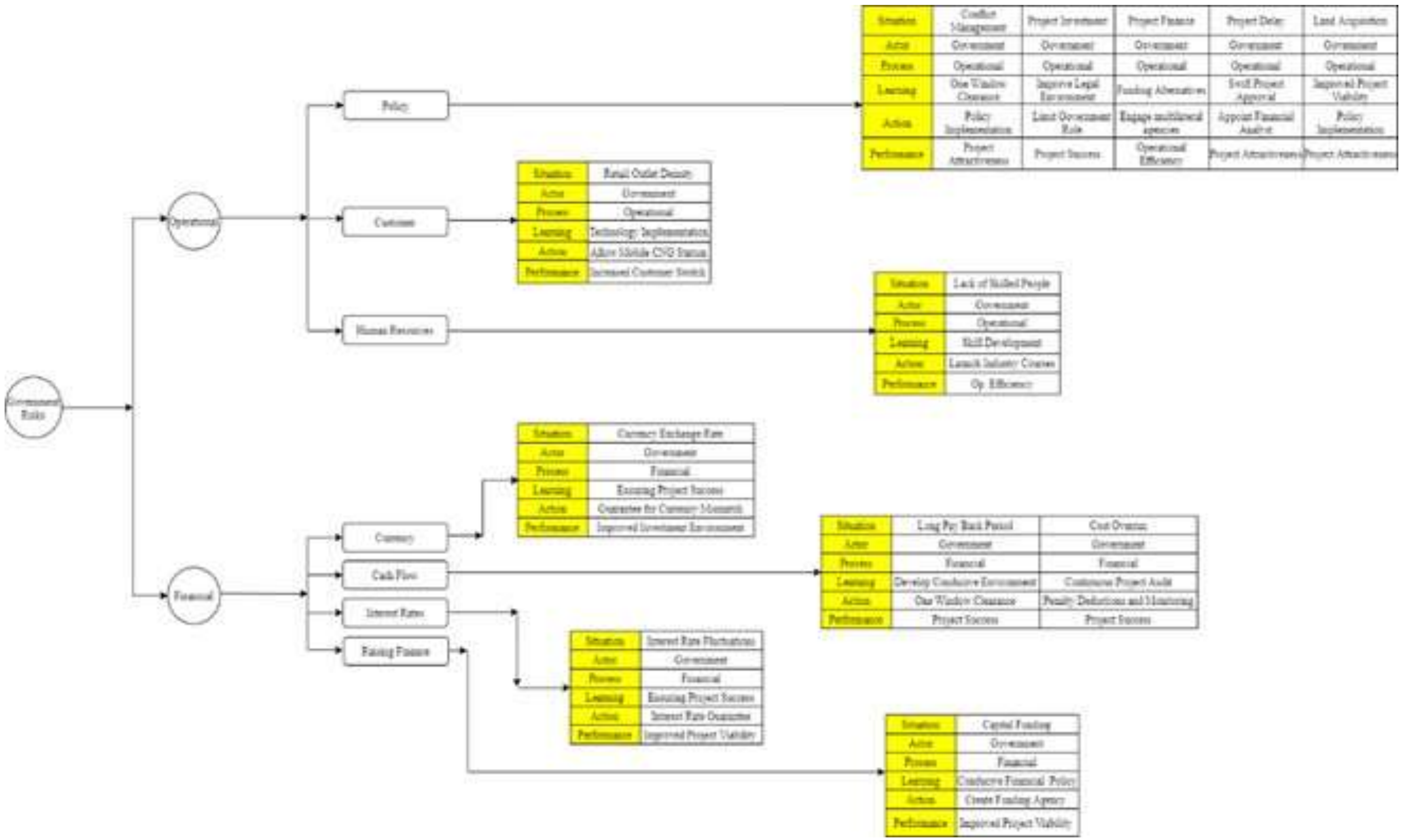


Figure 4.16: Risk mitigation strategies for the government

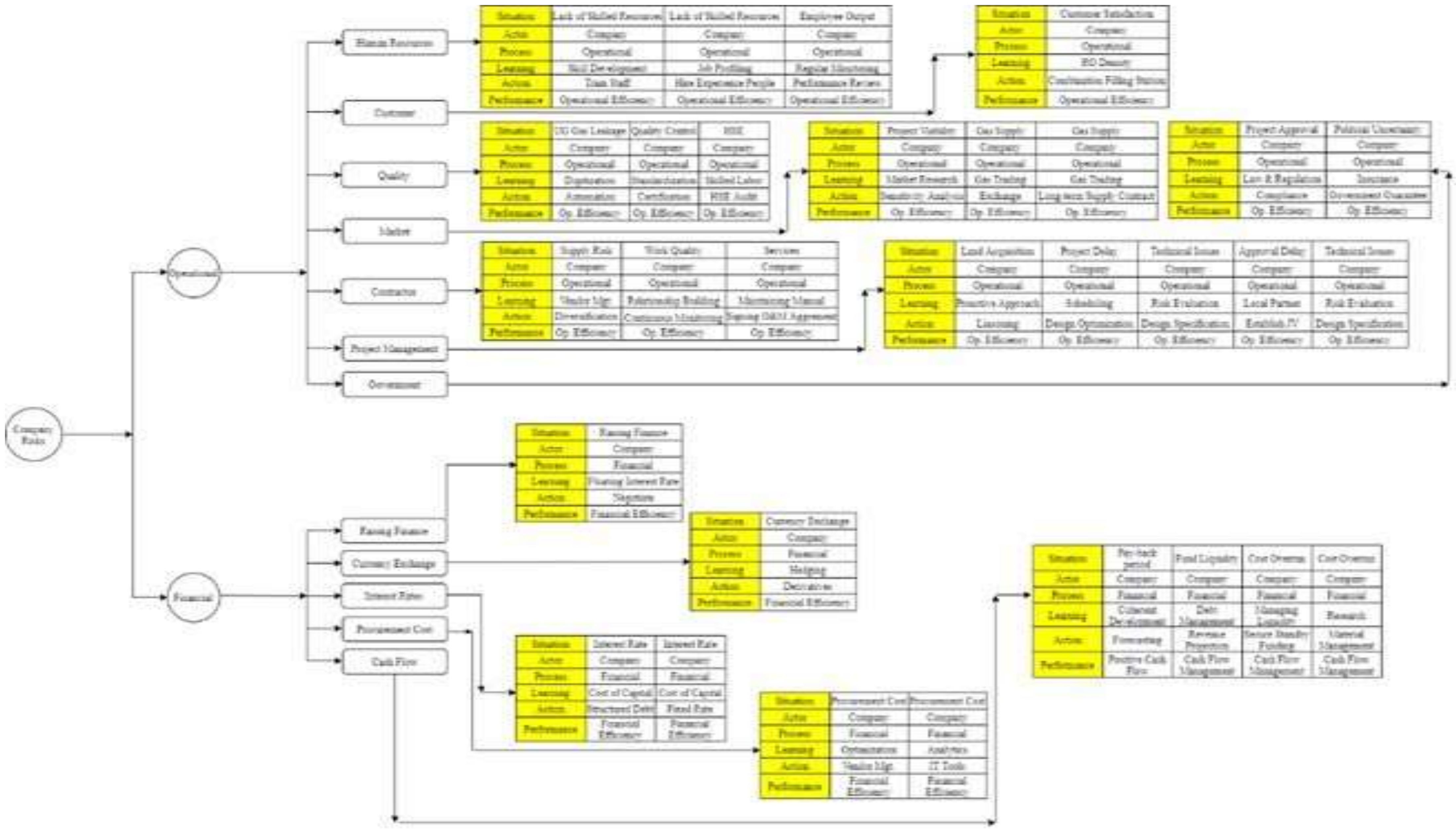


Figure 4.17: Risk mitigation strategies for the CGD company

Action: This section proposes some steps to change and enhance the situation in CGD projects when it comes to developing risk mitigation techniques. CGD companies may formulate strategies differently and take a different approach to risk mitigation. Companies should form relationships with stakeholders, create a favourable business climate, and transparently make decisions to improve the risk reduction strategy implementation. As a result, both the government and the corporation should design strategies to implement risk reduction techniques to accomplish their respective objectives effectively.

Performance: The CGD project's overall performance will be improved by implementing operational and financial risk mitigation techniques. CGD companies and the government will be better prepared to implement mitigation plans to avoid project delays if they have a thorough awareness of the risks. It will also aid in the improvement of communication between the government and CGD companies. Implementing mitigation methods will improve the customer experience, project management processes, and financial results.

Table 4.12: Risk mitigation startegies for financial and operational risks

Risk Factors	Variables	Mitigation Strategies
Credit Risk	Interest Rate	1. Reduce capital costs by converting debt into a fixed-rate bank loan.
		2. Work out a deal for a floating interest rate.
		3. Inviting foreign joint venture partners and tapping into the international capital market to reduce interest rate risks.
		4. Request that the government guarantee an interest rate.
	Land Acquisition	5. Land purchase tax exemption
		6. Provision of single window clearance
	Currency Exchange	7. Hedging through specialized traded funds, forward contracts, dual currency or currency options.
		8. Request government to offer assurance against currency mismatches

	Payback Period	9. Ensure that development is consistent with shortening the payback period.
		10. Obtain standby financing or establish a supply contract with a fixed price.
		11. Perform financial analysis to ensure consistent cash flow throughout the project's life cycle.
	Raising Project Funding	12. Introduce legislation to establish a funding agency to assist CGD businesses.
		13. Hire a financial analyst to assess the project's viability and expedite project approvals.
Working Capital Risk	Custom Duties	14. Request a tax break for importing CGD equipment from the government.
	Managing Liquidity	15. Ensure fund liquidity by projecting revenue.
		16. A single government agency to offer adequate approvals for projects to be implemented.
		17. Establish a penalty deduction and monitoring system to deter cost overruns.
	Procurement Cost	18. Proper vendor management.
		19. Use IT technologies to make the purchase process go more smoothly.
CRM	Lack of Skilled Workforce	20. Fill critical jobs with experienced human resources.
		21. Worker performance is evaluated to ensure high labour and equipment productivity.
	Managing Customers	22. Choose a station with a combination of filling stations.
		23. Increase the number of CNG RO.
	Difficulty in localizing Managers	24. Provide regular training to foster technical and commercial capabilities.
	Franchise Training	25. Provide regular training to foster technical and commercial capabilities.
	Lack of Facilities	26. Provide regular training to foster technical and commercial capabilities.

Project Management	Project Execution	27. Proactive liaison with local governments to ensure that land acquisitions go smoothly.
		28. Form local JVs
		29. Establish interim milestones to stay on track with project deadlines.
		30. Optimize the design to avoid delays.
		31. Establish a procedure for monitoring and supervising the contractor's work regularly.
	Low penetration of gas-based equipment & appliances	32. The government should enact legislation to encourage the manufacture of CGD equipment.
	Construction Obstruction	33. Look for government guarantees as a form of insurance.
		34. Request that the government offer a single-window clearance system and promote transparency.
	Limited OEMs for CNG Kit	35. Invest in or diversify supplier base.
HSE	Locating underground leaks and pipe	36. Automated process to detect subterranean gas leaking
	Difficulty in quality control	37. Process standardisation is ensured through quality certification.
	Absence of Stricter Environment Regulations	38. Safety and health audits regularly Enforce strict environmental restrictions to encourage the use of CNG.
		39. Automated process to detect subterranean gas leaking

Source: Author Analysis

RO 2(C): To study the risk mitigation approach for the mechanistic and organic management systems.

Based on Burns and Stalker's approach, the researcher looked at RM's mechanistic and organic strategies. The main characteristic of mechanistic organisations has been linked to control, whereas organic organisations have been linked to a great degree of flexibility. Control is a method aimed at mitigating any unfavourable changes. On the other hand, flexibility refers to an organization's ability to adapt to unpredictably and rapidly occurring external events that may impact its performance (D. Aaker, 1984). (S.L. Brown, 1997) found that the companies rarely used pure mechanistic and organic approaches. Instead, the two methods need to be combined.

To develop a joint risk mitigation process with management style-specific risk mitigation approaches. The collected data was used to understand the project environment, such as participants' roles, the project work breakdown structure, schedule, RM and collaborative activities. The focus was more on the importance of JRM structure, elements that influenced collective work, and the project actors' working associations. The respondents were specifically probed to understand how they categorize and deal with risks, how frequently they organize joint workshops and collaborate on the project and the benefits and drawbacks of the current system. Following this, the collected data was analyzed using the Grounded Theory methodology.

In this study, the researcher identified the management approach for successfully implementing the mitigation strategies developed for each identified risk grouped according to their inherent theme of the contingency theory, as shown in Figure 4.18. (David Howell, 2010) identified five themes which are uncertainty, complexity, team empowerment, criticality and urgency. In the CGD project, uncertainty arose because of a delay in approval from the government and its agencies at different project stages. The project confronts complexity difficulties due to the high degree of differentiation and interconnection of project aspects. The CGD projects are too exposed to certain complexities during the project execution and contracting. The following construct is team empowerment which includes factors such as team composition, culture and communication. The CGD projects are facing a shortage of trained human resources, low labour and equipment productivity.

On the other hand, urgency deals with the project issues caused because of time constraints. Delay in the CGD project because of the execution and contractual issues led to cost escalation and loss of customer confidence. The last construct is criticality which analyzes the risk factors crucial for ensuring the CGD project success. The risk factors are currency volatility, financial performance, cost overrun, design, HSE compliance, etc.

In the next step, the researcher has presented a separate management style-specific risk mitigation approach for the company and the government, the CGD project's two major stakeholders, as shown in Figure 4.19 and Figure 4.20. Based on the interview, the risks are classified from the viewpoint of mechanistic and organic management approaches. In CGD projects, the respondents felt that a collaborative approach is necessary due to the complex nature of the project and the involvement of multiple stakeholders.

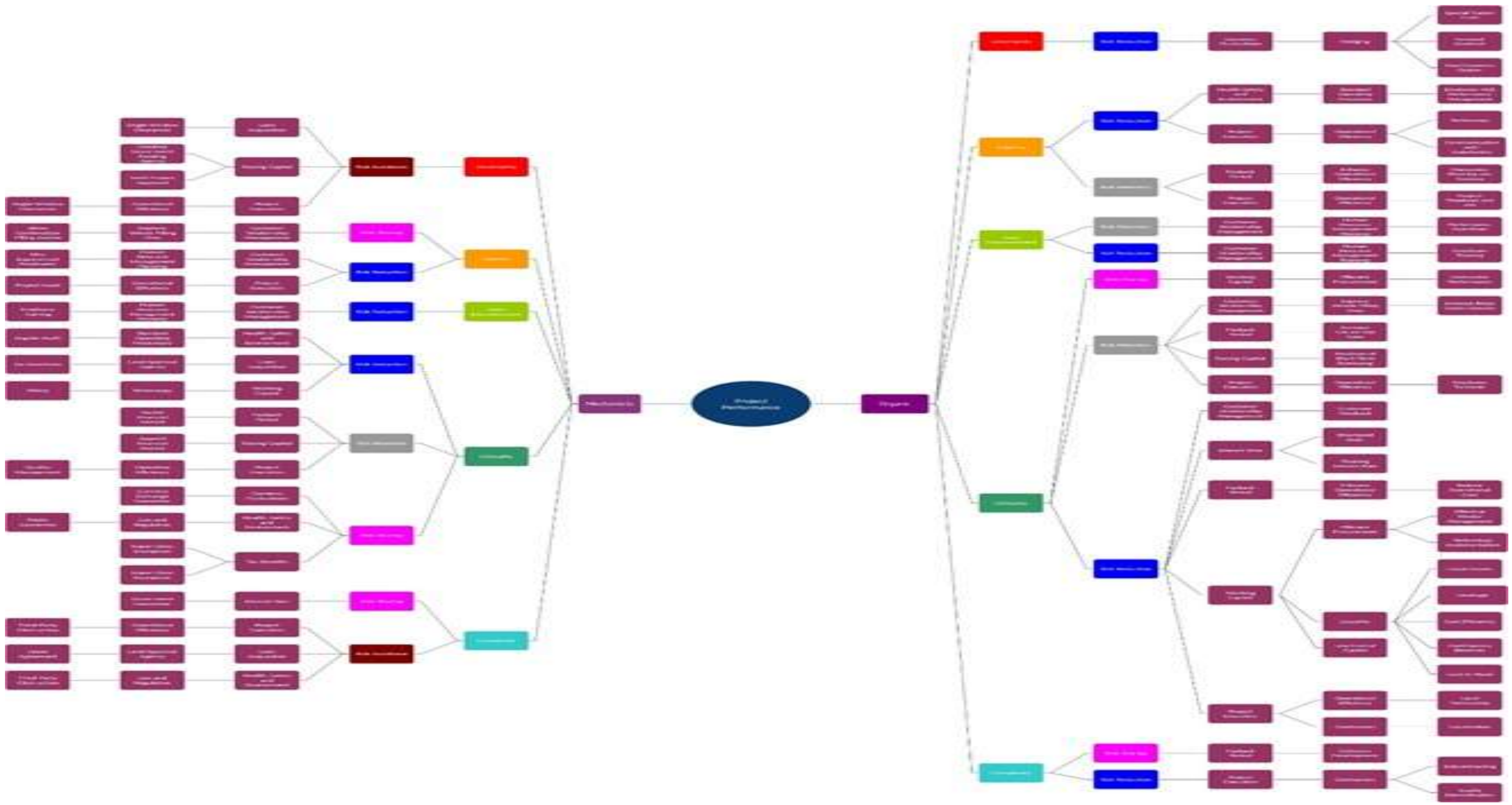


Figure 4.18: Construct wise risk mitigation strategies

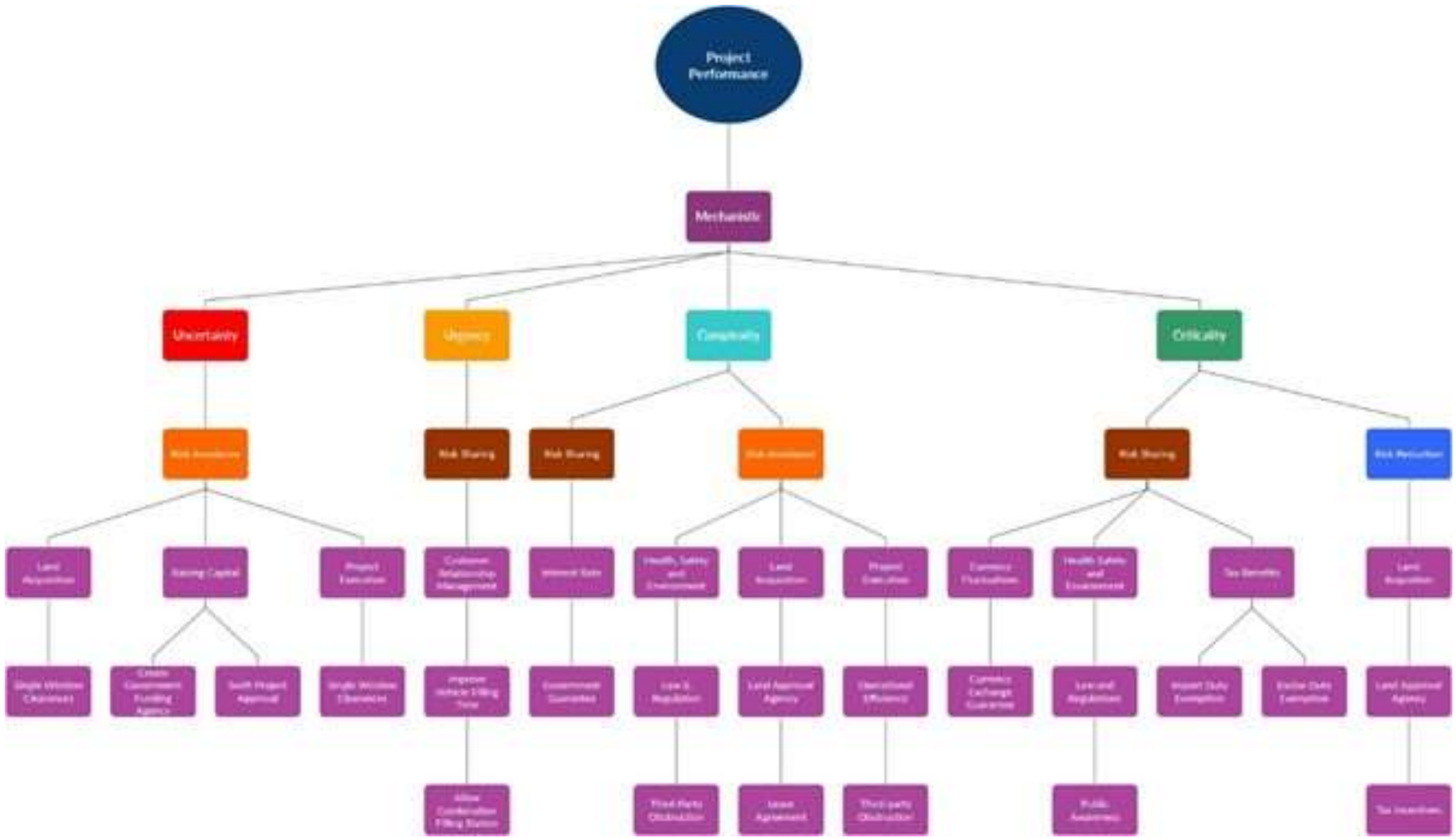


Figure 4.19: Management style and risk mitigation approach - Government

In CGD projects, the company has to collaborate and coordinate with multiple agencies to lay down the pipelines, acquire land, permits, and capital raising and seek government intervention on currency volatility, fluctuating interest rates, etc. The suggested framework recommends following a mechanistic approach by developing a long-term standard process in collaboration with government agencies to establish natural gas as a preferred fuel in India. Additionally, there are certain risks for which the company is required to develop standard operating guidelines such as ensuring quality standards and adherence to turnaround time, audit process across levels, HSE, operations etc.

Areas that require the CGD company to be flexible are human resource training, raising finance, managing communication with the stakeholders and government bodies, developing customer relationship practices, supply diversification, and operational efficiency, as shown in Figure 4.20.

The findings suggest that effective implementation of joint risk management in the CGD project requires both the government and the company to collaborate to achieve common objectives and value each other competencies. Moreover, the study’s findings support (Burns T., 1961) outcomes that mechanistic management style is suitable in a stable environment such as government agencies while an organic system is apt for changing business climate. Given that the CGD projects comprise uncertainty and changes, a collaborative approach for managing projects is best.

The study's critical theoretical contribution is that JRM necessitates a blend of structured and collaborative processes, requiring a balance of mitigation approach to mitigate risks, identified and classified as per contingency constructs, and flexibility to deal with unforeseen events.

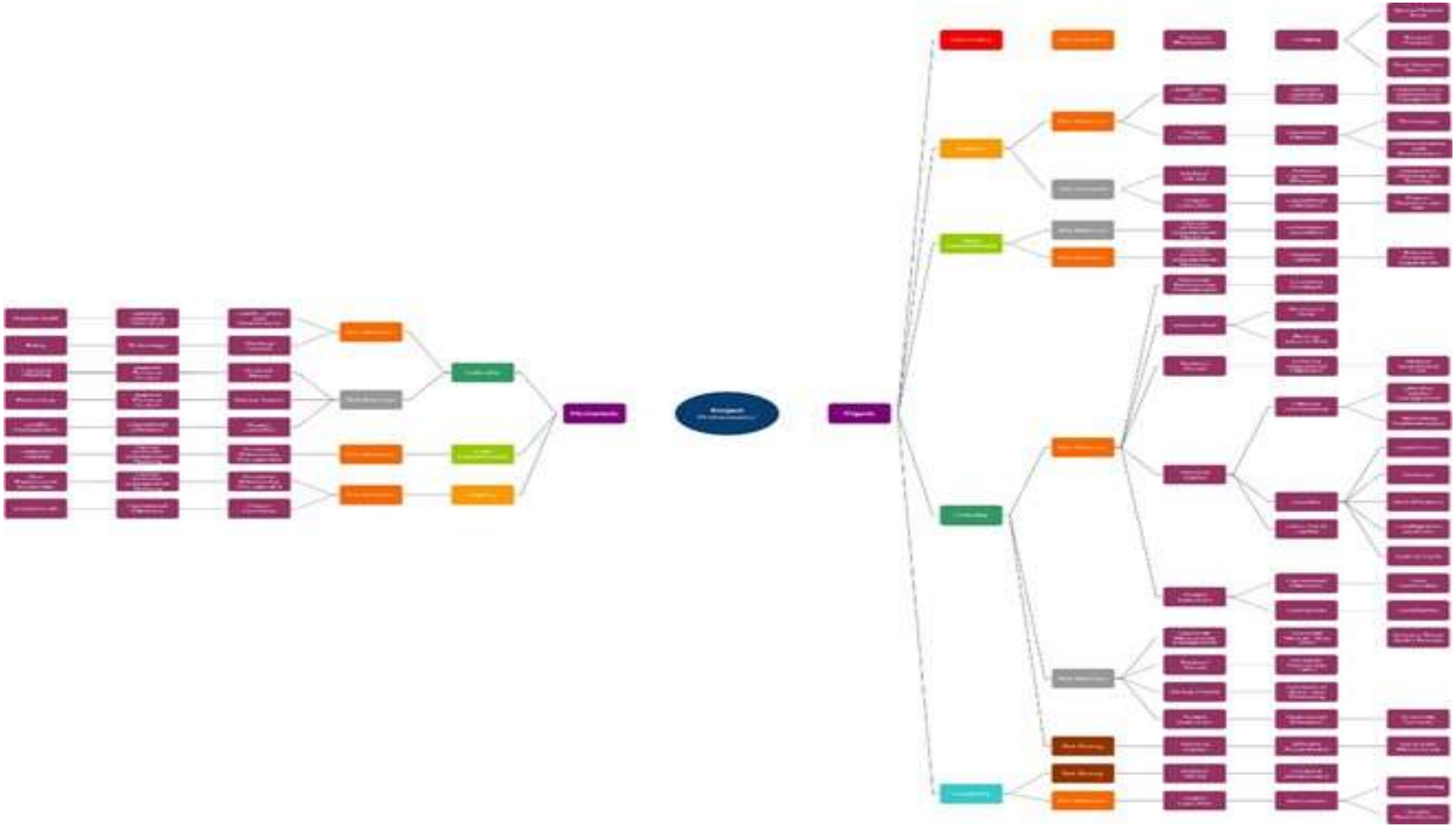


Figure 4.20: Management style and risk mitigation approach - Company

4.3.3. Findings

Since 2014, the Indian government has given the CGD business a significant boost. However, to attain the objectives, the government and companies need to develop a joint risk mitigation approach to ensure the CGD projects' time-bound completion.

On the financial side, the CGD project requires a significant upfront capital investment to conduct surveys, estimate demand, and build core infrastructure. Aside from that, CGD businesses make substantial investments monthly to expand their network to increase natural gas sales. Because the payback period for CGD company is considerable, long development and structured reimbursement profile with swelling payments on the back of gradual growth in natural gas sales can somewhat mitigate the financial leverage risk. The company's financial leverage might be impacted by slowing gas sales volume growth or a delay in operations due to project execution errors or regulatory risk. Furthermore, raising money for the project is more challenging for small CGD companies with limited natural gas sales potential.

To fund long-term investments, most companies depend on short-term borrowings. To reduce their risks, the financial institution usually charges these companies a high interest rate. The CGD company's liquidity is further impacted by the protracted payback time. Companies with sufficient liquid assets can satisfy short-term obligations and limit the impact of any occurrences that could harm cash flows.

Currency exchange is one risk that does not apply to all CGD companies in India. Only a few CGD businesses distribute LNG imported from other countries, and they rely on natural gas marketing corporations for import and re-gasification services. Gas marketing companies typically sign back-to-back foreign currency-based price agreements with exporters. As a result, they bill CGD companies in dollars. On the other hand, the CGD companies make payments in Indian currency, putting them at risk of currency fluctuations. If the Indian currency depreciates, CGD enterprises may be forced to pass on the cost increases to their customers. As a result, the companies' ability to deal with regular currency swings is essential.

The government should ensure that LNG is available duty-free at all times. -use limitations for natural gas-consuming industries due to insufficient local output. Exempting CNG conversion kits, cylinders, and equipment from customs duty and excise is also necessary, as the high cost is a significant burden on companies and customers. The research outcomes show that all stakeholders agree that the Indian government should address the taxation policy for CGD companies. One solution could be to include natural gas in the GST.

On the operational front, the lack of cooperation between the firms and the local and central governments is a significant concern during the project's implementation. The majority of state governments lack the infrastructure needed to create CGD networks. Many CGD projects are behind schedule due to delays in obtaining clearances from state and federal government agencies such as the Railway, the National and State Highway Administration, the Public Works Department, and others. Furthermore, the gas supply is disrupted by random third-party excavation on the CGD network. As a result, a streamlined method must be devised to meet set targets. To address the problem, the PNGRB should cooperate with state governments and municipal governments to develop a system to overcome the bottlenecks in the growth of the CGD network.

As perceived by the data analysis, stakeholders are also concerned about a shortage of quality suppliers for essential equipment in the country. Furthermore, the available providers are booked to capacity. The government needs to promote the development of ancillary businesses to support CGD companies. To incentivize OEMs, the government should also prohibit the retrofitting of CNG kits into old/in-use vehicles. The marketing of pre-installed CNG kits will increase not just engine safety but also performance.

Apart from soliciting government assistance, CGD companies must learn from petroleum retail companies' best practices to improve customer experiences at their locations. The study's findings emphasised the importance of implementing innovative technology to reduce the time it takes to fill up vehicles with CNG at the proper pressure. Companies will boost CNG sales volume and attract PNG customers because of trained labour and value-added services. Industrial and commercial customers play a significant role for CGD companies as they are responsible for most gas sales volume. As a result, hiring locals will help CGD company management transition industrial and commercial customers from other fuels to natural gas early in the network expansion process, ensuring a significant sales volume.

The management of HSE standards throughout activities is a critical part of the CGD project. Companies must employ multi-pronged techniques that include cutting-edge technology to discover subsurface leaks and establish quality standards to manage operational efficiency. The study also emphasises the need of enforcing environmental regulations and raising public awareness about the advantages of natural gas over established fuels. In addition, the PNGRB must verify that quality standards for safety and vendors are developed and implemented.

In brief, building a CGD network is a complicated task that necessitates close collaboration and cooperation among various stakeholders, including the national government, state governments, local communities, various government agencies, and equipment vendors. As a result, the project management process includes negotiations, approvals, quality assurances, skilled labour, and contractual problems. The suggested joint risk mitigation framework, combined with a strategy-specific management approach, would allow the government and CGD enterprises to create a favourable climate and avoid project delays.

Furthermore, the research findings answer the research problem by demarketing mitigation techniques based on management styles and recommending necessary actions for the actors accountable for strategy implementation. The framework helps to clarify the collaborative interaction between the project's numerous stakeholders. The study's critical theoretical contribution identifies a link between contingency themes and attributes of mechanistic and organic approaches, which are crucial for JRM implementation.

CHAPTER 5

RECOMMENDATION & CONCLUSION

This chapter summarises the research results, emphasising the significance of the natural gas demand forecasting and identifying and mitigating the operational risks causing the CGD project delay in India. It also identifies the study's limitations and suggests areas for additional investigation, followed by recommendations. The contribution to the business problem and current literature is also presented in this chapter.

5.1 Reiteration of the research aims

As discussed in previous chapters, the realized aims of this study evolved throughout the data collection and analysis stages. The research began with identifying demand estimation for natural gas for India and CNG demand in the eastern corridor states of India. The finding suggests the presence of untapped demand for natural gas and the importance of CGD network development to tap it. The following research focused on identifying the finanical and operational risks and developing mitigation strategies to avoid delays in the CGD projects. At last, the research aim eventually focused on understanding the extent of mechanistic and organic management approaches in the projects, affecting the joint risk mitigation approach following the tenets of contingency theory.

5.2 Recommendations

- Promote a joint risk mitigation program to improve coordination between the government and the company to avoid project delays.
- Encourage collaboration and policy alignment between central and state government and develop domestic CGD ancillary industry

- Collaborate with academic institutions to develop a skilled workforce for the CGD industry.
- Improve CRM process to improve service quality and boost revenue.
- Apply for ISO certification to ensure operational safety and increased collaboration with academic institutions, NGOs and government bodies to promote natural gas.

5.3 Conclusion

Indian CGD industry has witnessed robust growth in the last two decades. However, the sector is still developing, and companies need to overcome business risks to ensure timely project commencement. The construction of CGD networks is a capital-intensive operation with an extended return period. It is a complex system with lots of branches. Furthermore, managing the project's distinctiveness, ambiguity, and complexity is challenging. The management of the CGD project requires collaboration among the project actors to implement the joint risk mitigation framework.

The first goal of this study is to estimate the demand for natural gas at the national and eastern corridor region levels. To study the dynamics of natural gas demand in India, the researcher employed a dynamic econometric model. The model revealed several intriguing findings that policymakers might use to help achieve a 15% natural gas contribution in primary energy by 2030. The study discovered that income, price, and population had less statistical significance in estimating natural gas demand, implying that demand may be restricted within the country. The government's continued focus on expanding the CGD network might give the natural gas business the boost it needs, serving many end-users. The construction of pipeline infrastructure is critical for the CGD network's expansion, as it will allow LPG consumers to transition to PNG and position CNG as the primary transportation fuel.

The researcher applied the Hodrick Prescott filter to project CNG demand estimation for the eastern corridors of the country. The analysis indicates a rising trend for the CNG demand in the country. However, to realize the CNG demand, the companies need to avoid the CGD project delays. The researcher addressed this problem in the study's second objective by identifying the financial and operational risks causing CGD project delay and developing the appropriate mitigation strategies for the government and the CGD companies to avoid project delays. The researcher used factor analysis to identify the critical risk factors. Following this, the researcher used the grounded theory methodology to develop the mitigation strategies and SAP-LAP framework to identify the actors responsible for taking the appropriate actions.

Furthermore, the research shows that businesses must manage the coexistence of different management styles. The study highlighted the importance of addressing the imbalance between control and flexibility while implementing JRM by integrating the contingency theory and its constructs with the risk management practices. The research findings validate the previous research and recommend that risk be identified and categorised as per the contingency construct to develop a risk mitigation approach and adopt an appropriate management style for effective implementation. Moreover, the research findings suggest that a strong emphasis on control stifles collaboration in projects and, as a result, will not generate conducive conditions for JRM.

5.4 Contribution to the theory

In general, the literature on project risk management and contingency theory have developed independently from each other. The literature on project risk management has traditionally focused on procedural elements and various tools and approaches for risk assessment. Generally, the literature has been primarily focused on project risk classifications, risk variables and relevant mitigation strategies.

Although risk substantially impacts project objectives, the impact of control-oriented and flexibility-oriented methods on risk mitigation has not been studied. This thesis brings together the fields of project risk management and management approaches, using the construct of contingency theory framework to develop a joint risk mitigation framework.

Contingency theory has been evolving since the 1950s. The theory suggests that the ability of an organisation to adapt to its surroundings is linked to its effectiveness. There must also be harmony between the surroundings and the building (Drazin, 1985) (Pennings, 1992). (Woodward, 1958) proposed that technological development determine differences in organizational attributes such as control, rules and procedures, and authority. It was followed by introducing concepts on mechanistic and organic organizations (T. Burns, 1961). Project contingency theory argued that effective project management is context-dependent, i.e., diverse conditions involve diverse organizational structures (Howell, 2010).

(T. Burns, 1961) investigated the environment under which mechanistic and organic prospers. Many researchers followed their works and supported the proposed theory. Several studies have recently been undertaken to examine the impact of mechanistic and organic management practices on project management (Geraldi, 2008) (J. Koppenjan, 2011) (S. Lenfle, 2010). The findings suggest that companies have to manage the coexistence of both the management approaches to achieve the project objectives. To summarise, risk management is a component of project management influenced by mechanistic and organic management approaches (Osipova, 2013).

The research findings contribute to project contingency theory by mapping the project risks and their mitigation strategies with the construct variables and suggesting the appropriate management approach. It will enable companies to develop strategies according to the nature of threats and develop appropriate strategies. The study proposes a three-step process which are:

- Study of work break down structure; activity-wise risk identification and mitigating approach;
- Mapping with contingency theory constructs (uncertainty, complexity, criticality, urgency and team empowerment) as shown in figure 16;
- Segregation of risks and mitigation approach according to the management styles (Mechanistic and organic)

The study's key theoretical contribution is identifying a link between contingency themes and characteristics of mechanistic and organic techniques, which is critical for JRM implementation to deal with unforeseen events. The findings demonstrate that the adoption of management styles can be explained through contingency constructs such as uncertainty, urgency, complexity, criticality and team empowerment.

5.5 Potential limitations of the study

There are some limitations of this research. The non-availability of state-level natural gas consumption data did not allow the researcher to use an error correction model for natural gas consumption forecasting. Second, the researchers only looked at operational and financial risks related to CGD projects in India, leaving other risks out of the analysis.

5.6 The potential scope for future research

The findings of this study will assist the CGD industry in developing long-term business plans and taking proactive efforts to avoid operational and financial risks that cause project delays and cost increases. The importance of government support in creating a favourable climate for the CGD industry to prosper is also highlighted in this study. The report, however, does not address all of the hazards that cause delays in CGD projects. Therefore, further research might be undertaken to conduct a thorough risk assessment of CGD projects. Besides this, the factors that influence management system selection are essential topics that need to be explored further. Evaluating how to combine various management systems to accomplish JRM while avoiding over-formalization of the risk management process is another area that could be probed further in future.

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Annexure A: List of Reference

A, I. E. (2019). *WORLD ENERGY OUTLOOK 2019.* Paris: International Energy Agency.

A. Avila, O. T. (2016). Management of Partner Ecosystems in the Enterprise Software Industry. *IWSECO@ ICIS*, (pp. 39-55).

A. Strauss, J. C. (1998). *Basics of qualitative research techniques.* Thousand oaks, CA: Sage Publications.

A. Nieto-Morote, F. R.-V. (2011). A fuzzy approach to construction project risk assessment. *International Journal of Project Management*, 220-231.

Aaker, D. A. (1984). The need for strategic flexibility. *The Journal of Business Strategy*.

Agency, I. E. (2021). *India Energy Outlook 2021.* Paris: International Energy Agency (IEA).

Ahrens, T. C. (2004). Accounting for flexibility and efficiency: A field study of management control systems in a restaurant chain. *Contemporary accounting research*, 271-301.

Akintoye, A. M. (1997). Risk analysis and management in construction. *International Journal of Project Management*, 1-38.

Aliahmadi, A. S.-E. (2011). Design a new intelligence expert decision making using game theory and fuzzy AHP to risk management in design, construction, and operation of tunnel projects (case studies: Resalat tunnel). *The International Journal of Advanced Manufacturing Technology*, 789-798.

Almarri, K. G. (2014). Application of resource-based view to project management research: supporters and opponents. *Procedia-Social and Behavioral Sciences*, 437-445.

Anirbid Sircar, S. S. (2017). Challenges & Issues in Natural Gas Distribution Industry . *Journal of Petroleum Engineering & Technology* , 1-8.

Arshinder, K. A., & Deshmukh, S. G. (2007). Supply chain coordination issues: An SAP–LAP frame work. *Asia Pacific Journal of Marketing and Logistics*, 240-264.

Atul Rawat, S. G. (2019). Natural Gas Demand Estimation for India: Error Correction Modelling. *International Journal of Engineering and Advanced Technology*, 429-437.

Aven, T. R. (2010). *Risk management.* Berlin: Springer.

B. G. Glaser, A. L. (1968). The discovery of grounded theory; strategies for qualitative research. *Nursing research*, 364.

B. G. Glaser, J. H. (2004). Remodeling Grounded Theory. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*. doi:https://doi.org/10.17169/fqs-5.2.607

B. J. Sauser, R. R. (2009). Why projects fail? How contingency theory can provide new insights – A comparative analysis of NASA's Mars Climate Orbiter loss. *International Journal of Project Management*, 665-679.

Babchuk, W. A. (1997). Glaser or Strauss: Grounded theory and adult education. *The Midwest Research-to-Practice Conference in Adult, Continuing and Community Education.* Michigan State University.

Babchuk, W. A. (1997). *The rediscovery of grounded theory: Strategies for qualitative research in adult education.* Lincoln: The University of Nebraska.

Baer, R. A. (2008). Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment*, 329-342.

Barki, H. R. (2001). An integrative contingency model of software project risk management. *Journal Management of Information System*, 37-69.

Bank, W. (2021, May 31). *Data Bank*. Retrieved from The World Bank: https://data.worldbank.org/country/india

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 99-120.

Basak, M. C. (2019). Influence of Non-Technical Risks on Project Schedule Overrun: The Perspective of Upstream Gas Projects in Australia. *Offshore Technology Conference.* OnePetro.

Baumeister, R. F. (1997). Writing narrative literature reviews. *Review of General Psychology*, 311-320.

Bengston, A. A. (2006). *Sourcebook of family theory and research.* London: Sage Publications.

Bernstein, P. L. (1997). *Desafio aos deuses: a fascinante história do risco.* Gulf Professional Publishing.

Betts, S. C. (2003). Contingency theory: Science or technology? *Journal of Business & Economics Research*, 123-130.

Bigliani, Roberta. (2013). *Reducing Risk in Oil and Gas Operations.* Framingham, USA: IDC Energy Insights.

BODGER, J. a. (1984). Further Issues in Forecasting Primary Energy Consumption. *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE*, 267-280.

Bogdan, R. C. (2006). Qualitative research in (validation) and qualitative (inquiry) studies. In *It is a method-appropriate education: An introduction to theory and methods.*

Boote, D. N. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational researcher*, 3-15.

Brandsater, A. (2002). Risk assessment in the offshore industry. *Safety Science*, 231-269.

Brito, A. J. (2009). Multi-attribute risk assessment for risk ranking of natural gas pipelines. *Reliability engineering & System safety*, 187-198.

Brito, A. J. (2010). A multicriteria model for risk sorting of natural gas pipelines based on ELECTRE TRI integrating Utility Theory. *European Journal of Operational Research*, 812-821.

Brown, S. L. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative science quarterly*.

Brown, S. (2010, December 1). *Likert Scale Examples for Surveys*. Retrieved from ANR Program Evaluation: http://beinspired.no/wp-content/uploads/2019/04/likertscaleexamplesforsurveys.pdf

Bun, M. J. (2019). OLS and IV estimation of regression models including endogenous interaction terms. *Econometric Reviews*, 814-827.

Bureau, P. I. (2021, June 21). *Shri Dharmendra Pradhan dedicates to the nation 201 CNG plants and commencement of PNG supply in Jhansi; Inaugurates CNG distribution through MRUs; Mobile energy fuelling is* *the future in India, says Shri Pradhan.* Retrieved from Press Information Bureau: https://pib.gov.in/PressReleasePage.aspx?PRID=1725330

Burns, T. a. (1961). Mechanistic and organic systems. *Classics of organizational theory*, 209-214.

Bwo-Nung Huang, M. C. (2008). Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. *Ecological Economics*, 41-54.

C. B. Chapman, S. W. (2003). *Project risk management – Processes, techniques and insights.* Chichester: John Wiley & Sons.

Çakır, A. E. (2012). Applying contingency theory to international organizations: The case of European integration. *Journal of International Organizations Studies*, 7-24.

CARE. (2021, March 1). *Rating Methodology – City Gas Distribution Companies.* Retrieved from Careratings: https://www.careratings.com/upload/NewsFiles/GetRated/Rating%20Methodology%20-%20CGD_March21%20(15-3-2021).pdf

Carr, V. T. (2001). A fuzzy approach to construction project risk assessment and analysis: construction project risk management system. *Advances in engineering software*, 847-857.

Center, I. K. (2020, 02 25). *Total Variance Explained*. Retrieved from IBM: https://www.ibm.com/support/knowledgecenter/SSLVMB_23.0.0/spss/tutorials/fac_cars_tve.html

Chan, M. (2011, April). Fatigue: the most critical accident risk in oil and gas construction. *Construction Management and Economics,* 341-353.

Chapman, R. J. (1998). The effectiveness of working group risk identification and assessment techniques. *International Journal of Project Management*, 333-343.

Charmaz, K. (2000). Constructivist and objectivist grounded theory. In *Handbook of qualitative research* (pp. 509-535).

Charmaz, K. (2008). Grounded theory as an emergent method. In P. L. S. N. Hesse-Biber, *Handbook of emergent methods* (pp. 155-170). New York: Guliford Press.

Charmaz, K. (2014). *Constructing grounded theory: A practical guide through qualitative analysis.* Thousand Oaks, California: Sage Publications.

Corbin, J. S. (2008). Strategies for qualitative data analysis. In *Basics of Qualitative Research: Basics of Qualitative Research. Techniques and procedures for developing grounded theory 3.*

Creswell, J. W. (2004). *Principles of qualitative research: Designing a qualitative study.* University of Nebraska, Lincoln: Office of Qualitative & Mixed Methods Research.

Crouhy, M., Galai, D., & Mark, R. (2006). *The Essentials of Risk Management.* New York: The McGraw-Hill Companies.

Cutler J Cleveland, R. K. (2000, February). Aggregation and the role of energy in the economy. *Ecological Economics*, 301-317.

D. Aaker, B. M. (1984). The need for strategic flexibility. *Journal of Business Strategy*, 74-82.

D. F. Hendry, G. M. (1978). Serial correlation as a convenient simplification, not a nuisance. *Economic Journal*, 549-563.

D. S. Kezsbom, K. E. (2001). *The new dynamic project management: winning through the competitive advantage.* USA: Wiley.

D., H. (2009). *Managing Risk in Projects.* Surrey: Gower Publishing Limited.

D.F. Hendry, A. P. (1984). Dynamic specification. *Handbook of econometrics,* 1023-1100.

D.F.Hendry, G. A. (1977). Testing dynamic specification in small simultaneous systems: an application to a model of Building Society behaviour in the United Kingdom. *Frontiers in Quantitative Economics*.

Dale F. C., G. S. (2005). *Project Risk Management Guidelines.* West Sussex: John Wiley & Sons Ltd.

Daniel J. Graham, S. G. (2002). The Demand for Automobile Fuel: A Survey of Elasticities. *Journal of Transport Economics and Policy*, 1-25.

David Howell, C. W. (2010). A project contingency framework based on uncertainty and its consequences. *International Journal of Project Management*, 256-264.

David Tranfield, D. D. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, 207-222.

Dermot Gately, H. G. (2002). The Asymmetric Effects of Changes in Price and Income on Energy and Oil Demand. *The Energy Journal*, 19-55.

Dey, P. (2004). Analytic hierarchy process helps evaluate project in Indian oil pipelines industry. *International Journal of Operations & Production Management*, 588-604.

Dey, P. K. (2010). Managing project risk using combined analytic hierarchy process and risk map. *Applied Soft Computing*, 990-1000.

Dey, P. K. (2012). Project risk management using multiple criteria decision-making technique and decision tree analysis: a case study of Indian oil refinery. *Production Planning & Control: The Management of Operations*, 903-921.

Dey, P. T. (1994). Planning for project control through risk analysis: a petroleum pipeline-laying project. *International journal of project management,* 23-33.

Dille, T. S. (2011). Managing inter-institutional projects: the significance of isochronism, timing norms, and temporal misfits. *International Journal of Project Management*, 480-490.

Division, E. &. (2020). *Indian Petroleum & Natural Gas Statistics.* New Delhi: Ministry of Petroleum & Natural Gas.

Drazin, R. V. (1985). Alternative forms of fit in contingency theory. *Administrative science quarterly*, 514-539.

Dublin, R. (1978). *Theory development.* New York: Free Press.

Duijne, F., Aken, D., & Schouten, E. (2008). Consideration in developing complete and quantified methods for risk assessment. *Safety Science*, 245-254.

Dvir, D. L. (1998). In search of project classification: a non-universal approach to project success factors. *Research Policy*, 915-935.

Dyche, J. O. (2002). *The CRM handbook: A business guide to customer relationship management.* Addison-Wesley Professional.

Ebrahimnejad, S., Mousavi, S. M., & Seyrafianpour, H. (2010). Risk identification and assessment for build–operate–transfer projects: A fuzzy multi attribute decision making model. *Expert Systems with Applications*, 575-586.

Egan, T. (2002). Grounded theory research and theory building. *Advances in Developing Human Resources*, 277-95.

EIA. (2016, February 2). *Carbon Dioxide Emissions Coefficients*. Retrieved from Energy Information Administration: https://www.eia.gov/environment/emissions/co2_vol_mass.php

EIA. (2020, September 24). *Natural gas explained*. Retrieved from Energy Information Administration: https://www.eia.gov/energyexplained/natural-gas/natural-gas-and-the-environment.php

El Hussein, M. H. (2014). Using grounded theory as a method of inquiry: Advantages and disadvantages. *Qualitative Report*.

El-Shehaby, M., Nosair, I., & Sanad, A. (2014). RISK ASSESSMENT AND ANALYSIS FOR THE CONSTRUCTION OF OFF SHORE OIL & GAS PROJECTS. *International Journal of Scientific Research and Education*. Retrieved from http://ijsae.in/ijsaeems/index.php/ijsae/article/view/88/42

Erdogdu, E. (2010). Natural gas demand in Turkey. *Applied Energy*, 211-219.

F. Urban, R. B. (2007). Modelling energy systems for developing countries. *Energy Policy*, 3473–3482.

F.J. Acedo, C. B. (2006). The Resource-based Theory: Dissemination and Main Trends. *Strategic Management Journal*, 621-636.

Fevre, C. L. (2019). *A review of prospects for natural gas as a fuel in road transport.* Oxford: The Oxford Institute for Energy Studies.

FICCI. (2020). *India Roadmap on Low Carbon and Sustainable Mobility.* New Delhi: FICCI.

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics.* California: SAGE Publications Ltd.

Floricel, S. M. (2001). Strategizing for anticipated risks and turbulence in large-scale engineering projects. *International Journal Project Management*, 445-455.

Floricel, S., & Miller, R. (2001). Strategizing for anticipated risks and turbulence in large-scale engineering projects. *International Journal of project management*, 445-455.

Fusch, P. I. (2015). Are we there yet? Data saturation in qualitative research. *The qualitative report*, 1408.

Gangotra, A. S. (2016). Strategies in managing risks in the adoption of business analytics practices: A case study of a telecom service provider. *Journal of Enterprise Information Management*.

George Alogoskoufis, R. S. (1991). ON ERROR CORRECTION MODELS: SPECIFICATION, INTERPRETATION, ESTIMATION. *Journal of Economic Surveys*, 97-128.

Geraldi, J. G. (2008). The balance between order and chaos in multi-project firms: A conceptual model. *International Journal of Project Management*, 348-356.

Ghosh, A. (1993). Hedging with stock index futures: Estimation and forecasting with error correction model. *Journal of futures markets*, 743-752.

Ghosh, S. J. (2004). Identifying and assessing the critical risk factors in an underground rail project in Thailand: a factor analysis approach. *International Journal of Project Management*, 633-643.

Glaser, B. (1998). *Doing grounded theory: issues and discussions.* Mill Valley, CA: Sociology Press.

Glaser, B. G. (1978). *Theoretical sensitivity*. Mill Valley, CA: Sociology Press.

Global, I. (2020, 6 10). *What is Error Correction Model*. Retrieved from IGI Global: https://www.igi-global.com/dictionary/error-correction-model/39424

Global, N. (2019, December 31). *Current Natural Gas Vehicle Statistics*. Retrieved from NGV Global: https://www.iangv.org/current-ngv-stats/

Goulding, C. (1999, June 1). *Grounded theory: Some reflections on paradigm, procedures and misconceptions.* Retrieved from Working paper series: https://wlv.openrepository.com/handle/2436/11403

Govan, P. D. (2016). The resource-based view on project risk management. *Journal of Construction Engineering and Management*, 04016034.

Guadagnoli, E. W. (1988). Relation of sample size to the stability of component patterns. *Psychological Bulletin*, 265-275.

Gujarati, D. (2012). *Econometrics by Example.* India: Palgrave Macmillan.

Gumber, A. (2008). *Challenges in Development of CNG Infrastructure - India's Experience.* Delhi: GAIL.

Gumber, A. (2008). Development of CNG Infrastruture - India's Experience. *19th World Petroleum Conference* (pp. 1-21). Spain: World Petroleum Council.

Gupta, A., Kar, S. K., Ray, A., & Shastry, D. V. (2017). Human Resource Challenges for Gas Sector in India. In G. A. Kar S., *Natural Gas Markets in India* (pp. 331-345). Singapore: Springer.

H. Heath, S. C. (2004). Developing a grounded theory approach: a comparison of Glaser and Strauss. *International journal of nursing studies*, 141-150.

Han, Z. Y. (2011). Comparison study on qualitative and quantitative risk assessment methods for urban natural gas pipeline network. *Journal of hazardous materials*, 509-518.

Hanson, E. M. (1979). School management and contingency theory: An emerging perspective. *Education Administration Quarterly*, 98-116.

Hao, M. J. (2017). Risk analysis of urban gas pipeline network based on improved bow-tie model. *IOP Conference Series: Earth and Environmental Science* (p. 012059). IOP Publishing.

Hasan, A. (2016). Security of Cross-Country Oil and Gas Pipelines: A Risk-Based Model. *Journal of Pipeline Systems Engineering and Practice*, 1-8.

Hatmoko, J. U. (2019). Mapping delay risks of EPC projects: a case study of a platform and subsea pipeline of an oil and gas project. *IOP Conference Series: Materials Science and Engineering* (p. 012095). IOP Publishing.

Hillson, D. (2002). Extending the risk process to manage opportunities. *International Journal of project management*, 235-240.

Hillson, D. (2002). Extending the risk process to manage opportunities. *International Journal of project management*, 235-240.

Hillson, D. (2002). Extending the risk process to manage opportunity. *International Journal of Project Management*, 235-240.

Hodrick, R., & Prescott, E. (1997). Postwar U.S. business cycles: An empirical investigation. *J. Money credit Bank*, 1-16.

Howell, D. W. (2010). Aproject contingency framework based on uncertainty and its consequences. *International Journal of Project management*, 256-264.

Howell, D. W. (2010). Aproject contingency framework based on uncertainty and its consequences. *International Journal of Project Management*, 256-264.

Hurst, I. B. (1990). Estimating energy and oil demand functions. *Energy Economics*, 93-102.

Huson JoherAli Ahmed, K. M. (2011). Role of oil price shocks on macroeconomic activities: An SVAR approach to the Malaysian economy and monetary responses. *Energy Policy*, 8062-8069.

Ibbs, C. K. (2000). Assessing project management. *Project Management Journal*, 32-43.

ICCT. (2016, April). *India Bharat Stage VI Emission Standards.* Washington: International Council on Clean Transportation. Retrieved from th: https://theicct.org/sites/default/files/publications/India%20BS%20VI%20Policy%20Update%20vF.pdf

IGL. (2020). *Annual Report.* New Delhi: IGL.

Infrastructure, I. (2020, March https://indianinfrastructure.com/2020/03/20/strong-growth-prospects/). *Strong Growth Prospects*. Retrieved from Indian Infrastructure.

J. B. Alam, Z. W. (2013). Energy demand and economic consequences of transport policy. *International Journal of Environmental Science and Technology*, 1075-1082.

J. Koppenjan, W. V. (2011). Competing management approaches in large engineering projects: the Dutch RandstadRail project. *International Journal of Project Management*, 740-750.

J.C. Van Niekerk, J. D. (2009). Glaserian and Straussian grounded theory: similar or completely different? *Proceedings of the 2009 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists*, (pp. 96-103).

Jebaraj, S., Iniyan, S., & Kota, H. (2007). Forecasting of commercial energy consumption in India using Artificial Neural Network. *International Journal of Global Energy Issues*, 276-301.

Jo, Y.-D., & Ahn, B. J. (2005). A method of quantitative risk assessment for transmission pipeline carrying natural gas. *Journal of Hazardous Materials*, 1-12.

Junchen Li, X. D. (2011). Forecasting the growth of China's natural gas consumption. *Energy*, 1380-85.

Jyoti Parikha, P. P. (2007). Demand projections of petroleum products and natural gas in India Jyoti. *Energy*, 1825-1837.

K. G. Corley, D. A. (2011). Building Theory about Theory Building: What Constitutes a Theoretical Contribution? *Academy of Management Review*, 12-32.

Kaplinski, O. (2013). Risk Management of Construction Works by Means of The Utility Theory: A Case Study. *11th International Conference on Modern Building Materials, Structures and Techniques* (pp. 533-539). Procedia Engineering.

Kar, S. K. (2017). Downstream Petroleum and Natural Gas Regulatory Developments in India. In S. K. Kar, *Natural Gas Markets in India* (pp. 275-316). Singapore: Springer.

Kelly, A. (2003). *Decision Making Using Game Theory: An Introduc-tion for Managers.* Cambridge: Cambridge University Press.

Kendall, J. (1999). Axial coding and the grounded theory controversy. *Western journal of nursing research*, 743-757.

Kline, P. (1999). *The handbook of psychological testing.* London: Routledge.

Koppenjan, J. V. (2011). Competing management approaches in large engineering projects: The Dutch RandstadRail project. *International Journal of Project Management*, 740-750.

Krane, H. P. (2009). Categorizing risks in seven large projects—what risks do the projects focus on? *PMI® Global Congress 2009—EMEA.* Amsterdam: Project Management Institute.

Kureshi, N. (2013). Project Performance and Contingency Theory. *Nadeem Kureshi*, 46-51.

Lawrence, P. R. (1967). *Organization and environment.* Homewood, IL: Richard and Irwin.

Lee, C.-C. (2005). Energy consumption and GDP in developing countries: A cointegrated panel analysis. *Energy Economics*, 415-427.

Lenfle, S. L. (2010). Lost roots: How project management came to emphasize control over flexibility and novelty. *California management review*, 32-55.

Li, M., Liu, L., Li, Y., & Xu, Y. (2018). Evaluating the Risk of Natural Gas Pipeline Operation Management in Intuitionistic Fuzzy Linguistic Environments. *Mathematical Problems in Engineering*, 1-13.

Lincoln YS, G. E. (1985). *Naturalistic inquiry.* Beverly Hills: Sage.

Lindkvist, L. S. (1998). Managing product development projects: on the significance of fountains and deadlines. *Organization studies*, 931-951.

Lizarralde, G. d. (2011). Structuring of temporary multi-organizations: Contingency theory in the building sector. *Project Management Journal*, 19-36.

Ma, L. C. (2013). Quantitative risk analysis of urban natural gas pipeline networks using geographical information systems. *Journal of Loss Prevention in the Process Industries*, 1183-1192.

Macgill, S. S. (2005). A new paradigm for risk analysis. *Futures*, 1105-1131.

Mahajan, R., Garg, S., & Sharma, P. B. (2013). Frozen corn manufacturing and its supply chain: Case study using SAP–LAP approach. *Global Journal of Flexible Systems Management*, 167-177.

Majumdar, S. K., & Gupta, M. P. (2001). E-business strategy of car industry: SAP–LAP analysis of select case studies. *Global Institute of Flexible Systems Management*, 13-28.

Mandal, N. G. (2010). Impact of Working Capital Management on Liquidity, Profitability and Non Insurable Risk and Uncertainty Bearing: A Case Study of Oil and Natural Gas Commission (ONGC). *Great Lakes Herald*, 21-42.

Mangla, S. K., Kumar, P., & Barua, M. K. (2014). A flexible decision framework for building risk mitigation strategies in green supply chain using SAP–

LAP and IRP approaches. *Global Journal of Flexible Systems Management, 15*(3), 203-218.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach.* Thousand Oaks, California: Sage Publications.

McCourt, W. (2001). Moving the public management debate forward: A contingency approach. In *The internationalization of public management: Reinventing the third world state.* Cheltenham, UK: Edward Elgar.

Meyer, A. D. (2002). Managing Project Uncertainty: From Variation to Chaos. *MIT Sloan Management Review*, 60.

MGL. (2020). *Annual Report FY20.* Mumbai: MGL.

MoPNG. (2019, October 31). *Policies and Guidelines.* Retrieved from Ministry of Petroleum and Natural Gas: http://petroleum.nic.in/sites/default/files/CGD_Case4_Case5.pdf

Morgan, G. (1997). *Images of organization.* SAGE Publications.

Mubin, S. &. (2013). Innovative Approach to Risk Analysis and Management of Oil and Gas Sector EPC Contracts from a Contractor's Perspective. *Journal of Business & Economics*.

Mubin, S. &. (2016). Risk analysis for construction and operation of gas pipeline projects in Pakistan. *Pakistan Journal of Engineering and Applied Sciences*.

Mukherjee, S. K. (1981). Energy policy and planning in India. *Energy*, 823-51.

Mukherjee, S., & Rao, R. K. (2019). Exploring policy options to include petroleum, natural gas and electricity under the goods and services tax (GST) regime in India. In S. Mukherjee, & R. K. Rao, *Goods and Services Tax in India* (p. 120).

Mukhtar A. Kassem, M. A. (2019). Risk factors in oil and gas construction projects in developing countries: a case study. *International Journal of Energy Sector Management*.

Nunnally, J. C. (1978). *Psychometric theory.* New York: McGraw-Hill.

Office, C. S. (2021, May 8). *Energy Statistics*. Retrieved from MINISTRY OF STATISTICS AND PROGRAMME IMPLEMENTATION:

http://www.mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2018.pdf

Osipova, E. E. (2013). Balancing control and flexibility in joint risk management: Lessons learned from two construction projects. *International Journal of Project Management*, 391-399.

Palanisamy, R. (2012). Building information systems flexibility in SAP–LAP framework: A case study evidence from SME Sector. *Global Journal of Flexible Systems Management*, 57-74.

Paul, K. (1996). *An easy guide to factor analysis.* New York: Routledge.

Pennings, J. (1992). Structural contingency theory: a reappraisal. *Research in Organization Behavior*, 267-309.

Perminova, O. G. (2008). Defining uncertainty in projects – a new perspective. *International journal of Project Management*, 73-79.

Perry, S. R. (1999). Career maturity and college student persistence. *Journal of College Student Retention: Research, Theory & Practice*, 41-58.

Phillips, A. W. (1954). Stabilization policy in a closed economy. *Economic Journal*, 290-323.

PMI. (2004). *A Guide to the Project Management Body of Knowledge.* USA: Project Management Institute Inc.

PMI. (2008). *A guide to the project management body of knowledge (PMBOK ® Guide).* Newtown Square: PMI.

PNGRB. (2020, August 13). *About PNGRB.* Retrieved from PNGRB: https://www.pngrb.gov.in/about-us.html

PNGRB. (2020, 03 31). *Natural gas pipeline network in India.* Retrieved from PNGRB: https://www.pngrb.gov.in/data-bank/NGPLReports23062020.pdf

PNGRB. (2020, June 30). *Natural Gas Pipelines Network in India.* Retrieved from PNGRB: https://www.pngrb.gov.in/data-bank/NGPLReports23062020.pdf

PNGRB. (2021, May 31). *City Gas Distributions*. Retrieved from PNGRB: https://www.pngrb.gov.in/eng-web/cgd-auth.html

PPAC. (2019, April 1). *Pipeline and City Gas Distribution Structure*. Retrieved from Petroleum Planning and Analysis Cell: https://www.ppac.gov.in/content/154_1_PipelineandCGDStructure.aspx

R. C. Clark, M. P. (1990). Risk analysis in the evaluation of non-aerospace projects. *Interdisciplinary Applied-Oriented Journal of Knowledge-based System*, 17-24.

R. M, D. J. (2016). The econometrics of the Hodrick-Prescott filter. *Review of Economics and Statistics*, 310-317.

Rajbhandari, L. S. (2011). An approach to measure effectiveness of control for risk analysis with game theory. *In 2011 1st Workshop on Socio-Technical Aspects in Security and Trust* (pp. 24-29). IEEE.

Rao RD, P. J. (1996). Forecast and analysis of demand for petroleum products in India. *Energy Policy*, 583-92.

Raz, T. S. (2002). Risk management, project success, and technological uncertainty. *R&D Management*, 101-109.

Rawat, A., Gupta, S., & Rao, T. j. (2019). Sustainable Development through Natural Gas Network Development in India. *ICEEE* (pp. 22-29). Stavanger: DEStech Transactions.

RBI. (2021, May 5). *HANDBOOK OF STATISTICS ON INDIAN STATES*. Retrieved from Reserve Bank of India: https://www.rbi.org.in/Scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20States

Reddy BS, B. P. (2003, June). Integrated energy–environment-policy analysis: a case study of India. *Utilities Policy*, 59-73.

Redmill, F. (2002). Risk analysis: A subjective process. *Engineering Management Journal*, 91-96.

Robert U. Ayres, B. (2005, June). Accounting for growth: the role of physical work. 181-209.

Rowley, J. S. (2004). Conducting a literature review. *Management research news*, 1-9.

Roychowdhury, A. (2010). *CNG programme in India: The future challenges.* Center for Science and Environment.

Rui, Z. C. (2018). A comprehensive investigation on performance of oil and gas development in Nigeria: technical and non-technical analyses. *Energy*, 666-680.

Rusticus, S. (2014). *Encyclopedia of Quality of Life and Well-Being Research.* Dordrecht: Springer Netherlands. Retrieved from Springer.

Rzayeva, G. (2014). Natural Gas in the Turkish Domestic Energy Market – Policies and Challenges. *Oxford Institute for Energy Studies*, 1-79.

S. Jebaraja, S. I. (2006). A review of energy models. *Renewable and Sustainable Energy Reviews*, 281-311.

S. Lenfle, C. L. (2010). Lost roots: how project management came to emphasize control over flexibility and novelty. *California Management Review*, 32-55.

S.L. Brown, K. E. (1997). The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly*, 1-34.

Sadeghi, B., M., M. M., & Kashani, H. (2016). Defining mitigation strategies for recurring EPC contract risks. *Construction Research Congress* , 2773-2782.

Sadeh, A. D. (2000). The role of contract type in the success of R&D defense projects under increasing uncertainty. *Project Management Journal*, 14-22.

Salmon, M. (1982). Error correction mechanisms. *Economic Journal,* 615-29.

Sargan, J. D. (1964). Wages and prices in the United Kindom: a study in econometric methodology. *Econometric analysis for national economic planning*, 25-54.

Saunders, B. J. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. Quality & quantity, 1893-1907.

Saunders, M. M. (2012). Perspectives from family caregivers receiving home nursing support: findings from a qualitative study of home care patients with heart failure. Home Healthcare Now, 82-90.

Sauser, B. J. (2009). Why projects fail? How contingency theory can provide new insights–A comparative analysis of NASA's Mars Climate Orbiter loss. *International Journal of Project Management*, 665-679.

Schein, E. (2010). *Organizational culture and leadership.* San Francisco, CA: Jossey-Bass.

Schoonoven, C. B. (1981). Problems with contingency theory: Testing assumptions hidden within the language of contingency "theory.". *Administrative Science Quarterly*, 349-377.

Scott, W. R. (1981). Developments in organization theory: 1960-1980. *American Behavioral Scientist*, 407-422.

Selltiz, C. C. (1962). Factors influencing attitudes of foreign students toward the host country. *Journal of Social issues*, 7-23.

(2017). *Shell World Energy Model.* Amsterdam: Shell International. Retrieved from Royal Dutuh Shell: https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenarios-energy-models/world-energy-model/_jcr_content/par/textimage.stream/1510344160326/d62f12b8fe88e85dc3349c38b1ca5e44cc22c5ccc6f70beed634020cfb527c82/shell-world-energy-mo

Shenhar, A. D. (2007). *Reinventing Project Management: the Diamond Approach to Successful Growth and Innovation.* Cambridge: Harvard Business Press.

Sine, W. D. (2006). Revisiting Burns and Stalker: Formal structure and new venture performance in emerging economic sectors. *Academy of management journal*, 121-132.

Sircar A, S. S. (2017). Challenges & Issues in Natural Gas Distribution Industry. *Journal of Petroleum Engineering & Technology*, 1-8.

Sireci, S. G. (1998). Gathering and analyzing content validity data. *Educational Assessment*, 299-321.

Smith, N. J. (2014). *Managing risk in construction projects.* John Wiley & Sons.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 333-339.

Söderlund, J. (2004). Building theories of project management: past research, questions for the future. *International journal of project management*, 183-191.

Srivastava, A. G. (2010). New methodologies for security risk assessment of oil and gas industry. *Process Safety and Environmental Protection*, 407-412.

Strauss, A. (1998). *Qualitative analysis for social scientists.* New York: Cambridge University Press.

Subhes C.Bhattacharyyaa, G. R. (2010, April). Modelling energy demand of developing countries: Are the specific features adequately captured? *Energy Policy*, 1979-1990.

Suganthia, L., & Samuel, A. A. (2012). Energy models for demand forecasting - A review. *Renewable and Sustainable Energy Reviews*, 1223-1240.

Sushil. (2000a). Situation-actor-process options: Mapping and enhancing flexibility. *Systems Research and Behavioral Science*, 301-309.

Sushil. (2001). SAP-LAP Framework. *Global Journal of Flexible Systems Management*, 51-55.

Syed Kamarul Bakri Syed Ahmad Bokharey, K. V. (2010). Risks and Mitigation Measures in Build-Operate-Transfer Projects. *International Journal of Civil and Environmental Engineering*, 81-87.

T. Burns, G. S. (1961). *The management of innovation.* London: Tavistock.

T. Raz, E. M. (2001). Use and benefits of tools for project risk management. *International Journal of Project Management*, 9-17.

Taroun, A. (2014). Towards a better modelling and assessment of construction risk: Insights from a literature review. *International Journal of Project Management*, 101-115.

Tavakol, M., & Dennick, R. (2011). Making Sense of Cronbach's Alpha. *International Journal of Medical Education*, 53-55.

Tchrakian, T. T. (2011). Real-time traffic flow forecasting using spectral analysis. *IEEE Transactions on Intelligent Transportation Systems*, 519-526.

Thakkar, J. K. (2008). A conceptual role interaction model for supply chain management in SMEs. *Journal of Small Business and Enterprise Development*, 74-95.

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review*, 356–367.

Turner, J. R. (1993). *The handbook of project-base management: improv- ing the processes for achieving strategic objectives.* England: McGraw-Hill.

Uddin, S. M., Iqbal, M., Khan, R. I., & Sakib, M. N. (2017). Opportunities, Challenges and Future Developments of CNG (Compressed Natural Gas) Sector in Bangladesh. *International Conference on Mechanical, Industrial and Materials Engineering* (pp. 73-78). Rajshahi: ICMIME2017

UITP. (2020, August 13). *INDIA WILL IMPLEMENT EURO-VI EMISSION STANDARD FOR VEHICLES BY 2020*. Retrieved from UITP: https://india.uitp.org/articles/euro-vi-emission-standards-by-2020

Ujjawal Kumar, V. J. (2010). Time series models (Grey-Markov, Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy consumption in India. *Energy*, 1709-1716.

Urquhart, C. (2012). *Grounded theory for qualitative research: A practical guide.* Sage Publications.

Utilities, S. (2017, March 1). *Daughter Booster Stations*. Retrieved from Smart Utilities: https://smartutilities.net.in/2017/03/16/daughter-booster-stations/

Vagias, W. M. (2006, 1 1). *Likert-type scale response anchors.* Clemson: Clemson University. Retrieved from Clemson International Institute for Tourism & Research Development, Department of Parks, Recreation and Tourism Management.

Vaid, M. (2014). India’s Natural Gas Infrastructure: Reassessing Challenges and Opportunities. *Strategic Analysis*, 508-527.

Van Donk, D. P. (2008). From organising as projects to projects as organisations. *International Journal of Project Management*, 129-137.

Van Thuyet, N., Ogunlana, S. O., & Dey, P. K. (2007). Risk management in oil and gas construction projects in Vietnam. *International journal of energy sector management*, 175-194.

W.D. Sine, H. M. (2006). Revisiting Burns and Stalker: formal structure and new venture performance in emerging economic sectors. *Academy of Management Journal*, 121-132.

Wadango, B. A.-K. (2014). Contingency theory, performance management and organizational effectiveness in the third sector. *International Journal of Productivity and Performance Management*, 680-703.

Ward, S. C. (2003). Transforming project risk management into project uncertainty management. *International Journal of Project Management*, 97-105.

Weber, K. O. (2009). One size does not fit all---a contingency approach to data governance. *Journal of Data and Information Quality*, 1-27.

Whetten, D. A. (1989). What constitutes a theoretical contribution? *Academy of management review*, 490-495.

Wideman, R. (1992). *Project and Program risk management: a guide to managing project risks and opportunities.* Univerza v Mariboru

Wietze Lise, K. M. (2007). Energy consumption and GDP in Turkey: Is there a co-integration relationship? Energy Economics, 1166-1178.

Williams, M., & Moser, T. (2019). The Art of Coding and Thematic Exploration in Qualitative Research. *International Management Review* , 45-56.

Woodward, J. (1958). *Management and technology.* H.M. Stationary Office.

Woods, M. (2009). A contingency theory perspective on the risk management control system within Birmingham City Council. *Management Accounting Research*, 69-81.

Y.L.Shen. (1997). Project risk management in Hong Kong. *International Journal of Project Management*, 101-105.

Yusof SM, A. E. (2000). Critical success factors in small and medium enterprises: survey results. *Total Qual Manag*, 448-462.

Zia Wadud, H. S. (2011). Modeling and Forecasting Natural gas demand in Bangladesh. *Energy Policy*, 7372-7380.

Zhao, Y. L. (2011). Forecast for construction engineering risk based on fuzzy sets and systems theory. *Systems Engineering Procedia*, 150-161.

Appendix B: CGD networks in India

S.No.	Name of the CGD Network	Area Covered	Authorized Company
1	Sonipat CGD Network	Sonipat	Gail Gas Limited
2	Meerut CGD Network	Meerut	Gail Gas Limited
3	Kakinada CGD Network	Kakinada	Bhagyanagar Gas Limited
4	Dewas CGD Network	Dewas	Gail Gas Limited
5	Kota CGD Network	Kota	Rajasthan State Gas Ltd./ Gail Gas Limited
6	Mathura CGD Network	Mathura	JV of M/s DSM Infratech Pvt. Ltd. & M/s Saumya Mining Pvt. Ltd.
7	Chandigarh CGD Network	Chandigarh	M/s Indian Oil Adani Gas Private Limited
8	Allahabad CGD Network	Allahabad	M/s Indian Oil Adani Gas Private Limited
9	Jalandhar CGD Network	Jalandhar	M/s Jay Madhok Energy Pvt. Ltd.
10	Jhansi CGD Network	Jhansi	M/s Central UP Gas Ltd.
11	Bhavnagar CGD Network	Bhavnagar	M/s Gujarat Gas Ltd.
12	Jamnagar CGD Network	Jamnagar	M/s Gujarat Gas Limited
13	Kutch CGD Network	Kutch (West)	M/s Gujarat Gas Limited
14	Bengaluru Rural and Urban CGD Network	Bengaluru Rural and Urban Districts	M/zs GAIL Gas Limited
15	Daman CGD Network	UT of Daman	M/s Indian Oil-Adani Gas Pvt. Limited

16	Panipat CGD Network	Panipat	M/s Indian Oil-Adani Gas Pvt. Limited
17	Raigarh CGD Network	Raigarh District(Maharashtra) excluding area already authorized	M/s Mahanagar Gas Limited
18	Dadra Nagar Haveli CGD Network	UT of Dadra & Nagar Haveli	M/s Gujarat Gas Limited
19	Thane CGD Network	Thane District(Maharashtra) excluding area already authorized	M/s Gujarat Gas Limited
20	Amritsar CGD Network	Amritsar District (Punjab)	M/s GSPL
21	Pune CGD Network	Pune District(Maharashtra) excluding area already authorized	Mahesh Gas Limited
22	East Godavari District (excluding area already authorized) CGD Network	East Godavari District	Godavari Gas Private Limited
23	West Godavari District CGD Network	West Godavari District	Godavari Gas Private Limited
24	Udham Singh Nagar CGD Network	Udham Singh Nagar	IndianOil-Adani Gas Pvt.Ltd.
25	Haridwar CGD Network	Haridwar	Haridwar Natural Gas Private Limited
26	Tumkur CGD Network	Tumkur	MEIL
27	Dharwad CGD Network	Dharwad	IndianOil-Adani Gas Pvt.Ltd.
28	Krishna District CGD Network	Krishna District (excluding area already authorized)	MEIL
29	Belgaum CGD Network	Belgaum	MEIL
30	Ernakulam District (Kerala)	Ernakulam District (Kerala) GA	Indian Oil - Adani Gas Private Limited
31	Saharanpur District (UP)	Saharanpur District GA	Bharat Petroleum Corporation Limited
32	Amreli District	Amreli District GA	Gujarat Gas Limited
33	Patan District	Patan District GA	Sabarmati Gas Limited
34	Bhatinda District	Bhatinda District GA	Gujarat State Petronet Limited
35	Rupnagar District	Rupnagar District GA	Bharat Petroleum Corporation Limited
36	Dahej Vagra Taluka	Dahej Vagra Taluka GA	Gujarat Gas Limited
37	Fatehgarh Sahib District	Fatehgarh Sahib District GA	IRM Energy Pvt. Limited
38	Dahod District	Dahod District GA	Gujarat Gas Limited
39	North Goa District	North Goa District GA	Goa Natural Gas Pvt. Ltd.
40	Panchmahal District	Panchmahal District GA	Gujarat Gas Limited

41	Anand (excluding the area already authorized)(Gujarat)	Anand (excluding the area already authorized)(Gujarat) GA	Gujarat Gas Limited
42	Banaskantha District	Banaskantha District GA	IRM Energy Pvt. Limited
43	Yamunanagar District	Yamunanagar District GA	Bharat Petroleum Corporation Limited
44	Rewari District	Rewari District GA	Indraprashtha Gas Limited
45	Ratnagiri District	Ratnagiri District GA	Unison Enviro Pvt. Limited
46	Dhar District	Dhar District GA	Perigon Infratech Pvt. Limited
47	Solapur District	Solapur District GA	IMC Limited
48	Ludhiana CGD Network	Ludhiana GA	Jay Madhok Energy Pvt. Limited
49	Kutch (E) CGD Network	Kutch (E) GA	Jay Madhok Energy Pvt. Limited
50	South Goa CGD Network	South Goa District GA	IndianOil-Adani Gas Pvt.Ltd.
51	Karnal CGD Network	Karnal District GA	Indraprastha Gas Ltd.
52	Ambala & Kurukshetra CGD Network	Ambala & Kurukshetra District GA	Consortium of HPCL & Oil India Ltd.
53	Bulandshahr Part CGD Network	Bulandshahr Part District GA	Indian Oil-Adani Gas Pvt. Ltd.
54	Kolhapur CGD Network	Kolhapur District GA	Consortium of HPCL & Oil India Ltd.
55	Bagpat District CGD Network	Bagpat District GA	Consortium of Essel Gas Company Limited & Avinash EM Projects Private Limited
56	Rohtak District CGD Network	Rohtak District GA	BPCL
57	Ahmedabad District (excluding the area already authorized) CGD Network	Ahmedabad District (excluding the area already authorized) GA	M/s Gujarat Gas Limited
58	Jalandhar (except area already authorized), Kapurthala & SBS Nagar Districts CGD Network	Jalandhar (except area already authorized), Kapurthala & SBS Nagar Districts GA	M/s Think Gas Pvt. Ltd
59	Ludhiana (except area already authorized), Barnala, Moga Districts CGD Network	Ludhiana (except area already authorized), Barnala, Moga Districts GA	M/s Think Gas Pvt. Ltd
60	Kamrup & Kamrup Metropolitan Districts CGD Network	Kamrup & Kamrup Metropolitan Districts GA	Assam Gas
61	Aurangabad, Kaimur & Rohtas Districts CGD Network	Aurangabad, Kaimur & Rohtas Districts GA	IOCL
62	Gaya & Nalanda Districts CGD Network	Gaya & Nalanda Districts GA	IOCL
63	Panchkula District (Except areas already authorized), Sirmaur Districts, Shimla & Solan Districts CGD Network	Panchkula District (Except areas already authorized), Sirmaur Districts, Shimla & Solan Districts GA	IOAGPL
64	Hisar District CGD Network	Hisar District GA	Haryana City Gas (Kapil Chopra enterprise)
65	Barwala & Ranpur Talukas District CGD Network	Barwala & Ranpur Talukas GA	Adani Gas Limited

66	Navsari Dist (Except areas already authorized), Surat district (except area already authorized), Tapi (except area already authorized) & the Dangs district District CGD Network	Navsari Dist (Except areas already authorized), Surat district (except area already authorized), Tapi (except area already authorized) & the Dangs district GA	Adani Gas Limited
67	Kheda Districts (Except areas already authorized), Morbi district(except area already authorized) & Mahisagar district District CGD Network	Kheda Districts (Except areas already authorized), Morbi district(except area already authorized) & Mahisagar district GA	Adani Gas Limited
68	Narmada (Rajpipla) District CGD Network	Narmada (Rajpipla) District GA	Gujarat Gas
69	Porbandar District CGD Network	Porbandar District GA	Adani Gas Limited
70	Sonipat District (Except areas already authorized) & Jind District CGD Network	Sonipat District (Except areas already authorized) & Jind District GA	HPCL
71	Srikakulam, Vishakhapatnam and Vizianagaram Districts CGD Network	Srikakulam, Vishakhapatnam and Vizianagaram Districts GA	IOCL
72	Cachar, Hailakandi & Karimganj Districts CGD Network	Cachar, Hailakandi & Karimganj Districts GA	Assam Gas
73	Diu & Gir Somnath Districts CGD Network	Diu & Gir Somnath Districts GA	IRM Energy
74	Junagadh District CGD Network	Junagadh District GA	Torrent Gas
75	Bilaspur, Hamirpur & Una Districts CGD Network	Bilaspur, Hamirpur & Una Districts GA	BGRL
76	Bokaro, Hazaribagh & Ramgarh Districts CGD Network	Bokaro, Hazaribagh & Ramgarh Districts GA	IOCL
77	Chitradurga & Devangere District CGD Network	Chitradurga & Devangere District GA	Unison Enviro
78	Balliari & Gadag Districts CGD Network	Balliari & Gadag Districts GA	BGRL
79	Ramanagara District CGD Network	Ramanagara District GA	MNGL
80	Kozhikode & wayanad Districts CGD Network	Kozhikode & wayanad Districts GA	IOAGPL
81	Kannur, Kasargod & Mahe Districts CGD Network	Kannur, Kasargod & Mahe Districts GA	IOAGPL
82	Guna District CGD Network	Guna District Talukas GA	IOCL
83	Rewa District CGD Network	Rewa District GA	IOCL
84	Ahmednagar & Aurangabad District CGD Network	Ahmednagar & Aurangabad Districts GA	BGRL
85	Valsad (except area already authorized), Dhule & Nashik Districts CGD Network	Valsad (except area already authorized), Dhule & Nashik Districts GA	MNGL

86	Sindhudurg District CGD Network	Sindhudurg District GA	MNGL
87	Bargarh, Debagarh & Sambalpur Districts CGD Network	Bargarh, Debagarh & Sambalpur Districts GA	BGRL
88	Puducherry District CGD Network	Puducherry District GA	Consortium of SKN Haryana City Gas
89	SAS Nagar district (Except areas already authorized), Patiala & Sangrur Districts CGD Network	SAS Nagar district (Except areas already authorized), Patiala & Sangrur Districts GA	Torrent Gas
90	Alwar (Other than Bhiwadi) & Jaipur Districts CGD Network	Alwar (Other than Bhiwadi) & Jaipur Districts GA	Torrent Gas
91	Dholpur	Dholpur	Essel Gas Company Limited
92	Coimbatore District CGD Network	Coimbatore District GA	IOCL
93	Cuddalore, Nagapatinam & Tiruvarur Districts CGD Network	Cuddalore, Nagapatinam & Tiruvarur Districts GA	Adani Gas Limited
94	Ramanathapuram District CGD Network	Ramanathapuram District GA	Consortium of AG&P LNG Marketing Pte. Ltd
95	Salem DistrictCGD Network	Salem District GA	IOCL
96	Tiruppur DistrictCGD Network	Tiruppur District GA	Adani Gas Limited
97	Bhadradri Kothagudem & Khammam Districts CGD Network	Bhadradri Kothagudem & Khammam Districts GA	MEIL
98	Jagtial, Peddapalle, Karimnagar & Rajanna Sircilla Districts CGD Network	Jagtial, Peddapalle, Karimnagar & Rajanna Sircilla Districts GA	IOCL
99	Nalgonda. Suryapet & Yadadri Bhuvanagiri Districts CGD Network	Nalgonda. Suryapet & Yadadri Bhuvanagiri Districts GA	MEIL
100	Allahabad (Except areas already authorized), Bhadohi & Kausambi Districts CGD Network	Allahabad (Except areas already authorized), Bhadohi & Kausambi Districts GA	IOAGPL
101	Giridih & Dhanbad Districts CGD Network	Giridih & Dhanbadi Districts GA	GAIL Gas
102	Dakshina Kannada Districts CGD Network	Dakshina Kannada Districts GA	GAIL Gas
103	Bhopal & Rajgarh Districts CGD Network	Bhopal & Rajgarh Districts GA	Consortium of Think Gas Investment Pte. Ltd.
104	Satna & Shandol Districts CGD Network	Satna & Shandol Districts GA	BGRL
105	Latur & Osamanabad Districts CGD Network	Latur & Osamanabad Districts GA	Unison Enviro

106	Sangli & Satara Districts CGD Network	Sangli & Satara Districts GA	BGRL
107	Sundargarh & Jharsuguda Districts CGD Network	Sundargarh & Jharsuguda Districts GA	GAIL Gas
108	Balasore, Bhadrak & Mayurbhanj Districts CGD Network	Balasore, Bhadrak & Mayurbhanj Districts GA	Adani Gas Limited
109	Ganjam, Nayagarh & Puri Districts CGD Network	Ganjam, Nayagarh & Puri Districts GA	GAIL Gas
110	Jagatsinghpur & Kendrapara Districts CGD Network	Jagatsinghpur & Kendrapara Districts GA	BGRL
111	Jajpur & Kendujhar Districts CGD Network	Jajpur & Kendujhar Districts GA	BGRL
112	Karaikal & NagapattinamDistricts CGD Network	Karaikal & Nagapattinam Districts GA	Torrent Gas
113	Kota (except area already authorized), Baran & Chittontarh (Only Rawatbhata Taluka) Districts CGD Network	Kota (except area already authorized), Baran & Chittontarh (Only Rawatbhata Taluka) Districts GA	Torrent Gas
114	Chennai & Tiruvallur Districts CGD Network	Chennai & Tiruvallur Districts GA	Torrent Gas Private Limited
115	Medak, Siddipet & SangareddyDistricts CGD Network	Medak, Siddipet & Sangareddy Districts GA	Torrent Gas
116	Gomati Districts CGD Network	Gomati Districts GA	TNGCL
117	West Tripura (Except areas already authorized) Districts CGD Network	West Tripura (Except areas already authorized) Districts GA	TNGCL
118	Auraiya, Kanpur Dehat & Etawah Districts CGD Network	Auraiya, Kanpur Dehat & Etawah Districts GA	Torrent Gas
119	Faizabad & Sultanpur Districts CGD Network	Faizabad & Sultanpur Districts GA	Green Gas
120	Gorakhpur, Sant Kabir Nagar & KushinagarDistricts CGD Network	Gorakhpur, Sant Kabir Nagar & Kushinagar Districts GA	Torrent Gas
121	Meerut (Except areas already authorized), Muzaffarnagar & Shamali Districts CGD Network	Meerut (Except areas already authorized), Muzaffarnagar & Shamali Districts GA	IGL
122	Moradabad (Except areas already authorized)Districts CGD Network	Moradabad (Except areas already authorized) Districts GA	Torrent Gas
123	Unnao (Except areas already authorized)Districts CGD Network	Unnao (Except areas already authorized) Districts GA	Green Gas

124	Dehradun District Districts CGD Network	Dehradun District Districts GA	GAIL Gas
125	Begusarai District CGD Network	Begusarai District GA	Consortium of Think Gas Investment Pte. Ltd
126	Surendranagar (Except areas already authorized) District CGD Network	Surendranagar (Except areas already authorized) District GA	Adani Gas Limited
127	Bhiwani, Charkhi Dadri and Mahendragarh Districts CGD Network	Bhiwani, Charkhi Dadri and Mahendragarh Districts GA	Adani Gas Limited
128	Jhajhar District CGD Network	Jhajhar District GA	Haryana City Gas (Kapil Chopra enterprise)
129	Nuh and Palwal Districts CGD Network	Nuh and Palwal Districts GA	Adani Gas Limited
130	Udupi District CGD Network	Udupi District GA	Adani Gas Limited
131	Bilwara and Bundi Districts CGD Network	Bilwara and Bundi Districts GA	Adani Gas Limited
132	Chittorgarh (Other than Rawatbhata) and Udaipur Districts CGD Network	Chittorgarh (Other than Rawatbhata) and Udaipur Districts GA	Adani Gas Limited
133	Jangaon, Jayashankar Boopalpally, Mahbubabad, Warangal Urban and Warangal Rural Districts CGD Network	Jangaon, Jayashankar Boopalpally, Mahbubabad, Warangal Urban and Warangal Rural Districts GA	MEIL
134	Bulandshahr (Except areas already authorized), Aligarh and Hathras Districts CGD Network	Bulandshahr (Except areas already authorized), Aligarh and Hathras Districts GA	Indian Oil-Adani Gas Pvt. Ltd.
135	Bidar District CGD Network	Bidar District GA	Bharat Gas Resources Limited
136	Amethi, Pratapgarh and Rai Bareli Districts CGD Network	Amethi, Pratapgarh and Rai Bareli Districts GA	Bharat Gas Resources Limited
137	Angul and Dhekanal Districts CGD Network	Angul and Dhekanal Districts GA	Bharat Gas Resources Limited
138	Barmer, Jaisalmer and Jodhpur Districts CGD Network	Barmer, Jaisalmer and Jodhpur Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
139	Medchal Rangareddy and Vikarabad Districts CGD Network	Medchal Rangareddy and Vikarabad Districts GA	MEIL
140	Burdwan District CGD Network	Burdwan District GA	Indian Oil-Adani Gas Pvt. Ltd
141	Malappuram Districts CGD Network	Malappuram Districts GA	Indian Oil-Adani Gas Pvt. Ltd
142	Palakkad and Thrissur Districts CGD Network	Palakkad and Thrissur Districts GA	Indian Oil-Adani Gas Pvt. Ltd
143	Kaithal District CGD Network	Kaithal District GA	IGL
144	Sirsa, Fatehabad and Mansa (Punjab) Districts CGD Network	Sirsa, Fatehabad and Mansa (Punjab) Districts GA	Gujarat Gas
145	Shivpuri District CGD Network	Shivpuri District GA	Consortium of Think Gas Investment Pte. Ltd

146	Sidhi and Singrauli Districts CGD Network	Sidhi and Singrauli Districts GA	Bharat Gas Resources Limited
147	Ujjain (Except area already authorized) District, Dewas (Except area already authorized) District and Indore (Except area already authorized) District CGD Network	Ujjain (Except area already authorized) District, Dewas (Except area already authorized) District and Indore (Except area already authorized) District GA	Gujarat Gas
148	Jhabua, Banswara, Ratlam and Dungarpur Districts CGD Network	Jhabua, Banswara, Ratlam and Dungarpur Districts GA	Gujarat Gas
149	Ferozepur, Faridkot and Sri Muktsar Sahib Districts CGD Network	Ferozepur, Faridkot and Sri Muktsar Sahib Districts GA	Gujarat Gas
150	Hoshiarpur and Gurdaspur Districts CGD Network	Hoshiarpur and Gurdaspur Districts GA	Gujarat gas
151	Ajmer, Pali and Rajsamand Districts CGD Network	Ajmer, Pali and Rajsamand Districts GA	IGL
152	Jalore and Sirohi Districts CGD Network	Jalore and Sirohi Districts GA	Gujarat Gas
153	Kanpur (Except area already authorized) District, Fatehpur and Hamirpur Districts CGD Network	Kanpur (Except area already authorized) District, Fatehpur and Hamirpur Districts GA	IGL
154	Araria, Purnia, Katihar and Kishanganj Districts CGD Network	Araria, Purnia, Katihar and Kishanganj Districts GA	IOCL
155	Arwal, Jehanabad, Bhojpur and Buxar Districts	Arwal, Jehanabad, Bhojpur and Buxar Districts GA	IOCL
156	Khagaria, Saharsa and Madhepura Districts	Khagaria, Saharsa and Madhepura Districts GA	IOCL
157	Lakhisarai, Munger and Bhagalpur Districts	Lakhisarai, Munger and Bhagalpur Districts GA	IOCL
158	Muzaffarpur, Vaishali, Saran and Samastipur Districts	Muzaffarpur, Vaishali, Saran and Samastipur Districts GA	IOCL
159	Sheikhpura, Jamui and Deoghar Districts	Sheikhpura, Jamui and Deoghar Districts GA	IOCL
160	Chatra and Palamu Districts	Chatra and Palamu Districts GA	BGRL
161	Alapuzzha, Kollam and Thiruvananthapuram Districts	Alapuzzha, Kollam and Thiruvananthapuram Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
162	Ashoknagar District	Ashoknagar District GA	IOCL
163	Gwalior (Except already authorized) District and Sheopur District	Gwalior (Except already authorized) District and Sheopur District GA	RSGL
164	Morena District	Morena District GA	IOCL
165	Anuppur, Bilaspur and Korba Districts	Anuppur, Bilaspur and Korba Districts GA	Adani Gas Limited

166	Jhansi (Except area already authorized) District, Bhind, Jalaun, Lalitpur and Datia Districts	Jhansi (Except area already authorized) District, Bhind, Jalaun, Lalitpur and Datia Districts GA	Adani Gas Limited
167	Basti and Ambedkarnagar Districts	Basti and Ambedkarnagar Districts GA	Torrent Gas Private Limited
168	Gonda and Barabanki Districts	Gonda and Barabanki Districts GA	Torrent Gas Private Limited
169	Azamgarh, Mau and Ballia Districts	Azamgarh, Mau and Ballia Districts GA	Torrent Gas Private Limited
170	Anantapur and YSR (Kadapa) Districts	Anantapur and YSR (Kadapa) Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
171	Sri Potti Sriramulu Nellore District	Sri Potti Sriramulu Nellore District GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
172	Chittoor, Kolar and Vellore Districts	Chittoor, Kolar and Vellore Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
173	West Singhbhum District	West Singhbhum District GA	GAIL Gas Limited
174	Bagalkot, Koppal and Raichur Districts	Bagalkot, Koppal and Raichur Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
175	Chikkamagaluru, Hassan and Kodagu Districts	Chikkamagaluru, Hassan and Kodagu Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
176	Kalaburagi and Vijayapura Districts	Kalaburagi and Vijayapura Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
177	Mysuru, Mandya and Chamarajanagar Districts	Mysuru, Mandya and Chamarajanagar Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
178	Uttara Kannada, Haveri and Shivamogga Districts	Uttara Kannada, Haveri and Shivamogga Districts GA	Consortium of AG&P LNG Marketing Pte Ltd. and Atlantic Gulf and Pacific
179	Bareilly (Except area already authorized) District, Pilibhit and Rampur Districts	Bareilly (Except area already authorized) District, Pilibhit and Rampur Districts GA	HPCL
180	Farrukhabad, Etah and Hardoi Districts	Farrukhabad, Etah and Hardoi Districts GA	HPCL
181	Mainpuri and Kannauj Districts	Mainpuri and Kannauj Districts GA	HPCL
182	Shahjahanpur and Budaun Districts	Shahjahanpur and Budaun Districts GA	HPCL
183	Bijnor and Nainital Districts	Bijnor and Nainital Districts GA	HPCL
184	Darjeeling, Jalpaiguri and Uttar Dinajpur Districts	Darjeeling, Jalpaiguri and Uttar Dinajpur Districts GA	HPCL

185	Nadia (Except Area already authorized) District and North 24 Parganas (Except Area already authorized) District	Nadia (Except Area already authorized) District and North 24 Parganas (Except Area already authorized) District GA	HPCL
186	South 24 Parganas (Except Area already authorized) District	South 24 Parganas (Except Area already authorized) District GA	HPCL
187	Howrah (Except Area already authorized) District and Hoogly (Except Area already authorized) District	Howrah (Except Area already authorized) District and Hoogly (Except Area already authorized) District GA	HPCL
188	Seraikela-Kharsawan District	Seraikela-Kharsawan District GA	GAIL Gas
189	Raisen, Shajapur and Sehore Districts	Raisen, Shajapur and Sehore District GA	GAIL Gas
190	Nawada and Koderma Districts	Nawada and Koderma District GA	IOCL
191	Mirzapur, Chandauli and Sonbhadra Districts	Mirzapur, Chandauli and Sonbhadra District GA	GAIL Gas
192	Jaunpur and Ghazipur Districts	Jaunpur and Ghazipur District GA	IOAG Private. Limited
193	Agartala CGD Network	Agartala CGD Network	Tripura Natural Gas Ltd
194	Upper Assam CGD Network	Upper Assam CGD Network	Assam Gas Company Ltd
195	Firozabad Geographical Area (Taj Trapezium Zone)	Firozabad Geographical Area (Taj Trapezium Zone) in the state of UP	GAIL Gas Ltd
196	Agra CGD Network	Agra	Green Gas Limited
197	Hyderabad CGD Network	Hyderabad	Bhagyanagar Gas Limited
198	Indore CGD Network	Indore including Ujjain	Aavantika Gas Limited
199	Gwalior CGD Network	Gwalior	Aavantika Gas Limited
200	Ghandhinagar Mehsana Sabarkantha CGD Network	Ghandhinagar Mehsana Sabarkantha	Sabarmati Gas Limited
201	Pune City including Pimpri Chichwad CGD Network	Pune City including Pimpri Chiechwad and along with adjoining contiguous areas of Hinjewadi, Chakan & Talegaon GA	Maharashtra Natural Gas Limited
202	Kanpur CGD Network	Kanpur GA	Central U.P. Gas Limited
203	Bareilly CGD Network	Bareilly GA	Central U.P. Gas Limited
204	Delhi CGD Network	National Capital Territory of Delhi	Indraprastha Gas Limited
205	Mumbai CGD Network	Mumbai & Greater Mumbai	Mahanagar Gas Limited

206	Vijaywada CGD Network	Vijaywada GA	Bhagyanagar Gas Limited
207	Mumbai CGD Network(GA-2)	Thane City & adjoining contiguous areas including Mira Bhayender, Navi Mumbai, Thane City,Ambernath, Bhiwandi,Kalyan, Dombivily, Badlapur, Ulhasnagar, Panvel,Kharghar & Taloja.	Mahanagar Gas Limited
208	Kolkata CGD Network	Kolkata Municipal Corporation and parts of adjoining districts of North 24Parganas, South 24Parganas, Howrah, Hooghly and Nadia	Greater Calcutta Gas Supply Corporation Limited
209	Lucknow CGD Network	Lucknow GA	Green Gas Limited
210	Vadodara CGD Network	Vadodara GA	Acceptance of Central Govt. to Vadodara Gas Limited
211	Ghaziabad CGD Network	Ghaziabad GA	Acceptance of Central Govt. to Indraprastha Gas Limited.
212	Anand	Anand area including Karjari & Vadtal Villages (in Kheda District)	Charotar Gas Sahakari Mandali Limited
213	Valsad	Valsad Geographical Area	M/s Gujarat Gas Limited
214	Hazira	Hazira Geographical Area	M/s Gujarat Gas Limited
215	Rajkot	Rajkot Geographical Area	M/s Gujarat Gas Limited
216	Surendranagar	Surendranagar Geographical Area	M/s Gujarat Gas Limited
217	Navsari	Navsari Geographical Area	M/s Gujarat Gas Limited
218	Nadiad	Nadiad Geographical Area	M/s Gujarat Gas Limited
219	Khurja	Khurja Geographical Area	Adani Gas Limited
220	Moradabad	Moradabad Geographical Area	Siti Energy Limited
221	Surat-Bharuch-Ankleshwar	Surat-Bharuch-Ankleshwar Geographical Area	M/s Gujarat Gas Limited
222	Bhiwadi	Bhiwadi (in Alwar District) Geographical Area	M/s Haryana City Gas Distribution Limited
223	Ahmedabad City & Daskroi area	Ahmedabad City & Daskroi Geographical Area	Adani Gas Limited
224	Khordha CGD Network	Khordha District GA	GAIL (India) Limited
225	Cuttack CGD Network	Cuttack District GA	GAIL (India) Limited
226	Patna CGD Network	Patna District GA	GAIL (India) Limited
227	Ranchi CGD Network	Ranchi District GA	GAIL (India) Limited
228	East Singhbhum CGD Network	East Singhbhum District GA	GAIL (India) Limited
229	Varanasi CGD Network	Varanasi District GA	GAIL (India) Limited

Appendix C: Research Analysis (Objective 1)

Null Hypothesis: LTGASCON has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.474195	0.1284
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LTGASCON)
Method: Least Squares
Date: 05/23/18 Time: 14:24
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTGASCON(-1)	-0.027894	0.011274	-2.474195	0.0174
C	0.542374	0.181281	2.991893	0.0046

R-squared	0.124622	Mean dependent var	0.095633
Adjusted R-squared	0.104264	S.D. dependent var	0.114485
S.E. of regression	0.108353	Akaike info criterion	-1.563425
Sum squared resid	0.504832	Schwarz criterion	-1.483129
Log likelihood	37.17707	Hannan-Quinn criter.	-1.533492
F-statistic	6.121641	Durbin-Watson stat	1.559117
Prob(F-statistic)	0.017377		

Null Hypothesis: LTGASCON has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.474195	0.1284
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.011218
HAC corrected variance (Bartlett kernel)	0.011218

Phillips-Perron Test Equation
Dependent Variable: D(LTGASCON)
Method: Least Squares
Date: 05/23/18 Time: 14:25
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTGASCON(-1)	-0.027894	0.011274	-2.474195	0.0174
C	0.542374	0.181281	2.991893	0.0046

R-squared	0.124622	Mean dependent var	0.095633
Adjusted R-squared	0.104264	S.D. dependent var	0.114485
S.E. of regression	0.108353	Akaike info criterion	-1.563425
Sum squared resid	0.504832	Schwarz criterion	-1.483129
Log likelihood	37.17707	Hannan-Quinn criter.	-1.533492
F-statistic	6.121641	Durbin-Watson stat	1.559117
Prob(F-statistic)	0.017377		

Null Hypothesis: D(LTGASCON) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.747259	0.0004

Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LTGASCON,2)
Method: Least Squares
Date: 05/23/18 Time: 14:25
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	-0.703630	0.148218	-4.747259	0.0000
C	0.066578	0.022209	2.997762	0.0046

R-squared	0.349205	Mean dependent var	-0.001945
Adjusted R-squared	0.333710	S.D. dependent var	0.137166
S.E. of regression	0.111964	Akaike info criterion	-1.496894
Sum squared resid	0.526507	Schwarz criterion	-1.415794
Log likelihood	34.93166	Hannan-Quinn criter.	-1.466818
F-statistic	22.53647	Durbin-Watson stat	2.025369
Prob(F-statistic)	0.000024		

Null Hypothesis: D(LTGASCON) has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.735493	0.0004
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.011966

HAC corrected variance (Bartlett kernel)	0.011792

Phillips-Perron Test Equation
Dependent Variable: D(LTGASCON,2)
Method: Least Squares
Date: 05/23/18 Time: 14:26
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	-0.703630	0.148218	-4.747259	0.0000
C	0.066578	0.022209	2.997762	0.0046

R-squared	0.349205	Mean dependent var	-0.001945
Adjusted R-squared	0.333710	S.D. dependent var	0.137166
S.E. of regression	0.111964	Akaike info criterion	-1.496894
Sum squared resid	0.526507	Schwarz criterion	-1.415794
Log likelihood	34.93166	Hannan-Quinn criter.	-1.466818
F-statistic	22.53647	Durbin-Watson stat	2.025369
Prob(F-statistic)	0.000024		

Null Hypothesis: LPRICE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.221281	0.2018
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPRICE)
Method: Least Squares
Date: 05/23/18 Time: 14:28

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPRICE(-1)	-0.093977	0.042308	-2.221281	0.0316
C	0.786832	0.317851	2.475477	0.0173

R-squared	0.102935	Mean dependent var	0.088058
Adjusted R-squared	0.082073	S.D. dependent var	0.318364
S.E. of regression	0.305020	Akaike info criterion	0.506546
Sum squared resid	4.000591	Schwarz criterion	0.586842
Log likelihood	-9.397276	Hannan-Quinn criter.	0.536479
F-statistic	4.934088	Durbin-Watson stat	1.874167
Prob(F-statistic)	0.031648		

Null Hypothesis: LPRICE has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.240101	0.1955
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.088902
HAC corrected variance (Bartlett kernel)	0.081125

Phillips-Perron Test Equation
Dependent Variable: D(LPRICE)
Method: Least Squares
Date: 05/23/18 Time: 14:28
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPRICE(-1)	-0.093977	0.042308	-2.221281	0.0316
C	0.786832	0.317851	2.475477	0.0173

R-squared	0.102935	Mean dependent var	0.088058
Adjusted R-squared	0.082073	S.D. dependent var	0.318364
S.E. of regression	0.305020	Akaike info criterion	0.506546
Sum squared resid	4.000591	Schwarz criterion	0.586842
Log likelihood	-9.397276	Hannan-Quinn criter.	0.536479
F-statistic	4.934088	Durbin-Watson stat	1.874167
Prob(F-statistic)	0.031648		

Null Hypothesis: D(LPRICE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.982297	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPRICE,2)
Method: Least Squares
Date: 05/23/18 Time: 14:28
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPRICE(-1))	-0.939546	0.157054	-5.982297	0.0000
C	0.084163	0.051333	1.639548	0.1086

R-squared	0.460070	Mean dependent var	-0.007470
Adjusted R-squared	0.447215	S.D. dependent var	0.437115
S.E. of regression	0.324993	Akaike info criterion	0.634364

Sum squared resid	4.436064	Schwarz criterion	0.715464
Log likelihood	-11.95601	Hannan-Quinn criter.	0.664440
F-statistic	35.78788	Durbin-Watson stat	1.948503
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LPRICE) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.963515	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.100820
HAC corrected variance (Bartlett kernel)	0.095459

Phillips-Perron Test Equation
Dependent Variable: D(LPRICE,2)
Method: Least Squares
Date: 05/23/18 Time: 14:29
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPRICE(-1))	-0.939546	0.157054	-5.982297	0.0000
C	0.084163	0.051333	1.639548	0.1086

R-squared	0.460070	Mean dependent var	-0.007470
Adjusted R-squared	0.447215	S.D. dependent var	0.437115
S.E. of regression	0.324993	Akaike info criterion	0.634364
Sum squared resid	4.436064	Schwarz criterion	0.715464
Log likelihood	-11.95601	Hannan-Quinn criter.	0.664440
F-statistic	35.78788	Durbin-Watson stat	1.948503

Prob(F-statistic)	0.000000

Null Hypothesis: LGDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.148521	0.9374
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP)
Method: Least Squares
Date: 05/23/18 Time: 14:30
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	-0.001805	0.012155	-0.148521	0.8826
C	0.126477	0.323873	0.390516	0.6981

R-squared	0.000513	Mean dependent var	0.078407
Adjusted R-squared	-0.022731	S.D. dependent var	0.077527
S.E. of regression	0.078403	Akaike info criterion	-2.210486
Sum squared resid	0.264321	Schwarz criterion	-2.130190
Log likelihood	51.73594	Hannan-Quinn criter.	-2.180552
F-statistic	0.022058	Durbin-Watson stat	1.881569
Prob(F-statistic)	0.882626		

Null Hypothesis: LGDP has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-0.188405	0.9324
Test critical values: 1% level	-3.584743	
5% level	-2.928142	
10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.005874
HAC corrected variance (Bartlett kernel)	0.007191

Phillips-Perron Test Equation
Dependent Variable: D(LGDP)
Method: Least Squares
Date: 05/23/18 Time: 14:31
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	-0.001805	0.012155	-0.148521	0.8826
C	0.126477	0.323873	0.390516	0.6981

R-squared	0.000513	Mean dependent var	0.078407
Adjusted R-squared	-0.022731	S.D. dependent var	0.077527
S.E. of regression	0.078403	Akaike info criterion	-2.210486
Sum squared resid	0.264321	Schwarz criterion	-2.130190
Log likelihood	51.73594	Hannan-Quinn criter.	-2.180552
F-statistic	0.022058	Durbin-Watson stat	1.881569
Prob(F-statistic)	0.882626		

Null Hypothesis: D(LGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic		-6.123676	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP,2)
Method: Least Squares
Date: 05/23/18 Time: 14:32
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDP(-1))	-0.942684	0.153941	-6.123676	0.0000
C	0.074350	0.016970	4.381208	0.0001

R-squared	0.471694	Mean dependent var	0.000470
Adjusted R-squared	0.459115	S.D. dependent var	0.107641
S.E. of regression	0.079164	Akaike info criterion	-2.190193
Sum squared resid	0.263213	Schwarz criterion	-2.109094
Log likelihood	50.18425	Hannan-Quinn criter.	-2.160118
F-statistic	37.49941	Durbin-Watson stat	1.956710
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LGDP) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.143674	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.005982
HAC corrected variance (Bartlett kernel)	0.006397

Phillips-Perron Test Equation
Dependent Variable: D(LGDP,2)
Method: Least Squares
Date: 05/23/18 Time: 14:32
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDP(-1))	-0.942684	0.153941	-6.123676	0.0000
C	0.074350	0.016970	4.381208	0.0001

R-squared	0.471694	Mean dependent var	0.000470
Adjusted R-squared	0.459115	S.D. dependent var	0.107641
S.E. of regression	0.079164	Akaike info criterion	-2.190193
Sum squared resid	0.263213	Schwarz criterion	-2.109094
Log likelihood	50.18425	Hannan-Quinn criter.	-2.160118
F-statistic	37.49941	Durbin-Watson stat	1.956710
Prob(F-statistic)	0.000000		

Model A:

Estimation Equation:
=========================
LTGASCON = C(1)*LTGASCON(-1) + C(2)*LPRICE + C(3)*LGDP

Substituted Coefficients:
=========================
LTGASCON = 0.947580592475*LTGASCON(-1) + 0.0143515978675*LPRICE + 0.0309592192428*LGDP

Dependent Variable: LTGASCON
Method: Least Squares
Date: 05/23/18 Time: 16:03
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTGASCON(-1)	0.947581	0.022804	41.55295	0.0000
LPRICE	0.014352	0.026381	0.544003	0.5893
LGDP	0.030959	0.010718	2.888429	0.0061

R-squared	0.994210	Mean dependent var	16.11137
Adjusted R-squared	0.993934	S.D. dependent var	1.412549
S.E. of regression	0.110013	Akaike info criterion	-1.512089
Sum squared resid	0.508323	Schwarz criterion	-1.391645
Log likelihood	37.02201	Hannan-Quinn criter.	-1.467189
Durbin-Watson stat	1.519121		

Null Hypothesis: U has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.076327	0.0001
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(U)
Method: Least Squares
Date: 05/23/18 Time: 16:05
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U(-1)	-0.763051	0.150315	-5.076327	0.0000
C	0.000794	0.016095	0.049329	0.9609

R-squared	0.380248	Mean dependent var	-0.000573
Adjusted R-squared	0.365492	S.D. dependent var	0.134007

S.E. of regression	0.106745	Akaike info criterion	-1.592364
Sum squared resid	0.478566	Schwarz criterion	-1.511265
Log likelihood	37.03201	Hannan-Quinn criter.	-1.562289
F-statistic	25.76910	Durbin-Watson stat	2.001324
Prob(F-statistic)	0.000008		

ECM Model A:

Estimation Equation:
=========================
D(LTGASCON) = C(1)*D(LTGASCON(-1)) + C(2)*D(LPRICE) + C(3)*D(LGDP) + C(4)*U(-1)

Substituted Coefficients:
=========================
D(LTGASCON) = 1.09589783513*D(LTGASCON(-1)) - 0.0266204929275*D(LPRICE) - 0.0782819861812*D(LGDP) - 0.92152838635*U(-1)

Dependent Variable: D(LTGASCON)
Method: Least Squares
Date: 05/23/18 Time: 16:08
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	1.095898	0.211138	5.190425	0.0000
D(LPRICE)	-0.026620	0.052406	-0.507967	0.6143
D(LGDP)	-0.078282	0.200235	-0.390951	0.6979
U(-1)	-0.921528	0.269089	-3.424623	0.0014

R-squared	0.192906	Mean dependent var	0.095440
Adjusted R-squared	0.132374	S.D. dependent var	0.115801
S.E. of regression	0.107865	Akaike info criterion	-1.529367
Sum squared resid	0.465393	Schwarz criterion	-1.367168
Log likelihood	37.64606	Hannan-Quinn criter.	-1.469215
Durbin-Watson stat	2.023689		

Variance Inflation Factors

Date: 05/23/18 Time: 16:11
Sample: 1971 2016
Included observations: 44

Variable	Coefficient Variance	Uncentered VIF
D(LTGASCON(-1))	0.044579	3.785230
D(LPRICE)	0.002746	1.135059
D(LGDP)	0.040094	1.852542
U(-1)	0.072409	3.139341

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.487313	Prob. F(2,38)	0.6181
Obs*R-squared	1.100294	Prob. Chi-Square(2)	0.5769

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/23/18 Time: 16:13
Sample: 1973 2016
Included observations: 44
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	-0.018780	0.215697	-0.087066	0.9311
D(LPRICE)	0.000397	0.053103	0.007474	0.9941
D(LGDP)	0.014974	0.205857	0.072742	0.9424
U(-1)	0.781072	0.868531	0.899303	0.3742
RESID(-1)	-0.786053	0.834517	-0.941926	0.3522
RESID(-2)	-0.222205	0.247855	-0.896512	0.3756

R-squared	0.024902	Mean dependent var	-0.001063
Adjusted R-squared	-0.103400	S.D. dependent var	0.104029
S.E. of regression	0.109275	Akaike info criterion	-1.463782
Sum squared resid	0.453755	Schwarz criterion	-1.220484
Log likelihood	38.20321	Hannan-Quinn criter.	-1.373555
Durbin-Watson stat	2.074184		

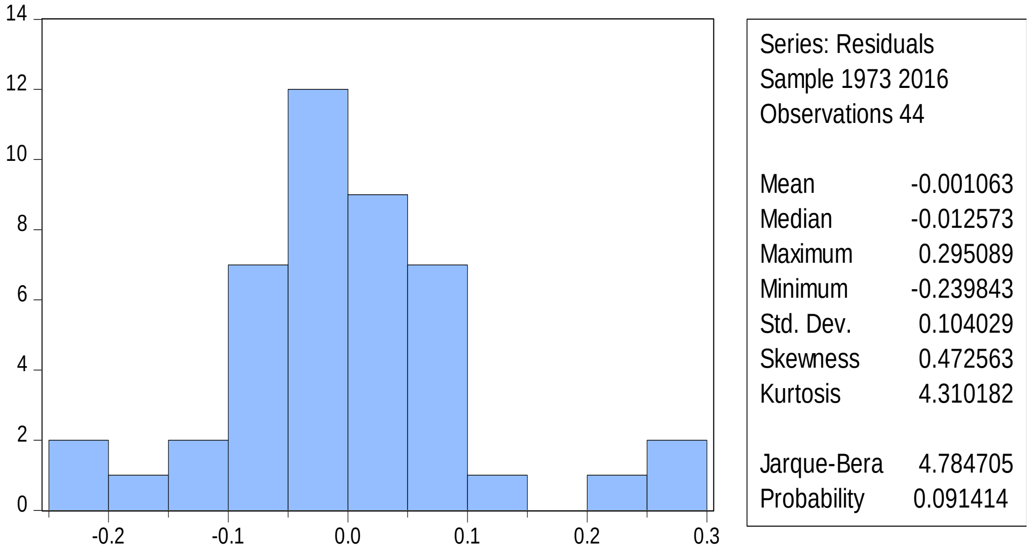
Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

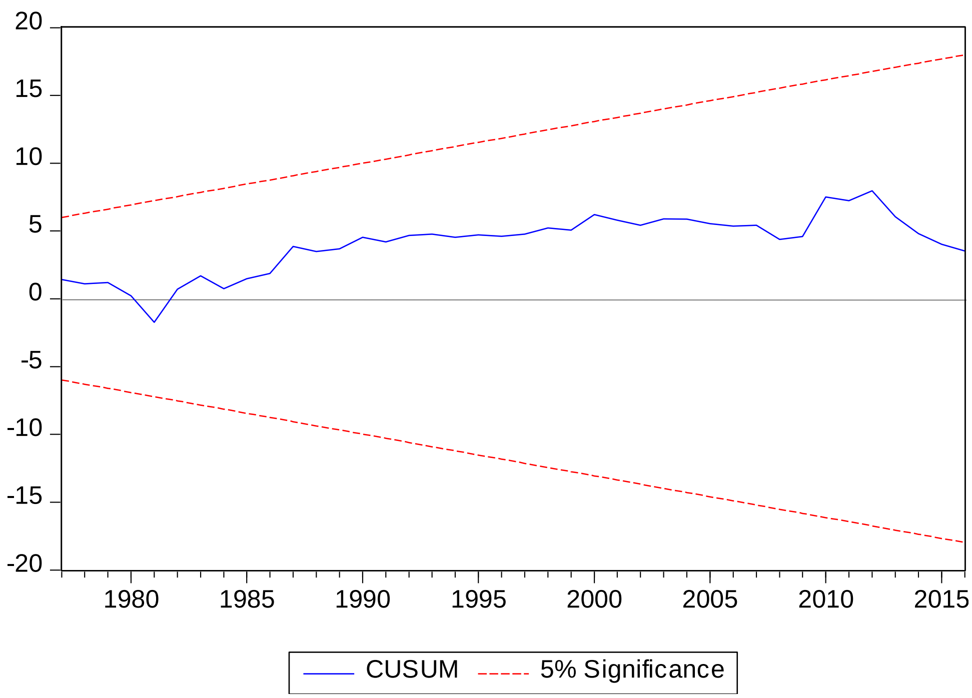
F-statistic	1.708600	Prob. F(4,39)	0.1677
Obs*R-squared	6.560871	Prob. Chi-Square(4)	0.1610
Scaled explained SS	8.920516	Prob. Chi-Square(4)	0.0631

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/23/18 Time: 16:15
Sample: 1973 2016
Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.002000	0.007852	-0.254646	0.8003
D(LTGASCON(-1))	0.110690	0.071037	1.558192	0.1273
D(LPRICE)	0.003074	0.009165	0.335430	0.7391
D(LGDP)	0.022883	0.037518	0.609906	0.5455
U(-1)	-0.158403	0.075561	-2.096365	0.0426

R-squared	0.149111	Mean dependent var	0.010577
Adjusted R-squared	0.061840	S.D. dependent var	0.019408
S.E. of regression	0.018798	Akaike info criterion	-5.003449
Sum squared resid	0.013782	Schwarz criterion	-4.800700
Log likelihood	115.0759	Hannan-Quinn criter.	-4.928260
F-statistic	1.708600	Durbin-Watson stat	1.680703
Prob(F-statistic)	0.167665		





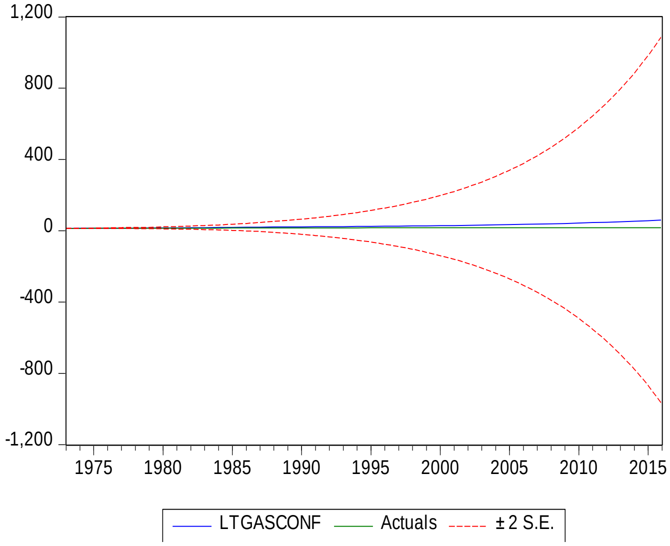
Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	14.13902	(3, 40)	0.0000
Chi-square	42.41706	3	0.0000

Null Hypothesis: C(1)=C(2)=C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	1.095898	0.211138
C(2)	-0.026620	0.052406
C(3)	-0.078282	0.200235

Restrictions are linear in coefficients.



Forecast: LTGASCONF	
Actual: LTGASCON	
Forecast sample: 1971 2016	
Adjusted sample: 1973 2016	
Included observations: 44	
Root Mean Squared Error	16.42236
Mean Absolute Error	11.86816
Mean Abs. Percent Error	69.04299
Theil Inequality Coef.	0.350034
Bias Proportion	0.522270
Variance Proportion	0.458461
Covariance Proportion	0.019269
Theil U2 Coefficient	96.77696
Symmetric MAPE	44.11202

Null Hypothesis: LGDPP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.109104	0.9630
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LGDPP)
Method: Least Squares
Date: 05/24/18 Time: 11:04
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDPP(-1)	0.001781	0.016326	0.109104	0.9136
C	0.048823	0.098815	0.494083	0.6238

R-squared	0.000277	Mean dependent var	0.059528
Adjusted R-squared	-0.022973	S.D. dependent var	0.077843
S.E. of regression	0.078732	Akaike info criterion	-2.202113
Sum squared resid	0.266544	Schwarz criterion	-2.121817
Log likelihood	51.54755	Hannan-Quinn criter.	-2.172180
F-statistic	0.011904	Durbin-Watson stat	1.872419
Prob(F-statistic)	0.913627		

Null Hypothesis: LGDPP has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		0.021514	0.9555
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.005923
HAC corrected variance (Bartlett kernel)	0.007328

Phillips-Perron Test Equation
Dependent Variable: D(LGDPP)
Method: Least Squares
Date: 05/24/18 Time: 11:05

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDPP(-1)	0.001781	0.016326	0.109104	0.9136
C	0.048823	0.098815	0.494083	0.6238

R-squared	0.000277	Mean dependent var	0.059528
Adjusted R-squared	-0.022973	S.D. dependent var	0.077843
S.E. of regression	0.078732	Akaike info criterion	-2.202113
Sum squared resid	0.266544	Schwarz criterion	-2.121817
Log likelihood	51.54755	Hannan-Quinn criter.	-2.172180
F-statistic	0.011904	Durbin-Watson stat	1.872419
Prob(F-statistic)	0.913627		

Null Hypothesis: D(LGDPP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.080339	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDPP,2)
Method: Least Squares
Date: 05/24/18 Time: 11:06
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDPP(-1))	-0.935424	0.153844	-6.080339	0.0000
C	0.056226	0.015056	3.734575	0.0006

R-squared	0.468156	Mean dependent var	0.000732
Adjusted R-squared	0.455493	S.D. dependent var	0.107636
S.E. of regression	0.079425	Akaike info criterion	-2.183612
Sum squared resid	0.264952	Schwarz criterion	-2.102512
Log likelihood	50.03946	Hannan-Quinn criter.	-2.153536
F-statistic	36.97053	Durbin-Watson stat	1.959799
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LGDPP) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.103582	0.0000
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.006022
HAC corrected variance (Bartlett kernel)	0.006473

Phillips-Perron Test Equation
Dependent Variable: D(LGDPP,2)
Method: Least Squares
Date: 05/24/18 Time: 11:07
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDPP(-1))	-0.935424	0.153844	-6.080339	0.0000
C	0.056226	0.015056	3.734575	0.0006

R-squared	0.468156	Mean dependent var	0.000732
Adjusted R-squared	0.455493	S.D. dependent var	0.107636
S.E. of regression	0.079425	Akaike info criterion	-2.183612

Sum squared resid	0.264952	Schwarz criterion	-2.102512
Log likelihood	50.03946	Hannan-Quinn criter.	-2.153536
F-statistic	36.97053	Durbin-Watson stat	1.959799
Prob(F-statistic)	0.000000		

Null Hypothesis: LPOPULATION has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 8 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.240249	0.9999
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPOPULATION)
Method: Least Squares
Date: 05/24/18 Time: 11:08
Sample (adjusted): 1980 2016
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPOPULATION(-1)	0.000565	0.000456	1.240249	0.2260
D(LPOPULATION(-1))	2.832552	0.149849	18.90271	0.0000
D(LPOPULATION(-2))	-3.297416	0.434822	-7.583361	0.0000
D(LPOPULATION(-3))	1.825524	0.616638	2.960447	0.0065
D(LPOPULATION(-4))	-0.177878	0.624927	-0.284638	0.7782
D(LPOPULATION(-5))	-1.111863	0.606837	-1.832226	0.0784
D(LPOPULATION(-6))	1.954009	0.573389	3.407824	0.0021

D(LPOPULATION(-7))	-1.586614	0.381513	-4.158746	0.0003
D(LPOPULATION(-8))	0.509121	0.116930	4.354075	0.0002
C	-0.002189	0.002468	-0.886708	0.3834
@TREND("1971")	-2.95E-05	1.39E-05	-2.119942	0.0437

R-squared	0.999989	Mean dependent var	0.017976
Adjusted R-squared	0.999985	S.D. dependent var	0.003746
S.E. of regression	1.46E-05	Akaike info criterion	-19.18298
Sum squared resid	5.58E-09	Schwarz criterion	-18.70406
Log likelihood	365.8851	Hannan-Quinn criter.	-19.01414
F-statistic	235533.6	Durbin-Watson stat	1.691960
Prob(F-statistic)	0.000000		

Null Hypothesis: LPOPULATION has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		6.173833	1.0000
Test critical values:	1% level	-4.175640	
	5% level	-3.513075	
	10% level	-3.186854	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.62E-07
HAC corrected variance (Bartlett kernel)	6.27E-07

Phillips-Perron Test Equation
Dependent Variable: D(LPOPULATION)
Method: Least Squares
Date: 05/24/18 Time: 11:09
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.

LPOPULATION(-1)	0.033933	0.002758	12.30166	0.0000
C	-0.190164	0.017537	-10.84350	0.0000
@TREND("1971")	-0.000948	5.37E-05	-17.66898	0.0000

R-squared	0.989181	Mean dependent var	0.018879
Adjusted R-squared	0.988665	S.D. dependent var	0.003918
S.E. of regression	0.000417	Akaike info criterion	-12.66225
Sum squared resid	7.31E-06	Schwarz criterion	-12.54181
Log likelihood	287.9007	Hannan-Quinn criter.	-12.61735
F-statistic	1919.967	Durbin-Watson stat	0.143928
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LPOPULATION) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 7 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.710456	0.0341
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPOPULATION,2)
Method: Least Squares
Date: 05/24/18 Time: 11:10
Sample (adjusted): 1980 2016
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPOPULATION(-1))	-0.031824	0.008577	-3.710456	0.0009
D(LPOPULATION(-1),2)	1.930598	0.137783	14.01192	0.0000
D(LPOPULATION(-2),2)	-1.506884	0.296116	-5.088828	0.0000

D(LPOPULATION(-3),2)	0.468223	0.344806	1.357934	0.1857
D(LPOPULATION(-4),2)	0.197966	0.334337	0.592115	0.5587
D(LPOPULATION(-5),2)	-0.865592	0.331089	-2.614378	0.0144
D(LPOPULATION(-6),2)	1.059894	0.275375	3.848914	0.0007
D(LPOPULATION(-7),2)	-0.510471	0.118084	-4.322934	0.0002
C	0.000859	0.000235	3.648639	0.0011
@TREND("1971")	-1.27E-05	3.21E-06	-3.949798	0.0005

R-squared	0.993298	Mean dependent var	-0.000308
Adjusted R-squared	0.991064	S.D. dependent var	0.000156
S.E. of regression	1.48E-05	Akaike info criterion	-19.17955
Sum squared resid	5.91E-09	Schwarz criterion	-18.74417
Log likelihood	364.8218	Hannan-Quinn criter.	-19.02606
F-statistic	444.6336	Durbin-Watson stat	1.714499
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LPOPULATION) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.904072	0.1712
Test critical values:	1% level	-4.180911	
	5% level	-3.515523	
	10% level	-3.188259	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.26E-08
HAC corrected variance (Bartlett kernel)	3.15E-08

Phillips-Perron Test Equation
Dependent Variable: D(LPOPULATION,2)

Method: Least Squares
Date: 05/24/18 Time: 11:10
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPOPULATION(-1))	-0.080331	0.020387	-3.940344	0.0003
C	0.002053	0.000527	3.893215	0.0004
@TREND("1971")	-3.34E-05	6.02E-06	-5.548616	0.0000

R-squared	0.635208	Mean dependent var	-0.000262
Adjusted R-squared	0.617413	S.D. dependent var	0.000188
S.E. of regression	0.000116	Akaike info criterion	-15.21525
Sum squared resid	5.54E-07	Schwarz criterion	-15.09360
Log likelihood	337.7355	Hannan-Quinn criter.	-15.17014
F-statistic	35.69635	Durbin-Watson stat	0.340145
Prob(F-statistic)	0.000000		

Model B:

Estimation Equation:
=========================
LTGASCON = C(1)*LTGASCON(-1) + C(2)*LGDPP + C(3)*LPOPULATION + C(4)*LPRICE

Substituted Coefficients:
=========================
LTGASCON = 0.951488352713*LTGASCON(-1) - 0.0484226179132*LGDPP + 0.133858435387*LPOPULATION + 0.0336650740651*LPRICE

Dependent Variable: LTGASCON
Method: Least Squares
Date: 05/24/18 Time: 11:13
Sample (adjusted): 1972 2016
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTGASCON(-1)	0.951488	0.029398	32.36540	0.0000

LGDPP	-0.048423	0.054783	-0.883897	0.3819
LPOPULATION	0.133858	0.045509	2.941386	0.0054
LPRICE	0.033665	0.030360	1.108845	0.2740

R-squared	0.994439	Mean dependent var	16.11137
Adjusted R-squared	0.994032	S.D. dependent var	1.412549
S.E. of regression	0.109120	Akaike info criterion	-1.508041
Sum squared resid	0.488198	Schwarz criterion	-1.347449
Log likelihood	37.93093	Hannan-Quinn criter.	-1.448174
Durbin-Watson stat	1.605395		

Null Hypothesis: U has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.314605	0.0001
Test critical values:	1% level	-3.588509	
	5% level	-2.929734	
	10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(U)
Method: Least Squares
Date: 05/24/18 Time: 11:16
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U(-1)	-0.803855	0.151254	-5.314605	0.0000
C	0.000521	0.015924	0.032733	0.9740

R-squared	0.402093	Mean dependent var	0.000141
Adjusted R-squared	0.387857	S.D. dependent var	0.135006
S.E. of regression	0.105628	Akaike info criterion	-1.613388
Sum squared resid	0.468610	Schwarz criterion	-1.532289
Log likelihood	37.49454	Hannan-Quinn criter.	-1.583313

F-statistic	28.24503	Durbin-Watson stat	1.994527
Prob(F-statistic)	0.000004		

ECM Model B:

Estimation Equation:
=========================
D(LTGASCON) = C(1)*D(LTGASCON(-1)) + C(2)*D(LGDPP) + C(3)*D(LPOPULATION) + C(4)*D(LPRICE) + C(5)*U(-1)

Substituted Coefficients:
=========================
D(LTGASCON) = 1.10711400186*D(LTGASCON(-1)) - 0.085816665467*D(LGDPP) - 0.254187504177*D(LPOPULATION) - 0.0148536414048*D(LPRICE) - 0.95916399026*U(-1)

Dependent Variable: D(LTGASCON)
Method: Least Squares
Date: 05/24/18 Time: 11:19
Sample (adjusted): 1973 2016
Included observations: 44 after adjustments

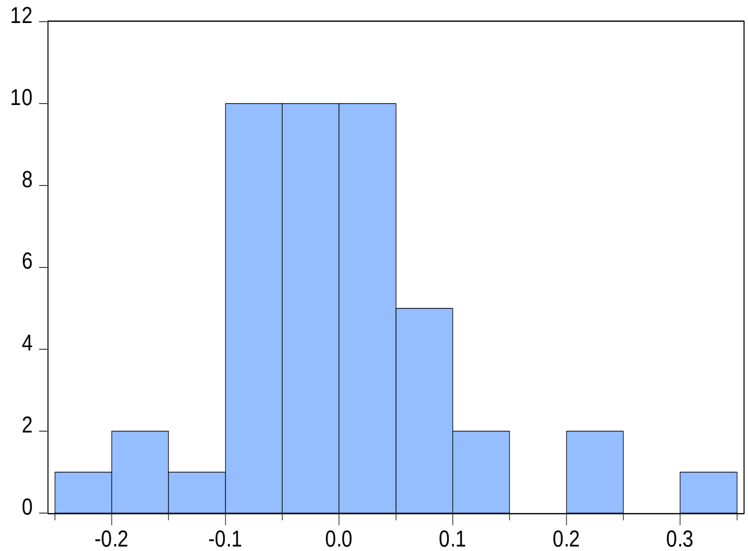
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	1.107114	0.611331	1.810989	0.0779
D(LGDPP)	-0.085817	0.209684	-0.409267	0.6846
D(LPOPULATION)	-0.254188	3.512395	-0.072369	0.9427
D(LPRICE)	-0.014854	0.052493	-0.282965	0.7787
U(-1)	-0.959164	0.624516	-1.535851	0.1326

R-squared	0.209684	Mean dependent var	0.095440
Adjusted R-squared	0.128626	S.D. dependent var	0.115801
S.E. of regression	0.108098	Akaike info criterion	-1.504919
Sum squared resid	0.455719	Schwarz criterion	-1.302170
Log likelihood	38.10822	Hannan-Quinn criter.	-1.429730
Durbin-Watson stat	1.991160		

Variance Inflation Factors
Date: 05/24/18 Time: 11:27
Sample: 1971 2016

Included observations: 44

Variable	Coefficient Variance	Uncentered VIF
D(LTGASCON(-1))	0.373726	31.59648
D(LGDPP)	0.043967	1.598252
D(LPOPULATION)	12.33692	17.08664
D(LPRICE)	0.002755	1.133923
U(-1)	0.390021	16.27842



Series: Residuals	
Sample 1973 2016	
Observations 44	
Mean	-0.000656
Median	-0.016305
Maximum	0.318093
Minimum	-0.247119
Std. Dev.	0.102945
Skewness	0.633961
Kurtosis	4.750008
Jarque-Bera	8.561953
Probability	0.013829

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.084601	Prob. F(2,37)	0.9191
Obs*R-squared	0.200296	Prob. Chi-Square(2)	0.9047

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/24/18 Time: 11:29
Sample: 1973 2016
Included observations: 44
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTGASCON(-1))	-0.019107	0.638654	-0.029918	0.9763
D(LGDPP)	-0.005249	0.221671	-0.023681	0.9812
D(LPOPULATION)	0.103211	3.701154	0.027886	0.9779
D(LPRICE)	0.000480	0.053798	0.008924	0.9929
U(-1)	0.267477	1.063935	0.251404	0.8029
RESID(-1)	-0.247732	0.925547	-0.267660	0.7904
RESID(-2)	-0.098869	0.240775	-0.410626	0.6837

R-squared	0.004511	Mean dependent var	-0.000656
Adjusted R-squared	-0.156920	S.D. dependent var	0.102945
S.E. of regression	0.110728	Akaike info criterion	-1.418572
Sum squared resid	0.453644	Schwarz criterion	-1.134724
Log likelihood	38.20859	Hannan-Quinn criter.	-1.313308
Durbin-Watson stat	2.035723		

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

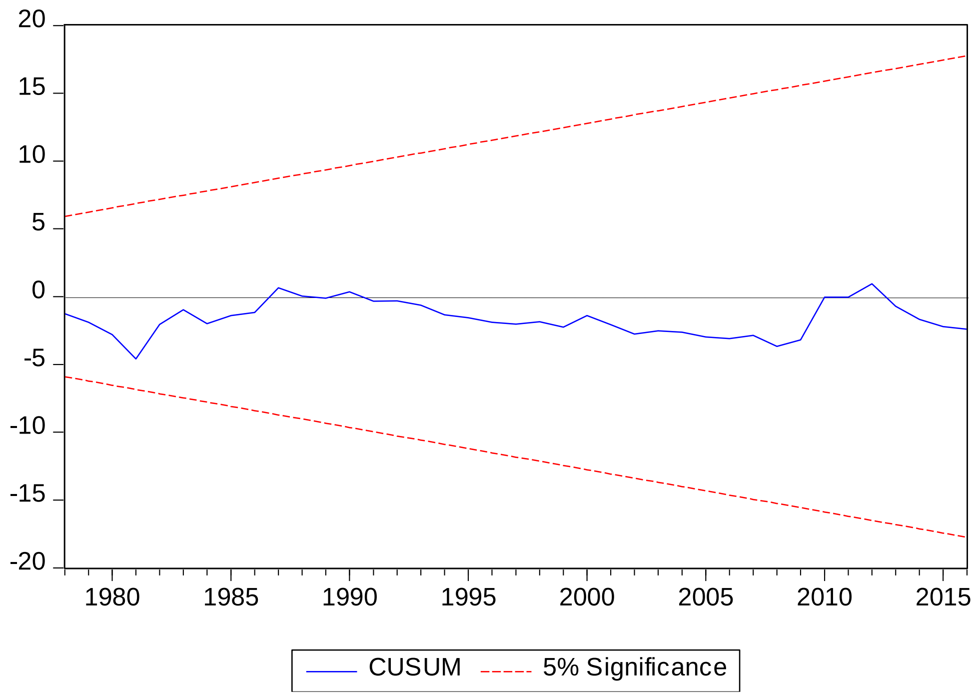
F-statistic	1.463514	Prob. F(5,38)	0.2245
Obs*R-squared	7.104819	Prob. Chi-Square(5)	0.2130
Scaled explained SS	10.41992	Prob. Chi-Square(5)	0.0642

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/24/18 Time: 11:29
Sample: 1973 2016
Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.037469	0.023131	1.619890	0.1135
D(LTGASCON(-1))	0.314461	0.168480	1.866458	0.0697
D(LGDPP)	0.022193	0.040105	0.553375	0.5832
D(LPOPULATION)	-3.186517	1.943330	-1.639719	0.1093
D(LPRICE)	0.010603	0.009829	1.078755	0.2875
U(-1)	-0.350462	0.169148	-2.071928	0.0451

R-squared	0.161473	Mean dependent var	0.010357

Adjusted R-squared	0.051141	S.D. dependent var	0.020244
S.E. of regression	0.019720	Akaike info criterion	-4.888292
Sum squared resid	0.014777	Schwarz criterion	-4.644994
Log likelihood	113.5424	Hannan-Quinn criter.	-4.798066
F-statistic	1.463514	Durbin-Watson stat	1.755082
Prob(F-statistic)	0.224497		



Wald Test:
Equation: Untitled

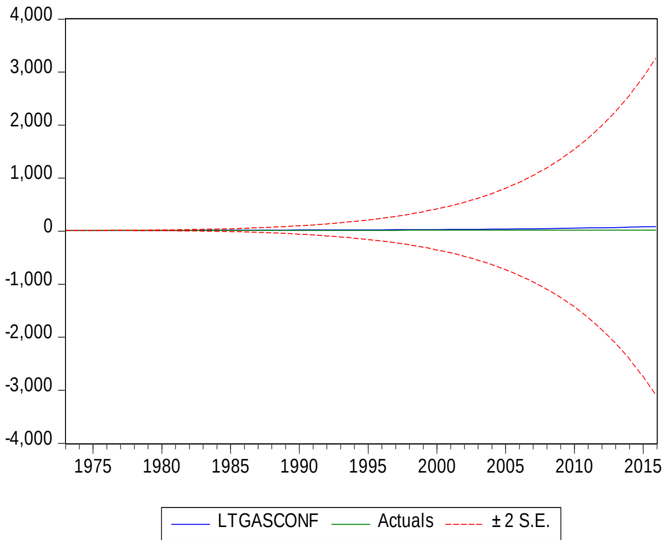
Test Statistic	Value	df	Probability
F-statistic	10.90917	(4, 39)	0.0000
Chi-square	43.63669	4	0.0000

Null Hypothesis: C(1)=C(2)=C(3)=C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	1.107114	0.611331

C(2)	-0.085817	0.209684
C(3)	-0.254188	3.512395
C(4)	-0.014854	0.052493

Restrictions are linear in coefficients.



Forecast: LTGASCONF	
Actual: LTGASCON	
Forecast sample: 1971 2016	
Adjusted sample: 1973 2016	
Included observations: 44	
Root Mean Squared Error	24.78635
Mean Absolute Error	16.37671
Mean Abs. Percent Error	94.60859
Theil Inequality Coef.	0.456923
Bias Proportion	0.436544
Variance Proportion	0.544725
Covariance Proportion	0.018731
Theil U2 Coefficient	145.4008
Symmetric MAPE	50.51267

Model: C (CGD-A):

Null Hypothesis: LCGDGASCON has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.198007	0.6459
Test critical values:	1% level	-3.959148	
	5% level	-3.081002	
	10% level	-2.681330	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 15

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LCGDGASCON)
Method: Least Squares
Date: 05/24/18 Time: 14:49
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCGDGASCON(-1)	-0.210113	0.175386	-1.198007	0.2540
D(LCGDGASCON(-1))	-0.543305	0.224426	-2.420868	0.0323
C	3.478338	2.410443	1.443028	0.1746

R-squared	0.471840	Mean dependent var	0.378594
Adjusted R-squared	0.383814	S.D. dependent var	1.607008
S.E. of regression	1.261462	Akaike info criterion	3.479276
Sum squared resid	19.09543	Schwarz criterion	3.620886
Log likelihood	-23.09457	Hannan-Quinn criter.	3.477767
F-statistic	5.360204	Durbin-Watson stat	2.077267
Prob(F-statistic)	0.021707		

Null Hypothesis: LCGDGASCON has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.485732	0.5147
Test critical values:	1% level	-3.920350	
	5% level	-3.065585	
	10% level	-2.673459	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 16

Residual variance (no correction)	1.890882
HAC corrected variance (Bartlett kernel)	1.199593

Phillips-Perron Test Equation
Dependent Variable: D(LCGDGASCON)
Method: Least Squares
Date: 05/24/18 Time: 14:50
Sample (adjusted): 2001 2016
Included observations: 16 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCGDGASCON(-1)	-0.294033	0.176472	-1.666180	0.1179
C	4.350032	2.423757	1.794748	0.0943

R-squared	0.165482	Mean dependent var	0.358311
Adjusted R-squared	0.105874	S.D. dependent var	1.554636
S.E. of regression	1.470037	Akaike info criterion	3.724920
Sum squared resid	30.25411	Schwarz criterion	3.821494
Log likelihood	-27.79936	Hannan-Quinn criter.	3.729866
F-statistic	2.776154	Durbin-Watson stat	2.876485
Prob(F-statistic)	0.117885		

Null Hypothesis: D(LCGDGASCON) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.687875	0.0000
Test critical values:	1% level	-3.959148	
	5% level	-3.081002	
	10% level	-2.681330	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 15

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LCGDGASCON,2)
Method: Least Squares

Date: 05/24/18 Time: 14:53
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	-1.639040	0.213198	-7.687875	0.0000
C	0.618651	0.340663	1.816020	0.0925

R-squared	0.819703	Mean dependent var	0.002942
Adjusted R-squared	0.805834	S.D. dependent var	2.910306
S.E. of regression	1.282404	Akaike info criterion	3.458916
Sum squared resid	21.37928	Schwarz criterion	3.553322
Log likelihood	-23.94187	Hannan-Quinn criter.	3.457910
F-statistic	59.10342	Durbin-Watson stat	2.080542
Prob(F-statistic)	0.000003		

Null Hypothesis: D(LCGDGASCON) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-12.58476	0.0000
Test critical values:	1% level	-3.959148	
	5% level	-3.081002	
	10% level	-2.681330	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 15

Residual variance (no correction)	1.425285
HAC corrected variance (Bartlett kernel)	0.393196

Phillips-Perron Test Equation
Dependent Variable: D(LCGDGASCON,2)

Method: Least Squares
Date: 05/24/18 Time: 14:54
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	-1.639040	0.213198	-7.687875	0.0000
C	0.618651	0.340663	1.816020	0.0925

R-squared	0.819703	Mean dependent var	0.002942
Adjusted R-squared	0.805834	S.D. dependent var	2.910306
S.E. of regression	1.282404	Akaike info criterion	3.458916
Sum squared resid	21.37928	Schwarz criterion	3.553322
Log likelihood	-23.94187	Hannan-Quinn criter.	3.457910
F-statistic	59.10342	Durbin-Watson stat	2.080542
Prob(F-statistic)	0.000003		

Estimation Equation:
=========================
LCGDGASCON = C(1)*LCGDGASCON(-1) + C(2)*LPRICE + C(3)*LGDP

Substituted Coefficients:
=========================
LCGDGASCON = 0.340984954121*LCGDGASCON(-1) + 2.80013336214*LPRICE - 0.507160645279*LGDP

Dependent Variable: LCGDGASCON
Method: Least Squares
Date: 05/24/18 Time: 14:57
Sample (adjusted): 2001 2016
Included observations: 16 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCGDGASCON(-1)	0.340985	0.254587	1.339364	0.2034
LPRICE	2.800133	1.666448	1.680300	0.1168
LGDP	-0.507161	0.423663	-1.197085	0.2526

R-squared	0.631404	Mean dependent var	13.93405
Adjusted R-squared	0.574697	S.D. dependent var	2.079071

S.E. of regression	1.355873	Akaike info criterion	3.614128
Sum squared resid	23.89907	Schwarz criterion	3.758988
Log likelihood	-25.91302	Hannan-Quinn criter.	3.621546
Durbin-Watson stat	2.495174		

Null Hypothesis: U has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.194427	0.0015
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 13

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(U)
Method: Least Squares
Date: 05/24/18 Time: 15:00
Sample (adjusted): 2004 2016
Included observations: 13 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U(-1)	-2.751956	0.529790	-5.194427	0.0006
D(U(-1))	0.971519	0.379959	2.556908	0.0308
D(U(-2))	0.426604	0.209031	2.040864	0.0717
C	0.416842	0.267153	1.560315	0.1531

R-squared	0.865006	Mean dependent var	0.077964
Adjusted R-squared	0.820008	S.D. dependent var	2.214392
S.E. of regression	0.939466	Akaike info criterion	2.960650
Sum squared resid	7.943373	Schwarz criterion	3.134481
Log likelihood	-15.24423	Hannan-Quinn criter.	2.924920
F-statistic	19.22319	Durbin-Watson stat	2.173080

Prob(F-statistic)	0.000298

ECM: Model(c): (CGD-A):

Estimation Equation:

=========================

D(LCGDGASCON) = C(1)*D(LCGDGASCON(-1)) + C(2)*D(LPRICE) + C(3)*D(LGDP) + C(4)*U(-1)

Substituted Coefficients:

=========================

D(LCGDGASCON) = 0.263709382467*D(LCGDGASCON(-1)) + 2.50853989877*D(LPRICE) - 2.05410769682*D(LGDP) - 1.19263335197*U(-1)

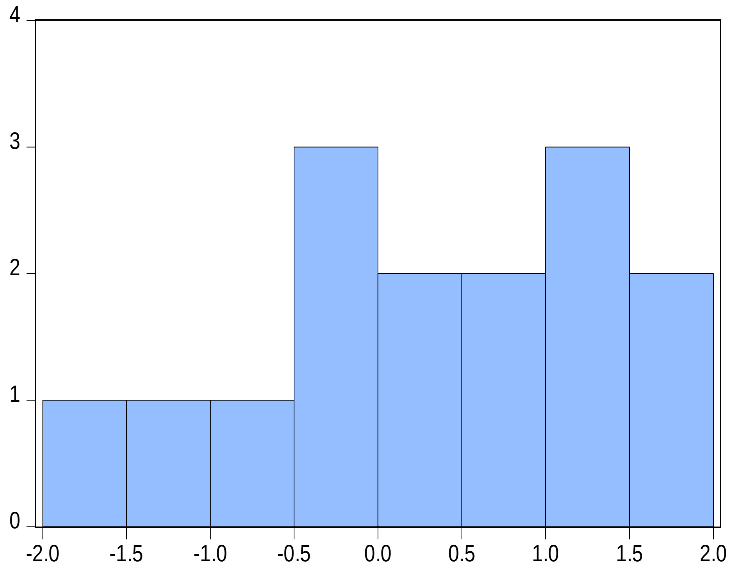
Dependent Variable: D(LCGDGASCON)
Method: Least Squares
Date: 05/24/18 Time: 15:07
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	0.263709	0.431045	0.611791	0.5531
D(LPRICE)	2.508540	2.033223	1.233775	0.2430
D(LGDP)	-2.054108	3.342961	-0.614458	0.5514
U(-1)	-1.192633	0.514539	-2.317867	0.0407

R-squared	0.507315	Mean dependent var	0.378594
Adjusted R-squared	0.372946	S.D. dependent var	1.607008
S.E. of regression	1.272538	Akaike info criterion	3.543082
Sum squared resid	17.81287	Schwarz criterion	3.731895
Log likelihood	-22.57311	Hannan-Quinn criter.	3.541070
Durbin-Watson stat	2.096693		

Variance Inflation Factors
Date: 05/24/18 Time: 15:10
Sample: 2000 2016
Included observations: 15

Variable	Coefficient Variance	Uncentered VIF
D(LCGDGASCON(-1))	0.185800	4.394200
D(LPRICE)	4.133994	1.681108
D(LGDP)	11.17539	1.729535
U(-1)	0.264750	3.860065



Series: Residuals
Sample 2002 2016
Observations 15

Mean	0.302385
Median	0.444150
Maximum	1.818484
Minimum	-1.901832
Std. Dev.	1.083688
Skewness	-0.422968
Kurtosis	2.357051
Jarque-Bera	0.705619
Probability	0.702711

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.512049	Prob. F(2,9)	0.6157
Obs*R-squared	1.532453	Prob. Chi-Square(2)	0.4648

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/24/18 Time: 15:13
Sample: 2002 2016
Included observations: 15
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	-0.245788	0.610786	-0.402413	0.6968
D(LPRICE)	0.621226	2.334020	0.266162	0.7961
D(LGDP)	2.032451	4.072920	0.499016	0.6297
U(-1)	0.354358	0.779125	0.454815	0.6600
RESID(-1)	-0.400059	0.930651	-0.429870	0.6774
RESID(-2)	-0.355191	0.590728	-0.601276	0.5625

R-squared	0.027265	Mean dependent var	0.302385
Adjusted R-squared	-0.513143	S.D. dependent var	1.083688
S.E. of regression	1.333044	Akaike info criterion	3.701981
Sum squared resid	15.99305	Schwarz criterion	3.985201
Log likelihood	-21.76486	Hannan-Quinn criter.	3.698964
Durbin-Watson stat	1.927989		

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

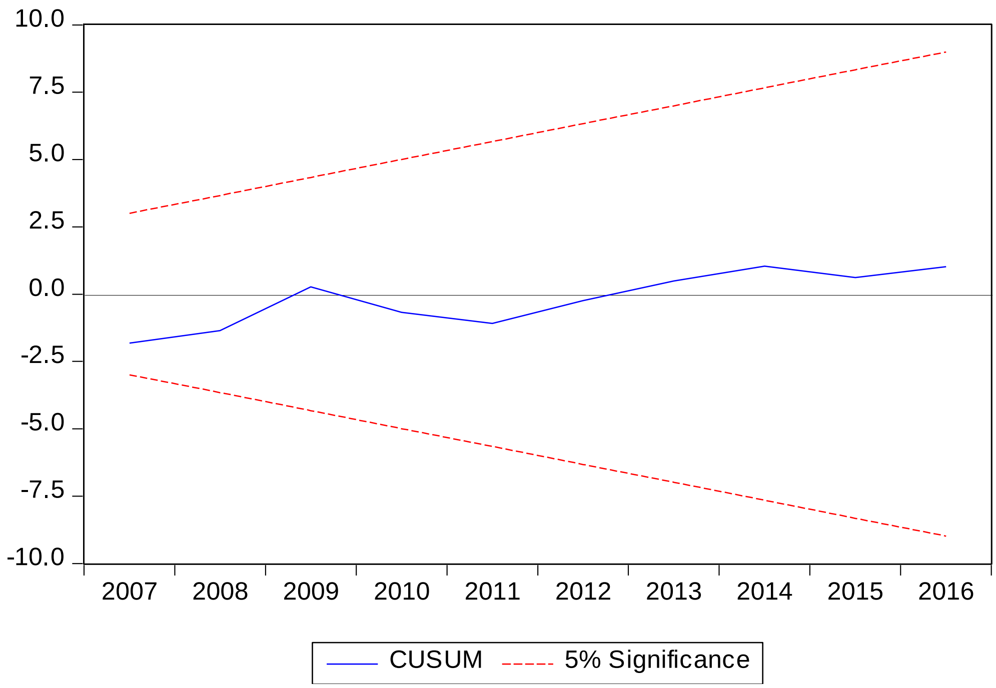
F-statistic	0.609443	Prob. F(4,10)	0.6652
Obs*R-squared	2.939961	Prob. Chi-Square(4)	0.5679
Scaled explained SS	0.809566	Prob. Chi-Square(4)	0.9372

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/24/18 Time: 15:14
Sample: 2002 2016
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.719313	0.627962	1.145473	0.2787
D(LCGDGASCON(-1))	0.334756	0.462647	0.723567	0.4859
D(LPRICE)	-1.171341	2.126728	-0.550771	0.5939
D(LGDP)	3.825294	5.002170	0.764727	0.4621
U(-1)	-0.277396	0.579585	-0.478611	0.6425

R-squared	0.195997	Mean dependent var	1.187525

Adjusted R-squared	-0.125604	S.D. dependent var	1.243922
S.E. of regression	1.319733	Akaike info criterion	3.653937
Sum squared resid	17.41694	Schwarz criterion	3.889953
Log likelihood	-22.40453	Hannan-Quinn criter.	3.651423
F-statistic	0.609443	Durbin-Watson stat	2.101986
Prob(F-statistic)	0.665196		



Wald Test:
Equation: Untitled

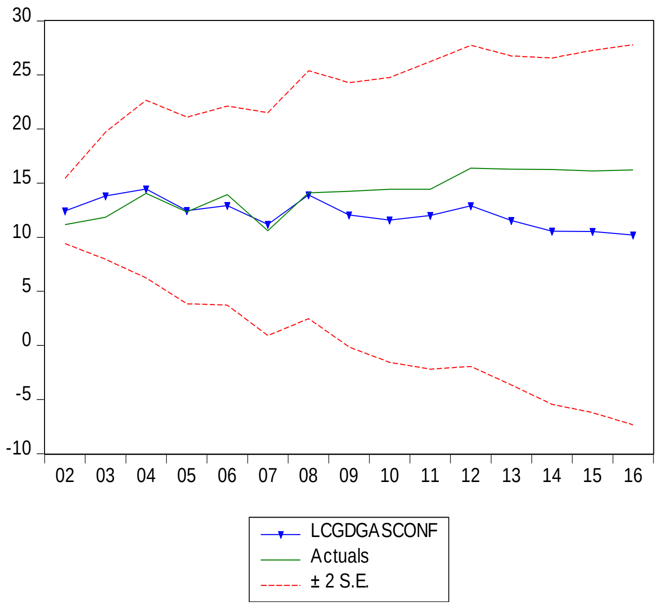
Test Statistic	Value	df	Probability
F-statistic	0.509148	(3, 11)	0.6841
Chi-square	1.527444	3	0.6760

Null Hypothesis: C(1)=C(2)=C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.263709	0.431045

C(2)	2.508540	2.033223
C(3)	-2.054108	3.342961

Restrictions are linear in coefficients.



Forecast: LCGDGASCONF	
Actual: LCGDGASCON	
Forecast sample: 2000 2016	
Adjusted sample: 2002 2016	
Included observations: 15	
Root Mean Squared Error	3.274279
Mean Absolute Error	2.570393
Mean Abs. Percent Error	17.00977
Theil Inequality Coef.	0.123479
Bias Proportion	0.369230
Variance Proportion	0.037026
Covariance Proportion	0.593744
Theil U2 Coefficient	1.607759
Symmetric MAPE	19.26914

Model: C (CGD-B):

Estimation Equation:

=========================

LCGDGASCON = C(1)*LCGDGASCON(-1) + C(2)*LGDPP + C(3)*LPOPULATION + C(4)*LPRICE

Substituted Coefficients:

=========================

LCGDGASCON = -0.0301573875251*LCGDGASCON(-1) + 2.81589593114*LGDPP - 2.73451452405*LPOPULATION + 1.71391381972*LPRICE

Dependent Variable: LCGDGASCON
Method: Least Squares
Date: 05/24/18 Time: 15:22
Sample (adjusted): 2001 2016
Included observations: 16 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.

LCGDGASCON(-1)	-0.030157	0.314515	-0.095886	0.9252
LGDPP	2.815896	1.766246	1.594283	0.1369
LPOPULATION	-2.734515	1.429643	-1.912725	0.0799
LPRICE	1.713914	1.655837	1.035074	0.3210

R-squared	0.708303	Mean dependent var	13.93405
Adjusted R-squared	0.635379	S.D. dependent var	2.079071
S.E. of regression	1.255423	Akaike info criterion	3.505141
Sum squared resid	18.91306	Schwarz criterion	3.698288
Log likelihood	-24.04113	Hannan-Quinn criter.	3.515032
Durbin-Watson stat	2.325310		

Null Hypothesis: U has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.439463	0.0041
Test critical values:	1% level	-3.959148	
	5% level	-3.081002	
	10% level	-2.681330	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 15

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(U)
Method: Least Squares
Date: 05/24/18 Time: 15:27
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U(-1)	-1.186244	0.267204	-4.439463	0.0007
C	0.052917	0.299125	0.176906	0.8623

R-squared	0.602554	Mean dependent var	0.081200

Adjusted R-squared	0.571981	S.D. dependent var	1.770388
S.E. of regression	1.158244	Akaike info criterion	3.255252
Sum squared resid	17.43986	Schwarz criterion	3.349659
Log likelihood	-22.41439	Hannan-Quinn criter.	3.254247
F-statistic	19.70883	Durbin-Watson stat	2.099152
Prob(F-statistic)	0.000667		

ECM:

Estimation Equation:

=========================

D(LCGDGASCON) = C(1)*D(LCGDGASCON(-1)) + C(2)*D(LGDPP) + C(3)*D(LPOPULATION) + C(4)*D(LPRICE) + C(5)*U(-1)

Substituted Coefficients:

=========================

D(LCGDGASCON) = -0.145042081253*D(LCGDGASCON(-1)) - 7.16485936096*D(LGDPP) + 71.1713206606*D(LPOPULATION) + 1.29813754727*D(LPRICE) - 0.686683053278*U(-1)

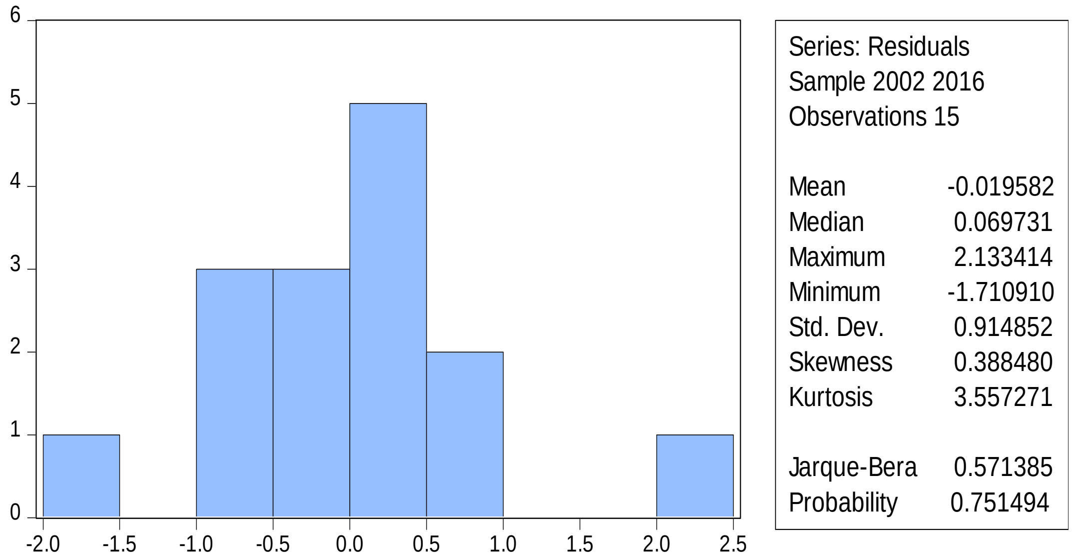
Dependent Variable: D(LCGDGASCON)
Method: Least Squares
Date: 05/24/18 Time: 15:28
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	-0.145042	0.280788	-0.516553	0.6167
D(LGDPP)	-7.164859	4.803363	-1.491634	0.1667
D(LPOPULATION)	71.17132	38.12984	1.866552	0.0915
D(LPRICE)	1.298138	1.532823	0.846893	0.4169
U(-1)	-0.686683	0.431336	-1.591991	0.1425

R-squared	0.675751	Mean dependent var	0.378594
Adjusted R-squared	0.546052	S.D. dependent var	1.607008
S.E. of regression	1.082733	Akaike info criterion	3.258056
Sum squared resid	11.72311	Schwarz criterion	3.494072
Log likelihood	-19.43542	Hannan-Quinn criter.	3.255541
Durbin-Watson stat	2.273783		

Variance Inflation Factors
Date: 05/24/18   Time: 15:30
Sample: 2000 2016
Included observations: 15

Variable	Coefficient Variance	Uncentered VIF
D(LCGDGASCON(-1))	0.078842	2.575676
D(LGDPP)	23.07230	4.094237
D(LPOPULATION)	1453.885	3.768822
D(LPRICE)	2.349546	1.319800
U(-1)	0.186051	2.983309



Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.519627	Prob. F(2,8)	0.6135
Obs*R-squared	1.724569	Prob. Chi-Square(2)	0.4222

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/24/18   Time: 15:30

Sample: 2002 2016
Included observations: 15
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCGDGASCON(-1))	-0.203350	0.505800	-0.402037	0.6982
D(LGDPP)	0.696295	5.103849	0.136425	0.8949
D(LPOPULATION)	3.090181	43.20202	0.071529	0.9447
D(LPRICE)	-0.091071	1.784843	-0.051025	0.9606
U(-1)	0.333377	0.559939	0.595380	0.5680
RESID(-1)	-0.381592	0.594620	-0.641741	0.5390
RESID(-2)	-0.341923	0.638119	-0.535829	0.6066

R-squared	0.114537	Mean dependent var	-0.019582
Adjusted R-squared	-0.549561	S.D. dependent var	0.914852
S.E. of regression	1.138820	Akaike info criterion	3.402587
Sum squared resid	10.37529	Schwarz criterion	3.733010
Log likelihood	-18.51940	Hannan-Quinn criter.	3.399067
Durbin-Watson stat	1.876030		

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

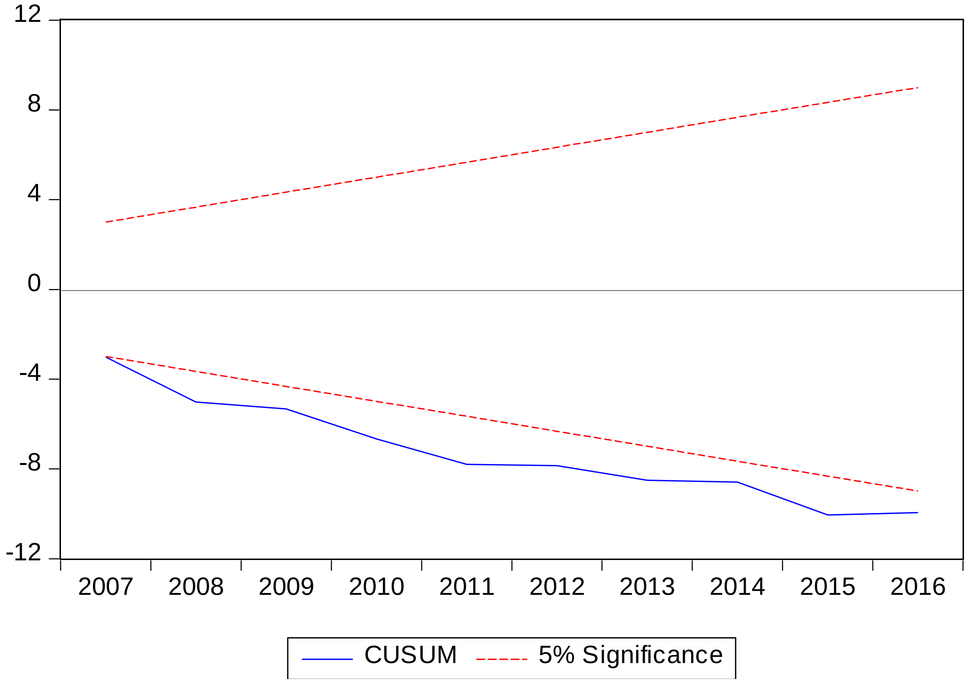
F-statistic	0.706160	Prob. F(5,9)	0.6334
Obs*R-squared	4.226547	Prob. Chi-Square(5)	0.5173
Scaled explained SS	2.369054	Prob. Chi-Square(5)	0.7961

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/24/18 Time: 15:31
Sample: 2002 2016
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.655518	3.026999	-0.546917	0.5977
D(LCGDGASCON(-1))	0.048268	0.353812	0.136424	0.8945

D(LGDPP)	7.426131	6.598145	1.125488	0.2895
D(LPOPULATION)	128.2791	233.7847	0.548706	0.5966
D(LPRICE)	-1.068896	1.936740	-0.551905	0.5945
U(-1)	-0.147994	0.563258	-0.262747	0.7987

R-squared	0.281770	Mean dependent var	0.781541
Adjusted R-squared	-0.117247	S.D. dependent var	1.284795
S.E. of regression	1.358028	Akaike info criterion	3.739118
Sum squared resid	16.59815	Schwarz criterion	4.022338
Log likelihood	-22.04339	Hannan-Quinn criter.	3.736101
F-statistic	0.706160	Durbin-Watson stat	2.988935
Prob(F-statistic)	0.633436		



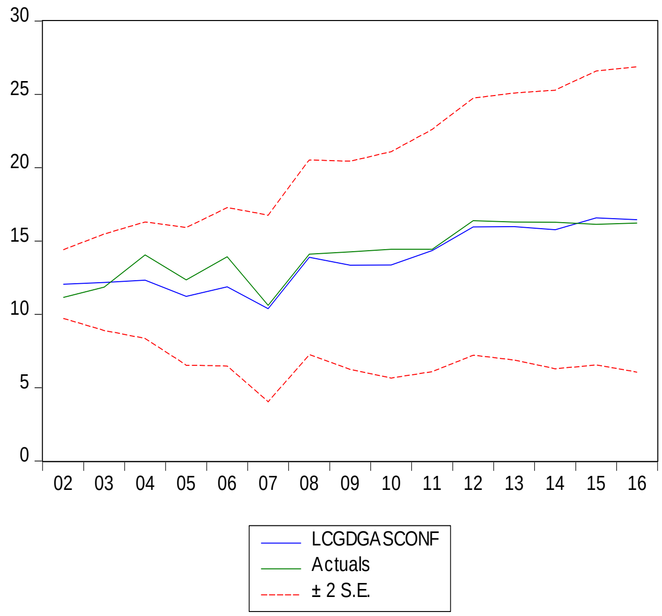
Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.146922	(4, 10)	0.3894
Chi-square	4.587686	4	0.3323

Null Hypothesis: C(1)=C(2)=C(3)=C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.145042	0.280788
C(2)	-7.164859	4.803363
C(3)	71.17132	38.12984
C(4)	1.298138	1.532823

Restrictions are linear in coefficients.



Forecast: LCGDGASCONF
Actual: LCGDGASCON
Forecast sample: 2000 2016
Adjusted sample: 2002 2016
Included observations: 15

Root Mean Squared Error	0.902856
Mean Absolute Error	0.700446
Mean Abs. Percent Error	5.096796
Theil Inequality Coef.	0.032090
Bias Proportion	0.247997
Variance Proportion	0.013058
Covariance Proportion	0.738945
Theil U2 Coefficient	0.524392
Symmetric MAPE	5.274324

Appendix D: Questionnaire Survey & Response Sheets

Name ______________________________________

Position ______________________________________

Company ______________________________________

Description	**Weightage**
Strongly Disagree	1
Disagree	2
Neither Agree nor disagree	3
Agree	4
Strongly Agree	5

Questionnaire		1	2	3	4	5	
1	Natural gas market development is critical for India's future growth						
2	Government support in domestic natural gas industry growth						
3	Grid development in East India is key to India's natural gas market growth						
4	Rate the factors impacting the CGD business growth						Rank
(i)	Inadequate infrastructure						
(ii)	Lack of local government supports						
(iii)	Shortage of skilled workforce						
(iv)	Lack of reliable contractors						
4	Financial risks impacting CNG business						
(i)	High interest rate						
(ii)	Long pay back period						
(iii)	Difficulty in procuring funds from local financial institutions						

(iv)	Land acuisition charges						
(v)	Increase in procurement costs						
(vi)	High customs duties on imported capital goods and intermediary goods						
(vii)	Insufficient cash flow necessary for business scale expansion						
(viii)	Managing Liquidity						
(ix)	Take or pay gas contracts						
(x)	Current exchange rate						
(xi)	Tax burden (Uniform pan- India taxation on CNG & PNG)						
5	Rank the operational risks associated with CNG business						
(i)	Project execution						
(ii)	Vehicle filling time						
(iii)	Locating underground leaks and pipe						
(iv)	Insufficient production capacity due to lack of facilities						
(v)	Low penetration of gas-based equipment & appliances						
(vi)	Construction work by local bodies/conflict management						
(vii)	Difficulty in quality control						
(viii)	Stricter environmental regulations						
(ix)	Managing customers						
(x)	Shortage of skilled workforce						
(xi)	Franchisees and subcontractors training for CNG station						
(xii)	Difficulty in localizing managers and site supervisors						
(xiii)	Limited OEM fitted CNG vehicles						

Appendix E: Survey Response

Survey	Q 1	Q 2	Q 3	Q4 (1)	Q4 (2)	Q4 (3)	Q4 (4)	Q4 (5)	Q4 (6)	Q4 (7)	Q4 (8)	Q4 (9)	Q4 (10)	Q4 (11)	Q5 (1)	Q5 (2)	Q5 (3)	Q5 (4)	Q5 (5)	Q5 (6)	Q5 (7)	Q5 (8)	Q5 (9)	Q5 (10)	Q5 (11)	Q5 (12)	Q5 (13)
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Appendix F: Validation

Operational Risk Mitigation

Question	Respondent 1 (Torrent Gas)	Respondent 2 (Adani Gas)
1) How can company improve the operational performance against the below mentioned parameters? A. Underground gas leakage B. Meeting operational standards C. HSE Issues	A. We can introduce automation for detecting underground gas leakage. This will lead to reduced manhours for detecting the leakages and attending the same. B. In CGD, all quality aspects are to be followed as per T4S guidelines put forward by PNGRB . Strict adherence to those guidelines has to be governed in order to improve operational efficiency. C. Strict adherence to HSE Policy defined by the company and perform regular internal and external audits of HSE practices followed in the company as well as for the contractors as well.	A. i) Proper distance in between gas line and other utilities passing through that passage. ii.) Use of warning mate, tiles and U-block, root markers for the awareness that from here high pressure gas line is passing at the depth of x meters. iii.) Online monitoring and controlling of pipeline network through SCADA. iv.) Maintaining the Quality standards in welding and testing of each joints with the use of technology like lock pressure test, continuous patrolling of a route. B. i) Prepared readiness for emergency response to disruption of the continuous operation. ii.) Continuous training program allows company to develop and strengthen the skills of your firms employee. iii.) Following all the standard designed by PNGRB. C.i) Use of Personal protection equipment's

		ii.) Use of oxygen and natural gas detectors while O&M iii.) Asset integration is the most important factor in HSE iv.) Detail HAZOP study of the project to identify the deviation with respect to standards
2) How CGD companies can overcome political and compliance risk?	Intervention of Government to promote NG as a fuel will boost the demand and it will help us to move towards gas based economy. Reduction of taxes on Industrial PNG and CNG will boost demand of NG against other major polluting fuels specially in air quality sensitive zone. Companies can push for cover from government so as to protect them from any uncertainty in the permission process by introducing single window policy, limiting number of days for granting permission and processing application and have a control on taxes applicable on NG. Compliance management has to be developed and maintained with local regulatory bodies.	These are totally depends on the liasoning contractor and escalating capacity of the firm's management to the top government officials'.
3) What are the ways to address contractor issues such as supply disruption, work quality, &	Companies can go for multiple contractors at multiple locations or single locations. Increased number of contractors can result into competitive rates , performance enhancement	A. Diversify suppliers or invest in suppliers B. Introduce process for regular monitoring & supervision of contractor's work

equipment services?	and also reduce dependency on a single or few contractors which can lead to delayed projects due to internal conflicts. A standard monitoring process has to be developed by the company and to be maintained in order to regularly monitor the progress of contractor and supervise their work for further work allotment. Company can either secure AMC contract with contractors for O&M management along with their equipments.	C. Securing operation & maintenance agreement with the contractors to overcome poor machinery & equipment installations D. PO order of the contractor should be such strong that it can cater all aspect of the project. E.) Continuous training program allows contractor to develop and strengthen men power skills of your contractors employee.
4) How can companies overcome market risks such as gas pricing?	Companies can maintain gas portfolio where companies can enter into Long term, mid term and short term contracts in order to secure gas quantity and to hedge any uncertainty possible in future. Companies should maintain their portfolio where they have option to go for spot LNG contracts where they reduce the weighted average cost of NG in case of very low spot RLNG prices. Recently, IGX has started its operations. So companies can enter the gas trading market at gas exchange nationally and internationally at other gas trading platforms as well.	A.) Entering into gas trading at exchange B.) Open access to pipeline career C.) Securing long-term supply contract from the international market
5) How can companies improve	Increased penetration of CNG Retail outlets to cater	A.) Improve RO availability throughout the

CNG customer satisfaction?	the demand. Mobile CNG stations can be developed and tested with the support of Government in order to reach out far-away places till the Retail Outlet is not commissioned in that area or if the demand is low. This can lead to increased reliability on CNG availability.	highways in between the cities. B.) Quality of the services C.) Time saving and fast checkout services

Financial Risk Mitigation

Questions	CA 1	CA 2
1) How does interest rate affects the cost of capital in utility projects? How it impacts can be mitigated?	1. Utility project normally take long time to complete & Interest on Borrowed capital are normally capitalised to the cost of the project. 2. If Project is mainly financed by the debt fund i.e borrowed capital the interest on debt is to be added to the cost of utility project consequently the cost of utility will also enhanced which lead to high cost of utility to the end consumer. 3. The Decision of selection of proper finance should be baded on the market condition, if the prevailing market rate of interest on debt fund is low and expected to increase in future then one should negotiate with lending agencies at fixed rate of interest, whereas if prevailing market rate is high and expected to be reduce in	1. Laying of Gas Network not only involve time but certainly incur huge amount of funds. Usage of Gas by consumer and thereon collecting revenue will be at a very later stage. Interest on Borrowed Funds for Capital Investment adds cost to the project. High Interest Rate may sometime disrupt the project plan. 2. Negotiation with Funding agencies to be done in terms of Floating Rate of Interest. Further negotiation to be done that Interest shall be payable on Completion of Project with Moratorium Period.

	future then negotiate the funding agencies for providing floating rate of interest.	
How creation of Government funding agency can help Utility companies in raising finance?	1. Central Government / State Government in collaboration with utilitiy companies can issued such type of bond which is guarnateed by the government. 2. The Utility companies can give option to bond holder either to take interest at fixed rate or the utility company will meet the cost of utility consumed by the cosumer to certain extend. It will encourage the bond consumer to invest in such bond and provide a hedge against inflation also.	1. State Government can float Specific Interest Bearing Bonds and collect money from General Public. These bonds can be Guaranteed by Government, to be repayable after certain period, say 10-15 yrs. These Bonds are termed as Infrastructure Bonds. 2. Such Government Agency can liaison with State and Central Govt and can involve designated funds. Further such project can also be involved in Finance Budget of State and Central Government.
How Utility companies can improve their cash flows?	1. To Provide Electronic Clearing System (ECS) facility for specific consumer so that payment can be received instantly as soon as it become due 2. To Raise fund from othe than fixed charge instrument such as equity / Promoter contribution. Instrument having fixed charge i.e interest leads to outflow of cash by way of interest at every fixed interval irrespective of profit or loss, whereas in case of equity dividend need to distributed only when there is surplus to company. 3. To use assets on lease instead of buying such assets.	1. Raising Funds from Convertible Bonds and Debenture --> So that there is no threat of repayment immediately. This will help in managing Pay-Back Period. 2. Obtain Machines on Hire Purchase model to defer Cash Outflow 3. Seek Advertisements on Project Site. 4. Seek Single Window Clearance system from Govt for Sites, Permissions, registrations, labour etc. 5. Focus on Monitoring Overheads. 6. Have Fixed Price Contracts from vendors. 7. Funds Management through Investment Planning.

	Buying an assets results to huge cash outflow instantaly whereas leasing make it defer in installments	8. Working strongly on negotiating credit period from vendors.
What are the ways to hedge against the currency risk?	1. Buy Currency future / Options to hege agaisnt currency Risk	1. Govt can provide Guarantee against Currency risk 2. Buy a currency hedged mutual fund, forward contracts, Dual currency or currency options
How to you foresee the role of Vendor management & Data Analytics in reducing the procurement cost?	1.Cost management techniques can be applied for reducing Procurement cost such as Just in Time, Economic Quantity Order (EQO) and setting up inventory levels such as 2.Maximum and minimum Inventory Levels. Decision support system (DSS), Enterprise Resource Planning (ERP) and Data Mart also held in reducing the procurement cost.	1. Company can liaision with Govt to Identify Vendors through GeM (Government E-Marketplace) 2. Vendor Management through GeM will help in best available rates. 3. Monitoring available Credit period will add to Cash Flow management as well. 4. Further Costing Management should be applied to ascertain Level setting like Minimum Level, Maximum Level, Re-order Level of Inventory. Further EOQ (Economic Order Quantity) should be worked out to have optimum utilization of resources and reducing procurement cost. 5. Implementing ERP will help in managing operations, reducing data management costs, accounting costs, payroll management and compliances.

Appendix G: Interview Transcript

Q1. Raising finance is a challenge for any new business setup. How can CGD company raise a fund while ensuring a short payback period? What are the approach (standard or flexible) followed by the company during the process?

Answer1: It usually takes two to three years for a CGD company to develop the infrastructure, including, among others, the pipeline network, a city gas station, and CNG stations before commencing operations. After the start of operations, sales scale-up is typically slow, and it takes three to four years to reach a commercially viable level. The slower scale-up of sales and the significant upfront capital outlays also mean the payback period of a CGD project is seven to eight years. The companies can reduce the payback period through streamlined development across verticals and ensuring low operational costs.

Q2. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 2: Uncertainty, Critical

Q3. What are the standard practices followed by the CGD company in case of delay in raising funds?

Answer 3: As the CGD business is capital intensive, raising resources from the banks at competitive rates will be critical. Financing plays a crucial role for CGD projects having debt-equity raion of 2:1. Primary factors influencing CGD project cost are cost structure, ownership structure, and focus areas. The government could play a vital role by creating a funding agency to support CGD operations and appointing financial analysts to check project viability. The existence of adequate buffers of liquid assets/bank lines to meet short-term obligations is viewed positively—similarly, the Negotiate for floating interest rate.

Q4. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 4. Complex, Critical

Q5. What are the measures to improve the land acquisition process?

Answer 5. The delay in land acquisition can break the Indian government's vision of establishing CNG as the preferred fuel. The government could support the industry by establishing a single agency to access the land at the central and state levels. Additionally, tax relaxation on the ground purchased for setting up CNG stations could relieve the CGD companies facing the challenge of rising land prices post-award of license.

Q6. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 6: Critical, complex

Q7. Does your company import natural gas? If Yes, mention the tools or strategies to be adopted to mitigate price risk?

Answer 7: the CGD companies have back-to-back foreign currency pass-through clauses in contracts with large commercial and industrial consumers. For all other PNG and CNG consumers, the impact of depreciation in rupee vis-à-vis the dollar is passed through periodic price increases. Thus, the ability to take frequent price changes remains crucial. Additionally, for any imports (of compressors, etc.), the CGD company may avail buyer's credit for which the hedging policy is assessed. The company can do hedging by using specialized traded funds, forward contracts, dual currency or currency options. The other way is to ask the government to provide a guarantee against currency mismatches.

Q8. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 8: Uncertainty, critical

Q9. How can a CGD company improve their working capital performance?

Answer 9: A CGD project entails significant upfront CAPEX, besides which the CGD entities incur large CAPEX regularly to expand the network and grow sales. A long maturity and structured repayment profile with ballooning of payments, given the gradual scale-up of volumes, can partially offset the risk associated with high financial leverage, as the payback period for CGD business can belong. The existence of adequate buffers of liquid assets/bank lines to meet short-term obligations is viewed positively. Companies should ensure rapid project development in zones to ensure early revenue flow, implement penalties on project delay and constant monitoring to avoid cost overrun.

Q10. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 10: Critical and urgent

Q11. What are the key focus areas to improve financial performance in your company?

Answer 11: In a nutshell, a key metric to analyse CGD company performance is the gross margin (Gas Sale Price - Gas Purchase price) on a per SCM basis. Therefore, the company should focus on maintaining operating profitability. The other important aspect is keeping the cost of capital low and having low financial leverage to offset the high business risk associated with slow build-up in volumes, slow pace of approvals, high regulatory oversight, etc. The existence of adequate buffers of liquid assets/bank lines to meet short-term obligations is a must. Similarly, the extent to which movements in interest rates would impact an issuer is also evaluated. The company can also seek a government guarantee on the interest rate. The companies can also avoid exposure to interest rate changes by reducing capital cost through structure debt into a fixed-rate loan with banks or negotiating for floating interest rates with the banks. The companies can go for foreign JV partners to tap into the overseas capital market. In the end, the company should have dedicated financial analysts to check its performance and ensure the project's economic viability.

Q12. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 12: Critical and Urgent

Q13. What are the best practices followed by the CGD companies to improve operational and financial performance?

Answer 13: Financial have already been mentioned in the previous question. For operational, we seek to continuously expand the customer base to maximize the potential sales volumes and secure additional volumes from existing customers based on our record of satisfactory performance in our earlier dealings. The efforts to enhance the quality of products and upgrade their performance parameters aim to derive optimum value from the existing customer base and target a more significant customer profile. Historically, the strength of our relationships has resulted in substantial recurring revenue from existing customers.

At the organizational level, cost optimization and cost reduction initiatives are implemented and are closely monitored. The Company controls costs through the budgetary mechanism and its review against actual performance with the critical objective of aligning them to the financial model. The focus on these initiatives has taught the importance of cost reduction and control across the organization

The company firmly believes that technological obsolescence is a practical reality. Technological obsolescence is evaluated continually, and the necessary investments are made to bring in the best of the prevailing technology. Established contacts with leaders in technology, particularly in the company’s operations, have dividends in our ability to access newer and evolving processes and their applications in the company.

Our Commitment towards total quality management is to forge our organisation's Human Resources into a team that promotes continual improvement in the quality of products and services. Considerable focus is given to adherence to targeted dates and commitment to quality in every project. Customer feedback is studied with personal interaction with them before, during and after project completion.

A third party carried out a risk analysis of MNGL installations, including Mother Stations and Pipelines, to identify the potential hazards, assess the impact of all probable risks, and mitigate mitigation measures to reduce hazards. Failure of the pipeline can occur due to several different causes such as external interference, corrosion, fatigue, material defects, etc. Standard operating procedures and an effective safety management system are adopted to reduce accidents to a considerable extent. Awareness of hazards among our customers is our prime target in safety education.

Risk in human resources matters are sought to be minimized and contained by following a policy of providing equal opportunity to every employee, inculcate in them a sense of belonging and commitment, and effectively train them in spheres other than their specialization. Employees are encouraged to make suggestions on innovations, cost-saving procedures, free exchange of other positive ideas relating to manufacturing procedures etc. It is believed that a satisfied and committed employee will give his best and create an atmosphere that cannot be conducive to risk exposure.

Q14. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 14: uncertainty, complex, critical, urgent

Q15. How can taxation and procurement issues be effectively managed?

Answer 15: The competitiveness that CNG and PNG enjoy over substitute fuels also derives from the supportive taxation structure that these fuels want in most states. There is no certainty that State Governments will not see that as an opportunity to earn additional tax revenues as it has been the case with liquid transportation fuels such as motor spirit, high-speed diesel and aviation turbine fuel. Already, some states like Uttar Pradesh are levying very high taxes on CNG and PNG, impacting these fuels' competitiveness vis-a-vis substitutes. The government should keep taxes low on PNG and CNG to make them competitive and establish them as the preferred fuel. Moreover, removing customs duties on equipment imports would allow companies to improve financial and operational performance.

The cost of revenues has a very high degree of inflationary certainty. To de-risk, the Company has established specific policies for procurement of long delivery and strategic raw materials and stores and those amenable to just-in-time inventories. The companies are improving their vendor management and implementing the best IT practices to address the procurement issues.

Q16. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 16: Complex, critical, urgent

Q17. How can CGD companies improve customer relationship management?

Answer 17: We seek to continuously expand the customer base to maximize the potential sales volumes and secure additional volumes from existing customers based on our record of satisfactory performance in our earlier dealings. The efforts to enhance the quality of products and upgrade their performance parameters aim to derive optimum value from the existing customer base and target a more significant customer profile. Historically, the strength of our relationships has resulted in substantial recurring revenue from existing customers. Implementation of the technology enables companies to build a relationship with customers. Considerable focus is given to adherence to targeted dates and commitment to quality in every project. Customer feedback is studied with personal interaction with them before, during and after project completion. The companies are working on increasing CNG outlet density, training employees to improve customer experience and increase productivity, hiring experienced people at leadership positions etc. The companies are also seeking government approval to start combining filling stations to reduce the vehicle filling time.

Q18. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 18: Critical, Team empowerment and Urgent

Q19. What are the best practices to improve the project execution in the CGD operations?

Answer 19: The CGD projects are exposed to multiple obstructions such as damage to pipeline infrastructure due to their party work, delay in permissions and approvals from the government and its agencies, contractual and design issues, dependence on foreign suppliers, limited original equipment manufacturers. The companies have been trying their best to avoid delay by liasioning with local government and its agencies, setting project timelines, partnering with local companies, conducting periodical audits, and diversifying suppliers/contractors. The industry also seeks government support in policy implementation to promote local manufacturers, single window clearances, and government support in overcoming problems caused by third parties.

Q20. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 20: Critical, Complex, team empowerment, urgent

Q21. What support do CGD companies seek from the government during the construction process?

Answer 21: The industry seeks government support in the form of policy implementation to promote local manufacturers, single-window clearances, interest rate and currency exchange rate guarantee for raising capital, establish funding agency, implementation of strict environmental laws to promote natural gas and government support in overcoming problem caused by third parties.

Q22. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 22: Uncertainty, complex, critical

Q23. How can switching costs be reduced for the customers?

Answer 23: Rising energy prices and the drive for low carbon fuels will likely make power switching increasingly desirable to end-users. Fuel switching can result in lower operational and maintenance costs for customers. Household use of gas has picked up in India, especially when multiple services of Natural Gas in households has been effectively demonstrated. The concept of a single switch solution in the household sector is picking up momentum from gas being used for cooking, water heating, space conditioning, air conditioning, refrigeration, power generation, and fueling the vehicle. The government can further boost it by creating a conducive environment for promoting local manufacturers to produce gas-based appliances; incentives for using gas-based products and low priced gas availability will help.

Q24. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 24: Critical and urgent

Q25. How can CGD companies improve HSE performance and gain the trust of new customers?

Answer 25: following the guidelines of PNGRB in which risk management means the programme that embraces all administrative & operational programmes designed to reduce the risk of emergencies involving acutely hazardous materials. The basic procedure in a risk analysis adopted at MNGL is as follows:

1. Identify potential failures or incidents

2. Calculate the number of materials that may be released in each failure, estimate the probability of such occurrences

3. Evaluate the consequences of such occurrences.

A third party carried out a risk analysis of MNGL installations, including Mother Stations and Pipelines, to identify the potential hazards, assess the impact of all probable risks, and mitigate mitigation measures to reduce hazards. Failure of the pipeline can occur due to several different causes such as external interference, corrosion, fatigue, material defects, etc. Standard operating procedures and an effective safety management system are adopted to reduce accidents to a considerable extent. Awareness of hazards among our customers is our prime target in safety education.

To control air pollution, the Company runs its Compressors at CNG station on Natural gas and uses external catalytic convertors to avoid fugitive emissions from them. Extensive plantation of trees around the CNG Stations is undertaken for a green and clean environment

Q26. According to you, do you think the suggested strategies would help in reducing any of the following

1. Uncertainty 2. Criticality 3. Complexity 4. Team Empowerment 5. Urgent

Answer 26: Critical, urgent, team empowerment