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MANAGEMENT | RESEARCH ARTICLE

Performance evaluation of reverse logistics: A case of LPG agency

Kottala Sri Yogi^{1*}

Abstract: Majority of the manufacturing companies are incorporating the practice of reverse logistics in their value chain. In manufacturing processes, the concept of reverse logistics plays a vital role in enhancing the company's profit margin for sustainable business growth. For every company, there is a need of performance measurement system to be established as successful business tool. However to predict better results, how smartly the inputs for the transformation or business process are being effectively and efficiently used has to be analyzed. Drawing attention to the growing popularity in adapting the best practices of reverse logistics among different manufacturing industries, this paper aims to build a methodology in order to measure the performance of liquefied petroleum gas (LPG) agencies. To do so, it has undertaken the Asian emerging market-India as a case study and improved the understanding of performance measurement in reverse logistics to refilling LPG cylinders. Further, it has suggested a framework affecting the implementation of reverse logistics activities and its network.

Subjects: Logistics; Manufacturing Engineering; Reverse Logistics

Keywords: manufacturing; reverse logistics; performance measurement and LPG

ABOUT THE AUTHOR



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Kottala Sri Yogi received his full-time PhD in Operations Management from Indian Institute of Technology (IIT) Roorkee, Department of Management Studies, Uttarakhand (January 2010–September 2014). His research interests include Reverse Logistics, Quality Control, and Sustainable Supply Chain Management. His doctoral work has appeared in referred international conference proceedings as well as referred national Journal of India. At graduation level, he did B.Tech specializing Mechanical Engineering from Acharya Nagarjuna University, India then obtained Masters in Engineering specializing in Industrial Engineering & Management from Rajiv Gandhi Pradyogikia Vishwavidyalaya, Bhopal, Madhya Pradesh, India and qualified in GATE examination twice. Currently working as an assistant professor in the Department of Industrial and Production Engineering, Institute of Technology, Guru Ghasidas Vishwavidyalaya (A Central University), Bilaspur, Chhattisgarh, India.

PUBLIC INTEREST STATEMENT

Developed new three-phase methodology for performance evaluation of reverse logistics network: a Case of LPG agency of emerging market of Asian economy: India. This methodology helps to calculate order fulfillment, lead time, inventory carrying cost, acceptable stock turnover ratio, volume flexibility, cylinder utilization ratio, CCT of working stock cylinders at distributors, and working stock ratio that are being key performance indicators of successful implementation to reverse logistics.

1. Introduction

The reverse logistics strategy has recently attracted the attention of both researchers and practitioners, given its successful implementation in many companies including Apple, Dell, and Sony. The growing number of articles on reverse logistics in the literature is an indication of the importance of the strategy and of its role in improving the competitiveness of an organization (Sriyogi, 2012).

Many companies started incorporating the reverse logistics strategies into their supply chain, as some of the reasons are increase in flow of returns of the product, product recalls, warranty returns, service returns, end-of-use returns, end-of-life returns, and so on (Ravi & Shankar, 2005). In some companies, the refilling activities are ubiquitous viz., collection of empty cold drink bottles and collection of empty cylinders (liquefied petroleum gas, LPG) from consumers. While refilling activity is one of the transformation processes of company's core business activity, managing these type of closed loop supply chain networks is complex as well as lot of uncertainty in predicting the forecast demand for refilling activity.

Main difficulties associated with implementing reverse logistics activities are the degree of uncertainty in terms of the timing and quantity of products. Thus, managing return flow usually requires a specialized infrastructure and relatively high handling cost and time (Kannan, Pokharel, & Sasi Kumar, 2009). Many researchers developed, suggested different models (qualitative and quantitative) in solving the issues related to inventory and customer demand. Improved logistics performance and higher profits have significant relation with human capital investment and have brand image on the Indian logistics industry (Jhawar, Garg, & Khera, 2014). A conceptual framework for the value-based SCM is proposed which links the SC complexity drivers' dynamics and uncertainties to SC-related drivers of company value using case study of FMCG Industry (Brandenburg, Kuhn, Schilling, & Seuring, 2014). Prominent environmental issues in logistics are consumption of non-renewable natural resources, air emissions, congestion and road usage, noise pollution, and both hazardous and non-hazardous waste disposal (Camm, 2001).

Jun and Kim (2006) present the following main characteristics of reverse logistics:

- (1) An uncertainty of returned time of a product.
- (2) An uncertainty of quality of a returned product, i.e. uncertainty of recovered value.
- (3) An uncertainty of configurations of parts or components of returned products.
- (4) An uncertainty of locations.
- (5) An uncertainty of amounts of recovered products.

However, performance measurement system (PMS) methodologies for reverse logistics especially for refilling activity in the literature is limited. In this paper, we have made an attempt for developing a methodology of PMS for reverse logistics considering a case of LPG agency in urban and rural area of India using existing limited literature. Thus; this research work shall be a significant contribution for building the theory in area of PMS for reverse logistics networks.

The organization of this paper is as follows. Section 2 describes briefly the literature review covering PMSs and importance of reverse logistics importance of performance measurement, process performance measure, and Indian LPG Scenario. Section 3 describes the methodology, and hypotheses framework for the study. Section 4 reports the results and discussion, and Section 5 comprises the conclusion.

2. Literature review

2.1. PMS and reverse logistics

2.1.1. Importance of measurement

Performance measurement and metrics have an important role to play in setting objectives, evaluating performance, and determining future courses of actions, based on strategic, operational, or

tactical focus (Gunasekaran, Patel, & McGaughey, 2004). Harrington states that “If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it”. In fact, the lack of relevant performance measures has been recognized as one of the major problems in process management and the management of supply chain performance measures based on reliability, responsiveness, cost, and asset (Huang, Sheoran, & Keskar, 2005; Lai, Ngai, & Cheng, 2002). Key considerations offered for analyzing PMSs are described as the overall set of metrics used to quantify both the efficiency and the effectiveness of action (Shepherd & Gunter, 2006). Processes’ (internal and external) perspective concentrates on meeting the demands and requirements of stakeholders while achieving productivity and efficiency in the work flows. Due to the uncertainty and variability of product returns, the processes help to create and deliver the value proposition to stakeholders therefore enhancing the RL performance.

2.1.2. *Process performance measure*

One of the performance measures is RL cycle time: Average cycle time a product is being returned from the customer to the time the product is put back into the market.

Network capacity: Appropriate infrastructure and allocation of resources should be chosen for a cost-effective and efficient RL network.

Transport capacity Transport planning and load management of vehicles to minimize damage to product returns and at maximizing vehicle utilization.

Recovery efficiency rate: Recovery efficiency and rate measures the ability of an enterprise to simultaneously meet cost, quality, and environmental impacts, and conserve valuable resources.

Processes’ (internal and external) perspective concentrates on meeting the demands and requirements of stakeholders while achieving productivity and efficiency in the work flows. Due to the uncertainty and variability of product returns, the processes help to create and deliver the value proposition to stakeholders therefore enhancing the RL performance.

American Reverse Logistics Executive Council defined reverse logistics as “the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal” (Rogers & Tibben-Lembke, 1991). Interpreting the Rogers and Tibben-Lembke’s definition for purpose of recapturing value relevant to the case of LPG considered in this study is highly being practiced in Indian LPG industry.

Comprehensive PM System and scorecard for RL, and different performance measures have been assigned into six different perspectives. The Overall Comprehensive Performance Measurement Index has been calculated and prioritized performance measures are determined to focus on for continuous improvement (Shaik & Abdul-Kader, 2012). Manufacturers tend to view reverse logistics as the process of receiving defective products or reusable containers. Reverse Logistics has become an important entity and plays an important role in a company’s competitive advantage, making the pursuit of their function a strategic decision (Schwarz, 1989). Performance measures based on goals of supply chain (Otto & Kotzab, 2003). Instrument to measure the collaboration in a supply chain consisting of two members: suppliers and retailers (Simatupang & Sridharan, 2005). Giannakis (2007) assessed the performance of supplier relationships. Forslund & Jonsson (2007) observed integration of performance management process for delivery service in customer/supplier dyads.

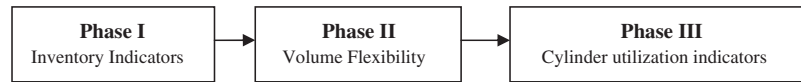
Additionally, the literature (Table 1) shows that usage of quantitative techniques in investigating the issues of distribution process, inventory models, facility location, flexibility issues, and performance parameters in relation to reverse logistics that has been covered.

Table 1. Summary of literature findings: reverse logistics strategies

Author	Approach	Findings
Haas, Murphy, and Lancioni (2003)	Quantitative	Investigated the distribution processes of the reverse flows using data envelopment analysis (DEA)
Gooley(1998) Dobos (2003)	Quantitative	Optimal inventory policies in the reverse logistics systems, based on quadratic holding costs, manufacturing costs, and disposal costs
Fleischmann et al. (1997)	Quantitative	Models focusing on designing for disassembly and logistics network design using mathematical programming
Fleischmann, Krikke, Dekker, and Flapper (2000)	Quantitative	Designing for disassembly and logistics network design using mathematical programming
Klausner and Hendrickson (2000), Knemeyer, Ponzurick, and Logar (2002)	Quantitative	End-of-life product take-back models were also developed to allow the user to determine the optimal amount to spend on buy-back
Meade and Sarkis (2002)	Quantitative	Decision-making models have been developed that link operational characteristics in the reverse logistics process to the selection of third party logistics providers
Krikke (1998)	Quantitative	Network Redesign for Discarded Copiers
De Brito (2004)	Quantitative	Control issues, critical factors under uncertainty in a reverse logistics network
Realf, Ammons, and Newton (2004)	Quantitative	Reverse logistics network design robust optimization with sensitivity analysis
Ko and Evans (2007)	Quantitative	Design of dynamic integrated distribution network optimization for both forward and backward network simultaneously using MINLP
Lu and Bostel (2007)	Quantitative	Two Stage location problems with three types of facilities in a remanufacturing network
Geethan, Jose, and Sunil Chandar (2011)	Quantitative & Qualitative	Considered return value, carrying cost percentage, return transit time as performance indicators of reverse logistics
Beamon (2009)	Quantitative	Volume flexibility, demand variance, delivery flexibility, product flexibility parameters for supply chain performance
Nakabi, Zitouni, and Bouksour (2012)	Quantitative	Cylinder turnover ratio, cylinder cycle time, Working stock ratio as performance parameters reference to LPG distribution industry of Morocco
Slack (1987)	Quantitative	Flexibility measurement of production system
Dowlatshahi (2000)	Qualitative	Reverse logistics system strategic factors: strategic costs, overall quality, customer service, environmental concerns, and legislative concerns
Thierry, Salomon, and Van Nunen (1995)	Quantitative	Categorized networks by type of product recovery options
Teunter, van der Laan, and Inderfurth (2000)	Quantitative	Worked on inventory systems linked with reverse logistics, for calculating the opportunity cost rates
Srivastava (2008)	Qualitative	Conceptual model simultaneous location-allocation of facilities for a cost-effective and efficient reverse logistics (RL) network

Proposed framework from Figure 1 has been divided into three phases: first phase covers quantitative analysis of inventory indicators covering order fulfillment lead time, carrying cost in percentage; second phase covers quantitative analysis of flexibility measures i.e. volume flexibility, mean demand and demand variance; and finally in third phase, cylinder utilization indicators, cylinder utilization ratio, CCT of working stock cylinders at distributors, and working stock ratio have been covered. All phases have been investigated by a quantitative analysis considering the real data of two agencies located in urban and rural areas of Andhra Pradesh, India. The quantitative analysis has also been tested using some statistical tools viz., two tailed *t*-tests as well as correlation with support of appropriate hypothetical framework developed.

Figure 1. Reverse logistics performance measurement for LPG agency (Indian context) a framework.



Source: Author.

2.2. Indian LPG scenario

LPG being an environment friendly and clean fuel has tremendous potential as replacement for traditional fuels like coal and firewood. On account of dearth of traditional fuel, the use of LPG as cooking fuel has become unavoidable most widely used for people in both urban and rural areas. LPG acts as ideal fuel for modern kitchens, synonymous with safety, reliability, and convenience.

2.2.1. About LPG

LPG is available in compact 5 kg cylinders for rural, hilly, and inaccessible areas, 14.2 kg cylinders for domestic use, and 19 and 47.5 kg for commercial and industrial use. LPG is blend of butane and propane readily liquefied under moderate pressure. LPG vapor is heavier than air, thus it normally settles down in low-lying places. Since LPG has only faint scent, a mercaptan odorant is added to help in its detection.

India is the third Largest consumer of LPG in the world after the USA, China. Major market of LPG is domestic sector and home delivery of LPG cylinders 3 million per day (i.e. 900 million/year). It has steady growth rate of 8% p.a. in LPG consumption in India.

From Table 2, consumers-domestic LPG usage by china is top one among the five nations followed by the USA. Among the Asian Countries, apart from China, LPG usage is high in India and Japan. Due to high population and less availability of alternate fuels for cooking purpose, majority of nations using LPG for domestic purpose.

From Table 3, it shows that during 2009–2010 demand stands at 12,746 TMT, Indigenous Production in 2009–2010 was 10,323 TMT. However, imports are being made at the rate of 22% of total LPG demand. Indigenous LPG production is run through state , private, and fractionators, and there is a increase in domestic LPG Connections. There is a need to focus on areas where LPG penetration is low

Table 2. Top 5 consumers-domestic LPG usage (in millions)

Consumer	LPG usage (million)
China	17,180
USA	14,783
India	11,270
Japan	7,605
Mexico	7,027

Source: Chandra, A. (2010). World LPG Forum-2010-Madrid.

Table 3. LPG penetration in domestic sector

Indigenous production	Urban	Rural	Total
Population (millions)	326.2	838.8	1,165
Households (millions)	95	159	254
LPG connections (millions)	83.8	31.2	115.0
Penetration of LPG (%)	88	19.6	45

Source: Chandra, A. (2010). World LPG Forum-2010-Madrid.

Table 4. Projected growth of LPG for 2011–2015

All figures in TMT	2011–2012	2012–2013	2013–2014	2014–2015
LPG	14,920	16,140	17,418	18,680
Projected growth (%)	8	8.1	7.9	7.3
<i>Indigenous production</i>				
Refineries	5,963	6,903	7,033	7,513
Fractionators	2,112	2,112	2,112	2,112
RIL	2,500	2,000	2,000	2,000
ESSAR	800	800	2,000	2,000
Total production	11,375	11,815	13,145	13,625
Imported required	3,545	4,325	4,273	5,055

Note: Tables 2–4 (Accessed on March 12, 2014) http://petrofed.winwinhosting.net/upload/Apurva_Chandra.pdf.

Source: Chandra, A. (2010). World LPG Forum-2010-Madrid.

by giving incentives to raise population coverage from 50 to 75%. Lot of increasing drift in LPG usage i.e. from 107 to 160 millions by 2015. Few consumers are also changing their using of cooking fuel from Kerosene of LPG.

2.3. Common LPG kitchen—making LPG affordable

As part of affordability for poor or low-income group in rural areas where population is 5,000, concept of community kitchens has been initiated as part of corporate social responsibility. This concept save consumption in LPG as well as less impact on climate change. Researchers predict that by 2015 projected growth in LPG demand shall be 8–9% especially in domestic sector.

From Table 4, projected growth of LPG for 2011–2015 interpretation is that even after indigenous production imports required during 2011–2012 to 2014–2015 varies from 122 to 118%, it has significant role on usage of LPG. Due to high demand, supply of LPG is being regulated by government through authorized retailers to consumers and made a policy of supplying LPG cylinders to consumers limiting to 12 per year (subsidised price) and order placement for refilling shall be made for every 21 days.

Wholesale price index (WPI) represents the price of goods at a wholesale stage i.e. goods that are sold in bulk and traded between organizations instead of consumers. WPI is used as a measure of inflation in some economies. WPI is used as an important measure of inflation in India. Fiscal and monetary policy changes are greatly influenced by changes in WPI. WPI is an easy and convenient method to calculate inflation. Inflation rate is the difference between WPI calculated at the beginning and the end of a year. The percentage increase in WPI over a year gives the rate of inflation for that year. From Table 5, WPI for LPG is constant for three years and raised by 9.47% and decreased by 4.73% 2008–2009 and 2009–2010 in next three years i.e. 2010–2013 increased by 11.11, 12.06, and 9.56%, respectively.

Table 6 depicts that the international price of LPG have been increase from year to year. Therefore, Government of India gives subsidies and other administrative measures to control domestic fuel prices which are below the global price level. Due to higher consumption, there is a large demand for LPG. As no major role of market forces, hence price control and subsidies have strong relation which effect market prices and consumption of LPG across the nation (Pongadi, 2014).

3. Research methodology

The objectives of this work is to evaluate the reverse logistics performance concerning inventory, volume flexibility, and cylinder utilization indicators which are accomplished by quantitative analysis of proposed three phases. Performing statistical testing with tools viz., two tailed *t*-test and Pearson's

Table 5. Whole sale price index of LPG from 2005 to 2012

Year	Wholesale price index (base year 2005)
2005–2006	106.1
2006–2007	106.1
2007–2008	106.1
2008–2009	117.2
2009–2010	111.9
2010–2011	125.9
2011–2012	143.17
2012–2013	158.32

Source: Office of the Economic Adviser, Ministry of Commerce and Industry.

Table 6. International price of LPG from 2005 to 2012

Year	International price in US (\$)
2005–2006	481.04
2006–2007	499.67
2007–2008	683.49
2008–2009	688
2009–2010	582.69
2010–2011	745.29
2011–2012	899.42
2012–2013	887.08

Source: Petroleum Planning and Analysis Cell, New Delhi, India.

correlation on the data collected through survey on the performance measures identified from the literature. To suggest the key performance indicators to be incorporated for effective decision-making in reverse logistics network with reference to the LPG agencies considered in this work.

Hypotheses framework:

H₁: The order fulfillment lead time (OFLT) has significant relation with number of orders placed by consumers.

H₂: The level of stock has significant relation with orders fulfilled within one day.

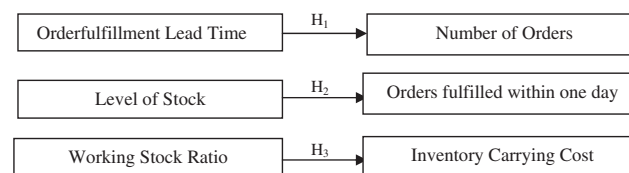
H₃: The working stock ratio has significant relation with inventory carrying cost.

The framed hypotheses have been tested for both the rural and urban agencies separately (Figure 2).

3.1. About the case company

One of the largest packed LPG brands in the world and has been conferred the coveted “Consumer Super brand” status by the Super brands Council of India. Having launched LPG marketing in the mid-60s has been credited with bringing about a “kitchen revolution,” spreading warmth and cheer in millions of households with the introduction of the clean and efficient cooking fuel. It has led to a

Figure 2. Framework of hypotheses for reverse logistics performance measurement for LPG agency (Indian context).



substantial improvement in the health of women, especially in rural areas by replacing smoky and unhealthy chulha. Today, it has become an ideal fuel for modern kitchens, synonymous with safety, reliability, and convenience. With the status of an exclusive business vertical within the corporation, the network delivers 1.2 million cylinders a day to the doorsteps of over 53 million households, making the second largest marketer of LPG globally, after SHV Gas of the Netherlands.

3.1.1. Rural agency

The rural agency having 15,000 single and 4,000 double connections which is located in Mummidivaram is a small village located in Mummidivaram Mandal of East Godavari district, Andhra Pradesh with total 6,560 families residing. The Mummidivaram village has population of 23,732 of which 11,733 are males while 11,999 are females as per Population Census 2011.

3.1.2. Urban agency

The urban agency having 9,000 single and 4,500 double connections which is located in Vijayawada, population of Vijayawada in 2011 is 1,048,240; of which male and female are 524,918 and 523,322, respectively. Although Vijayawada city has population of 1,048,240; its urban/metropolitan population is 1,491,202 of which 750,770 are males and 740,432 are females. The majority of city population has working-class as well as business-class culture.

From Figure 3, reverse logistics activities in rural and urban LPG agency described as consumers interact for order placement with their unique consumer identity number through telephone or by person; once the order request from consumer is placed, based on priority number, agency fullfills the order or request the consumer to wait at least for one week depending on the transit inventory as well as level of stock in their respective godown. For every 15 days, agencies place their order with refilling station, and parallely empty LPG cylinders are transported to refilling station. In rural and urban agencies, similar kind of activities for fulfilling the consumer demand with different assets for delivery of LPG to consumer household is being practiced.

3.1.3. Survey methodology

In order to accomplish the said objectives, an empirical approach is adopted that uses survey research design to investigate the reverse logistics performance measures concerning rural and urban LPG agencies. A questionnaire (refer Appendix A) was designed based on identified reverse logistics performance measures in consultation with SCM consultants and academic experts. Questionnaire has been filled by respondent using personal interview. Questionnaire has open-ended, close-ended as well some descriptive questions.

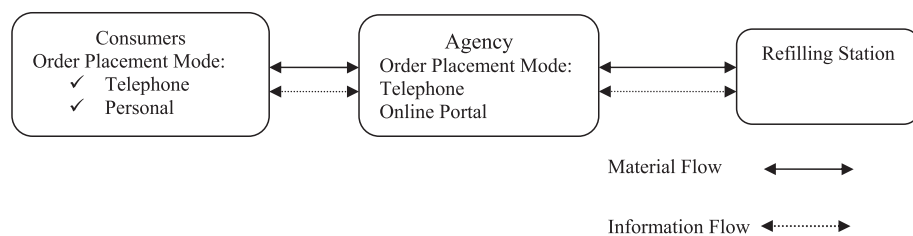
4. Results and discussion

Testing of Hypotheses results: To suggest better implications of the study, hypotheses framed has been tested using two tailed t-test as follows.

From Table 7, Hypothesis 1, Hypothesis 2, and Hypothesis 3 have been accepted that implies that in rural agency, there is a significant relation between order fulfillment lead time and number of orders, as well as significant relation between level of stock and order fulfilled within 24 h; the

Figure 3. Reverse logistics activities in urban and rural LPG agency.

Source: Author.



working stock ratio has significant relation with inventory carrying cost and has been validated by using the two tailed t-test.

From Table 8, Hypothesis 1 and Hypothesis 2 have been accepted that implies that in urban agency, there is a significant relation between order fulfillment lead time and number of orders, as well as significant relation between level of stock and order fulfilled within 24 h. Hypothesis 3 has been rejected.

In order to validate our hypothesis, we have also performed correlation. From Table 9, for interpretation of the correlation coefficient and its associated significant value of *p*. The Pearson’s correlation among performance measures in rural agency interpreted as follows: order fulfillment in 24 h and level of stock show positive correlation ($r = 0.93048$). Similarly, number of orders placed by consumers and level of stock are strongly correlated ($r = 0.850351$), and there is significant correlation between number of orders and order fulfillment in 24 h with correlation coefficient $r = 0.914211$.

The Pearson’s correlation among three performance measures in rural agency interpreted as follows: order fulfillment in 24 h and level of stock show positive correlation ($r = 0.277649$). Similarly, number of orders placed by consumers and level of stock are strongly correlated ($r = 0.154372$) and there is significant correlation between number of orders and order fulfillment in 24 h with correlation coefficient $r = 0.910068$ (Table 10 and Figure 4).

From Graph 1, it has been observed that overall OFLT is high in urban agency as compared to rural agency. OFLT is high in urban agency which has advantage of geographical location i.e. proximity to filling station is near as compare to rural agency.

Table 7. Hypotheses testing results (rural agency)

	Mean	Variance	Degree of freedom (ν)	t_c	t_o	Condition	Result
Hypothesis 1	$n_1 = 23.84$	$S_1 = 132.76$	22	± 1.717	-0.090586	$t_o < t_c$	Accepted
	$n_2 = 3,672.30$	$S_2 = 3,148,538.20$				$-0.090586 < 1.717$	
Hypothesis 2	$n_1 = 2,738.46$	$S_1 = 1,796,439$	22	± 1.717	-7.46412	$t_o < t_c$	Accepted
	$n_2 = 1,320.14$	$S_2 = 410,116.34$				$-7.46412 < 1.717$	
Hypothesis 3	$n_1 = 0.92$	$S_1 = 0.4106$	04	± 2.132	2.089583	$t_o < t_c$	Accepted
	$n_2 = 0.31998753$	$S_2 = 0.0234296$				$2.089583 < 2.132$	

Note: At $\alpha = 0.05$ i.e. 5% significant level.

Table 8. Hypotheses testing results (urban agency)

	Mean	Variance	Degree of freedom (ν)	t_c	t_o	Condition	Result
Hypothesis 1	$n_1 = 23.23$	$S_1 = 127.39$	22	± 1.717	-52.97	$t_o < t_c$	Accepted
	$n_2 = 3,275.53$	$S_2 = 3,275.38$				$-52.97 < 1.717$	
Hypothesis 2	$n_1 = 355.38$	$S_1 = 1.451E+27$	22	± 1.717	-3,500.668	$t_o < t_c$	Accepted
	$n_2 = 1,840.59$	$S_2 = 796,717.3$				$-3,500.668 < 1.717$	
Hypothesis 3	$n_1 = 1.42$	$S_1 = 0.33$	04	± 2.132	7.867371	$t_o < t_c$	Rejected
	$n_2 = 0.319988$	$S_2 = -0.15999$				$7.867371 > 2.132$	

Note: At $\alpha = 0.05$ i.e. 5% significant level.

Table 9. Pearson’s correlation among reverse logistics performance measures (in rural agency)

Pearson’s correlation	Level of stock	Order fulfillment in 24 h	Number of orders
Level of stock	1		
Order fulfillment in 24 h	0.93048**	1	
Number of orders	0.850351**	0.914211**	1

**Correlation is significant at the 0.01 level.

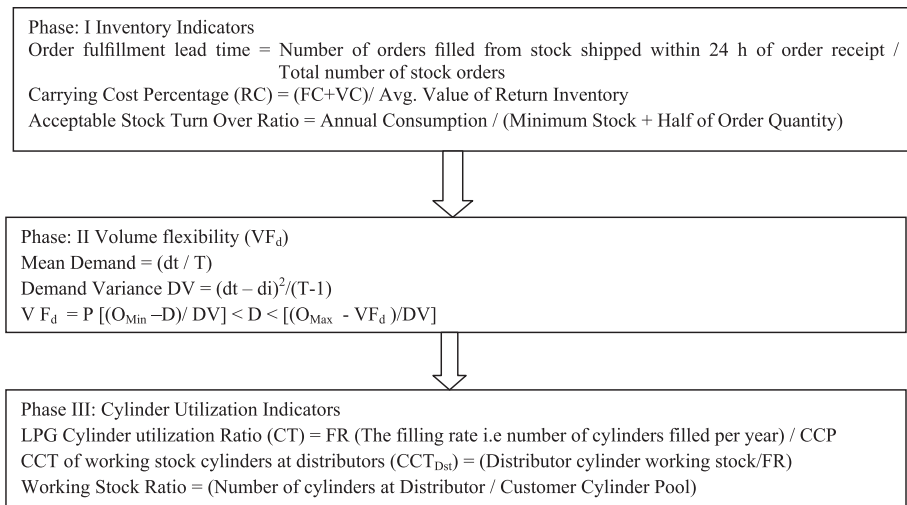
Table 10. Pearson’s correlation among reverse logistics performance measures (in urban agency)

Pearson’s correlation	Level of stock	Order fulfillment in 24 h	Number of orders
Level of stock	1		
Order fulfillment in 24 h	0.277649**	1	
Number of orders	0.154372**	0.910068**	1

**Correlation is significant at the 0.01 level.

Figure 4. A methodology for reverse logistics PMS for LPG network.

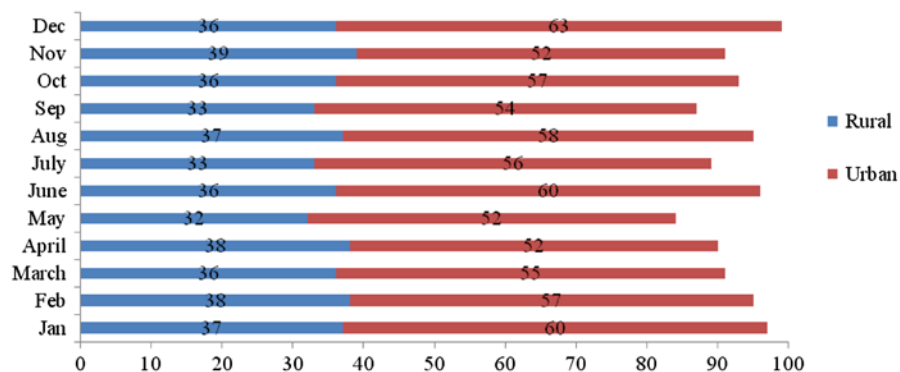
Source: Author.



4.1. Cost carrying percentage

To maintain consumer serviceability, calculating the cost of inventory is necessary to determine profit to be achieved from the existing inventory levels. The targeted level of consumer service is set by agency’s management of inventory levels which is expressed as percentage of units available to

Graph 1. Order fulfillment lead time in percentage rural vs. urban agency in 2012.



fulfill the order upon the receipt of consumer order. From Table 11, carrying cost percentage in rural and urban agency has been steadily decreased during 2010–2012. The reason for steady decrease is due to number of orders during 2010–2012 recorded low. Forecasting techniques help in scheduling the number of orders and inventory level; however, lot of uncertainty in balancing the carrying cost which has explicit relation with orders being placed by consumers is linked with consumption of LPG at household.

From Graph 2, acceptable stock turnover ratio indicates fluctuation of inventory. In the reverse logistics network considered in this study, the acceptable stock turnover ratio is fluctuating in both the rural as well as urban agency, However, in rural agency, fluctuations are also followed in some steady path. Whereas in urban agency, it has been observed as a sinusoidal wave pattern for first eight months of the year. The acceptable stock turnover ratio is very much close to the acceptable stock turnover rate and hence inventory investment is under good control. Estimation of acceptable stock turnover ratio is an indicator of efficiency of conversion process i.e. in relation to the case considered, the refilling activity of LPG by parent company has high responsiveness.

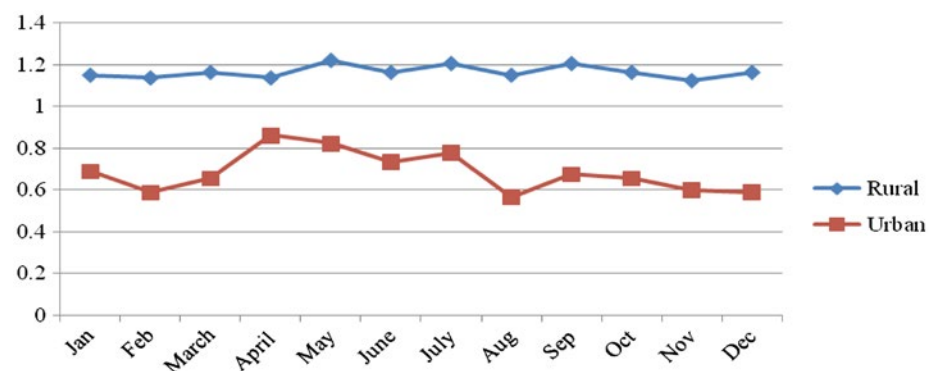
From Graph 3, mean demand of rural agency during 2012 for three different cases for delivery of refilled LPG to consumers has been qualitatively judged using the phrases i.e. more than 8 days-below average, within 6 days-average, and within 2 days-excellent (Accessed on March 7, 2015, https://www.hindustanpetroleum.com/documents/pdf/LPG_MDG_2014.pdf). The mean demand reflects in calculation of the volume flexibility. From figure, mean demand for three cases considered have followed the same pattern during 2012 from January to December but demand range of 1,000–2,000 LPG cylinder has to be fulfilled during January–December as per the data collected using survey instrument.

From Graph 4, it shows that mean demand of urban agency during 2012 for three different cases for delivery of refilled LPG to consumer. From above figure, mean demand for three cases considered have followed the same pattern during 2012 from January to December but within demand range of 1,128–705 in the case of excellent, range of 376–235 in the case of average, and range of 282–176 in the case of below average.

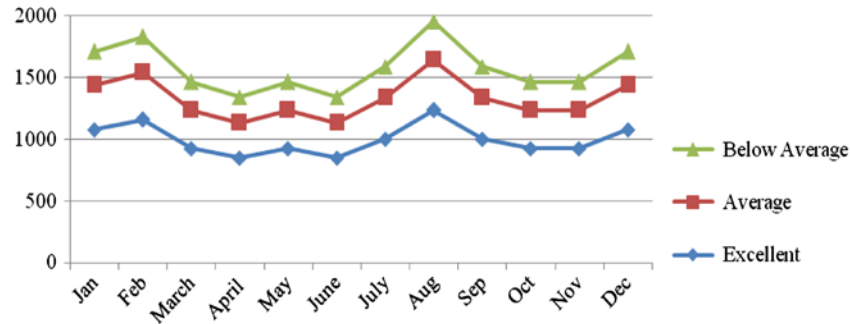
Table 11. Carrying cost (%) from 2010 to 2012

Year	Rural	Urban
2010	0.30	0.30
2011	0.18	0.27
2012	0.16	0.23

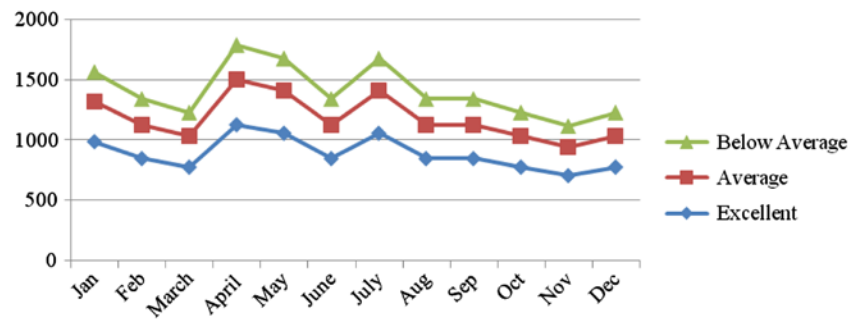
Graph 2. Acceptable stock turnover ratio of rural and urban agency in 2012.



Graph 3. Mean demand of rural agency during 2012 for different cases: below average, average, and excellent.



Graph 4. Mean demand of urban agency during 2012 for different cases: below average, average, and excellent.



4.2. Volume flexibility

From Table 12, volume flexibility can be best used to combat aggregate demand uncertainty for a set of products, such as uncertainty in demand. The rural agency maintained high volume flexibility as compared to urban agency in the current research work in two cases i.e. excellent and below average.

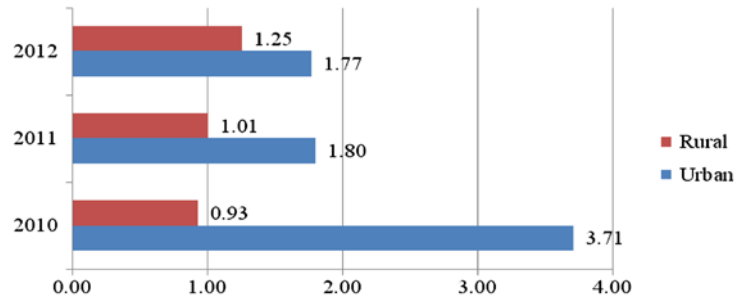
To handle the uncertainty of product demand in the market, organization needs to design reverse supply chain /logistics channels, and probabilities of disruption in these channels is high (Tang & Tomlin, 2008). To manage the efficient response to complexities, uncertainty in RL network incorporating flexibility is essential. Investigative studies on supply chain, flexibility has significant importance in recent literature of management and engineering (Vickery, Calantone, & Droge, 1999; Vokurka & O’Leary-Kelly, 2000). Majority of literature focused on production and manufacturing flexibility. Flexibility of RL and RL service providers is much essential (Meade & Sarkis, 2002). To increase the flexibility in reverse logistics, specific activity of building stock has significant role. The most acknowledged supply chain operations reference model in literature recognizes return with responsiveness, agility considering the flexibility which has significant role (Shepherd & Gunter, 2006). Considering volume flexibility has vital role in measuring the range of volumes to run organizations with sustainable profit, as well as in predicting variable demand (Lampe & Hofmann, 2014).

From Graph 5 about cylinder utilization indicators: The lower the LPG cylinder utilization ratio, the better unproductive cylinders or refilling of cylinders are being filled in less duration in the reverse logistics network; inference from this lower LPG cylinder utilization ratio reflects in consumption of LPG among the consumer is high. From figure, it can be interpreted that in rural agency, LPG cylinder

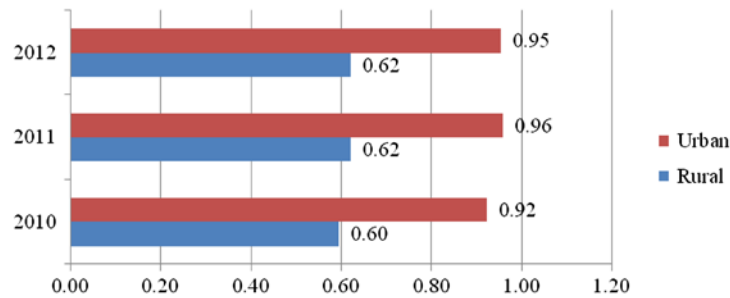
Table 12. Volume flexibility measures for rural and urban agencies

Case	Rural	Urban
Excellent	4	3.72
Below average	10.69	9.61

Graph 5. LPG cylinder utilization ratio rural vs. urban from 2010 to 2012.



Graph 6. CCT of working stock cylinders at distributors from 2010 to 2012.

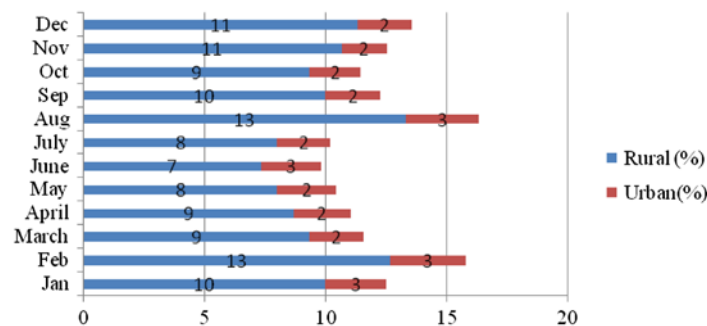


utilization ratio is consistently maintained low as compared to urban. However, in urban agency, LPG cylinder utilization ratio is high in 2010 but it has been drastically reduced to 48.51% in 2011 and maintained consistency for another year.

The lower the working stock cylinder ratio, it is the better working stock management it has been observed from Graph 6 that there was consistent low-working stock cylinder ratio i.e. 0.62 in rural agency during 2010–2012 which is a positive effect on the cylinder management. However, working stock cylinder ratio in urban is as high as compared to rural, but urban agency also administered the cylinder management ratio effectively during 2010–2012 in the reverse logistics network.

From Graph 7, working stock ratio depends upon the number of orders being placed by consumers. In this case of rural and urban agency, consistency is maintained during 2012. Major drawback in maintaining the working stock in reverse logistics network is because of uncertainty of stock levels and consumption of LPG by consumer which leads to placing a order in irregular interval of time. However, in traditional supply chain scope of incorporating JIT, VMI is high. But in the case of reverse logistics network, working stocking ratio helps the distributors to understand the level of stocks that are being held easily and be interpretable to make effective decisions in holding optimum inventory level, and also reflects in reducing the lead time. Scope of improved coordination reduces overall costs and gives economies of scale. Specific interdependencies of strategic decision-making and cost of capital of logistics are considered to be the study of microeconomic variables that influence the cost of capital of logistics service providers.

Graph 7. Working stock ratio: rural vs. urban agency in 2012.



5. Conclusions

Reverse logistics is one of the important networking functions of any LPG agency. Being stated that, this paper has addressed the factors affecting the implementation of PMSs to reverse logistics of a LPG agency. Based on data collected from urban and rural agencies, we found that order fulfillment, lead time, inventory carrying cost, acceptable stock turnover ratio, volume flexibility, cylinder utilization ratio, CCT of working stock cylinders at distributors and working stock ratio are the key performance indicators of successful implementation to reverse logistics. Specifically, it has been noticed that the strong relation exists between order fulfillment lead time and number of orders placed by consumers, orders have been fulfilled within one day, working stock ratio has strong relation with inventory carrying cost, and cylinder utilization indicators help in managing the reverse logistics assets and decision-making prioritized tools in maintaining the optimum level of stocks. Limitations of the study include relatively small sample, that is, one LPG agency from rural and urban areas to evaluate Reverse Logistics performance. Yet, the data are realistic that helps in generalizing the findings to other areas as well. Future research may consider firm- and industry-specific factors to evaluate the performance of reverse logistics and extend the number and types of reverse logistics flexibility. The observations eventually help LPG agencies in better management of reverse logistics measurement systems and decision-making at various channels involving through customer satisfaction.

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Appendix A

1. Total number of connections under your agency?

Year	2010	2011	2012
Single connection			
Double connection			

2. Warehouse/Godown capacity in Sq. ft. ____; Number of Cylinders per Sq. ft. ____;

3. Number of connections on Transfer per Year: _____;

Place of Transfer (a) Urban____; (b)Rural Area ____;

4. How do you collect cylinders:

Mode	Numbers	Capacity
Cycle		
Cycle rickshaws		
Auto rickshaws		
Minitruck		

5. Number of vehicles:

Mode	On rent	Agency asset
Auto rickshaws		
Minitruck		
Others (specify)		

6. If on rent or long-term contract (specify the Rent), how much agency have paid to the vehicle provider?

- Rent of Auto _____;
- Rent of Truck _____;
- Others (please specify) _____;

7. Mode of transport from your godown to refilling station. Capacity (In No. of cylinders)

- Tractor _____;
- Lorry _____;
- Mini Truck _____;
- Others (please specify) _____;

8. Transportation charges borne by?

- By agency
- Company
- 3PL (third party logistics)

9. Rate of charges (Per Trip) for transportation from your godown to refilling station?

- Lorries _____;
- Tractors _____;
- Trucks _____;

10. Total operating cost (including freight charges, administrative costs per month etc.):

11. Refilling cost per cylinder _____:

12. Number of persons involved in this distribution process like collecting cylinders from household via go down to refilling station?

- Number of persons
- Total Labor cost per month

Workers	At godown	At refilling station
Permanent		
On daily wage		

13. Distance from godown to refilling station in kilometer: _____;
14. Total sales per year
 - On Cylinder Deliver
 - On Accessories
 - On Connection Booking
15. Generally where do you face problem in this distribution system?
16. Period of peak demand for cylinders?
17. Reason for peak demand:
18. At what level of stock, you place an order for refilling? 18. How do you place the order For Refilling?
 - Telephone
 - Fax
 - E-mail
 - Post
19. Frequency of truck dispatches during a year: _____.
20. Time to reach refilled gas cylinders from refilling station to godown: _____;
21. Distribution whether depends upon demand or Not?



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