Supply Chain Performance Measurement Methodology for COVID-19 Disruption Recovery- Natural Gas Retailing in India

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Abstract

The coronavirus(COVID-19)pandemic disruption adversely impacted the Supply Chain for Natural Gas(NG) retailing, jeopardizing committed targets for thesocio-economic transition toa gas-based economyleading to inclusive growth in India. Furthermore, Omicron'srapid spread is a cause of global concern. This research aims to develop a conceptual Supply Chain Performance (SCP) measurement methodology for reducing recovery time post exogenous disruption. Exploratory research involving an integrative literature review identifies different approaches, frameworks, models, and techniques for Supply Chain PerformanceMeasurement(SCPM). Analysis reveals that the application of DMAIC improves the reliability of Supply Chain Management (SCM) functional processes during disruption recovery while synthesizing the Balanced Scorecard (BSC) with Triple Bottom Line(TBL) accounting approach provides a rigorous robust method to represents financial, social, and environmental performance goals. Accordingly, findings present a methodology with nine systematic steps to evaluate performance by City Gas Distribution(CGD)entities to accelerate NG retail consumption and speed up network expansion to meetthe growing clean energy demand of the urban populace. Additionally, anIndian model for transition to a gas-based economy is also presentedto distinguish competing goals to harmonize growth with environmental sustainability and ecological modernization. Though SCP is a mature concept, the literature on its methodology during disruption recovery for NG retailing is scanty. Hence, the proposed action-oriented SCPM methodology has practical implications for improving SCP, contributing uniquely to the retail SCM domain for NG. Its application will instigate industry practitioners to review Supply Chain Management (SCM) processes and strategies to improve service effectiveness and delivery efficiency.

Keywords: Balanced Score Card, City Gas Distribution, COVID-19, DMAIC, Ecological Modernization, Natural Gas, Supply Chain Performance, Sustainability, Triple Bottom Line

Introduction

Supply Chain Performance Measurement (SCPM) has matured over the years (Lin & Li, 2010). It gained prominence among practitioners and contemporary researchers (Guersola et al., 2018; Jagan Mohan Reddy et al., 2019; D. Mishra et al., 2018; Shekarian & Mellat Parast, 2020)for its ability to accurately determine the efficiency and effectiveness of Supply Chains (SC's) in delivering products, services at the right price, quality, and time in a competitive market environment to meet consumer requirements to the greatest extent economically(Neely et al., 1995). However, the Supply Chain Performance (SCP) has been impacted by rising exogenous disruptions (Dubey et al., 2019; Masys et al., 2014; Queiroz et al., 2020), making the usual business vulnerable (Christopher & Peck, 2004; Gallopín, 2006). The two waves of Low-Frequency High Impact (LFHI), COVID-19 pandemics(Ivanov & Das, 2020; Queiroz et al., 2020; WHO, 2022b)that struck the world successively in 2020, 2021 have had a detrimental global impact on the lifestyle, public health, business, SC's, economy(IMF, 2021), energy systems causing uncertainties.

This retarded GDP,inflicted compulsions beyond imagination, forced new practices, home isolation, work from home, online education, reinvented strategies to manage Supply Chain Disruption (SCD) in novatively (Accenture, 2020). As the global business was limping back to revival, the current "variant of concern" Omicron (WHO, 2022a) rapid spread threatens global recovery (IMF, 2022).Hence efficient operations of SCs is essentialfor disruption recovery by implementing new SCM strategies(Pettit et al., 2019), adapting digital SC models (Deloitte Global, 2020), crisis risk management (Culp, 2021), building sustainability (Rajak et al., 2021) etc., with available resources suiting environmental conditions to reduce recovery time(Barroso et al., 2012). Restoring SCP is essential to maneuver the SCM operations along the efficiency frontier curve (Shah Janat, 2019). Hence, a tailored SCPM methodology is paramount to portray a realistic picture during disruption recovery.

Past research classifies SCPM(Arzu Akyuz & Erman Erkan, 2010; Balfaqih et al., 2016; Gill, 2015; Gopal & Thakkar, 2012; Angappa Gunasekaran & Kobu, 2007; Jagan Mohan Reddy et al., 2019; Maestrini et al., 2017; D. Mishra et al., 2018; Najmi et al., 2013; Neely et al., 1995, 2005)intoan approach, framework, model, and techniques without emphasizing on the disruptive environment.Kennerley & Neely (2002) points out that the traditional measurement initiatives have been static. Different authors argue that businesses need to modify their SCPM to adapt to changing environments to remain relevant.Singh & Singh (2020), empirically concluded that SC operational performance improves with careful monitoring and implementation of the SCPM system. Past studies are silent regarding disruption as the cause of change in the external business environment, making the performance measurement ineffective and irrelevant (Meyer & V, 1994). Several authors argue that Performance Measurement System(PMS) must prioritize objectives as per changing environment, need to reflect changes, must be reviewed, revised at different levels, and suggest audit tools to identify the appropriateness of PMSs (Bititci et al., 2000; Bourne et al., 2000; Dixon et al., 1990; Wisner & Fawcett, 1991).However, SCPM solutions in practice only measure past performance, ignoring instantaneous or current performance.They are not suitable to provide an early warning with the onset of disruption risk. Therefore, an innovative SCPM methodology to support the hierarchical decision-making processes is required to trigger the top management to implement real-time strategies to restore SCP quickly during disruption.

As evidenced by the compilation in Table 1, research on COVID-19 impact is conducted in various Indian sectors. However, research in the Indian Natural Gas Sector, with a planned investment of USD 60 billion (MOPNG, 2021)to develop SC infrastructure for affordable clean energy access, is lacking.

Table-1 Studies on COVID-19 impact in the various Indian context

Author	Findings
A. Sharma, (2020)	impact and trend prediction in India
Bhatt, (2020)	impact of COVID-19 in India
Garg, (2020)	challenges faced by the Indian economy in sectors like tourism, entertainment/events/sports, tourism/hospitality, automobile industry, banking sector, MSME
Maheshwari & Goyal, (2020)	recovery strategies for the Indian aviation sector
Saveeta, (2020)	impact on key sectors like travel and tourism,agriculture, manufacturing
Joshi, (2021)	change in consumer buying behavior due to pandemic
S. Sharma et al., (2021)	the impact of COVID-19 on rapid urbanization
Soni, (2021)	the environmental perspective of COVID-19 in India

Source: Authors Compilation

NG is the fastest growing (Dara et al., 2020), hydrogen-rich (Economides & Wood, 2009), environment-friendly, clean fossil fuel(Kadam & Kar, 2019), a transition fuel, and global choice (Demirbas, 2006). Its share in the global primary energy mix is 24.2 %, whilethe share in India is only 6.7%(BP, 2021). Owning to its inherent benefits, national energy policy objectives of inclusive growth(NITI Aayog, 2017), and commitments made for arresting climate change in COP 21 Paris agreement, the Government of India(GOI), has set the target to increase the NG share in the primary energy mix from 6 % to 15 % by 2030 (MOPNG, 2020), with the dual objective to achieve economic growth and manage environmental concerns for ecological modernization (EM). The CGD is the most promising Indiansector, having a 22% share of total consumption, with an average daily consumption of 36.1 MM SCMD(PPAC, 2021b).This sector caters to the gas requirement of 85,05,907households, 33,709 commercial customers, 12,876 industrial customers,and 3,628 CNG stations(PPAC, 2021c). While the NG consumption in this sector has grown globally, the market in India is fast growing. The growth isdue to the recent authorization of 136 new Geographic Areas (GA) by PNGRB to establish the CGD network covering 41.74 % land area, 50.61 % population with the target to provide 423 lakh new PNG household connections, establish 8181 CNG stations and lay 1.74 lakh Inch-Km of steel pipeline (PNGRB, 2020). So the retail sector contribution is vital to achieving the GOI targets underpinning the commitments to provide affordable and clean energy access to its citizens for sustainable socio-economic development.However, the SC for NG retailing in India was the worst affected by the pandemic (PNGRB, 2020)due to demand volatility, hurdles in achieving predefined targets to provide new household connections, and establishing CNG stations.The literature provides names of different sectors for which the SCP with business as usual was studied (Balfaqih et al., 2016), except NG retailing.Considering the importance of NG for countries' socio-economic development and the absence of PMS for its retailing amid disruption recovery, the SC for the NG retail sector is the focus of this research.

Literature Review

The researcher conducted an analytical concept-centric,integrative literature review focusingon multidisciplinary concepts related to SCD, SCPM, DMAIC,EM theory, and sustainability to build a more profound knowledge to solve real-life problems for disruption recovery, socio-economic development, and environmental protection through synthesis.

Supply Chain Disruption in NG Retailing

COVID-19 adversely impacted SC'sglobally(Majumdar et al., 2020), causing a long-term crisis(Ivanov & Das, 2020). The SC for NG retailing in India is no exception.This SC is the Local Distribution Network (LDN) of interconnected underground pipelines, referred to as the City Gas

Distribution (CGD) network(PNGRB, 2018). Itdelivers Piped NG (PNG) to domestic, industrial, commercial segment retail customers having daily NG requirements up to 50,000 SCM and Compressed NG (CNG) to the transport segmentused as auto-fuel. The SCP and ratings of CGD companies gotadversely impacted(India, 2020), affecting working capital, procurement, gas sourcing, CNG operations(PNGRB, 2020). Material and labor shortage caused the construction activities for establishing the SC network for NG retailing to a standstill (Abdi, 2020). The retail segment experienced demand volatility during the nationwide lockdown, with a 58.29 % reduction in NG consumption in April 2020 (PNGRB, 2020). Upon easing restrictions with phase-wise upliftment of lockdown, the retail SC took eleven months to achieve pre-lockdown NG consumption levels. Therefore, a realistic SCPM during the post-disruption recovery period is vitalfor ensuring transition to a gas-based economy.

Supply Chain Performance Measurement Classification

SCP is a multi-perspective, multilevel concept (Gill, 2015) with quality, time, flexibility, cost(Neely et al., 1995)forming the basis for defining indicators to measure its performance classified as a model, approach, framework, and techniques (Jagan Mohan Reddy et al., 2019). The Balanced Score Card (BSC) (Kaplan & Norton, 1992) is an approach (Tiwari & Panicker, 2017)that measures both business and SCP (Brewer & Speh, 2000), integrating the customer, internal business, innovation, and learning, and financial perspective without focusing on the nature of the external environment and aspects related to environmental or social dimensions of sustainability. However, the approach enhances SC operations' response time, efficiency, and effectiveness (Bhagwat & Sharma, 2007). Another model, based on SC processes,an industry-standard, is the Supply Chain Operations Reference Model(SCOR) model (APICS, 2017), framed by the Supply Chain Council, having ten performance metrics within customer-facing and internal-facing measures.This model ignores exogenous factors that impact performance. The models are static (Persson & Araldi, 2009), reflect historical performance, and are silent regarding current performance. So far, none of these models applied to SC for NG retailing.

SCPM approach (Najmi et al., 2013)classified under perspective, process, and hierarchy,involves actions required to achieve performance. The BSC and SCOR models are perspective-based. The process-based approach emphasizes the SC process (Chan & Qi, 2003; A. Gunasekaran et al., 2001)to measure its performance during the operations stage to fulfill customer requirements in a responsive, effective and efficient manner without referringto the external environment. Resources, output, flexibility are the different measures in this approach (Beamon, 1999). Impactful financial and nonfinancial measures aligned to the SCM basic strategic, tactical, and operational processes are vital (A. Gunasekaran et al., 2001) to categorize strategic performance metrics at three hierarchy levels (A. Gunasekaran et al., 2004). Yeh et al., (2007) argued employing the six sigma technique with DMAIC; however, the approach does not consider the decision-making levels. The hierarchy-based approach first proposed by Askariazad & Wanous, (2009) using Analytic Hierarchy Process (AHP), is a value model that concurrently evaluates the SCP at strategic, tactical, and operational levels to prioritize critical performance measures in SC's. The process-based approach has been applied to measure SCP in isolation and not in combination without emphasizing exogenous environmental factors for performance measurement.

SCPM frameworks have been proposed as conceptual structure, set of ideas, skeleton structure without reference to the exogenous disruption. Several authors (Beamon, 1998; Melnyk et al., 2014; Neely et al., 1996; Shah & Singh, 2001) have extensively worked to enhance the scope of the framework connecting different SCM domains like SC strategy, SC operations,the relationship between the PMS and the environment to answer questions like what to measure, how to measure, data collection, and elimination of conflict in the measurement system.

Techniques (Coulin & Zowghi, 2005) provides tools to measure SCPM. The different techniques applied for SCPM are AHP, Data Envelopment Analysis(DEA), Delphi, Heuristic, Hybrid, Simulation (Najmi et al., 2013), Delphi/ Survey (Balfaqih et al., 2016), and Fuzzy set

approach (Chan & Qi, 2003). However, the techniques are silent regarding SCPM under disruption. Gill, (2015), in their meta-analysis, suggests developing models and design strategies to manage change in the business environment without empathizing with the cause of change.

Thus, the literature lacks evidence on the conceptual methodology to measure SCPM under disruption recovery, which the current research will fill.

Define–Measure–Analyse– Improve-Control(DMAIC) Cyclic Process

DMAIC (Yeh et al., 2007)is a five-stepsix sigma cyclic process applied standalone or in combination to compare the SCP (Dasgupta, 2003; P. Mishra & Sharma, 2014) by improving the process through standardization and root cause analysis of variation. Its repeated application discovers the best practice to move closer to a perfect process eliminating waste manifesting lean. Therefore, integrating DMAIC with the SCM process in the post-disruption uncertain environment will improve performance outcomes for sustainability through enhancing NG consumption.

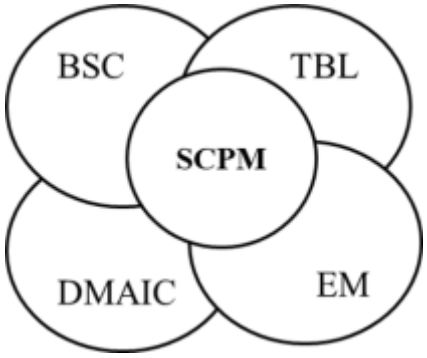
Sustainability and Ecological Modernization

Sustainability (Keeble, 1988)having three pillars (Birla, 2021; Rai, 2015)is a multidimensional concept viewed from the economic, environmental, and social lens under the Triple Bottom Line (TBL) accounting approach (Liu et al., 2017) to quantify performance. Integrating its environmental dimension with SCM leads to a green SCM (Sarkis, 2012). The retail SC for NG is one such green SC with a low carbon footprint that provides its doorstep delivery to minimize the adverse environmental impact caused by excessive consumption of polluting fossil fuels like coal and oil while providing affordable access to NG, thereby meeting the social need for clean energy. The intervention relating to GA authorization to establish SC networks for NG retailing is also viewed through an EM theoretical lens (Glynn et al., 2017)to achieve the environmental goals set by the Government of India under the 2015 Paris Agreement for Climate Change while advancing economic growth under the SDGs.

Theoretical Model

Figure 1 illustrates the theoretical SCPM model as an outcome of the aboveliterature review.

Figure 1 Theoretical Model



Research Objective

Sustainability and EM via NG are at the top of the GOI's agenda. While access to NG is critical for rapid urbanization and sustainable socio-economic development for human well-being, the SC for the NG retail sector was the most severely affected by the pandemic disruption deaccelerating growth and development. Literature review reveals that previous studies have been silent on SCPM for NG retailing in a disruptive environment and that evidence on the integration of the three classified SCP approaches is also lacking. Therefore, the current research in the context of SCM for NG retailing during disruption recovery aims to:

(i) develop a conceptual SCPM methodology synthesizing DMAICand BSC

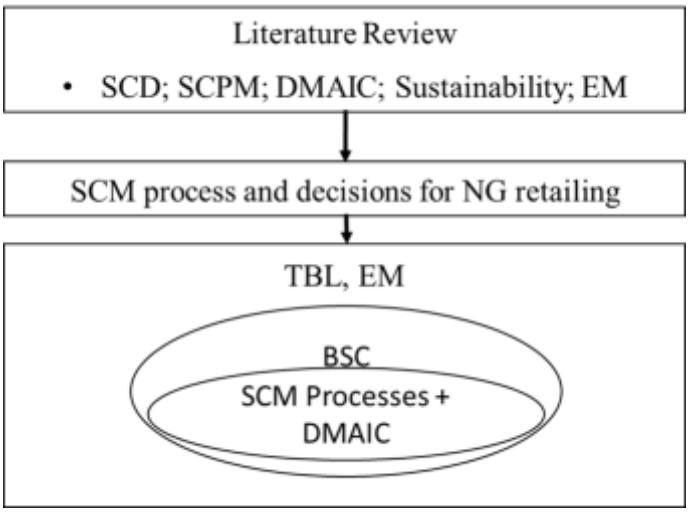
(ii) establish the sustainability of retail SC through the TBL accounting approach

(iii) propose an Indian model for sustainability and EM for transition to a gas-based economyto represent the situation

Research Design

The researcher used an exploratory methodology to synthesize multidisciplinary concepts from the literature.The research methodology is in Figure2

Figure 2 Research Methodology



SC for NG Retailing

The SC for NG retailing is a low carbon SC that serves a dual purpose of material and service flowswith the following primary functions-

(i) market mediation to create product variety i.e., PNG and CNG offered to prospective customers in the local market with the GA

(ii) deliver PNG continuously at contractual conditions to all end consumers

(iii) deliver CNG uninterruptedly at designated pressure at CNG outlets

(iv) provide transportation service of NG till the delivery point

The CGD entityis responsible for building, owning, and operating the SC network. The SCM processes are:

(i) Gas Sourcing: The CGD entity sources two types of gas (i) the domestic NG for which the producers' sale price at the source is fixed by PPAC(PPAC, 2021a) (ii) Re-gasified NG(RLNG), for which market forces determine its price at the import terminals. The domestic NG is sold as PNG-domestic to the household customers and as CNG to transport segment customers. The RLNG is sold as PNG to commercial and industrial segment customers. The CGD entity fixes the sale price for various segments of the customers in their GA, which is reviewed from time to time.

(ii) Customer Connectivity: The CGD entity creates the underground network of pipelines, the SC for gas delivery. Last-mile connectivity from the local distribution network (LDN) up to the burner tip is provided to each segment of the customer.

(iii) CNG Stations: The CGD entity establishes the CNG stations in different demand centers within their GA to supply CNG to the transport segment. As the demand builds up, the capacity of operating CNG stations is increased, or new CNG stations are established.

(iv) Gas Sale & Supply:

a. PNG domestic customers: When domestic customers submit their application for their household gas requirement, the CGD entity will install the gas meter after conducting a survey and provide last-mile connectivity to supply PNG against a security deposit.

b. PNG commercial and industrial customers: When these customers approach the CGD entity with their gas requirement, theCGD entity will enter into a bilateral contract for the sale of PNG. Supply will commence after the last mile connectivity is provided.

c. CNG customers: After the CNG stations are established, the CGD entity will provide CNG sales and refilling services to the customers in the transport segment.

(v) Operation and Maintenance(O&M): After commissioning the pipeline grid and CNG stations, O&M of the SC network adhering to the PNGRB guidelines is done by the CGD entity to ensure an uninterrupted supply of gas for all segments of customers. Efforts are made to maintain the network as if new, minimizing downtime.

The hierarchical decision-making levels in the retail SC involves the following:

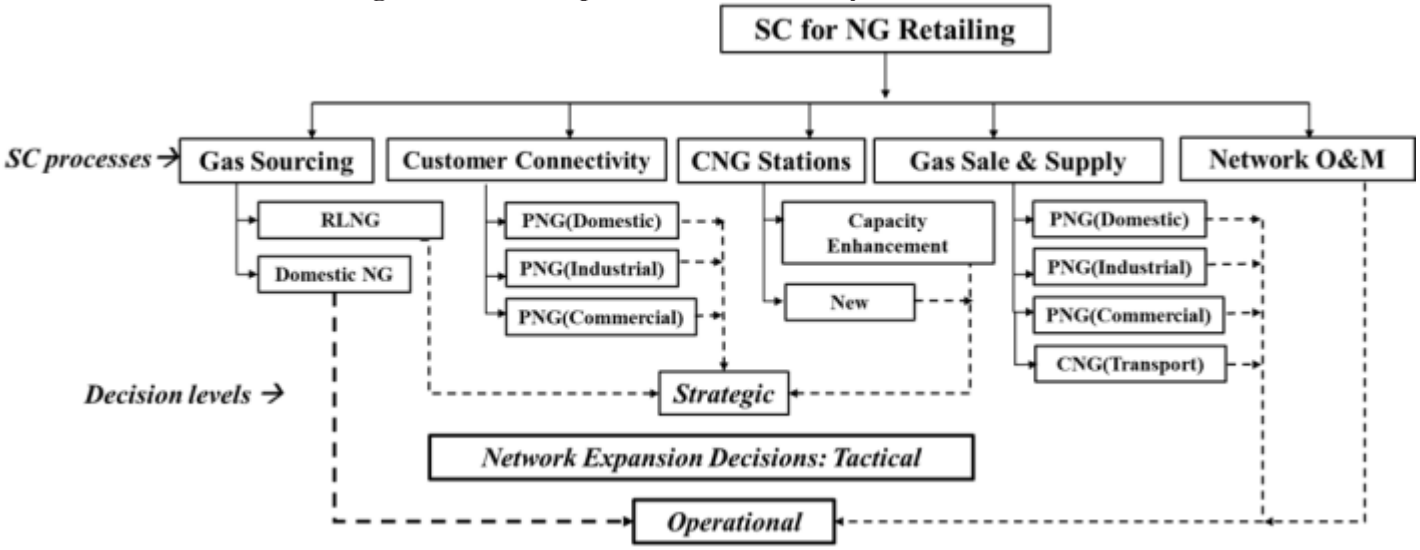
(i) **Strategic:** The decision related to cost price for purchase of RLNG, SC network design capacity, the sale price of PNG and CNG, capacity enhancement of CNG stations with demand buildup, plan to establish new CNG stations.

(ii) **Tactical:** The decision involves SC network expansion to cater to customers in new charge areas, which are demand centers in the GA.

(iii) Operational: These decisions relate to daily demand and supply management, post-sales, and service to PNG and CNG customers, O&M of SC network.

The SC process with hierarchy decision level for evaluating SCP is shown in Figure3

Figure 3Retail SC process with hierarchy decision levels



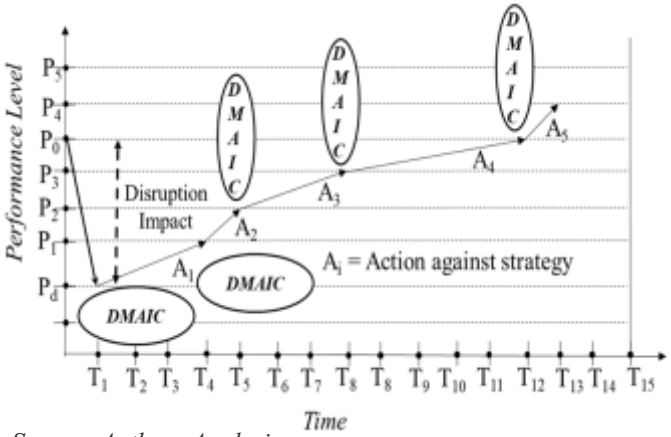
Source: Authors Analysis

Results and Analysis

SCPM methodology for NG Retailing during disruption recovery

Coronavirus created uncertainty, making it difficult to conduct business as usual, requiring rethink decision-making to realign SCM processes suiting changes in exogenous environment and strategies at different levels. As a result, the SCPM methodology applies DMAIC to improve the reliability of the SCM process's outcome, thereby increasing the effectiveness of the strategies to reduce recovery time for uninterrupted operations and expansion of the SC network. This outcome requires management to review current strategies and devise new strategies for restoring performance to pre-pandemic levels or higher for sustainability. DMAIC structures SC functional processes. It helps explore new solutions at the planning stage and implement control to ensure that performance measurement directs decision-makers to revisit strategic, tactical, and operational decisions for higher financial performance. The emergent problem caused by disruption is defined (D) with the degree of required improvement, its impact is quantified for measurement (M), and the root cause is analyzed (A) to improve (I) SCM processes with the appropriate solution to control (C) the severity of the disruptive event. Quantification is done by comparing pre-and post-disruptive performance parameters, denoted by P0 and Pd. Figure 4 illustrates the process.

Figure 4 SCPM mechanism



Source: Authors Analysis

As the BSC emphasizes enhancing future financial performance, elements that excel CGD entity's financial performance, create shareholders and customer value, improve business processes, and enableemployees learning and growth forexcellence in internal performance are applied after each cycle of DMAIC for real-time performance measurement. This approach allows the CGD entitiesto speed-up network expansion to reduce recovery time, increase retail customer base while managing environmental issues with increasing NG consumption, and replacehigher polluting fossil fuels with NG.The TBL accounting quantifies socio-economic and environmental performance. The stepwise SCPM methodology is-

1. Step-1: Identify the SCM problems caused by the disruption in the GA.
2. Step-2: Classify and quantify the impact of disruption under internal business, customers, innovation and learning, and financial perspective.
3. Step-3: Revisit SCM strategies. Reformulate, if required, aligngoals under each perspective with the business vision for disruption recovery.
4. Step-4: Defineobjectives,metrics,and targetsagainst goals of eachperspective
5. Step-5: Fix short term targets for each goal by striking a balance with the long term objectives
6. Step-6: Prepare SC process against each perspectiveto achieve the target
7. Step-7: Measure the results under each perspective after implementing the process.Compare it with the targets.
8. Step-8: Analyse the variation of outcomes under goals of each perspective to improvethe SCM process and set new targets to control the impact of disruption during the recovery period.
9. Step-9: Repeat Steps 4 to 8to continuously improve SCP to accelerate NG retail consumption, improving sustainability.

TBL accounting and EM

PNG and CNG offer distinct advantages (Gas, 2022; IGL, 2021a). CNG replaces higher polluting fuels like petrol and diesel in the transport segment (Ravindra et al., 2006); versatile PNG replaces polluting furnace oil, pet coke, and costlier liquid fuels in the industrial and commercial segments (IGL, 2022).TBL accounting quantifies the positive impact ofthe retail SC, as evident from the recent annual reports of a few CGD companies (ATG, 2021; IGL, 2021b)

(i) Economic: PNG for the domestic segment and CNG for the transport segment are competitively priced compared to the fuel it replaces. For instance, at the current PNG and domestic LPG price level in New Delhi, switching to PNG from domestic LPG results in monthly savings of Rs 450/-. Similarly,for every 1000 km of driving,switching to CNG saves Rs 440/- for a petrol car and Rs 520/- for a diesel car. Besides, switching to PNG has indirect and direct benefits for commercial and industrial segments like high combustion efficiency, eliminating preheating, pilferage, adulteration, spillage, pollutants, and storage at the site. These economic benefits reduce operating costs increasing the PAT.

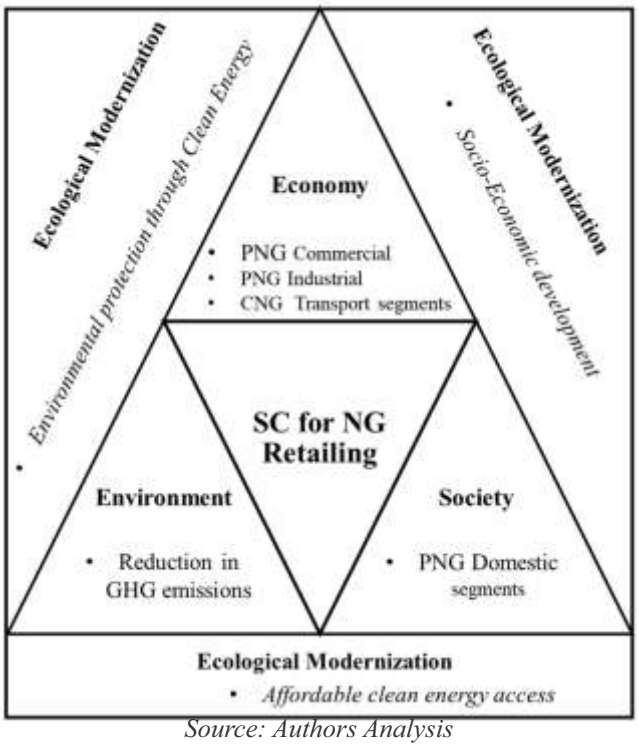
(ii) Environmental: NG replaces high polluting fossil fuels in the retail segment. For every unit of energy produced, NG emits 50 % less carbon dioxide than coal and 25 % less than oil. Likewise,NG emits approximately 70 % less carbon monoxide and 87 % less nitrogen oxides in the transport segment than equivalent gasoline vehicles (Demirbas, 2006). Thus fast recovery of retail SC post disruption is vital to increase NG consumption for reducing harmful emissions.

(iii) Social: NG offers several social benefits of reducing health-related issues and expenditure due to reduced emission of pollutants compared to other fossil fuels it replaces (Ishwaran et al., 2017). Its retail supply chain supports SDG-7 by providing affordable clean energy access to 70.47 % of the Indian population. At the same time creation of the retail SC across 136 new GA covering 41.74% population in 50.61 % promotes investment in the NG retail sector, generates direct and indirect employment supporting SDG-1 to reduce inequality and end poverty. Further, reducing the

emission of harmful greenhouse gas on switching to NG provides healthy life, well-being, and productivity supporting SDG-3.Thus, SC for NG retailing impacts the economy, environment, and society by enhancing social well-being and promoting EM through government interventions collaboration among associated organizations, society, and stakeholders (Spaargaren, 2000).

Figure 5 depicts the Indian model for sustainability and EM for transitioning to a gas-based economy to simultaneously achieve socio-economic development, affordable clean energy access, and environmental protection.

Figure 5Indian model for Sustainability and EM for transition to a gas-based economy



Source: Authors Analysis

Conclusions, Limitations, and Research Directions

The retail sector took eleven months to recover because the CGD entities were unprepared for unexpected coronavirus disruption. The proposed SCPM methodology is action-oriented,with nine systematic step ssignifying completion to reduce recovery time for sustainability advancing EM.Its repeated application will enhance process reliability, reducing waste to make the SC more responsive and efficient to maneuver along the efficiency frontier curve(Shah Janat, 2019). TheSCPM methodology with a future outlook is an innovative, unique contribution to the SCM domain for the NG retail sector since no such methodology exists. Applying DAMIC with the SCM process improves SCP while BSC (Gill, 2015) and TBL accounting (Birla, 2021) provide management with a robust tool to enhance financial, socio-economic, and environmental performance concurrently. The model combining the three sustainability dimensions with EM represents the situation topromote transdisciplinary collaboration among the decision-makers in government, commercial organizations, academicians, researchers, and society on accelerating NG transition to achieve committed targets under the SDGs. The methodology will assist the CGD entities under the 11th CGD bidding round (PNGRB, 2022a, 2022b)to proactively manage disruption from new variants like Omicron while planning infrastructure investment (PTI, 2022), advancing EM through NG, applying the model. This research on the NG retail sector domain being one of its kind, the scope only covers a systematic presentation of ideas at the conceptual level involving SCPM, disruption recovery, DMAIC, BSC, Sustainability,and EA. Empirical research will validate the methodology and model for its meaningful application. The research can be advanced by developing SC strategy model for disruption recovery with key performance indicators and corresponding metrics.

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