DETAIL ANALYSIS OF CITY GAS DISTRIBUTION SECTOR

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Abstract- The city gas distribution (CGD) industry is impacted by a number of variables, including infrastructure, regulation, health, and safety. An exploratory factor analysis is carried out to comprehend this industry. Without arriving at a predefined conclusion model, the Exploratory Factor Analysis (EFA) survey methodically streamlines related procedures and investigates the potential causative factor structure of a number of measured variables. To determine the most important factors impacting the industry, this article does a factor analysis in three major categories: site workers, technical level, and management level. Sixty surveys were created to get input on factors influencing the CGD industry. The survey is conducted via a number of channels, including personal meetings, employee appointments, email, phone calls, and Google Forms. The survey results indicate that the nine elements have an impact on this industry and need specific changes for its development. Five of these nine factors—the infrastructure component, the policy factor, the petrol consumption factor, the overall energy demand factor, and the economy factor—were chosen for investigation. Five main phases have been taken in the factor analysis process: factor analysis applicability, factor selection, factor loading, factor significance test, and factor loading matrix analysis. The findings of this exploratory factor analysis indicate that factors other than policy and petrol consumption that have a greater impact on the CGD market include infrastructure, overall energy demand, and the economy.

Keywords: CGD, EFA, Petrol consumption factors, energy demand factor etc.

1. INTRODUCTION

2018 saw a notable increase in the world's need for natural gas. The annual growth rate of production and demand started to accelerate to 4.9 percent (179 BCM), the fastest pace since 2010, when consumption started to recover after the global financial crisis. In 2018, gas constituted about 50% of the global increase in primary energy demand (Birol, 2019). It is anticipated that natural gas would be more significant in India when it comes to possible improvements in air quality (Dudley, 2019). The Indian government set its first national goal for bettering air quality in 2018, aiming to cut particle emissions by 20–30% by 2024. The Indian Petroleum and Natural Gas Regulatory Board held two rounds of bidding for new city gas distribution licences in 2018–19 in order to achieve this goal. More new licences than all of the ones that are now in use were granted—a total of 136. The objective is to promote the development of over $14 billion to increase natural gas accessibility in Indian cities, therefore enabling its utilisation for domestic cooking, small-scale industrial processes, and the transportation of natural gas-powered vehicles (Vliet, 2019). The City Gas Distribution (CGD) industry in India is expected to grow from around 9223 MMSCM (Million Metric Standard Cubic Metres) from 2020 to 25,570 MMSCM by 2030, growing at a rate of 10% annually. Increased demand for natural gas from the manufacturing, automotive, commercial, and residential end-user sectors is predicted to fuel market expansion. A growing number of businesses are being permitted and licenced to operate in CGD sectors in different geographies around the nation in rounds 9 and 10, thanks to an increasing variety of beneficial measures adopted by the Indian government in the CGD market (Singhal, 2019). For instance, Indian Oil Corporation and Adani Gas Limited secured the most number of gas distribution licences in 17 and 15 geographical areas, respectively, in the ninth and tenth rounds of city gas distribution.

The transition to a gas-based economy is also expected to create employment in the nation since gas is an inexpensive and ecologically benign fuel. The recently amended laws made it possible for more public and private companies to participate in the CGD market, which enhanced the coverage of the CGD network to 228 GA, which covers 52.80% of the country's land area and 70.86 percent of the cumulative total population. The distribution of city gas in India may be classified according to its kind, supply, end-use industry, and area. The CNG category drove India's petrol distribution earnings in 2019, which resulted in stringent environmental laws and an increase in the number of cars in the country equipped with CNG. Over the course of the projected period, a sharp rise in the nation's CGD industry is predicted, bolstered by the PNG and CNG sectors (Techsci Research, 2020). Natural gas seems to be essential for a country and is critical to economic progress because of the increased energy demand (Dudley, 2018). In the Indian natural gas market, the City Gas Distribution segment is expanding quickly. A number of variables, including infrastructure and natural gas prices, have an impact on the network's expansion. According to Moller and Lund (2010), the pipeline is seen as a safe, affordable, and efficient way to move gas from an upstream gas field or terminal to refineries or downstream consumers. Should the pipeline have an unanticipated breakdown, civilization will be severely disrupted and destroyed. In the case of an incident or business interruption, the pipeline operators must identify, eliminate, monitor, avoid, or transfer the risk while providing regular service. Regarding how to maintain safe and efficient pipeline transport, the risk associated with pipeline activities has become a contentious topic among international pipeline operating corporations (Jalil Vega et al., 2018). Many research on the hazards associated with pipeline activities are conducted from various angles. For example, an analysis is conducted on the feasibility of cross-country gas pipelines in India (Jalil Vega et al., 2018). The dangers that have been discovered are examined and taken into consideration for the construction of an Indian gas pipeline project (Shan et al., 2017). In order to assess the risk associated with the pipeline, the Savadkooh problem in Iran is examined (Unternaehrer et al., 2017). Following a natural catastrophe, possible threats to the networks of natural gas pipelines are discovered (Pan et al., 2017). An assessment is made of the danger that landfill slips during development provide to China's long-term gas pipeline project (Alhamwi et al., 2017). Han and Lee (2011) evaluated the risk and performance of a terminal gas pipeline transport network operating under various service circumstances. Both qualitative and quantitative analyses are conducted on the infrastructure of urban gas pipelines (Guo et al., 2016). Fuzzy logic is used to determine the uncertainty related to the pipeline risk analysis (Guo et al., 2017). For natural gas pipelines, quantitative risk assessment is advised (Ghatikar et al., 2016).

An effort is made to comprehend the aspects impacting the City Gas Distribution industry in this article. Nine key elements that have the greatest impact on this industry were found after an exploratory survey was conducted. Five of these nine factors—the infrastructure factor, policy factor, petrol consumption factor, total energy demand factor, and economic factor—were chosen for the factor analysis procedure. The factor analysis's findings indicate that the CGD sector is more impacted by the economy, infrastructure, and overall energy demand than by factors like petrol consumption and policy.

2. An explanation of the survey's deciding criteria

The questions posed and the core elements collected for the Captain of Industry (upper authority people), Middle-level Authority (technical people), and Lower Level People (vendors and third party people) form the basis of the factorial analysis. The following is an interpretation of the industry's response:

2.1. Factor 1: Infrastructure for gas

Building infrastructure should be a major responsibility of the government, with less emphasis on short-term demand. This may function as a network developer and facilitator (Fig. 1). The government should work to increase support for the CGD industry via initiatives like the Viability Gap support (VGF) and Public Private Partnership (PPP). A government grant will provide financial assistance to the prospective private business under the VGF programme for PPP-based gas pipeline initiatives, therefore increasing the projects' economic potential. PPP efforts serve as a means of enticing the private sector to invest in and develop capital-intensive gas transmission projects that need a lengthy gestation time. Because there is no consensus on this statement in our poll, the market cannot foresee the government's engagement in PPP and VGF at this time (Fig. 2).

2.2. Factor 2: Policy

One important element in the faster implementation of CGD networks is providing one window approvals to the CGD network. In India, the state of the economy has no effect on petrol prices. There is still government intervention in the market. The regulatory frameworks and regulations are still developing and have not yet taken form. various regions of the nation have various gasoline tax rates. This causes differences in the supply of petrol and other fuels as well as variations in the price of petrol. Therefore, it is advised that the tariff be rationalised in a separate state. 64.3%. According to our study, the respondents agree with this assertion (Fig. 3). The 2016 budget's limitations on the sale of interstate petrol are being examined by the industry (Fig. 4). To further expand CGD, local taxes would be eliminated, domestic gas would continue to be sent to CGD agencies on a priority basis, CGD businesses would place a strong focus on customer-centered initiatives, and the operational elements of gas supply pipelines and health would be better understood. As a result, it seems that all respondents agreed that there should be no possible conflicts of interest in the government or regulatory framework that serves as a foundation for the growth of CGD businesses. Government restrictions and prompt permission-granting are essential for the development of our nation's city gas distribution industry (Fig. 5).

2.3. Factor 3: Gas use

Lack of gas supply and a protracted licence granting time have a detrimental effect on management choices since private companies are more inclined to participate in lucrative ventures rather than sit about with capital funds in hand (Fig. 6). Over 60% of the participants believe that a lack of gas supply has a negative impact on managerial choices, which is why many projects stall out. Reducing consumption is necessary to reduce LNG imports. This requirement will be driven by the increased emphasis on reducing greenhouse gas emissions and the use of natural gas as a safer and more energy-efficient alternative. The only hindrance is the fact that natural gas's fuel dynamics vary depending on the market. Natural gas costs have significantly decreased internationally, and government action is needed to promote natural gas usage in certain industries (Fig. 7).

2.4. Factor 4: Factor for total energy demand

The majority of those who responded to the poll are in favour of using coal bed methane (CBM), one of India's unconventional hydrocarbon sources, for commercial purposes (Fig. 8). The new HELP programme's uniform licencing policy for petroleum exploration and production also permits a business to exploit other unconventional hydrocarbons, such as CBM and shale gas.

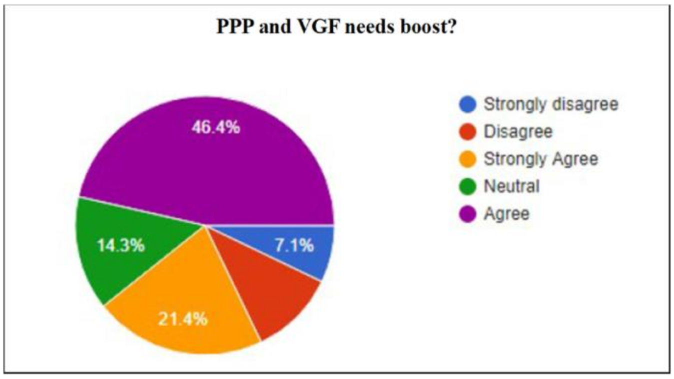


Fig. 1: Reaction to "PPP and VGF needs boost"

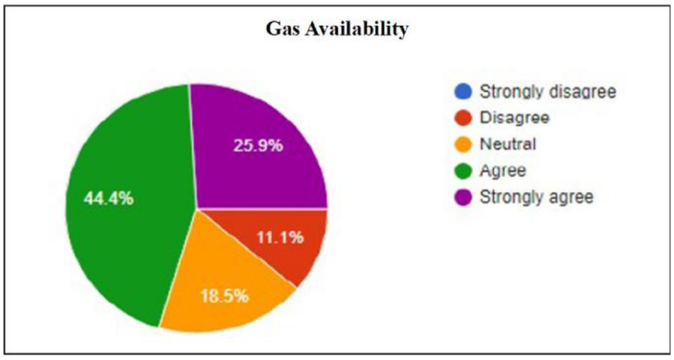


Figure 2: Answer on "gas availability"

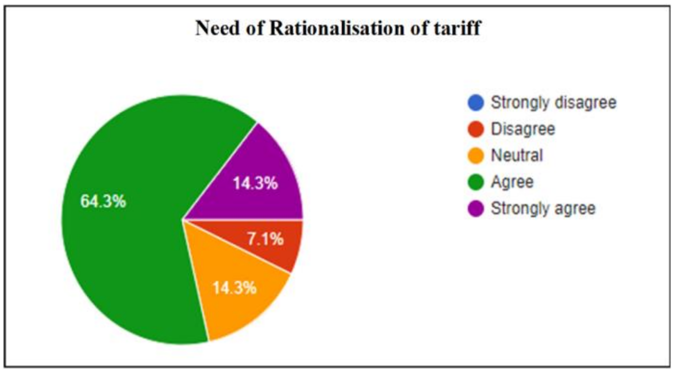


Figure 3: Reaction to "Requirement for Tariff Rationalisation"

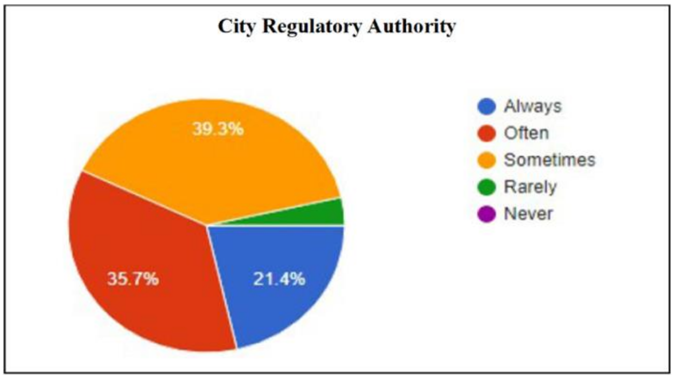


Figure 4: Answer about "City Regulatory Authority"

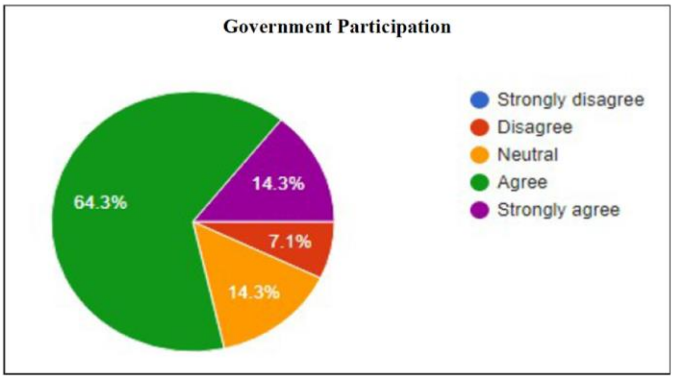


Figure 5: Reaction to "participation by the government"

2.5. Factor 2: The economic element

About 75% of respondents believe that there is a strong basis for raising domestic petrol prices, and this opinion was supported by our poll. Gas produced domestically is now priced using average gas prices from gas-surplus nations including the US, Russia, and Canada. GOI is getting ready to export gas in the future from deep-water, ultra-deep-water, high-pressure, and high-temperature regions, with a sharp rise in supply and a decline in domestic production (Fig. 9). However, given that fresh deep-water discoveries vary in cost and risk from USD 6e7 per MMBTU, the industry is certain that the existing pricing system does not provide sufficient chances for domestic capital investment.

Investors at the LNG regasification terminal preferred operations without mandatory third-party access rules in the contemporary cities seeing sector expansion. The primary reason the Dahej terminal started regasifying was for its joint venture, Petro net LNG Ltd (PLL), which imports LNG under long-term contracts. Nevertheless, it has begun to sell electricity to other merchants, such Gujarat State Petroleum Corporation (GSPC), in contrast to its equity owners. The Kochi port was far from completely operational, but it would most likely adopt Dahej's style. Reliance, GSPC, and Regasified Coal operate the Dahej LNG facility. As a result, the port of Dabhoi has regasified goods that its owner has imported and sold. Although not yet completely operating, the Kochi terminal could adopt Dahej's strategy.

In the future, these ports have the option to change their business plan to provide access to other businesses. The most recent However, terminals often use a variety of business strategies. The proposed Mundra Terminal will be no different. Similarly, the Jafrabad and Chhara terminals are intended to provide the necessary parties with long-term electricity immediately up front. The Jaigarh import terminal is probably going to provide most of their capacity under the toll road paradigm. It will guarantee a delicate equilibrium that protects the interests of Indian gas producers and users. Similar to this, the majority of survey participants said that CGD should demand the proposed access of third parties, however fairly (Fig. 10). Half of the survey respondents said that gas exchanging had been effective in reducing strained properties. They felt that the respondents were hesitant to say whether or not the gas exchange programme achieved the goals of the industry. No matter what kind of gas it is or where it comes from, being close to the source helps to minimise dependency on pipeline transportation (Fig. 11).

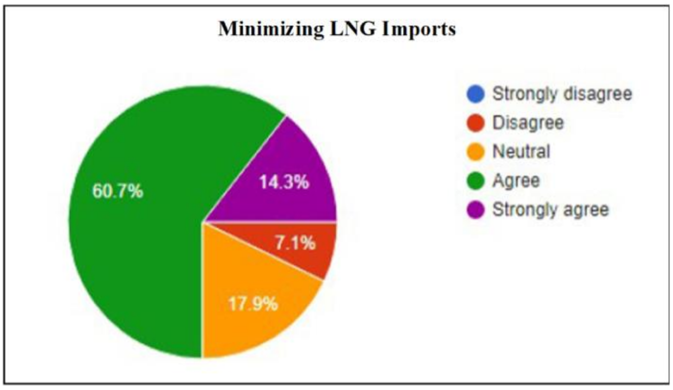
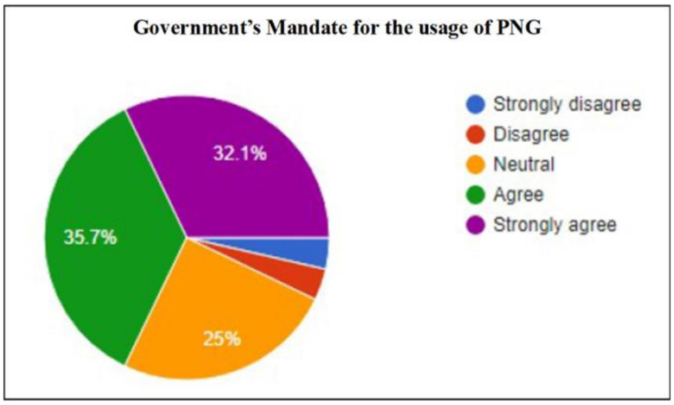


Fig. 6: Reaction to "minimising LNG imports"



Fi. 7: Answer to "Governments Mandate for the Usage of PNG"

3. Methodology

Factor analysis makes use of mathematical approaches to find patterns in a variety of parameters by simplifying the interrelated metrics. This statistical method is used to assess the dimensionality of a collection of variables (Pallant, 2011). The fundamental idea behind factor analysis is that several measured variables exhibit a consistent behavioural pattern because they are all connected with a latent (i.e., not clearly defined) variable.Confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) are the two main techniques in factor analysis (Matsunaga, 2010). CFA uses path analysis models to describe research variables and aims to verify assumptions. EFA looks through the information and tests hypotheses in an effort to identify complicated patterns (Zeynivandnezhad et al., 2019). EFA calls for actions like gathering samples, getting a matrix of correlations, deciding how many factors to include, extracting your first set of factors, rotating your factors to get the best outcome, defining your factor structure, and creating factor scores for additional research. The factor analysis approach known as EFA has been modified for this investigation. Questionnaires with around sixty items were created for the exploratory survey. These were categorised into three groups: site workers, technical level workers, and managers with current experience in the CGD business. These inquiries were developed with the assistance of literature reviews and discussions with subject-matter specialists from CGD industries. Nine variables—such as gas supply, gas infrastructure, municipal regulatory authority, tariff rationalisation, etc.—are chosen for this paper. A number of dummy runs were performed on FA once the factors were chosen. The real exam to be administered was decided by tabulating the fake results. Because it offered insight into the kinds of outcomes that may be anticipated, this was a crucial stage. After the survey's real data was acquired, a factor analysis was carried out using that information. To arrive at the final findings, the data were collated and analysed. Equation (1) is used to analyse the factor analysis.(Li and others, 2017):

$$Y_{kt} = b_{k1}F_{1t} + b_{k2}F_{2t} + \ldots + b_{kn}F_{nt} + u_{kt} \qquad \text{Equation (1)}$$

where. Ykt represents the tth observed value of the kth variable, bkn denotes the load of the kth variable's nth component, Fnt denotes the tth observed value of the nth factor, and ukt is the tth peculiarity of the kth variable. The variables utilised in factor analysis are shown in Table 1.

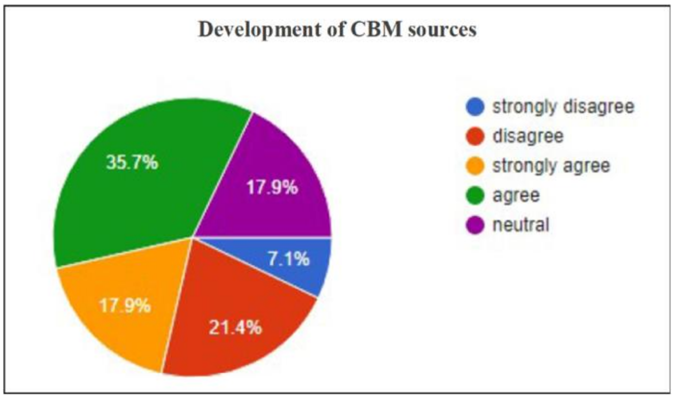


Fig. 8: Reaction to "CBM Source Development"

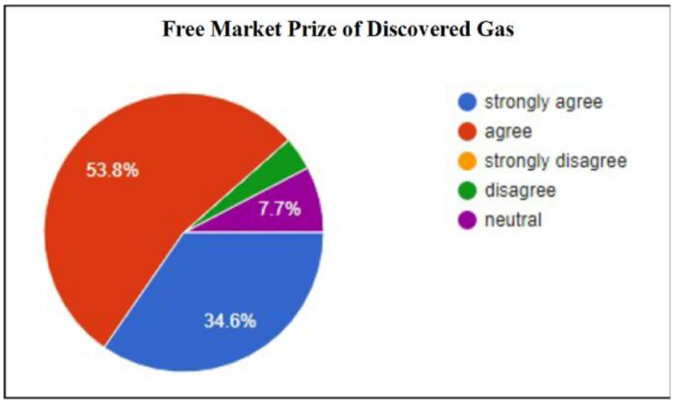


Fig. 9: Reaction to "Free Market Prize of Discovered Gas"

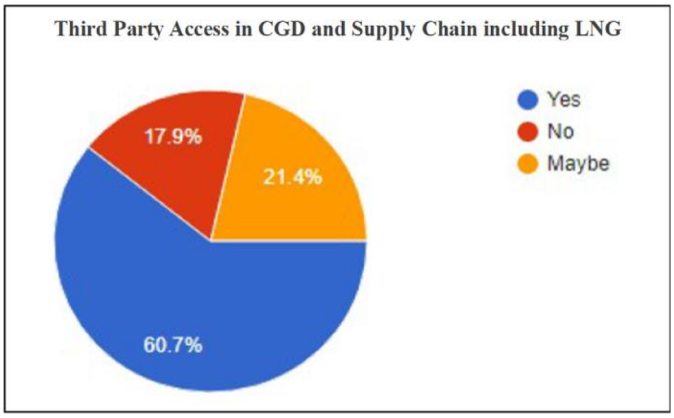


Fig. 10: Reaction to "Third party access in CGD and supply chain including LNG"

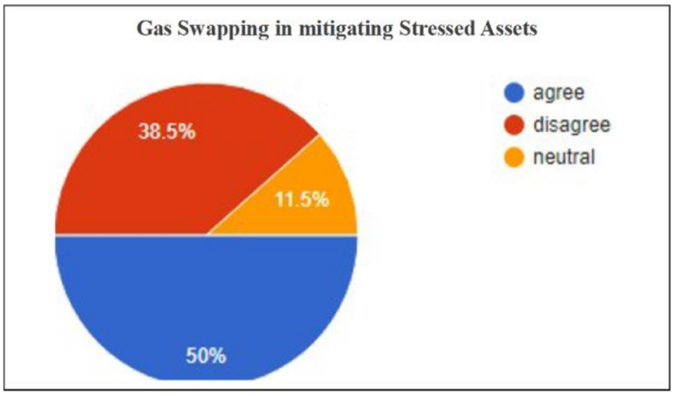


Fig. 11. Reaction to "Gas Swapping in Stressed Asset Mitigation"

4. Results and analysis

4.1. Applicability of factor analysis

The most significant outcome for factor analysis applicability is the test of sample adequacy. Among these methods for estimating factor analysis applicability is Kaiser-Meyer-Olkin (KMO). Knowing how well the data are suitable for factor analysis is known as the KMO check (Table 2). This exam evaluates the sample as a whole as well as the competency of each variable in the analysis. Statistics are computed of the variation across variables, some of which could be shared. The more factor analysis is promising for your outcomes, the lower the proportion. KMO gives back a value between 0 and 1. A number that is close to 1 is preferable, and a minimum of 0.5 is suggested to ensure that the findings are adequate. The sample size is sufficient since we get a KMO value of 0.474 for the Upper Authority, which supports our conclusion. Numerous factors are involved, one of which is the size of the data collection, which must be much bigger than 60.

Table 1: Elements of the municipal gas distribution system

Sr. No.	Variables
	Gas Infrastructure Gas Swapping Minimizing LNG imports Shifting to PNG and CNG fuels Gas availability City Regulatory authority Gas pricing/Gas economy Governments Participation Rationalization of Tariff

Table 2: Higher Level Authority: KMO and Bartlett's Test

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.474
Bartlett's Test of Sphericity	Approx. Chi-Square	42.104
	Df	36
	Sig.	.224

Table 3: Factor eigenvalue and variance contribution

Factor	Eigenvalue	Difference	Variance contribution	Accumulate variance contribution
Factor 1	5.64	0.86	0.26	0.36
Factor 2	2.67	0.23	0.10	0.46
Factor 3	2.34	1.03	0.08	0.64
Factor 4	1.29	0.86	0.02	0.76
Factor 5	1.15		0.06	0.84

An additional result of factor analysis software is communality. According to Table 3, the populations show how much variance is adjusted for each characteristic. All components or variables account for the initial communities, which are estimates of the variance for each characteristic. Estimates of the variation that each variable's components account for are called extraction communities. Since each variable accounts for an equal portion of the data set, principle component evaluation starts with the assumption that all variance is normal. As a result, populations for each variable are 1000. The common variance in the data model is represented by the anomalies in the extraction table. Therefore, it is reasonable to estimate that 82% of the volatility connected to petrol is the highest. Commonality will be 0.6 on average. Strong similarities across this list indicate that the extracted components provide a good definition for the variables.

4.2. Factor selection

Table 3 lists the factor eigenvalue and variance contribution of the model. The eigen values of the five components are 5.64, 2.67, 2.34, 1.29, and 1.15, respectively, as shown in Table 3. Every one of them is more than one. The five components' respective variance contributions are 0.26, 0.10, 0.08, 0.02, and 0.06. The five variables together have a cumulative variance contribution of 0.52. It is sufficient to use these five components to represent every variable.

Table 4 presents factor loading Following matrix rotation

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Eigenvalue
Gas Infrastructure	1.00	−0.38	0.10	0.01	−0.14	2.17
Gas Swapping	−0.38	1.00	0.24	0.15	0.02	1.67
Minimizing LNG imports	0.10	0.24	1.00	0.37	−0.55	1.38
Shifting to PNG and CNG fuels	0.01	0.15	0.37	1.00	−0.19	1.14
Gas availability	−0.14	0.02	−0.55	−0.19	1.00	0.89
City Regulatory authority	0.18	0.05	0.10	0.05	−0.19	0.61
Gas pricing/Gas economy	−0.06	−0.12	−0.40	−0.27	0.051	0.53
Governments Participation	−0.31	0.04	−0.17	0.07	−0.27	0.34
Rationalization of Tariff	0.19	−0.24	−0.14	−0.10	0.07	0.23

Table 5: Factors and their significance test.

Independent Variable	Coefficient	SD	t	p Value
Infrastructure factor	0.88***	0.15	9.04	0.00
Policy factor	−0.12	0.15	−1.30	0.16
Gas consumption factor	−0.36***	0.15	−3.12	0.0001
Total energy demand factor	1.39**	0.15	12.77	0.00
Economy Factor	4.62***	0.15	25.90	0.00

4.3. Factor loading

The loading of components after matrix rotation is shown in Table 4. Table 4's high absolute value of factor loading suggests that the variances of the variables and factors overlap. The difference between the variable and the factor in the direction of the transition is represented by the positive or negative value sign. Major loadings for gas infrastructure, a reduction in LNG imports, a switch to PNG and CNG fuels, city regulatory authority, and a rationalisation tariff are all included in factor 1. Factor 1, or the infrastructure factor, is designated in accordance with the principle of naming based on maximum load. Government engagement, price and economy of gas, availability of gas, and gas exchanging are the relatively low loading variables in the infrastructure factors. Gas swapping, reducing LNG imports, switching to PNG and CNG fuels, gas availability, local regulatory power, and government involvement are the factors in Factor 2 with the largest loadings. The policy component is identified as factor number two. Gas infrastructure, price and economy, and tariff rationalisation are the minimal loading factors. Gas infrastructure, gas swapping, reducing LNG imports, switching to PNG and CNG fuels, municipal regulatory authority, and government involvement are the main loading factors for Factor 4. Factor 4 is referred to as the gas consumption factor based on this. Gas supply, pricing/economics of gas, and tariff rationalisation are the elements with relatively low loading. The main loading factors for Factor 5 are the following: rationalisation tariff, gas pricing/economics, gas availability, and gas switching. Thus, the economy might be considered Factor 5. Gas infrastructure, reducing LNG imports, switching to PNG and CNG fuels, municipal regulatory authority, and government involvement are the least loading variables in this class.

4.4. Determine the variables' relevance

The significance test results are shown in Table 5, where "t" stands for the t-statistics and "p" for the probability of the statistical summary value. It is legitimate to take into account the null hypothesis, which would be equivalent to or more significant than the observed data. The remainder of the tests, with the exception of the policy factor, fail the null hypothesis based on the "p" value findings. They have a noticeable impact on the city gas distribution industry, whereas the infrastructure and policy factors have the opposite effects. As the system improves, the infrastructure variable gives the infrastructure element greater weight. The city gas distribution market is therefore most affected by improvements or disruptions in the infrastructure variable, as shown by the value of 0.88. Depending on the variables and the policy factor's coefficient, a change in policy would have an effect on the CGD market. The value of p is 0.16, and the infrastructure component and the CGD sector's volatility are distinct.It is often not possible to reject the null hypothesis at a 10% connotation level. The consumption of coal and oil is a component of the overall energy demand variable. It also shows the amount of petrol imported and carbon dioxide emitted. The CGD market is expected to develop owing to a rise in total energy consumption, as shown by the coefficient of 1.39.

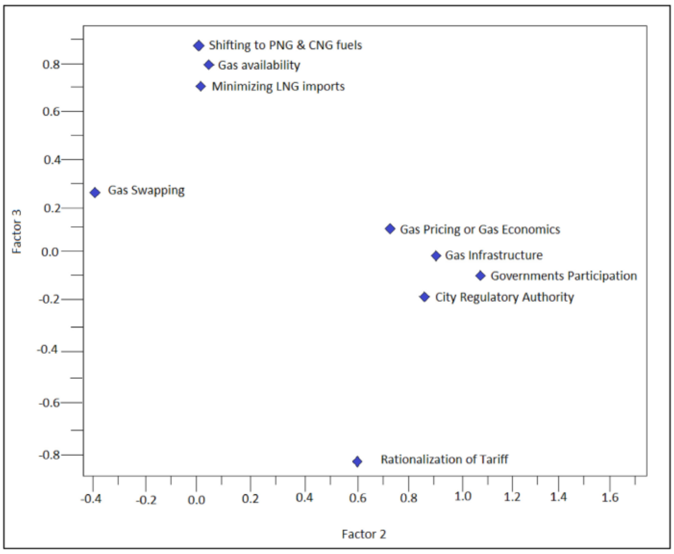


Figure 14. represents one of the nine variables utilised in the research. Factor loading matrix and variables analysis of factor 2 (x-axis) vs. factor 3 (y-axis).

4.5. Analysis of the factor loading matrix

Figs. 12 show the analytical result for the factor loading matrix and parameters. The relationship between a variable and a factor retrieved from the data is called a loading factor. The analysis of the factor loading matrix reveals the relationship between a factor and a variable obtained using the orthogonal rotation approach. Figure 12 shows the price and economics of gas, municipal regulations, and gas infrastructure. Governmental action and authority are more independent of the other factors. There may be a close relationship between the city's regulatory power, the availability, cost, and economy of petrol. These are all the essential indices used to determine the efficiency and development of the CGD network.

5. Conclusions

The factors influencing the CGD sector are assessed and understood in this research via the use of the factor analysis approach. The poll was posed to CGD entities. Three category questions have served as the foundation for the exploratory factor analysis survey. The three groups are site workers, technical level, and management level. Nine elements have been found to impact the CGD sector and call for some alteration in order to advance. Five factors—the infrastructure factor, the policy factor, the petrol consumption factor, the overall energy demand factor, and the economy component—are used from these nine variables for this study. A test for factor significance is run once the factors have been chosen and loaded. The results of the factor significance test show that the economy, infrastructure, policy, petrol consumption, and overall energy demand have coefficient values of 0.88, _0.12, _0.36, 1.39, and 4.62, respectively. These findings suggest that factors other than policy and petrol use that have the greatest impact on the CGD market include infrastructure, overall energy demand, and economics. The factor loading matrix demonstrated how more autonomous and independent the gas infrastructure, price and economics, municipal regulatory power, and government interference are from the other elements.

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